

# 9TH INTERNATIONAL CONFERENCE ON GLOBAL PRACTICE OF MULTIDISCIPLINARY SCIENTIFIC STUDIES

CONGRESS PROCEEDINGS BOOK

JANUARY 21-28, 2025 / HAYANA, CUBA



**EDITORS**

Prof. Dr. Mehmet Fırat BARAN

Assoc. Prof. Dr. Seyithan SEYDOŞOĞLU

Assist. Prof. Dr. Şahin AY

**9<sup>TH</sup> INTERNATIONAL CONFERENCE ON GLOBAL PRACTICE OF  
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adopted by Mariam Rasulan

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MULTIDISCIPLINARY SCIENTIFIC STUDIES**

**9th INTERNATIONAL CONFERENCE ON GLOBAL  
PRACTISE OF MULTIDISCIPLINARY SCIENTIFIC STUDIES**

**January 21-28, 2025  
Havana, CUBA**

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**PROCEEDINGS BOOK  
(Abstracts & Full Texts)**

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**EDITORS**

**Prof. Dr. Mehmet Fırat BARAN  
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## **9<sup>TH</sup> INTERNATIONAL CONFERENCE ON GLOBAL PRACTICE OF MULTIDISCIPLINARY SCIENTIFIC STUDIES**

### **EVALUATION PROCESS and POLICIES**

All applications have undergone double blind peer review process. In addition, each paper was accepted and the process of publishing in the book was carried out through editorial oversight. The published papers were presented and discussed at the meeting.

Full texts and abstracts published in accordance with the Symposium Policy have been prepared in accordance with ethical rules and APA standards. Authors of all papers are both ethically and legally responsible.

### **PARTICIPANTS COUNTRIES**

Türkiye, Algeria, Azerbaijan, Ethiopia, France, Georgia, India, Indonesia, Iran, Iraq, Japan, Macedonia, Malaysia, Moldova, Morocco, Nigeria, Pakistan, Romania, Serbia, Tunisia, Ukraine, Vietnam

### **TOTAL ACCEPTED ARTICLES: 248**

The Number of Accepted Papers from Türkiye: 98  
The Number of Accepted Full Papers from Other Countries: 150  
The Number of Total Papers: 248

**9<sup>TH</sup> INTERNATIONAL CONFERENCE ON GLOBAL PRACTICE OF  
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**January 21-28, 2025**

**Havana, CUBA**

**SYMPOSIUM SCHEDULE**

**9<sup>TH</sup> INTERNATIONAL CONFERENCE ON GLOBAL PRACTICE OF  
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**January 21-28, 2025 / Havana, CUBA**



**JANUARY 21-28, 2025 / HAVANA, CUBA**

**9<sup>TH</sup> INTERNATIONAL CONFERENCE ON  
GLOBAL PRACTICE OF MULTIDISCIPLINARY  
SCIENTIFIC STUDIES**

**CONFERENCE PROGRAM**

*Online and In-Person*

**MEETING ID: 884 2447 8604  
ZOOM PASSCODE: 090909**

# 9<sup>TH</sup> INTERNATIONAL CONFERENCE ON GLOBAL PRACTICE OF MULTIDISCIPLINARY SCIENTIFIC STUDIES

January 21-28, 2025 / Havana, CUBA

## Face to Face / Cuba Hotel

21.01.2025

HALL-1 / SESSION-1

HAVANA LOCAL TIME: 14:00

**HEAD OF SESSION: Prof. Dr. Chulpan Zaripova Chetin**

Authors	Affiliation	Presentation Title
Ramazan Çelik	<i>Trakya University</i>	Reflection of The News of Fidel Castro's Death on Turkish News Sites
Erman Trak	<i>Trakya University</i>	Tourist Perception Shaped by Visual Culture: The Classic Car Element in Turkish Tourists' Instagram Posts About Havana
Kemal Yıldız	<i>Manisa Celal Bayar University</i>	Taxonomic Contributions on <i>Silene L.</i> (Caryophyllaceae) Taxa Distributed in Türkiye
Fikrinaz Damla Akbaba Cansu Tutkun Fatma Tezel Şahin	<i>Bayburt University</i>	The Century of Türkiye Education Model and Preschool Education: A Route Map with The Perspectives of Teachers
Cansu Tutkun Elmas Holoğlu	<i>Bayburt University</i>	Integration of Technology-Based Applications into Education: an Analysis on Web, Vr and Ar Tools
Emine Cihan	<i>Selcuk University</i>	The Role of Physiotherapy in Prostate Cancer: A Systematic Review
Bayram Er Yaşar Yiğit Kaçmaz Hüseyin Uysal	<i>Alanya University</i>	Evaluation of The Satisfaction Levels of Foreign Tourists Purchasing Real Estate in Alanya By Real Estate Consultants
Ekin Aktürk	<i>Kafkas University</i>	Hemingway's Novel 'The Snows of Klimanjaro' According to Emile Benveniste's Theory of Enchanting
Ayşe Ediz Şenol Altan Onur Can	<i>Ankara Hac Bayram Veli University</i>	Prediction of The Borsa Istanbul Index Using Macroeconomic Data with Artificial Neural Networks
Chulpan Zaripova Chetin	<i>Kafkas University</i>	The Concept of Homeland in The Poetry of Sibgat Hekim
Taha Güven Dilan Dali	<i>Van Training and Research Hospital</i>	Piezogenic Pedal Papules: A Case Report
Hilal Medetalibeyoğlu Abdurrahman Atalay	<i>Kafkas University</i>	Computational Investigation on $\eta^2$ -Type Interactions in $Cu_2+$ -Corannulene Complexes

(All speakers required to be connected to the session 10 min before the session starts)

Moderator is responsible for ensuring the smooth running of the presentation, managing the group discussion and dynamics.

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January 21-28, 2025 / Havana, CUBA

## Face to Face / Cuba Hotel

21.01.2025

HALL-1 / SESSION-1

HAVANA LOCAL TIME: 16:00

**HEAD OF SESSION: Prof. Dr. Murat Tunçtürk**

Authors	Affiliation	Presentation Title
Elif Baştuğ Güven Aslı Zeynep Kapoğlu Kiliç	<i>Van Yuzuncu Yil University</i>	Non-Surgical Endodontic Treatment of Mandibular Incisors with Periapical Lesions: Case Report Series
Aslı Zeynep Kapoğlu Kiliç Elif Baştuğ Güven	<i>Van Yuzuncu Yil University</i>	Evaluation of Dentistry Students' Post-Graduation Career Goals
Ruvejde Tunçtürk Murat Tunçtürk	<i>Van Yuzuncu Yil University</i>	Investigation of Antioxidant Activity, Total Phenolic and Flavonoid Substance Amounts of <i>Sanguisorba minor</i> (L.)
Murat Tunçtürk Ruvejde Tunçtürk	<i>Van Yuzuncu Yil University</i>	Determination of Mineral and Chemical Properties of Comfrey ( <i>Symphytum officinale</i> L.)
Nilgün Onursal	<i>Siirt University</i>	Comparative Analysis of Adsorption Isotherms of Lead (II) With Ergani Nut Shell
Nilgün Onursal	<i>Siirt University</i>	Investigation of Adsorption Kinetics of Lead (II) With Ergani Nut Shell
Burak Özdemir Füsün Gülser	<i>Van Yuzuncu Yil University</i>	Smart Agriculture Techniques in Plant Nutrition
Siyami Karaca Füsün Gülser Bulut Sarğın	<i>Van Yuzuncu Yil University</i>	Variation of Soil Carbon Sequestration in Soil Profiles of Semi-Arid Regions
Nurhan Keskin	<i>Van Yuzuncu Yil University</i>	Bibliometric Analysis of Studies on Organic Agriculture: Web of Science Application
Nurhan Keskin	<i>Van Yuzuncu Yil University</i>	Bibliometric Analysis of Publications on Good Agricultural Practices (GAPs) Based on The Web of Science Database
Melekber Sülüoğlu Durul	<i>Kocaeli University</i>	Tissue Culture Studies on Abiotic Stress Factors in Fruit Species
Mehmet Fırat Baran Erhan Kahya Seyithan Seydoşoğlu	<i>Siirt University</i>	Agricultural Application Examples of Yolo Deep Learning
Şahin Ay	<i>Siirt University</i>	Historical Process Of Special Communication Tax

(All speakers required to be connected to the session 10 min before the session starts)

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January 21-28, 2025 / Havana, CUBA

22.01.2025 / ONLINE



ANKARA LOCAL TIME: 10:00-12:00

SESSION-1 / HALL-1

Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

HEAD OF SESSION: Prof. Dr. Ali Beyhan Ucak

Authors	Affiliation	Presentation Title
Arzu Altuntaş	Siirt University	Landscape architecture practises against the urban heat island effect
Arzu Altuntaş	Siirt University	Public participation and its importance in landscape management approaches
Nizamettin Turan	Siirt University	Effect of Farm Manure on Plant Development
Gölgen Bahar Öztekin Ali Kemal Demircan	Ege University	The effects of biochar-enriched seedling medium on plant growth, yield, and quality in hydroponic lamb's lettuce cultivation
Ali Beyhan Uçak	Siirt University	Investigation of the correlation between yield and other parameters in second crop sweet corn plant
Ali Beyhan Uçak	Siirt University	Investigation of the correlation between yield and some parameters in chickpea plants
Negar Valizadeh Gülen Özyazici	East Azerbaijan Agricultural and Natural Resources Research and Education Center	Phytochemical investigation of valuable species of thymus genus
Negar Valizadeh Gülen Özyazici	East Azerbaijan Agricultural and Natural Resources Research and Education Center	Investigation of the effect of plant density and nutrition on the performance of satreja mutica under rainfed conditions

(All speakers required to be connected to the session 10 min before the session starts)

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January 21-28, 2025 / Havana, CUBA

22.01.2025 / ONLINE



ANKARA LOCAL TIME: 10:00-12:00

SESSION-1 / HALL-2



Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

**HEAD OF SESSION: Assoc. Prof. Dr. Fırat Pala**

Authors	Affiliation	Presentation Title
Fırat Pala Hüsrev Mennan	<i>Siirt University</i>	Characteristics of weeds
Fırat Pala Hüsrev Mennan	<i>Siirt University</i>	Chemical weed management
Alper Baydar Yeşim Bozkurt Çolak	<i>Siirt University</i>	Effects of restricted irrigation and different fertigation practices on the chlorophyll content of tomato plants
Sevilay Gül Levend Coşkuntuna	<i>Tekirdag Namik Kemal University</i>	Nutritional quality and usage of canola ( <i>Brassica rapa</i> L.) in animal nutrition
Bekir Sıtkı Şirikçi	<i>Yozgat Bozok University</i>	Development of chickpea production and competitiveness analysis
Ahmet Karahan Figen Balo	<i>Malatya Turgut Ozal University</i>	Energy efficiency analysis with alternative designs in double walled chimney systems
Ahmet Karahan Figen Balo	<i>Malatya Turgut Ozal University</i>	Optimal chimney design in industrial facilities using coal boilers for the management of environmental pollution
Nurettin Baran Mehtap Andırman	<i>Mus Alparslan University</i>	The place and importance of oilseed crops in the development of province Batman

(All speakers required to be connected to the session 10 min before the session starts)

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ANKARA LOCAL TIME: 10:00-12:00

SESSION-1 / HALL-3



Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

HEAD OF SESSION: Dr. Yasemin Akman

Authors	Affiliation	Presentation Title
Feyzanur Soğukpınar	<i>Sivas Cumhuriyet University</i>	The hidden face of a globalizing world: precarialization
Fırat İşlek Atilla Çakır	<i>Mus Alparaslan University</i>	Innovative packaging techniques and logistics systems in viticulture
Yasemin Akman		
Sinem Gökdoğan Kalender Yeliz Mercan	<i>Kırklareli University</i>	Effects of health tourism on foreign trade
Selma Özcan Emre Kalay	<i>Trakya University</i>	Effects of reforms in Saudi Arabia on women
Zouha Bouamor	<i>Selçuk University</i>	Medical tourism in Turkey: a SWOT analysis
K. Aparca	<i>Symbiosis International Deemed University</i>	LGBTQIA+ marriage laws in India
Mehmet Emin Birpınar		Comparative analysis of ERA5 and ERA5-Land reanalysis data for drought evaluation using the standardized precipitation index (SPI)
Ahmad Abu Arra Eyüp Şişman	<i>Yıldız Technical University</i>	Impacts of probability distribution function model selection on drought analysis: comparing gamma and best-fit distributions
Ahmad Abu Arra Eyüp Şişman	<i>Yıldız Technical University</i>	

(All speakers required to be connected to the session 10 min before the session starts)

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ANKARA LOCAL TIME: 10:00-12:00

SESSION-1 / HALL-4



Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

## HEAD OF SESSION: Gheorghe GIURGIU

Authors	Affiliation	Presentation Title
Gheorghe Giurgiu Manole Cojocaru	Deniplant-Aide Sante Medical Center	The influence of Imuniplant on the microbiome in patients with inflammatory bowel disease
Abidova Səriyyə Elşən Qızı	Scientific Research	Testimonies of ethnic groups who witnessed the 1918 genocide in Guba
Müjkan Məmmədzadə	Dissertation of the Military Scientific Research Institute	Model Of Education Management In Higher Military Educational Institutions
Lahouel Khemissi Gasmi Meriem	University of Abbes Laghrour	Improvement of tin oxide thin film for the wastewater Treatment Process and its effects on our health
Y. Ben-Ali I. El Kadmiri M. El- Aouni Z. Rahou Abdelaziz Hallaoui Moulay Driss Belrhiti Abdelouahed Essahlaoui D. Bria	Mohamed I University	Filter based on the defective star waveguides system with coaxial cables
Anna Kopiczko Patrycja Widłak Joanna Cieplińska Małgorzata Jusiakowska-Piputa	Józef Piłsudski University of Physical Education in Warsaw	Prevalence And Risk Factors Of Osteosarcopenia Among Postmenopausal Women
Patrycja Widłak Anna Kopiczko Bartłomiej Michalak Zbigniew Tyc	Józef Piłsudski University of Physical Education in Warsaw	Comparison Of Functional Fitness In Athletes Training Soccer And Karate Using The Fms (Functional Movement Screen) Test
Gulnar Atakishiyeva Sevinc Mukhtarova Sima Musayeva Ilhama Hamdullayeva Irada Shikhaliyeva Mehmet Akkurt	Baku State University	Hırshfield Surface Analysis Of (E)-1-(2,2-Dichloro-1-(4-Nitrophenyl) Vinyl)-2-(4-Fluorophenyl) Diazine
Gulnar Atakishiyeva Nigar Ahmedova Sevinç Muhtarova Shukufa Eyvazova Naila Veysova Namiq Shikhaliyev	Baku State University	Benziliden-2-Fenilhidrazin Dihalogendiazabutadienlərin Sintezi
Monika Stojanova Sani Demiri Yalçın Kaya Marina T. Stojanova Dragutin A. Djukic	Association for Scientific- Research	The Effect Of Linden Extracts On The Antioxidant Potential Of Iced Tea

(All speakers required to be connected to the session 10 min before the session starts)

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# 9<sup>TH</sup> INTERNATIONAL CONFERENCE ON GLOBAL PRACTICE OF MULTIDISCIPLINARY SCIENTIFIC STUDIES

January 21-28, 2025 / Havana, CUBA

22.01.2025 / ONLINE



ANKARA LOCAL TIME: 10:00-12:00

SESSION-1 / HALL-5



Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

**HEAD OF SESSION: Victoria POSTOLACHE**

Authors	Affiliation	Presentation Title
Shehar Bano	<i>Government College</i>	Synthesis And Biological Screening Of Amides Using
Talha Mashhood	<i>University</i>	Coumarin-3-Carboxylic Acid
Talha Mashhood	<i>Government College</i>	Synthesis And Biological Screening Of Hydrazone By Using
Shehar Bano	<i>University</i>	Cholic Acid
Aniekan Essienubong Ikpe		Deep Learning Architecture for Data-Driven Damage
Imoh Ime Ekanem	<i>Akwa Ibom State Polytechnic</i>	Detection in Non-Linear Dynamic Systems: A Systemic
Emem Okon Ikpe		Review on Structural Health Monitoring
Benacer Hamza	<i>Oum El Bouaghi University</i>	Natural and social parameters in the process of city formation lessons from Medina
Victoria Postolache	<i>Alecu Russo Balti State</i> <i>University</i>	Particularities Of Risks And Threats To Economic Security In The Banking Sector
Ma. Lam Le Thanh	<i>University of Architecture</i>	Hybrid Office Trends In Ho Chi Minh City
Nguyễn Thị Bích Vân	<i>University of Architecture</i> <i>Hochiminh City</i>	Color Trends 2025: Exploring the Palette of Calm and Vibrancy in Interior Design
Nguyễn Thị Bích Vân	<i>University of Architecture</i> <i>Hochiminh City</i>	Innovative Sustainable Materials in Interior Design Trends and Applications in 2025
Ivanka Hadzic	<i>Scientific Institute of</i>	Technopathies That Influence The Appearance Of Hoof
Ivan Pavlovic	<i>Veterinary Medicine of Serbia</i>	Disease In Cattle Farms On A Connected Breeding System

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22.01.2025 / ONLINE



ANKARA LOCAL TIME: 10:00-12:00

SESSION-1 / HALL-6



Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

## HEAD OF SESSION: Madhumangal Pal

Authors	Affiliation	Presentation Title
Chukwulenwenwa John Orié Udoka Cornelius Isaac Caroline Nma Ogbowu Huma Ikram	<i>Industrial Technology Education</i>	Impact of Constructing A Tripartite Mechanical Free Energy System For Home Appliances That Does Not Require Fuel Combustion.
Hannah Tariq Muhammad Raza Shah Darakhshan Jabeen Haleem	<i>University of Karachi</i>	Nanoformulations of Apomorphine to Enhance Cognitive Profile
Kamaruddin Radzuan Bong Sing Huey	<i>Universiti Utara Malaysia</i>	Implementing Lean Management in a Manufacturing Organization: Success Factors and Strategies for Overcoming Challenges
Henos Ejigu Wondimagegn Dawit Asrat Getahun Tiruwork Tamiru Tolla	<i>Bahir Dar University</i>	Dynamics Of Gender Disparity In Perceived Linguistic Competence, Engagement Profiles, And Science Learning Outcome Among 7th Students
Priscilla Rebecca Rodrigues Geeta Shrivastava	<i>Himalayan University</i>	Industrial Effluents and Their Impact on Public Health: Exploring Socio-Legal Challenges and Solutions
Vignesh K K. Selvam Arsha G	<i>Palar Agricultural College</i>	Studies On Integrated Plant Disease Management On <i>Sarocladium oryzae</i> CAUSES Sheath Rot Of Rice ( <i>Oryza sativa</i> L.)
Vignesh K K. Selvam Arsha G	<i>Palar Agricultural College</i>	Efficacy Of Green Synthesized Zinc Nanoparticles On <i>Pyricularia grisea</i> Causes Blast In Ragi ( <i>Eleusine coracana</i> L.)
Madhumangal Pal	<i>Vidyasagar University</i>	The eigenvalues and eigenvectors of neutrosophic matrices
Intan Radina binti Ahmad Jasmin Ilyani binti Ahmad	<i>Tuanku Sultanah Bahiyah Polytechnic</i>	Factors Influencing Student's Enrolment In Tvet Programmes: A Study Of Malaysian Polytechnics

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ANKARA LOCAL TIME: 12:30-14:30

SESSION-2 / HALL-1



Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

HEAD OF SESSION: Assoc. Prof. Dr. Ayhan Aksakalli

Authors	Affiliation	Presentation Title
Yasemin Nadir Pınar Kiran	<i>Sağlık Bilimleri University</i>	Investigation of infection focus and factors in febrile neutropenic patients, 10-year retrospective study
Ayhan Aksakalli	<i>Bayburt University</i>	Observation and faith: quantum mechanics and the construction of reality in theology
Mehmet Furkan Şener	<i>İzmir Bakırçay University</i>	Karstic depressions of western anatolia (Turkey): distributional characteristics and tectonism
Hüseyin Ergin	<i>Köşk Central Family Health Center</i>	Current approaches in smoking cessation treatment
Hüsnüye Merve Demirer Ramazan Demirer	<i>Istanbul Gelisim University</i>	The effects of tai chi exercises on elderly individuals
Mohit Jain	<i>Jai Narain Vyas University</i>	Revamping hospitality: fast fashion's shift towards sustainable sourcing
Merve Köksal Gözde Kiliç	<i>Amasya University</i>	Antioxidant activity of of smilax excelsa l. stem extract
Sultan Acun Gözde Kiliç	<i>Amasya University</i>	Probiotics and evaluation of potential antioxidant features

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22.01.2025 / ONLINE



ANKARA LOCAL TIME: 12:30-14:30

SESSION-2 / HALL-2

Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

HEAD OF SESSION: Dr. Selver Bezin

Authors	Affiliation	Presentation Title
Nurhayat Özdemir	<i>İnönü University</i>	Analysis Of Capers (Capparis spinosa And Capparis ovata)
Sena Havva Özüpek		Medicinal And Aromatic Plants By Gc-Ms Ftir And Sem-Edx
Gamze Nur Güven	<i>Bursa Uludağ University</i>	Development of Polyethylene-Like Materials with Boron
Mustafa Kurban		Additives in F8BT Polymers: Investigation of Electronic and
Şekip Esat Hayber		Optical Enhancements for Photovoltaic Applications.
Büşra Yavuz	<i>Ali Kemal Belviranlı</i>	The Relationship Between Prenatal Stress And Traumatic
Halime Esra Meram	<i>Obstetrics and Gynecology</i>	Childbirth Perception With Prenatal Attachment In Pregnant
	<i>Hospital</i>	Women
Sema Samatya Yılmaz	<i>Kocaeli University</i>	Effect Of Peg Addition On Crystallinity, Thermal And Mechanical Properties Of Pla/Boron Carbon Nitride Films
Merve Ercan Kalkan		
Nurseli Görener Erdem		
Murat Efgan Kibar		
Esra Bilgin Şimşek		
Ayşe Aytaç		
Merve Ercan Kalkan	<i>Kocaeli University</i>	Investigation Of The Thermal Properties, Wettability, And Antibacterial Activity Of Boron Carbon Nitride Added Pla/Peg Films
Sema Samatya Yılmaz		
Nurseli Görener Erdem		
Murat Efgan Kibar		
Esra Bilgin Şimşek		
Ayşe Aytaç		
Selver Bezin	<i>Van Yuzuncu Yil University</i>	Metaphor Analysis In Mental Health

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ANKARA LOCAL TIME: 12:30-14:30

SESSION-2 / HALL-3



Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

HEAD OF SESSION: Başak Çelik

Authors	Affiliation	Presentation Title
Başak Çelik	Ankara Sosyal Bilimler University	The Protection of Spare Parts Designs
Hüseyin Hakan Ince	Dicle University	Examination of the Common Text of the Turkish Century
Murat Hevedanlı		Maarif Model Curriculums in Terms of Literacy Skills
Büşranur Kovalar	Sivas Cumhuriyet University	Relationship Between Crime, Migration And Anomie
Mohd Adil Siddique	NIT Raipur	Impact Assessment of Acid Mine Drainage on Ground Water Quality of
M. D. Patel		
Ravi K Jade		
Aarif Jamal	Federal Polytechnic	Evaluating the Effectiveness of Public-Private Partnerships in Urban Transportation Systems: A Business Model Perspective
Yusuf Kolapo Ibrahim		
Samuel Seun Salako	MIS/IT Specialist in Ministry of Safron	Integrated Mental Health And Psychosocial Support (Mhpss) Framework By Mis/It Specialist A Digital Strategy
Muhammad Faisal		

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ANKARA LOCAL TIME: 12:30-14:30

SESSION-2 / HALL-4



Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

## HEAD OF SESSION: Vaishali Krishna

Authors	Affiliation	Presentation Title
Ashrafal Amin Mehedi Hasan Fahim Azizur Rahman Masbahul Islam	<i>Tokyo International University</i>	SAARC: An Evaluation of its Successes, Failures, and the Call for Enhanced Cooperation
Amritha LJ Sreejith J	<i>SRM University</i>	Personal financial literacy among Post Graduates Indians
Khadija Benamar Rachid Lahlali Saad Ibsouda Koraichi Kawtar Fikri-Benbrahim	<i>Microbial Biotechnology and Bioactive Molecules Laboratory</i>	Volatile Plant-Derived Compounds as Sustainable Solutions Against <i>Penicillium expansum</i> : In Vitro Studies analysis
Fozia Anjuma Arooj Anwara Muhammad Shahidb	<i>Government College University Faisalabad</i>	Development Of Nanonutrients From Municipal Waste Incinerator Bottom Ash Using Orthogonal Array Design
Deepak Bansal	<i>Indian Institute of Finance</i>	Design And Development Of Novel Approach For File Sharing For Security Using Blockchain Technology
Nadagouda Kalyani Chathura Balasai Yalakacharla Narasimha Devara Guru Venkata Prasad Dasari Rahul Gandhi Bommepalli Pradeep Reddy	<i>G. Pulla Reddy Engineering College</i>	Study on Compressive Strength of Quarry Dust as Fine Aggregate in Concrete
Nadagouda kalyani Peddada Jagadeeswara rao Yalakacharla Narasimha Devara Guru Venkata Prasad Dasari Rahul Gandhi Bommepalli Pradeep Reddy	<i>G. Pulla Reddy Engineering College</i>	Effect Of Flaky Aggregates On The Strength And Workability Of Concrete
Abubakari, Iddirisu	<i>University of Zululand</i>	Digital Humanities among Ghanaian Students: Prospects and Challenges
Vaishali Krishna	<i>Jawaharlal Nehru University</i>	Global Business Models and the Role of International Relations in Shaping Human Resource Management Practices

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ANKARA LOCAL TIME: 12:30-14:30

SESSION-2 / HALL-5



Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

## HEAD OF SESSION: Fahim Yar Baig

Authors	Affiliation	Presentation Title
Sabra Inam Afshan Naseem Irfan Bashir	<i>University of Management and Technology</i>	Redefining Teaching: The Role of Social Media in High School Classrooms
Muhammad Aminu Musa	<i>Ahmadu Bello University</i>	Exploring Sustainable Open-Plan Office Building Design For Optimal Daylighting And Thermal Comfort In The Temperate Dry Climate Of Nigeria
Akbar Nikkhah	<i>University of Zanjan</i>	On Energy Policies in Dairy Production: Moderated Dietary Starch for Maximized Profitability
Vesna Karapetkovska-Hristova Bardha Ibishi Viktor Kolovski Ivan Pavlovic	<i>University "St. Kliment Ohridski"</i>	Impact Of Filtration On The Antioxidant And Bioactive Properties Of Propolis
Taoufik Ahall Hasan Ouakhir Nordine Nouyati Aziz Maziane Nadia Ennaji Mimoun Goumih Mohamed Rizki	<i>Abdelmalek Essaadi University</i>	Monitoring and modelling of sediment transport in the streams: case study of Mkhdach catchment (Middle Atlas/Morocco)
Fahim Yar Baig	<i>Architectural Engineering Student of Ahlul Bayt International University</i>	Enhancing Safety and Productivity: Comprehensive OH&S Practices for Modern Construction Projects
Fahim Yar Baig	<i>Architectural Engineering Student of Ahlul Bayt International University</i>	The Evolution and Impact of Islamic Architecture in Contemporary Society
Samira Mehrafza Fahim Yar Baig	<i>Architectural Engineering Student of Ahlul Bayt International University</i>	Ethical Implications of Artificial Intelligence in Education and Architectural Design
Zineb Ait Fares Miloudi Hlaibi Noureddine Kamil Rachid Ouchn	<i>Hassan II University of Casablanca</i>	Polymeric membranes for desalination using membrane distillation: A review

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ANKARA LOCAL TIME: 12:30-14:30

SESSION-2 / HALL-6



Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

## HEAD OF SESSION: **Habil. Cristina Raluca**

Authors	Affiliation	Presentation Title
Sadiq, M.S Singh, I.P Ahmad, M.M Sani, B.S Nazifi, I.K Aliyu, A.S	<i>Department of Agricultural Economics and Agribusiness</i>	Artificial Intelligence for Food Safety and Quality Control: A Research Review
Sadiq, M.S Singh, I.P Ahmad, M.M Sani, B.S Nazifi, I.K Aliyu, A.S	<i>Department of Agricultural Economics and Agribusiness</i>	Decentralized Finance (DeFi) in Agribusiness: A Research Review
Merzouki Mohammed Bouammali Boufelja Challioi Allal	<i>Mohammed I University</i>	Computational Analysis of the Inhibitory Potential of Flavone Derivatives on the SARS-CoV-2 Protein
Monika Lopuszanska-Dawid	<i>Józef Piłsudski University of Physical Education in Warsaw</i>	Urban Living and Women's Well-being: A Study of Mental Health and Health Behaviors in Polish Cities
Habil. Cristina Raluca	<i>University of Bucharest</i>	Turkey's Mental Health Policy and Service Delivery: Human Resources Management and People-Centered Care
Zineb Elaboudi Samira El Aouidi Radouan Saadi Azzouz Benkdad Zineb El Mouridi Abdelmourhit Laissaoui Abdelaziz Madinzi Salah Souabi	<i>University of Hassan II Casablanca</i>	Assessment of Soil-to-Plant Transfer Factors of Natural and Artificial Radionuclides in Agricultural Products from the Semi-Arid Meknes Region, Morocco
Rachid Kellal Mustapha Zertoubi Driss Benmessaoud Left	<i>Hassan II University of Casablanca</i>	Investigating the Corrosion control of <i>Eriobotrya japonica</i> (Loquat) Seed Extract for Carbon Steel Protection in Acidic Medium: A Sustainable and Eco-Friendly Approach
Ayoola, Yemisi Adeola Oyewole, Julius Ademola	<i>University of Ilesa</i>	Integrating Physics and English Language Learning: Exploring the Impact of Multimodal Instructional Strategies on Student Achievement in STEM and Language Proficiency
Oyewole, Julius Ademola Ayoola, Yemisi Adeola	<i>University of Ilesa</i>	Fostering Critical Thinking through Physics and English Integration: A Study of Argumentative Writing on Scientific Phenomena

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January 21-28, 2025 / Havana, CUBA

22.01.2025 / ONLINE



ANKARA LOCAL TIME: 15:00-17:00

SESSION-3 / HALL-1



Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

HEAD OF SESSION: Assoc. Prof. Dr. Görkem ÖZTÜRK

Authors	Affiliation	Presentation Title
Aykut Ekiyor Ayhan Erener	<i>Ankara Hacı Bayram Veli University</i>	The role of demographic characteristics in online insurance transaction customer relationship management: an application in the healthcare sector
Aykut Ekiyor Ayhan Erener	<i>Ankara Hacı Bayram Veli University</i>	Effects of customer relationship management in online insurance processes on customer satisfaction, trust, and loyalty: an application in the healthcare sector
Ilknur Ari Figen Balo	<i>Firat University</i>	Simulation analysis of energy efficiency of natural stone alternatives for sustainable buildings
Ilknur Ari Figen Balo	<i>Firat University</i>	Regional assessment of energy efficiency of building envelope for clean environment; İzmir province case study
Hazal Boydak Demir Figen Balo	<i>Dicle University</i>	Evaluation of energy performance of insulation options for building design in temperate climate regions
Hazal Boydak Demir Figen Balo	<i>Dicle University</i>	Energy performance analysis with simulation in buildings; mersin example
Rıfat Enes Bitkin Hüseyin Suha Aksoy	<i>Bingol University</i>	Investigation of the effect of soil reinforcement to limit the stress at the edge of buried pipe

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January 21-28, 2025 / Havana, CUBA

22.01.2025 / ONLINE



ANKARA LOCAL TIME: 15:00-17:00

SESSION-3 / HALL-2



Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

HEAD OF SESSION: Assoc. Prof. Dr. Abdurrahim YILMAZ

Authors	Affiliation	Presentation Title
Rufayi Karataş Sipan Soysal Fatih Demirel Abdurrahim Yilmaz	<i>Atatürk University</i>	Effect of Electromagnetic Areas on Seed Germination
Rufayi Karataş Sipan Soysal Fatih Demirel Abdurrahim Yilmaz	<i>Atatürk University</i>	Growth Regulatory Hormone Applications in Edible Legumes
Rufayi Karataş Sipan Soysal Fatih Demirel Abdurrahim Yilmaz	<i>Atatürk University</i>	Epigenome Analysis: A Molecular Approach to Crop Improvement
Rufayi Karataş Sipan Soysal Fatih Demirel Abdurrahim Yilmaz	<i>Atatürk University</i>	Molecular Mechanism of Heat Stress Tolerance in Wheat
Fatih Şevki Erkuş Şima Varol	<i>Van Yuzuncu Yil University</i>	A Life Cycle Assessment of Co-Digestion of Cattle Manure and Food Waste in a Plug-Flow Anaerobic Digester
Fatih Şevki Erkuş Koray Tuncay	<i>Van Yuzuncu Yil University</i>	Design and Evaluation of an Arduino-Based Real-Time Monitoring Sensor System for an Anaerobic Continuously Stirred Tank Reactor

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ANKARA LOCAL TIME: 15:00-17:00

SESSION-3 / HALL-3



Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

HEAD OF SESSION: Dr. Huzur Deveci

Authors	Affiliation	Presentation Title
Ilker Ari M. Salih Mamiş	<i>Siirt University</i>	Determination of voltage distribution on transformer windings under switching conditions using state-space approach
Ilker Ari M. Salih Mamiş	<i>Siirt University</i>	Transient analysis of lightning strike on distributed parameter transmission line using the state-space method
Kübra Kayapınar Emre Biçer	<i>Sivas University of Science and Technology</i>	The use of machine learning in high power batteries for state of charge estimation
Mehmet Orhan Şenaslan Ilyas Istif	<i>Gebze Technical University</i>	Evaluation of geometric effects on the impact resistance of laminated composite materials
Rıfat Enes Bitkin Hüseyin Suha Aksoy	<i>Bingol University</i>	Evaluation of the effect of pet waste on increasing the ultimate bearing capacity of a square-shaped foundation
Ahmet Dursun Soylu Sinan Köse	<i>Tarsus University</i>	Using ipe chassis for weight reduction in semi-trailer chassis for lpg tank transportation
Huzur Deveci	<i>Tekirdağ Namık Kemal University</i>	Determination of the accuracy of average temperature values obtained from different climate models in tr21 trakya region
Fatma Seda Çardak İsa Soylu	<i>Adana Alparsalan Türkeş Bilim ve Teknoloji Üniversitesi</i>	A study on the use of glass materials in the re-functioning of makam-1 danyal mosque

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ANKARA LOCAL TIME: 15:00-17:00

SESSION-3 / HALL-4



Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

## HEAD OF SESSION: Khanh Giang Le

Authors	Affiliation	Presentation Title
Sulaiman Muhammad Bello Rilwan Lawal Ahmed Tanimu	<i>Federal University of Education</i>	Application of Data Envelopment Analysis on Integrated Crop-Livestock Enterprises in Kaduna, Nigeria
Zaggoumi Hasna Bouda Said Neg Imane Marghali Sonia Trifi Neila Haddioui Abdelmajid	<i>Sultan Moulay Slimane University</i>	The genetic characterization of the Moroccan carob tree ( <i>Ceratonia siliqua</i> L.) using ISSR markers.
Usman Sani Kk Abdullahi Ahmad Muhammad Musa Halimatu Fago	<i>Extraction And Characterization Of Orange Peel Essential Oil For Flavour And Fragrance Application</i>	Extraction and characterization of orange peel essential oil for flavour and fragrance application
Abdullahi Bashiru Egamana Mercy Nna Suberu Onimisi Faruku Umar Abubakar Ozigi, Esther, Oyiza	<i>Federal University of Technology</i>	Magnitude Of Post Harvest Losses In Selected Food Crops In Niger State, Nigeria
K. Gajalakshmi S.Saravanan	<i>Annamalai University,</i>	Automated Detection of Rust in Images Using ResNet50: A Deep Learning Approach
Khanh Giang Le	<i>University of Transport</i>	A Bim-Gis Framework For 3d Modeling Of Infrastructure Assets
Bayan Kamal Eddine	<i>Modern University of Business and Science MUBS</i>	Curriculum Design, Planning, and Development in Response to Crises and Technological Transformation
Roman Truskavetsky Candidate Zubkovska Viktoriia Candidate Khyzhniak Iryna	<i>National Scientific Center "Institute for Soil Science and Agrochemistry Research named after A. N. Sokolovsky",</i>	Models Of Soil Fertility Elements Management
Amina Bibi Naima Sajjad Muhammad Kamran	<i>Thal University Bhakkar</i>	Banach and Hilbert Spaces in Economic Optimization

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ANKARA LOCAL TIME: 15:00-17:00

SESSION-3 / HALL-5



Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

## HEAD OF SESSION: ALIYU Abubakar

Authors	Affiliation	Presentation Title
Nezam Zarei Chamani Fereshte Shojaee	<i>Razi University</i>	Teacher-Student Communication Patterns in Online and In-person High School English Classrooms: A Comparative discourse Analysis
Aliyu Abubakar Muhammad Raihanatu Abdulahakeem Yusuf	<i>Federal University of Technology Minna,</i>	Reformulation of Two Step Implicit Linear Multi-Step Block Hybrid Method into Runge –Kutta Type Method for the Solution of Second Order Initial Value Problem (IVP)
Fathalah Elwahab Mohamed Sedki Siham Belkacemi Hassan Boukita Najiba Brhadda Rabea Ziri	<i>University Ibn Toufail</i>	Challenges and Management of Rice Helminthosporiosis ( <i>Bipolaris oryzae</i> ) in Morocco: A Review
Az-Iddin Chham Younes Rachdi Belaid Selhami Smail Ait Sait Ali Boujemaa Soubai Rachid Fakhreddine Noureddine Sajai Abdelaziz El Amrani	<i>Hassan II University,</i>	Efficient removal of dyes from real textile wastewater using Pistacia lentiscus material as a suitable bio-adsorbent
Alabi, Folaranmi Oluwole Odu Adejare Samuel	<i>Ajayi Crowther University</i>	Media Literacy, Popular Culture And National Development: An Exploration Of Intersection
B. Boukili M.K. Atouailaa A. Arifl A. Aboulouared M. Boulghalat A. Tousni M. El Idrissi	<i>Sultan Moulay Slimane University</i>	Theoretical investigation of new organic electron donor molecules for high performance dye solar cells in the field of green chemistry
Mohammed, C.M., Idris, U.S.B, Babagana, M. Koroka M.U.S. Ndatsu, A. Shuaeeb, A. I. Saifullahi, M.	<i>Federal University of Technology Minna</i>	Awareness Of University Science Pre-Service Teachers Towards Artificial Intelligence Chatbots For Learning In Minna, Niger State
Hamza. Ouachtouk Amine. Harbi Chaimaa Moukhfi Said. Azerblou Youssef. Naimi El Mostafa. Tace	<i>University Hassan II of Casablanca</i>	Double Perovskites: Multifunctional Materials for Sustainable Energy and Advanced Technologies through their Thermal and Electrical Properties

(All speakers required to be connected to the session 10 min before the session starts)

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# 9<sup>TH</sup> INTERNATIONAL CONFERENCE ON GLOBAL PRACTICE OF MULTIDISCIPLINARY SCIENTIFIC STUDIES

January 21-28, 2025 / Havana, CUBA

22.01.2025 / ONLINE



ANKARA LOCAL TIME: 15:00-17:00

SESSION-3 / HALL-6



Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

## HEAD OF SESSION: Khanh Giang Le

Authors	Affiliation	Presentation Title
Hakima Lagrini Fouad Bentiss Charafeddine Jama Mohamed Bensitel Abdelaziz Sahibed-Dine	<i>University Chouaib Doukkali,</i>	Impact of Silver Doping on Titanium Dioxide Nanopowders Synthesized by the Classical Sol-Gel Method (TiO <sub>2</sub> -C) and Biopolymer-Based Method (TiO <sub>2</sub> -BP)
Abdul Jalil Najam Ul Haq Taqwa Syed Saba Shaukat Bilal Bahadar	<i>University of Peshawar</i>	Utilization of Health Services by Rural Women in District Mansehra: Challenges, Accessibility, and Impact on Maternal Health
Boujemaa Soubai Younes Rachdi Smail Ait Said Ali Belaid Selhami Az-Iddin Chham Mohamed Tahiri	<i>Hassan II University</i>	Adsorption Properties of Cationic dyes in Water by Sheep Manure Biochar
Ly My Tien Le Thi To Quyen Nguyen Thi Huynh Phuong Nguyen Trong Nhan	<i>Can Tho University</i>	Analyzing The Quality Of Tourism Human Resources In An Binh Islet, Long Ho District, Vinh Long Province, Vietnam
Denada Ahmeti Bertina Hoxha	<i>Sports University of Tirana</i>	Impact Of Data Visualization On Sports Performance At School Age
R.Thiruchelvi P.Saravanan M.Chamundeeswari	<i>St. Josephs College of Engineering</i>	Valorization Of Diverse Waste-Derived Nanocellulose For Multifaceted Applications: A Review
S.U. Dzukogi., R. B. Salau., S. Idris	<i>Federal University of Technology,</i>	Quality Evaluation of Raw soya seed oil extract and corresponding commercial brands
Khanh Giang Le	<i>University of Transport and Communications</i>	Spatial Analysis Of Road Networks For Enhanced Urban Traffic Management
Halima Shehu F.C. Chike-Okoli	<i>Federal University of Technology</i>	Chinua Achebe: The Novelist As Critic And Editor

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9<sup>TH</sup> INTERNATIONAL CONFERENCE ON GLOBAL PRACTICE OF  
MULTIDISCIPLINARY SCIENTIFIC STUDIES

January 21-28, 2025 / Havana, CUBA

23.01.2025 / ONLINE



ANKARA LOCAL TIME: 10:00-12:00

SESSION-1 / HALL-1

Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

HEAD OF SESSION:

Authors	Affiliation	Presentation Title
Solmaz Najafi	<i>Van Yuzuncu Yil University</i>	Impact of Winter Seeding on Yield and Yield Components in Chickpea Genotypes
Solmaz Najafi	<i>Van Yuzuncu Yil University</i>	Enhancing Seed Germination in <i>Capparis spinosa</i> through Prechilling, Scarification, and Hormonal Treatments
Meriç Balcı	<i>Akdeniz University</i>	Determining the Critical Period for Weed Competition in Corn Production
Meriç Balcı	<i>Akdeniz University</i>	Efficiency of Nitrogen Fixation in Legumes Using Pesticides
Aykan Ayışık Solmaz Najafi Hossein Shamsavand Hassani Mehmet Ülker	<i>Van Yuzuncu Yil University</i>	Evaluation of Primary Tritipyrum ( <i>Triticum durum</i> × <i>Thinopyrum bessarabicum</i> ) Amphiploid Lines adaptation in Van-Saray Conditions, Türkiye
Aykan Ayışık Solmaz Najafi Hossein Shamsavand Hassani Mehmet Ülker	<i>Van Yuzuncu Yil University</i>	Karyological Evaluation of Natural Transchromosomal Primary Tritipyrum ( <i>Triticum durum</i> × <i>Thinopyrum bessarabicum</i> ) Amphiploid Lines under Van-Saray Conditions, Türkiye
Mina Najafi	<i>Ege University</i>	Investigation the Effect of Using Combination of Bio-organic and Chemical Fertilizers on Biological Yield and Yield Component of Sunflower
Mina Najafi	<i>Ege University</i>	Impact of Biofertilizers and Growth Enhancers on Yield Traits of Safflower
Khanh Giang Le	<i>University of Transport</i>	Enhanced automation of point cloud processing for building information modeling (bim)

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January 21-28, 2025 / Havana, CUBA

23.01.2025 / ONLINE



ANKARA LOCAL TIME: 10:00-12:00

SESSION-1 / HALL-2



Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

## HEAD OF SESSION: Omar KCHIT

Authors	Affiliation	Presentation Title
Omar Kchit	<i>Sidi Mohamed Ben Abdellah University</i>	On the index divisors of certain number fields of degree ten defined
Ghizlane Rahil Imane Rahil Mustapha Oujaoura Walid Bouarifi	<i>Mathematical Team and Information Processing National school of applied sciences SAFI,</i>	Feature Extraction and Analysis Techniques for Human Motion Understanding in Images and Videos
Muhammed Sani Babakatun Shahid Sani Anka	<i>School of Information Communication Technology</i>	Export Numeration On Groundnut Cake Biscuits (Kuli-Kuli) In Bida what do you mean by numeration of exports?
Analiza A. Payao Ronald B. Payao	<i>Lapu-Lapu City College</i>	Evaluating The Implementation Of Haccp Systems In Food Establishments In Lapu-Lapu City, Cebu: Pathways To Iso 22000:2005 Certification
Satish Kumar Singh Sachin Singh Parihar Sadanand Patel	<i>Central University of Punjab</i>	The Intersection Of Science, Law, And Public Health Policy: Legal Implications And Policy Challenges
Satish Kumar Singh Pallavi Lakhera	<i>Central University of Punjab</i>	The Role Of Forensic Science In Criminal Justice System: Legal Implications And Challenges
Shouket Ahmad Kouchay	<i>Islamic University Madinah</i>	Enhancing Quantum Communication Through AI: Integrating Machine Learning with Quantum Computing
Asmat Ullah Yahya Nadeem Salamat	<i>Khwaja Fareed University of Engineering and Information Technology</i>	Modified Buongiorno model for MHD micropolar Casson hybrid nanofluid transportation with non-linear thermal radiation through porous channel
Shouket Ahmad Kouchay	<i>Islamic University Madinah</i>	From Data to Discovery: Unveiling Garlic's Antimicrobial and Antiviral Secrets with Data Science

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January 21-28, 2025 / Havana, CUBA

23.01.2025 / ONLINE



ANKARA LOCAL TIME: 10:00-12:00

SESSION-1 / HALL-3



Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

## HEAD OF SESSION: Yusuf Feyisara Zakariya

Authors	Affiliation	Presentation Title
Aiswarya Gireesh Chinthu. I.B	<i>University of Kerala</i>	Kudumbashree: Financial Inclusion Of Women
Pooja Rasal Gaurav Kasar	<i>JES's SND College of Pharmacy</i>	Isatin Based Hybrid Molecule: A New Era In Anticonvulsant Research
Etibarria Belghalia Farid Elbamtari Abdelouahid Sbai Tahar Lakhlifi Mohammed Bouachrine	<i>University Moulay Ismail</i>	Virtual Screening and Dynamic Simulation of Baloxavir Derivatives Targeting EGFR, HER2, and ER $\alpha$ for Breast Cancer Treatment
Fadhli Fajri Muhammad Rido Nurliani Erni	<i>Tanah Laut State Polytechnic</i>	The Effect of Adhesive Dosage on The Physical Quality of Pelleted Laying Hens' Rations
Samer H. Al-Jashaami Safaa M. Almudhafar Basim A. Almayahi	<i>University of Kufa</i>	Environmental assessment of natural rangelands and their management potential
Yusuf Feyisara Zakariya	<i>Ahmadu Bello University</i>	Artificial Intelligence In Education: A Phenomenological Approach To Pre-Service Teachers' Experience?
Yusuf Feyisara Zakariya	<i>Ahmadu Bello University</i>	Teaching Generation Z Students For Productive Learning: A Guide For Secondary School Mathematics Teachers In A Digital Age
Mohamed Dhia Massoudi Mohamed Bechir Ben Hamida	<i>Laboratory of Ionized Backgrounds and Reagents Studies</i>	Enhancement of heat sink efficiency using cylindrical fins supported with helical trapezoidal wings and MHD radiative nanofluid
R. Anju Ishwarya M. Kamaraj	<i>SRM Institute of Science and Technology</i>	Marine Ecosystem Recovery: Bioremediation As An Eco-Friendly Remediation Approach

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January 21-28, 2025 / Havana, CUBA

23.01.2025 / ONLINE



ANKARA LOCAL TIME: 10:00-12:00

SESSION-1 / HALL-4



Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

## HEAD OF SESSION: Sagaya Aurelia P

Authors	Affiliation	Presentation Title
H. Fatihi H. Benaali A. Abbassi M. El Idrissi S. Taj B. Manaut	<i>Sultan Moulay Slimane University</i>	Advancing Solar Energy: A DFT and SLME Comparative Study of Lead-Free Double Halide Perovskites
Shirandas Surya Tawseef Ahmad M.Suresh Ch.Sunil Kumar	<i>Bharat Institute of Engineering and Technology,Mangalpally</i>	Robust Deepfake Detection Through Res-Next Cnn And Lstm-Based Rnn Fusion Using Deep Learning
Sagaya Aurelia P ARSHA G VGNESH K MEENA N	<i>CHRIST University  Palar Agricultural College</i>	Education4.0: An Artificial Intelligence Approach "The Role Of Nanotechnology In Plant Disease Management"
G.V.S.Srikar M. Suresh Tawseef Ahmad Ch.Sunil Kumar	<i>Bharat Institute of Engineering and Technology,Mangalpally</i>	Electronic Health Record using Blockchain
CHANDANA KOTHA M.Suresh Tawseef Ahmad Ch.Sunil Kumar	<i>Bharat Institute of Engineering and Technology</i>	Sign Language Detection
Mohd Arsh Khan Bushra Jamshed Ziaul Husain Mohd Faizan Ali Ariba Firdous Saimah Khan	<i>Integral University</i>	Advances in Sustainable Wastewater Treatment: Integrating Technology, Resource Recovery, and Environmental Innovation
Balasubramani G L Rinky Rajput Manish Gupta Pradeep Dahiya Jitendra K Thakur Rakesh Bhatnagar Abhinav Grover	<i>Jawaharlal Nehru University</i>	Structure-based drug repurposing to inhibit the DNA gyrase of Mycobacterium tuberculosis

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January 21-28, 2025 / Havana, CUBA

23.01.2025 / ONLINE



ANKARA LOCAL TIME: 10:00-12:00

SESSION-1 / HALL-5



Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

## HEAD OF SESSION: Neha

Authors	Affiliation	Presentation Title
Abdul Jalil Najam Ul Haq Taqwa Syed Saba Shaukat Bilal Bahadar	<i>University of Peshawar</i>	Bridging The Gap: The Role Of Youth-Led Initiatives In Poverty Alleviation And Gender Inequality Reduction In Pakistan
Sanjeev Kumar Sowmya Anand	<i>Department of Electrical and Electronics</i>	“Double Integral Sliding Mode MPPT Control of PV Cell”
Süreyya Yiğit	<i>New Vision University,</i>	The Search For An End To The Korean Conflict: Sunshine Policy
Favour C. Uroko Solomon Enobong	<i>University of Nigeria</i>	Jonah’s attitude and His emotional interference in the Nineveh Mission and its implication for social welfare
Neha	<i>Swami Vivekanand Subharti University</i>	Ethics In Sustainable Development Of Indian Economy: A Study
Syed Anam Shaheen Abbas Shah Muhammad Shoaib Muhammad Yasin Naz Shazia Shukrullah	<i>University of Agriculture</i>	Synthesis and Characterization of Silica-Chitosan Decorated Magnetic Nanostructure For Wastewater Treatment
Violla Makzhoum	<i>Modern University for Business and Science</i>	Developing Human Skills in the Age of Artificial Intelligence: Aligning Personal Competencies with Smart Technology Advancements
Eze Ikechukwu Bernard	<i>Nigeria Police Academy,</i>	Store Ambience And Customer Preference: A Study Of Shopping Malls In Federal Capital Territory Abuja, Nigeria
Rayan Ikram Addoun	<i>University m’Hamed Bougara of Boumerdes,</i>	Stability and regularity analysis of nonlinear wave equations with localised internal and Ventcell boundary conditions

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January 21-28, 2025 / Havana, CUBA

23.01.2025 / ONLINE



ANKARA LOCAL TIME: 12:30-14:30

SESSION-2 / HALL-1



Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

HEAD OF SESSION: Assoc. Prof. Dr. Meliha UZUN

Authors	Affiliation	Presentation Title
Tuğba ONAT Günay ÇERİT Meliha UZUN	Şırnak University	Claw Strength in Upper Extremity Sports
Günay ÇERİT Meliha UZUN Tuğba ONAT	Şırnak University	The Role of Exercise in Cancer
Elif Ece AKGUN	Ataturk University	Effects of Hypoxia on Proliferation and Differentiation of Adipose Stem Cells
Mustafa Atalan	Uşak University	Health effects of lycopene
Zeynep Nur Karakuş Yasemin Çelebi Gülşah Çalışkan Koç	Uşak University	Health and Nutritional Benefits of <i>Elaeagnus angustifolia</i> L.,
Zeynep Nur Karakuş Yasemin Çelebi Gülşah Çalışkan Koç	Uşak University	Health-Promoting Effects of Elderberry ( <i>Sambucus nigra</i> L.): A Nutritional Perspective
Esra BİLİCİ	Uşak University	The role of microRNAs in the genetic regulation processes of cells and their potential therapeutic uses
Elçin Gün Canik	Ondokuz Mayıs University	Tenkidi The detection and aveliation of animals in the humore and cartoons within the Cadaloz Humore Magazine according with the Tanzimat approach

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ANKARA LOCAL TIME: 12:30-14:30

SESSION-2 / HALL-2



Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

## HEAD OF SESSION: Saima Shaheen

Authors	Affiliation	Presentation Title
Maram Sahith Reddy M.Suresh Ch.Sunil Kumar Tawseef Ahmad	<i>Bharat Institute of Engineering and Technology</i>	Air Canvas (Virtual Painter)
Sanae Hanine Brahim Dinar	<i>Hassan I University</i>	The blue economy: the future of the Atlantic African Sea front Initiative?
Annah Siminle Amos Simon Olonkwoh Salihu Idris Suleiman	<i>Federal University of Technology</i>	Speciation Of Arsenic From Fish Pond Sediments From Talba Farm, Minna Metropolis
Olasehinde, Kayode John Sabitou Abdulmalik Usman, Umar Shehu	<i>Federal University Dutsin-Ma</i>	Assessment Of Sociocultural Practices Affecting The Girl-Child Education In Rural Areas Of Katsina State, Nigeria
Dona Mary Eldhose Sejian V	<i>College of Veterinary and Animal Science</i>	Significance of Optimum Nutrition During Transition Period in Dairy Cows
Mugesh S Avinash B Guided Saravanan S	<i>Annamalai University</i>	Power Production from Exhaust
Valandasu Ramakrishna Ch.Sunil Kumar Tawseef Ahmad M.Suresh	<i>Bharat Institute of Engineering and Technology</i>	Price Pulse
Ganesh Kumar R.Y Hiranmai Ajay Neeraj	<i>Central University of Gujarat</i>	Nano-biochar a novel strategy for the removal of contaminants from agricultural soil
Saima Shaheen	<i>Khyber Girls Medical College</i>	Thyroid Hormone Levels And Their Association With Plasma Zinc Levels Among Adolescent Afghan Refugees; A Cross-Sectional Study

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ANKARA LOCAL TIME: 12:30-14:30

SESSION-2 / HALL-3



Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

## HEAD OF SESSION: Zohaib Hassan Sain

Authors	Affiliation	Presentation Title
Boudraham Salima Mabrouki Jamal Ait Oujallal Ilham Anouzla Abdelkader Abrouki Younes	<i>Mohammed V University in Rabat</i>	Life-Cycle Assessment Of Hydrogen Refueling Stations Manufacturing For Water Desalination Applications
Imane Ahnouz	<i>Mohammed V University in Rabat,</i>	Evaluation of Neutron-Gamma Discrimination Approaches Using Scintillation Detectors
Loukili Hayat	<i>University of Hassan II - Casablanca</i>	Recent Advances In Nanotechnology-Based Membranes For Water Desalination
Kotla Ronith Ch.Sunil Kumar M.Suresh Tawseef Ahmad	<i>Bharat Institute of Engineering and Technology</i>	Cold Email Generator & Sender
Abderrahim Ait Lhaj Brahim Ouazik Mohamed El Hasnaoui Hassan Chaib	<i>Ibn Tofail University</i>	Structural and Electronic Properties of SnO 2 : A First- Principles Study Using Density Functional Theory with GGA, GGA+U et GGA+U+V Methods
Du Xuan Phu Thi Thai Nhat Duy Nguyen Hoang Duy	<i>Can Tho University</i>	Approaching Artificial Intelligence In Designing Visual Aids For Teaching Mathematics At High Schools
A. Attahiru	<i>Kebbi State University of Science and Technology</i>	Review On Mineral Composition Of Zingiberaceae Family
Zohaib Hassan Sain	<i>Superior University</i>	Investigating Education for Sustainable Development: Insights from Future Educators, Teaching Approaches, and Implementation Challenges

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January 21-28, 2025 / Havana, CUBA

23.01.2025 / ONLINE



ANKARA LOCAL TIME: 12:30-14:30

SESSION-2 / HALL-4



Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

## HEAD OF SESSION: ABROUKI Younes

Authors	Affiliation	Presentation Title
Hiwa Weisi Nezam Zarei Chamani	<i>Razi University</i>	The Effectiveness of Spontaneous Feedback on the Speaking Skills of Secondary School Students
Mehdi Shalchi Tousi	<i>Internatinal University</i>	Optimum Design of Reinforced Concrete Cantilever Retaining Walls Cricket Algorithm Algorithm(CA)
Shravani Settigari Tawseef Ahmad M.Suresh Ch.Sunil Kumar	<i>Bharat Institute of Engineering and Technology</i>	Detection Of Suicidal And Depression Posts And Prevention
Clementina Hashimu Bulus Rejoice Hamidu	<i>University of Jos</i>	Diagnostic Assessment Of Education Students' Areas Of Difficulties In Statistics At The University Of Jos, Plateau State, Nigeria
Asabe Edward Bash	<i>University of Jos</i>	Investigating The Effect Of Teacher- Student Ratio On Academic Performance Of Jss Ii Basic Science And Technology In Jos North, Plateau State.
Abrouki Younes	<i>Mohammed V University in Rabat</i>	Life-Cycle Assessment Of Water Desalination Plants: A Sustainable Perspective
Zenati Rania Boucherdoud Ahmed Seghier Abdelkarim Bendjelloul Meriem Aichouni Sara Elandaloussi El Hadj Ait Oujallal Ilham	<i>University Ahmed Zabana- Relizane</i>	Exploration Of The Specific Properties Of Materials For The Technology Industry
Mabrouki Jamal Boudraham Salima Moussadik Ali Abrouki Younes	<i>Mohammed V University in Rabat</i>	Life-Cycle Assessment Of Green Hydrogen Production Integrated With Water Desalination: Exploring Emerging Technologies

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ANKARA LOCAL TIME: 12:30-14:30

SESSION-2 / HALL-5



Zoom Meeting ID: 884 2447 8604 / Zoom Passcode: 090909

## HEAD OF SESSION: Nadia Akram

Authors	Affiliation	Presentation Title
Samaira Batool Muhammad Kamran	<i>International Islamic University</i>	Navigating the Paradoxes of Political Competition: Institutional Moderation and Poverty Dynamics in Developing Economies
Samaira Batool Muhammad Kamran	<i>International Islamic University</i>	Decoding Uncertainties: The Interplay of Political Competition, Institutional Fragility, and Poverty Dynamics in Developing Nations through Fuzzy Logic
Nadia Akram	<i>Government College University Faisalabad</i>	The Green Replacement Of Conventional Plastics
Zineb Moujoud Abdeslam El Bouari Omar Tanane	<i>Hassan II University of Casablanca</i>	Synthesis and Characterization of Lightweight Geopolymer for Building Energy Saving
Shalva Zarnadze Irine Zarnadze	<i>Deapartement of Nutrition,</i>	Urbanization, Health Risks and Population Health Literacy Problems
Mandadi Neeraj Reddy Tawseef Ahmad Sunil Kumar M.Suresh	<i>Bharat Institute of Engineering and Technology</i>	Speech Emotoin Recognition Using Machine Learning
Meike Lely Lewankoru Essuy K.A Pit'ay	<i>Universitas Kristen Indonesia</i>	Building a Liberative Christian Religious Education: A Perspective on Liberation Pedagogy
Chems Eddine Boukhedimi	<i>University of Tizi Ouzou</i>	Effect of house possessing on the attitude toward the use of PV solar energy: an exploratory study from Algeria

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**SYMPOSIUM PHOTOS**



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# ***ABSTRACTS***

**9<sup>TH</sup> INTERNATIONAL CONFERENCE ON GLOBAL PRACTICE OF  
MULTIDISCIPLINARY SCIENTIFIC STUDIES**

**January 21-28, 2025 / Havana, CUBA**

**GÖRSEL KÜLTÜR ÜZERİNDEN BİÇİMLENEN TURİSTİK ALGI: TÜRK  
TURİSTLERİN HAVANA'YA DAİR INSTAGRAM PAYLAŞIMLARINDA KLASİK  
OTOMOBİL UNSURU**

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**Özet**

Küba'nın başkenti Havana'yı ziyaret eden Türk turistlerin sosyal medya platformu Instagram üzerinden bu ziyareti görselleştirirken klasik otomobilleri ön planda tuttukları görülmektedir. Bu çalışma geleneksel kitle iletişim araçları ve sosyal medya üzerinden şekillenen ülkelere dair turistik algıların yine sosyal medya üzerinden yeniden üretimi üzerine bir örnek olarak ele alınmaktadır. Türk turistlerin zihinlerindeki Küba ve Havana algısında klasik otomobillerin diğer unsurlara oranla ne derece ağır bastığının incelendiği çalışmada görsel kültürün turistik algıları nasıl şekillendirdiğine dikkat çekilmektedir. Söz konusu incelemede Instagram'da Küba etiketiyle (#Küba) yapılan aramada algoritmanın sunduğu herkese açık on adet bireysel hesabın gönderileri değerlendirilmiştir. Bu hesapların dikkate alınma kriterleri algoritmanın gönderi önerileri arasında en üstte yer almaları ve bu gönderilerinde Havana'ya dair en az iki fotoğraf içermeleri olmuştur. Yapılan analizde gönderilerdeki fotoğraflarda Havana'daki klasik otomobillerin Küba'nın görsel temsil unsurları arasında ilk akla gelen Che Guevara simgeleri, yerel kıyafetli melez ve siyahi insan portreleri, salsa dansı, puro, renkli kolonyal dönem binaları gibi öğelere kıyasla hangi yoğunlukta oldukları incelenmektedir. Söz konusu incelemede klasik otomobillerin paylaşımlarda diğer görsel kültür öğelerine göre baskın olduğu görülmektedir. Sosyal medya üzerinden bu şekilde üretilmekte olan turistik Küba/Havana temsili potansiyel Türk ziyaretçiler için Küba'ya ilişkin bu doğrultuda bir görsel beklenti yaratmaktadır. Elde edilen bulgulara göre klasik otomobillerin, Türk turistlerdeki Küba algısını biçimlendirmede başat bir görsel unsur olduğu ve sosyal medya aracılığıyla aktarılan seyahat görsellerinin Türklerin turistik deneyimini etkilediği görülmektedir.

**Anahtar Kelimeler:** Küba Görselleri, Instagram, Klasik Otomobiller, Turistik Öğeler, Sosyal Medya

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**January 21-28, 2025 / Havana, CUBA**

**TOURIST PERCEPTION SHAPED BY VISUAL CULTURE: THE CLASSIC CAR  
ELEMENT IN TURKISH TOURISTS' INSTAGRAM POSTS ABOUT HAVANA**

**Abstract**

It is observed that Turkish tourists visiting Havana, the capital of Cuba, tend to highlight classic cars when visualizing this visit on the social media platform Instagram. This study is taken as an example of the reproduction of tourist perceptions about countries, shaped by traditional mass media and social media, once again through social media. The study examines the extent to which classic cars dominate other elements in the perception of Cuba and Havana in the minds of Turkish tourists, emphasizing how visual culture shapes tourist perceptions. In this analysis, posts from ten individual public accounts suggested by the Instagram algorithm were evaluated in a search under the hashtag #Küba (Cuba). These accounts were selected based on the criteria of appearing at the top of the algorithm's recommendations and containing at least two photos of Havana. The analysis examines the prominence of classic cars in photos of Havana compared to other visual representations of Cuba, such as Che Guevara symbols, portraits of mixed-race and Black people in local attire, salsa dancing, cigars, and colorful colonial-era buildings. The study reveals that classic cars are dominant in these posts compared to other visual cultural elements. This type of touristic representation of Cuba/Havana on social media creates a visual expectation of Cuba for potential Turkish visitors in this direction. The findings indicate that classic cars are a primary visual element shaping the perception of Cuba among Turkish tourists, and that travel visuals shared through social media influence Turkish tourists' experiences.

**Keywords:** Cuban Images, Havana Symbols, Classic Cars, Tourist Items, Social Media

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**ALANYA'DA KONUT SATIN ALAN YABANCI TURİSTLERİN MEMNUNİYET  
SEVİYELERİNİN EMLAK DANIŞMANLARI TARAFINDAN  
DEĞERLENDİRİLMESİ**

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**Özet**

Bu çalışmanın amacı; Alanya'da konut satın alan yabancı turistlerin memnuniyet düzeylerinin kurumsal portföye sahip ve yabancı turistler ile çalışan emlak danışmanları tarafından değerlendirilmesidir. Araştırma kapsamında nitel araştırma yöntemlerinden gömülü teori yöntemi kullanılmış olup, bu kapsamda yarı yapılandırılmış mülakatlar aracılığı ile veriler elde edilmiştir. Mülakatlar Mart-Nisan 2024 tarihinde Antalya ili Alanya ilçesinde 10 ayrı emlak firmasında 13 emlak danışmanı ile gerçekleştirilmiştir. Araştırma bulguları incelendiğinde katılımcı görüşlerinin 5 ana tema altında 20 alt temadan oluştuğu görülmektedir. Bahsi geçen ana temalardan ilki bina dış tasarımı olarak isimlendirilmiş olup bina cephesi ve klima motor yeri olmak üzere iki alt temadan oluşmaktadır. İkinci ana tema iç tasarım olarak isimlendirilmiştir. Bu tema; mutfak, ergonomi ve kullanılabilirlik, giriş holü, ebeveyn banyosu, konutların güneş alması ve manzara alt temalarını kapsamaktadır. Üçüncü ana tema malzeme ve işçilik kalitesi olarak isimlendirilmiş olup yalıtım, ince işçilik ve gösterişli malzeme alt temalarından oluşmaktadır. Sosyal alanlar olarak isimlendirilen dördüncü ana tema incelendiğinde fitness ve sauna, açık havuz, kapalı havuz, çocuk oyun alanı, kamelya ve barbekü alanı ve spor sahaları alt temalarını kapsamaktadır. Son olarak, genel alanlar olarak isimlendirilen beşinci ana tema incelendiğinde temanın bina veya site girişi, lobi ve garaj alt temalarından oluştuğu görülmektedir.

**Anahtar Kelimeler:** İkinci Konut Turizmi, Yerleşik Yabancı, Emlak

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**EVALUATION OF THE SATISFACTION LEVELS OF FOREIGN TOURISTS  
PURCHASING REAL ESTATE IN ALANYA BY REAL ESTATE CONSULTANTS**

**Abstract**

The aim of this study is to evaluate the satisfaction levels of foreign tourists purchasing real estate in Alanya through the perspectives of real estate consultants who work with foreign clients and possess an institutional portfolio. The study employs the grounded theory method, a qualitative research approach, with data collected through semi-structured interviews. These interviews were conducted with 13 real estate consultants from 10 different real estate firms in Alanya, Antalya, during March and April 2024. The findings of the research reveal that participants' views are categorized into 5 main themes comprising 20 sub-themes. The first main theme, "Exterior Design," includes two sub-themes: building façade and air conditioner motor placement. The second main theme, "Interior Design," encompasses sub-themes such as kitchen, ergonomics and functionality, entry hall, en-suite bathroom, sunlight exposure, and view. The third main theme, "Material and Workmanship Quality," is divided into sub-themes of insulation, fine craftsmanship, and ornate materials. The fourth main theme, "Social Areas," covers sub-themes including fitness and sauna, outdoor pool, indoor pool, children's play area, gazebo and barbecue area, and sports courts. Lastly, the fifth main theme, "General Areas," is composed of sub-themes related to building or site entrance, lobby, and garage.

**Keywords:** Second Home Tourism, Resident Foreigners, Real Estate

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**January 21-28, 2025 / Havana, CUBA**

**YAPAY SİNİR AĞI İLE BORSA İSTANBUL ENDEKSİNİN MAKRO VERİLERLE  
TAHMİNİ**

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**Özet**

Borsa; bir ülkedeki hisse senetleri, tahviller, emtialar gibi finansal varlıkların alım satım işlemlerinin gerçekleştirildiği finansal piyasalardır. Bu piyasada işlem gören varlıkların fiyat hareketleri yerli ve yabancı yatırımcıların yatırım kararlarında en önemli göstergelerden biridir. Bu nedenle, bu fiyat hareketleri temel alınarak farklı borsa endeksleri hesaplanmaktadır. Türkiye’de borsa işlemleri Borsa İstanbul’da (BIST) gerçekleşmekte ve bu borsada işlem gören hisse senetlerinden hareketle BIST 100 endeksi hesaplanmaktadır.

Finans piyasalarındaki gelişmelerin önceden tahmin edilmesi, tüm ekonomik aktörlerin alacakları kararlar üzerinde önemli bir etkiye sahiptir. Bu nedenle, borsa varlıklarının gelecekteki fiyat hareketlerinin öngörülmesi ve istikrarlı tahminler için farklı yöntemler kullanılmış ya da geliştirilmiştir. Bu amaçla kullanılan matematiksel yöntemlerden birisi de yapay sinir ağlarıdır (YSA).

İnsan beyninden esinlenerek tasarlanmış olan YSA modeli; öğrenme, genelleme ve tahminde bulunma işlemlerini yapmaktadır. Bu modelde veri, girdi katmanı aracılığıyla ağa sunulur. Gizli katmanlar da ağırlıklar, aktivasyon fonksiyonları ve bağlantılar aracılığıyla bu veriler işlenir ve son olarak çıktı katmanında işlenen verinin sonucu üretilir.

Bu çalışmada, BIST 100 endeksi YSA modeli kullanılarak tahmin edilmiştir. Modelin oluşturulmasında 2013-2024 yılları arasına ait günlük yayınlanan, döviz kurları, emtia fiyatları, dünya borsa endeksleri ve BIST 100 endeksi işlem hacmi değişkenleri ve aylık yayınlanan enflasyon, faiz, endeksler ve işsizlik oranı değişkenleri kullanılarak endeks iki defa hesaplanmıştır. Her iki farklı veri setine dayalı olarak yapılan tahminler karşılaştırılmış ve günlük verilerle hesaplanan endeksin daha başarılı sonuç verdiği görülmüştür.

**Anahtar Kelimeler:** BIST 100 Endeksi, Makroekonomik Veri, Yapay Sinir Ağı

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**PREDICTION OF THE BORSA ISTANBUL INDEX USING MACROECONOMIC  
DATA WITH ARTIFICIAL NEURAL NETWORKS**

**Abstract**

Stock markets are financial markets where financial assets such as stocks, bonds and commodities are traded in a country. The price movements of the assets traded in this market are one of the most important indicators in the investment decisions of domestic and foreign investors. Therefore, different stock market indices are calculated based on these price movements. In Turkey, stock market transactions take place on the Borsa Istanbul (BIST) and the BIST 100 index is calculated on the based of the stocks traded on this exchange.

Forecasting financial market developments has a significant impact on the decisions of all economic actors. For this reason, various methods have been used or developed to predict the future price movements of stock market assets and to make stable forecasts. One of the mathematical methods used for this purpose is the Artificial Neural Network (ANN).

The ANN model, which is inspired by the human brain, performs learning, generalization and prediction. In this model, data is presented to the network through the input layer. In the hidden layers, this data is processed through weights, activation functions and connections, and finally the result of the data processed in the hidden layers is produced in the output layer.

In this study, the BIST 100 index is predicted using an ANN model. In building the model, the index was calculated twice using daily published exchange rates, commodity prices, world stock market indices and BIST 100 index transaction volume variables and monthly published inflation, interest rates, indices and unemployment rate variables for the years 2013-2024. The forecasts based on the two different sets of data were compared and it was found that the index calculated using daily data gave more successful results.

**Keywords:** BIST 100 Index, Macroeconomic Data, Artificial Neural Network



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**PIEZOJENİK PEDAL PAPÜLLER: BİR OLGU SUNUMU**

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**Özet**

Piezojenik pedal papüller, genellikle topukta ortaya çıkan, yağ dokusunun dermisten herniasyonu ile oluşan küçük, sarımsı veya deri renginde yumuşak papül ve nodüllerdir. Ayakta dururken veya ayağa basıya bağlı olarak ortaya çıkarken, bası ortadan kalktığında kaybolurlar. Sıklıkla asemptomatik seyrederken nadiren ağrılı olabilirler. Bu metinde piezojenik pedal papüller tanısı konulan bir olgunun, hastalığın literatürde az sayıda bildirilmesi ve ayırıcı tanıda nasır, plantar siğiller gibi sık görülen tablolar ile karışabilmesi nedeniyle sunulması uygun görüldü.

Olgu: 29 yaşında kadın hasta, her iki ayak topuklarının arka ve iç yüzünde birkaç yıldır var olan şişlikler ile başvurdu. Alınan anamnezde lezyonların ayağa kalkınca belirginleştiğini, istirahat halindeyken kaybolduğunu ifade etti. Şişliklerin görünümü dışında herhangi bir şikayeti (ağrı vb.) mevcut değildi. Bilinen ek bir sistemik hastalığı veya aile öyküsü yoktu. Dermatolojik muayenesinde hasta ayakta dururken bilateral ayak topuklarının arka kısımlarında ve daha yoğun olarak topuk mediallyerinde milimetrik boyutlarda deri rengi subkutan papül ve nodüller saptandı (Şekil 1). Ayaklar yerden kaldırıldığında lezyonların kaybolduğu gözlemlendi. Klinik olarak piezojenik pedal papül tanısı konuldu. Fizik muayenede başka bulgu saptanmayan hastaya uzun süre ayakta durmaması, kilo alımı konusunda dikkatli olunması, destekleyici ortopedik tabanlık kullanımı önerildi. Subjektif şikayeti ve sistemik hastalık bulgusu olmayan hastada herhangi bir medikal veya cerrahi tedaviye gerek duyulmadı.



**Şekil 1.** Topukta basmakla ortaya çıkan deri rengi papül ve nodüller

**Anahtar Kelimeler:** Piezojenik pedal papül, ayak, topuk

**PIEZOGENIC PEDAL PAPULES: A CASE REPORT**

**Abstract**

Piezogenic pedal papules are small, yellowish or skin-colored soft papules and nodules that occur due to the herniation of fatty tissue through the dermis, usually appears on the heel. They occur while standing or due to pressure on the foot and disappear when the pressure is removed. While these lesions are often asymptomatic, they can rarely be painful. In this text, it was deemed appropriate to present a case diagnosed with piezogenic pedal papules because the disease is reported rarely in the literature and can be confused with common conditions such as callus and plantar warts in the differential diagnosis.

Case: A 29-year-old female patient presented with bumps on the back and inner surfaces of both heels that had been present for several years. She stated that the lesions became apparent when she stood up and disappeared when she was at rest. Patient had no other complaints (pain, etc.) part from the appearance of the bumps. There was no known additional systemic disease or family history. In dermatological examination, millimetric-sized skin-colored subcutaneous papules and nodules were detected on the backs of the heels of the feet and more intensely on the medial sides of the heels while the patient was standing (Figure 1). It was observed that the lesions disappeared when the feet were lifted off the ground. Clinically, a diagnosis of piezogenic pedal papule was made. No other findings were detected during the physical examination. The patient was advised to avoid standing for long periods, to be careful about weight gain, and to use supportive orthopedic insoles. Since the patient had no subjective complaints or signs of systemic disease, no medical or surgical treatment was required.



**Figure 1.** Skin-colored papules and nodules that appear on the heel when standing

**Keywords:** Piezogenic pedal papule, foot, heel

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**January 21-28, 2025 / Havana, CUBA**

**PERİAPİKAL LEZYONLU MANDİBULAR KESER DİŞLERİN CERRAHİ  
OLMAYAN ENDODONTİK TEDAVİSİ: OLGU SUNUMU SERİSİ**

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**Özet**

Bu vaka serisinin amacı, büyük, asemptomatik periapikal lezyonların etkili kök kanal dezenfeksiyonu ve kanal içi ilaç olarak kalsiyum hidroksit kullanılarak iyileşmesini sağlamaktır. **Olgu 1:** 55 yaşında erkek hasta panoramik radyografında 32 numaralı dişinde gözlenen periapikal lezyon ile kliniğimize yönlendirildi. Hasta anamnezinden, zaman zaman ilgili dişin kökü hizasındaki dişetinde fistülizasyon meydana geldiği ve herhangi bir ağrı şikayetinin olmadığı öğrenildi. Kemomekanik işlemleri takiben kanallara kalsiyum hidroksit medikamanı yerleştirilerek diş geçici olarak restore edildi. İki hafta sonra kalsiyum hidroksit pansumanı uzaklaştırıldı, kanallar rezin esaslı kök kanal patı ve açılı guta perkalarla dolduruldu. Diş kompozitle restore edildi. 3 ay, 6 ay, 1 sene sonraki takip randevularında dişin semptomsuz ve fonksiyonda olduğu, periapikal lezyon bölgesinde ise kemik iyileşmesinin gerçekleştiği görüldü. **Olgu 2:** 20 yaşında erkek hasta kliniğimize 31-41 numaralı dişlerin kökleri hizasındaki dişetinde zaman zaman aktifleşen fistülizasyon şikayetiyle başvurdu. Hastanın anamnezinden herhangi bir ağrı şikayetinin olmadığı öğrenildi. Panoramik radyografda ilgili dişlerin kök uçlarını içine alan radyolüsent bir lezyon olduğu görüldü. Kemomekanik preparasyonu takiben kanallara kalsiyum hidroksit medikamanı yerleştirilerek diş geçici olarak restore edildi. İkinci seansta kanal içindeki pansuman materyali uzaklaştırıldı, kanallar rezin esaslı kök kanal patı ve açılı guta perkalarla dolduruldu. Dişin kron restorasyonu kompozit rezin materyalle restore edildi. 1 sene sonraki takip randevusunda dişin semptomsuz ve fonksiyonda olduğu, periapikal lezyon bölgelerinde ise kemik iyileşmesinin gerçekleştiği görüldü. Bu vaka serisi, etkili kök kanal tedavisi yapıldığında ve kanal içi kalsiyum hidroksit tedavisi ile desteklendiğinde, büyük periapikal lezyonların cerrahi müdahaleye gerek kalmadan iyileşebileceğini göstermektedir.

**Anahtar Kelimeler:** Kök Kanal Tedavisi, Periapikal enfeksiyon, Kalsiyum Hidroksit, Dezenfeksiyon

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**January 21-28, 2025 / Havana, CUBA**

**NON-SURGICAL ENDODONTIC TREATMENT OF MANDIBULAR INCISORS  
WITH PERIAPICAL LESIONS: CASE REPORT SERIES**

**Abstract**

The aim of this case series is to provide effective root canal disinfection and healing of large, asymptomatic periapical lesions using calcium hydroxide as an intracanal medicament. **Case 1:** A 55-year-old male patient was referred to our clinic with a periapical lesion observed on tooth #32 in his panoramic radiograph. From the patient's anamnesis, it was learned that a fistula occasionally occurred at the level of the root of the relevant tooth on the gingiva, but there were no complaints of pain. Following chemomechanical preparation, calcium hydroxide medication was placed into the canals, and the tooth was temporarily restored. Two weeks later, the calcium hydroxide dressing was removed, the canals were filled with a resin-based root canal sealer and tapered gutta-percha cones. The tooth was restored with composite material. During the follow-up appointments conducted 3 months, 6 months, and 1 year later, the tooth was found to be asymptomatic and functional, with evidence of bone healing in the periapical lesion area. **Case 2:** A 20-year-old male patient was referred to our clinic with complaints of intermittent fistulization in the gingiva at the root level of teeth #31 and #41. The patient's anamnesis revealed no complaints of pain. Panoramic radiography revealed a radiolucent lesion encompassing the root apices of the affected teeth. Following chemomechanical preparation, calcium hydroxide medication was placed into the canals and the teeth were temporarily restored. During the second session, the intracanal dressing material was removed, and the canals were filled with a resin-based root canal sealer and tapered gutta-percha cones. The teeth were restored with composite resin material. At the 1-year follow-up appointment, the teeth were asymptomatic and functional, with evidence of bone healing in the periapical lesion areas. This case series demonstrates that large periapical lesions can ultimately achieve healing without surgical intervention when effective root canal treatment is achieved and supported by intracanal calcium hydroxide medication.

**Keywords:** Root Canal Treatment, Periapical infection, Calcium Hydroxide, Disinfection

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**January 21-28, 2025 / Havana, CUBA**

**DIŐ HEKİMLİĐİ ÖĐRENCİLERİNİN MEZUNİYET SONRASI KARİYER  
HEDEFLERİNİN DEĐERLENDİRİLMESİ**

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**Özet**

Bu çalışmanın amacı, diő hekimliği öğrencilerinin mezuniyet sonrası kariyer hedeflerinin belirlenmesi ve kararlarını etkileyen faktörlerin değerlendirilmesidir. Bu anket çalışmasına Van Yüzüncü Yıl Üniversitesi Diő Hekimliği Fakültesi 1.,2.,3.,4. ve 5. sınıf öğrencilerinden toplam 359 kişi katıldı. Öğrencilere diő hekimliğine bakış açıları, diő hekimliğini seçme nedenleri, mezuniyet sonrası kariyer hedefleri ve bunların nedenleri hakkında sorular yöneltildi. Sorular hakkındaki değerlendirmelerini çoktan seçmeli seçeneklerden birini seçerek belirtmeleri istendi. Anket soruları çevrimiçi uygulandı. Veriler yüzde olarak hesaplanarak değerlendirildi. Diő hekimliği öğrencilerinin %62,8'i uzmanlık eğitimi almak istediklerini bunlardan %36,6'sı cerrahi ve %33,6'sı ortodonti uzmanı olmak istediklerini belirtti. Bu alanları isteme kararlarını etkileyen en önemli faktörler olarak kendi ilgi ve becerilerini göstermişlerdir. Yurt dışında çalışmak isteyen öğrencilerin %67,4'ü ülkedeki çalışma koşullarından memnun olmadığını ve diő hekimlerine duyulan saygınlığın azaldığını düşündüğünü belirtmiştir. Bugün yine seçme şansınız olsa diő hekimliği mesleğini seçer miydiniz sorusuna 1.sınıf öğrencilerinin %57'si, 5.sınıf öğrencilerinin ise %23'ü olumlu cevap vermiştir. Diő hekimliği öğrencilerinin kariyerlerine yönelik hedefleri ve diő hekimliği mesleğinden memnuniyetleri sınıflara göre farklılık göstermektedir. Bunların sebepleri; diő hekimliği eğitiminin zorlu sürecini yaşamaları, öğrencilerin klinik uygulamalara başladıktan sonra ilgi ve becerilerini keşfetmeleri ve üst sınıflarda uzmanlık dallarıyla ilgili daha fazla bilgi sahibi olmaları olabilir.

**Anahtar kelimeler:** Kariyer hedefleri, Diő hekimliği öğrencileri, Uzmanlık eğitimi

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January 21-28, 2025 / Havana, CUBA

## EVALUATION OF DENTISTRY STUDENTS' POST-GRADUATION CAREER GOALS

### **Abstract**

The aim of this study is to determine the career goals of dentistry students after graduation and to evaluate the factors influencing their decisions. A total of 359 students from the 1st, 2nd, 3rd, 4th, and 5th years of the Faculty of Dentistry at Van Yüzüncü Yıl University participated in this survey study. The students were asked questions regarding their perspectives on dentistry, reasons for choosing the field, career goals after graduation, and the factors influencing these decisions. They were asked to indicate their evaluations of the questions by selecting one of the multiple-choice options. The survey questions were administered online. The data were calculated as percentages and analyzed. 62.8% of dental students expressed their desire to pursue specialization training, with 36.6% indicating a preference for a career in surgery and 33.6% in orthodontics. The most influential factors in their decision-making were their interest and being skilled in these fields. Among students who wish to work abroad, 67.4% are dissatisfied with the working conditions in their home country and believe that the respect for dentists has diminished. When asked whether they would choose the dental profession again if given the chance, 57% of first-year students responded affirmatively, while only 23% of fifth-year students did so. Career aspirations and satisfaction with the dental profession among dentistry students differ according to their academic year. These variations may stem from the challenging nature of dental education, the opportunity for students to explore their interests and abilities as they engage in clinical practice, and the increasing knowledge they acquire regarding their respective specialties

**Keywords:** Career goals, Dentistry students, Specialty education

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**January 21-28, 2025 / Havana, CUBA**

**TISSUE CULTURE STUDIES ON ABIOTIC STRESS FACTORS IN FRUIT  
SPECIES**

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**Abstract**

Fruit species are among the most cultivated products worldwide. Fruits rich in minerals, vitamins, antioxidants, fiber, organic acids and sugars are indispensable for our diet. As a result of breeding studies carried out on them, higher quality, more productive varieties are constantly being produced. In recent years, in vitro techniques have been used more frequently in the propagation of saplings of fruit species; improvement of their characteristics, and evaluation of their resistance to different conditions. Healthy, disease-free seedlings are produced with the help of tissue culture techniques. While seedlings are being propagated, their desired characteristics are also developed, and healthy choices can be made by revealing their resistance to different conditions. Tissue culture techniques shorten the selection process and are effective, especially in revealing the resistance to abiotic stress factors. In this study, the applications of tissue culture techniques on resistance to different abiotic stress conditions will be examined. By bringing the information together, collective literature data will be presented in the ground stage and planning of the studies to be carried out.

**Keywords:** Fruit, spp. abiotic stress, in vitro culture

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**MEYVE TÜRLERİNDE ABİYOTİK STRES FAKTÖRLERİNE YÖNELİK DOKU  
KÜLTÜRÜ ÇALIŞMALARI**

**Özet**

Meyve türleri dünya genelinde en çok yetiştirilen ürünler arasındadır. Mineral maddeler, vitaminler, antioksidanlar, lif, organik asitler ve şekerler bakımından zengin meyveler beslenme rejimimizin vazgeçilmezlerindedir. Üzerinde yürütülen ıslah çalışmalarının sonucunda sürekli daha kaliteli, verimli çeşitler ortaya konmaktadır. Son yıllarda meyve türlerinin fidanlarının çoğaltımı, özelliklerinin iyileştirilmesi, farklı koşullara dayanım durumlarının değerlendirilmesi konularında in vitro teknikler daha sık kullanılmaktadır. Doku kültürü teknikleri yardımı ile sağlıklı, hastalıklardan arı fidanlar üretilmektedir. Fidanlar çoğaltılırken, aynı zamanda istenen özellikleri geliştirilmekte, farklı koşullara dayanıklılık durumları ortaya konarak, sağlıklı seçimler yapılabilmektedir. Özellikle abiyotik stres faktörlerine dayanıklılık durumunun ortaya koması konusunda doku kültürü teknikleri seçim sürecini kısaltmakta, etkili olmaktadır. Bu çalışmada da farklı abiyotik stres koşullarına dayanım üzerine doku kültürü tekniklerinin uygulamaları incelenecektir. Bilgilerin bir araya getirilmesi ile yürütülecek olan çalışmaların kara aşamasında ve planlanmasında toplu bir literatür verisi ortaya konmuş olacaktır.

**Anahtar Kelimeler:** Meyve türleri, abiyotik stress, doku kültürü



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**January 21-28, 2025 / Havana, CUBA**

**NUTRITIONAL QUALITY AND USAGE OF CANOLA (*Brassica rapa L.*) IN  
ANIMAL NUTRITION**

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**Özet**

Kanola, Brassica cinsine ait bir yağlı tohum bitkilerinden biridir. Kanola, düşük sıcaklıklara ve tuzluluğa toleransı yüksek bir bitkidir. Alternatif yem bitkisi olarak Brassica türleri dünyanın birçok bölgesinde kaba yem üretiminin kısıtlı olduğu dönemlerde yem açığını kapatmak amacıyla yetiştirilmektedir. Dünyada soya fasulyesinden sonra protein kaynağı olarak ikinci sırada olan kanolanın Türkiye'deki üretimi de giderek artış göstermektedir. Antinutrisyonel faktörlerinin uzaklaştırılmasıyla elde edilen yeşil ot, kuru ot, silaj, küspe, yağ elde edilen kanola bitkisi hayvan beslemede güvenle kullanılmaktadır. Uygun hasat koşulları ve kaliteli fermentasyon süreci sonucunda elde edilen kanola silajlarının bazı besin madde değerleri yonca silajından fazla olmaktadır. Yüksek protein içeriği, asit deterjanda (ADF), nötral deterjanda çözünmeyen lif (NDF) içeriklerinin düşük olması ve kuru madde sindirilebilirliğinin (KMS) yüksek olması, kanola silajının ruminantlar için iyi kalitede bir kaba yem olduğunu göstermektedir.

**Anahtar Kelimeler:** Kanola, kaba yem, silaj, besleme

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**January 21-28, 2025 / Havana, CUBA**

**NUTRITIONAL QUALITY AND USAGE OF CANOLA (*Brassica rapa L.*) IN  
ANIMAL NUTRITION**

**Abstract**

Canola is one of the oilseed crops belonging to the genus Brassica. Canola is a plant with high tolerance to low temperatures and salinity. Brassica species are cultivated as alternative forage crops in many regions of the world in order to close the feed deficit in periods when forage production is limited. The production of canola, which ranks second in the world as a protein source after soya beans, is gradually increasing in Turkey. Canola plant, which is obtained from green grass, hay, silage, meal, oil obtained by removing antinutritional factors, is used safely in animal nutrition. The nutrient values of canola silages obtained as a result of appropriate harvest conditions and quality fermentation process are higher than alfalfa silage. High protein content, low acid detergent (ADF) and neutral detergent fibre (NDF) contents and high dry matter digestibility (DMD) indicate that canola silage is a good quality roughage for ruminants.

**Keywords:** Canola, forage, silage, feeding

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**January 21-28, 2025 / Havana, CUBA**

**THE PLACE AND IMPORTANCE OF OILSEED PLANTS IN THE  
DEVELOPMENT OF PROVINCE BATMAN**

**Mehtap ANDIRMAN**

**Nurettin BARAN**

**Abstract**

Recently, with the rapid increase in the population and the decrease in the production amount of oilseed plants, a deficit of vegetable oil has occurred. Therefore, Türkiye is largely dependent on foreign oil for both oilseeds and industrial products. Since most of the oilseed crops are hoe crops, they require a lot of labor and input in agriculture and therefore their production costs are high. However, these plants create a great job potential due to the need for a lot of labor in both the agriculture and the industrial sector where they are processed. As in many provinces of Türkiye, the local people of Batman province engage in agriculture and animal husbandry to survive. In the region, industrial crops, legumes, cereals, forage crops, as well as vegetables, fruits and ornamental plants are grown among field crops. In terms of agricultural production, it includes field crops with 90.69% and garden crops with 9.31%. As a result of the results shown by these ratios, field crops are of great importance in Batman. Among the oilseed plants among the field crops in the region, sesame, sunflower, peanut and soybean are grown. Local people generally cultivate oilseed plants to meet their own needs and to trade small amounts, even at low rates.

The climate and soil structure of the Batman region is suitable for growing oilseed plants. In order to process these plants, it is essential to encourage the vegetable oil industry in the region. In addition, it will also support the livestock sector in the region by using the remaining pulp after the plants are processed as animal feed. Another important issue is that oilseed plants, which are in the industrial plants group, are used as raw materials in the production of biodiesel, and it is thought that the farmers themselves will produce the energy requirement, which is the most costly for the producers, and will contribute to the formation of energy agriculture. As a result, it is envisaged that by introducing alternative plants to the agricultural production pattern of the region, it will provide a source of income for both the country's economy and farmers.

**Key Words:** Oilseed, Sesame, Peanut, Sunflower, Soybean, Batman

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January 21-28, 2025 / Havana, CUBA

## KÜRESELLEŞEN DÜNYANIN GİZLENEN YÜZÜ: PREKARYALAŞMA

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### Özet

Heraklitos, “Aynı nehirde iki kere yıkanılmaz” ve “Her şey akar” dediğinde toplumsal düzenin sonsuza kadar aynı kalmayacağını, değişim ve dönüşüme uğrayacağını vurgulamıştır. Küreselleşmenin ortaya çıktığı ilk süreçlerde ulaşım, değişim ve gelişim günümüzdeki hali kadar hızlı değildi. Fakat ilerleyen zamanlarda emeğin değer kaybetmesi başta yabancılaşma olmak üzere birçok sorunu da beraberinde getirmektedir. Küreselleşme toplumlar arası sınırları kırılğan hale getirmiş olsa bile oluşan toplumlar arası ve toplumlar içi çatışmalara engel olamamıştır. Sadece küreselleşme bağlamında değil, yerel ve ulusal ölçekte özellikle emeğin istihdamının sağlanamıyor olması üzerine çözüm üretilmesi gereken bir meseledir. Sosyolojik açıdan küreselleşme, parça olarak bireylerin, bütün olarak toplumların, toplumsal kurumların özellikle toplumsal yaşamların üzerinde etkili olan bir süreçtir. Küreselleşme ile birlikte kırılğan hale gelen sınırlar, ulusal ve uluslararası ölçekte yaşanan değişimler sınırsız bir dünya düzenini oluşturmaktadır. Küreselleşen hayat düzeninde öznel rahatsızlık ve belirsizlikler ortaya çıkmaktadır. Modernlik adı altında ele alınan tüm dönemlerde; risk, güven(ce)sizlik, eşitsizlik, belirsizlik ve çeşitli toplumsal kaygılar da var olmaktadır. Bu çalışmada da literatür taraması yapılarak küreselleşmenin prekarya üzerindeki etkilerinin incelenmesi amaçlanmaktadır. Çünkü, “Prekarya ne bir kurban, ne bir hain, ne de kahraman- sadece içinde hepimizden bir şeyler var.” Prekarya doğası gereği küresel bir niteliğe sahiptir. Esnekleşme ve güvencesizleşme ile insanlar istikrarsız işlerde mesleki kimlik kazanamadan çalışırken, bu sistemin günümüzde daha fazla genişlemektedir (Standing 2022: 320). Prekarya'nın yapmakta olduğu mesleğe, topluma ve kendisine yabancılaşması oluşmakta olan bu sınıfın en belirgin özelliğidir. Sonuç olarak küreselleşme ve esnekleşme ile birlikte de güvencesizlik alanları da genişlemektedir. Prekarya sınıfına dâhil olan bireylerin mesleki becerilere sahip olmasının yanı sıra bu vasıfların zamanla önemini kaybetmesi uzun vadede kişiye güvenli bir kimlik ve garanti altına alınmış bir hayat sunamamaktadır. Bu durumda prekaryanın riskli bir yaşamda endişe içerisinde yaşamasına sebep olmaktadır.

**Anahtar Kelimeler:** Küreselleşme, Prekaryalaşma, Güvencesizlik, Yabancılaşma, Esnekleşme

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## THE HIDDEN FACE OF A GLOBALIZING WORLD: PRECARIALIZATION

### **Abstract**

When Heraklitos said “You cannot bathe twice in the same river” and “Everything flows” he emphasized that the social order will not remain the same forever, but will undergo change and transformation. In the early stages of globalization, transportation, change and development were not as fast as they are today. However, the devolution of labor in later times brings along many problem, especially alienation. Even though globaliztion has made the borders between societies fragile, it has not prevent inter-societal and intr-societal conflicts. It is issue that needs to be addresse not only in the context of globalization, but also on a local and national scale, especially the lack of employment for labor. From a sociological point of view, globalization is a process that affects individual as a part, societies as a whole, social institutions and especially socaşl lives. The borders that have become fragile with globalization and the changes experienced on a national and international scale constitute a borderless world order. Subjective discomfort and uncertainties arise in the globalized life order. Risk, insecurity, inequality, uncertainty and various social concern also exist in all periods considered under the name of modernity. This study aims to examine the effects of globalization on the precariat through a literature review. Because, “the precariat is neither a victim, nor a traitor, nor a hero – it just has something of us all in it.”. The precariat is global in nature. With flexibilization and precarization, people work in unstable jobs without gaining professional identity, and this system is expanding today (Standing 2022: 320). The alienation of the precariat from the profession, society and itself is the most prominent characteristic of this emerging class. As a result, with globalization and flexibilization, the areas of precarity are also expanding. The fact individuals in the precariat class have professional skills, as well as the fact that these skills lose their importance over time, cannot offer a secure identity and a guaranteed life in the long run. This causes theprecariat to live in anxiety in a risk life.

**Keywords:** Globalization, Precarization, Precarity, Alienation, Flexibilization

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**SAĞLIK TURİZMİNİN DIŞ TİCARET ÜZERİNDEKİ ETKİLERİ**

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**Özet**

Sağlık turizmi, geleneksel mal ticaretinden farklı olarak hizmet sektörünü doğrudan etkileyen sektörlerden biridir. Yabancı hasta sayısındaki artış, bir ülkenin sağlık hizmeti ihracatı anlamına gelir. Bu hizmet ihracatı, döviz girdisi sağlayarak cari açığı azaltabilir ve ekonomiyi destekler. Sağlık turizmi, dış ticaretin hizmet ihracatı boyutunda stratejik bir alan olarak öne çıkmaktadır. Bu alanın büyümesi, sadece ekonomik katkı sağlamakla kalmayıp, aynı zamanda ülkelerin sağlık altyapısının gelişmesine de yardımcı olur. Bu nedenle, sağlık turizminin geliştirilmesi için devlet teşvikleri, uluslararası tanıtım faaliyetleri ve altyapı yatırımları büyük önem taşır. Türkiye, sağlık turizmi alanında rekabetçi fiyatlar, yüksek kaliteli sağlık hizmetleri ve coğrafi avantajlarıyla öne çıkan bir ülkedir ve katkıları arasında döviz geliri sağlamak, medikal ihracat ile turizm çeşitlendirmesi büyük bir yere sahiptir. Bu çalışmada sağlık turizmi için Türkiye'ye gelen hastaların sebepleri, yıllara göre sayısal büyüklükleri incelenerek, sağlık turizmindeki büyüme ele alınmaktadır.

**Anahtar Kelimeler:** Sağlık Turizmi, Sağlık Hizmetleri, Medikal İhracat, Hizmet İhracatı

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**EFFECTS OF HEALTH TOURISM ON FOREIGN TRADE**

**Abstract**

Health tourism, unlike traditional goods trade, is one of the sectors that directly affects the service sector. The increase in the number of foreign patients means a country's health service export. This service export can reduce the current deficit by providing foreign exchange inflow and supports the economy. Health tourism stands out as a strategic area in the service export dimension of foreign trade. The growth of this area not only provides economic contribution but also helps the development of the health infrastructure of countries. Therefore, state incentives, international promotional activities and infrastructure investments are of great importance for the development of health tourism. Turkey is a country that stands out with its competitive prices, high-quality health services and geographical advantages in the field of health tourism, and among its contributions, providing foreign exchange income, medical export and tourism diversification have a great place. In this study, the reasons for patients coming to Turkey for health tourism, their numerical sizes according to years are examined and the growth in health tourism is discussed.

**Keywords:** Health Tourism, Health Services, Medical Export, Service Export

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**SUUDI ARABİSTANDA GERÇEKLEŞEN REFORMLARIN KADINLAR ÜZERİNE  
ETKİLERİ\***

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**Özet**

Suudi kadınlar için getirilen reformlar, Irak'ın Kuveyt'i işgali Suudi Arabistan'ı da farklı alanlarda etkilemiştir. Bu dönemde Suudi kadınlar tarafından araba sürme yasağı ile ilgili başlatılan protestolar her ne kadar bastırılmışsa da 11 Eylül saldırıları ve Orta Doğu'yu kasıp kavuran Arap Baharı gibi olaylar, kadınların taleplerini ve seslerini duyuracakları bir ortam hazırlayıp harekete geçmelerini sağlamıştır. Bu makalenin temel amacı Velihaht Prens Muhammed Bin Selman'ın hazırladığı ve 2016 yılında uygulamaya koyduğu Vizyon 2030 Planı ile kadınların güçlendirilmesine yönelik reformların uluslararası arenada yaşanan savaşlar ve terör olaylarının Suudi kadınları üzerinde ne gibi etkilere sebep olduğunu ortaya koymaktır. Makalenin yöntemsel çalışmasında döküman analizi ve yarı yapılandırılmış görüşmelerden faydalanılmıştır. Bu bağlamda Suudi Arabistan'da Suudi kadınlarla mülakatlar yapılmıştır. Araştırmada özellikle Vizyon 2030 stratejik planı ile hem ılımlı İslam politikası hem de ülkenin modernize edilmesi için uygulanan politikalar Suudi kadının güçlendirilmesi, sosyal ve ekonomik yaşamlarının devlet tarafından desteklendiği yönünde bulgular elde edilmiştir. Kadınlara uygulanan araba sürme yasağının ve tek tip kıyafet zorunluluğunun kaldırılması, erkeklerin kadınlar üzerindeki vasiliğinin sona erdirilmesi, iş alanlarının çeşitlendirilmesi Suudi Arabistanda yaşanan en dikkat çekici değişimler olarak görülmüştür. Suudi toplumunda kadının rolünün sadece soy bağıını aktaran, annelik yapan ve evden çıkmaması gereken bireyler olarak algılanırken Prens Selman ile birlikte kadınların toplumsal ve kamusal alanda görünürlüğünü ve saygınlığını arttıran reformlarla bu algı değişime uğramıştır.

**Anahtar Kelimeler:** Mohammed Bin Selman, Suudi Kadınlar, Reform, Suudi Arabistan



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**EFFECTS OF REFORMS IN SAUDI ARABIA ON WOMEN\***

**Abstract**

The reforms introduced for Saudi women and the Iraqi invasion of Kuwait have also affected Saudi Arabia in different areas. Although protests were suppressed by Saudi women during this period regarding the driving ban, events such as the September 11 attacks and the Arab Spring that ravaged the Middle East enabled them to pass by preparing and operating an environment in which women would be distributed and make their voices heard. The main purpose of this article is to reveal the impact of the international wars and terrorist incidents on Saudi women caused by the Vision 2030 Plan prepared by Crown Prince Mohammed Bin Salman and implemented in 2016 and the reforms aimed at women's empowerment. Methodological functioning of the article document analysis and semi-interviews were used. In this context, interviews have been conducted with Saudi women in Saudi Arabia. In the study, findings were obtained that both moderate Islamic policy and the policies implemented to modernize the country, especially with the Vision 2030 strategic plan, are aimed at empowering Saudi women, and that their social and economic lives are supported by the state. The abolition of the driving ban imposed on women and the uniform dress code, the end of men's guardianship over women, diversification of business areas have been seen as the most remarkable changes experienced in Saudi Arabia. While the role of women in Saudi society is perceived only as individuals who transfer their family ties, practice motherhood and should not leave the house, this perception has changed with the reforms that have increased the visibility and respectability of women in social and public spheres together with Prince Salman.

**Keywords:** Mohammad Bin Salman, Saudi Women, Reform, Saudi Arabia

\*Bu makale tezden türetilmiştir.

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**THE INFLUENCE OF IMUNIPLANT ON THE MICROBIOME IN PATIENTS  
WITH INFLAMMATORY BOWEL DISEASE**

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**Abstract**

**Background** It is now evident that the gut microbiota has a profound effect on the host immune system. The interactions between the gut microbiota and inflammatory bowel disease are complex, dynamic and context-dependent. The gut microbiota and its metabolites have been shown to influence immune homeostasis both locally and systemically. Bacterial contents such as lipopolysaccharide and bacterial antigens can induce a inflammatory bowel disease. The biggest question in the field is whether inflammation causes gut dysbiosis or dysbiosis leads to disease induction or propagation.

**Objectives** To demonstrate role of plants in the management of inflammatory bowel disease. The direct modulation of gut microbiome that could diminish chronic inflammatory responses and ameliorate adaptive immune responses is major pathway to stabilize inflammatory bowel disease.

**Materials and methods** Recent reports indicate that dysbiosis is increased in inflammatory bowel disease. Plant modulation of the immune system can also have a role in the inflammatory bowel disease, acting to reduce or delay the onset of inflammatory bowel disease. Ongoing research in this field will ultimately lead to a better understanding of the role of diet and plants in chronic inflammation in patients with inflammatory bowel disease.

**Results** Plants may restore the composition of the gut microbiome and introduce beneficial functions to gut microbial communities, resulting in amelioration or prevention inflammatory bowel disease

**Conclusion** The gut microbiota is considered to be a master regulator of inflammatory bowel disease. Besides modifying the gut microbiota, plants modulates the immune system in patients with inflammatory bowel disease.

**Keywords:** inflammatory bowel disease, microbiome, immunomodulation, Imuniplant

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**IMPROVEMENT OF TIN OXIDE THIN FILM FOR THE WASTEWATER  
TREATMENT PROCESS AND ITS EFFECTS ON OUR HEALTH**

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**Abstract**

Generally speaking, the aim of wastewater treatment is to provide an effluent with a concentration that is within a valid range, Tin Oxide (SnO<sub>2</sub>) is an n-type semiconductor with a wide energy band gap that can have up to 4.1 eV, it's the basic material commonly used in gas sensing, photocurrent, optoelectronics devices, photochemical, oxidative catalysis, photocatalysis, dye-sensitized solar cell, SnO<sub>2</sub> structures can be fabricated via a wide range of procedures such as sol-gel, spray pyrolysis, magnetron sputtering, mechanochemical, precipitation, chemical vapor deposition, and hydrothermal.

This work deals with the Synthesis and characterization of Tin oxide thin film Prepared by sol gel method and dip coating technique for wastewater treatment Process and its effects on our health and economic, optical properties (uv-visible), such as transmittance, absorbance, reflectance, refractive index, dielectric constant and optical energy gap, structural properties using X-ray diffraction (XRD), morphology using scanning electron microscopy (SEM), for the wastewater treatment process, using the degradation of methylene blue (MB) photocatalysts.

**Keywords:** wastewater, MB, Sol-gel, SnO<sub>2</sub> Thin film, XRD, UV, SEM.

**FILTER BASED ON THE DEFECTIVE STAR WAVEGUIDES SYSTEM WITH  
COAXIAL CABLES**

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***Abstract***

We investigate in this paper the existence of one or two defect modes in the photonic band structure of a one-dimensional photonic comb-like waveguide (CWG) structure called also star waveguide (SWG) structure. This structure exhibits large forbidden bands (gaps) that originate both from the periodicity of the system and the resonance states of the grafted lateral branches. The defect modes result from the presence of defective backbone in the star waveguide structure and may occur in these gaps.

We have shown after the electromagnetic band structure with the presence of a geometrical defect of length 0.53 that there are two optical filters (two defect modes) of maximum transmission and a very high quality factor  $Q$  ( $Q_1 = 358$  and  $Q_2 = 1550$ ). In order to improve this quality factor and to keep these maximum transmission, we created the material defect (relative permittivity variation of defect) and we kept the same length of defect 0.53, we found that when the permittivity of defect equals 4.4, the quality factor  $Q_2$  of the second filter is improved from  $Q_2 = 1550$  up to  $Q_2 = 2202.2$  while the quality factor  $Q_1$  for the first filter is rest almost unchanged. Also, we have studied the band structure with the presence of material defect without geometrical defect, and we can also find two optical filters of maximum transmission and high quality factor  $Q$  ( $Q_1 = 1708$  and  $Q_2 = 9085$ ) when the relative permittivity of defect equals 2.6.

**Keywords:** *photonic star waveguide, defect modes, optical filter.*

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**PREVALENCE AND RISK FACTORS OF OSTEOSARCOPENIA AMONG  
POSTMENOPAUSAL WOMEN**

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**Abstract**

Longevity, the increase in the aging population requires greater attention to reducing the risk of osteoporosis and sarcopenia. These conditions are usually interrelated through several mechanisms and metabolic pathways and comprise a syndrome called osteosarcopenia. The study aimed to evaluate the prevalence and risk factors of osteosarcopenia among 300 postmenopausal Caucasian women aged  $62.5 \pm 3.9$  years. Bone mineral density (BMD) and bone mineral content (BMC) of the femoral neck and lumbar spine and muscle mass were assessed by dual-energy X-ray Absorptiometry (Swissray Norland Medical Systems, Madison, WI, USA). Hand grip strength (HGS) was measured using a dynamometer. Functional fitness was assessed using a 6-minute walking test. Physical activity was examined using the Yale Physical Activity Survey. The energy expenditure (kcal/week) was estimated by summing the time of each activity multiplied by the corresponding intensity code. Eating habits, consumption of dairy products, and protein intake were calculated from face-to-face interview data and Food Frequency Questionnaires. Osteosarcopenia occurred in 14.2% of women. The highest percentage of osteosarcopenia was in women with the lowest level of physical activity (PA) and high sitting time. Energy expenditure, protein intake, and total time PA (hours/week) were significantly higher in healthy women without osteosarcopenia. Consumption of dairy products during the day significantly lowers the risk of osteosarcopenia among women.

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Systematic participation in physical exercises significantly reduced the risk of osteosarcopenia. Lifestyle, especially physical inactivity and sedentary behavior, significantly affect the risk of developing osteosarcopenia in postmenopausal women.

**Keywords:** aging, osteosarcopenia, eating habits, physical activity, sedentary behaviors, postmenopausal women

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**COMPARISON OF FUNCTIONAL FITNESS IN ATHLETES TRAINING SOCCER  
AND KARATE USING THE FMS (FUNCTIONAL MOVEMENT SCREEN) TEST**

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**Abstract**

Regular physical activity affects all systems and organs of the human body. This impact is particularly noticeable in individuals who train professionally but also in those who train recreationally yet systematically. It is widely accepted that physical exercise positively influences the musculoskeletal system and overall fitness. This study aimed to examine how the specific training characteristics of two completely different sports—soccer and karate—affect the functional fitness of athletes. The study included 22 soccer players and 21 karate practitioners. All participants had been training their respective sports for approximately 8–10 years. Soccer players trained 4–5 times per week and belonged to the 4th–5th league categories, while karate practitioners trained an average of 3–4 times per week and held ranks between 3rd kyu and 2nd dan. All participants underwent the Functional Movement Screen (FMS) test, consisting of seven tasks designed to evaluate global stability, mobility, and neuromuscular coordination. The tests were conducted using a professional testing kit. The standard threshold for high-risk sports injuries was set at 14 points. Based on the analysis of the collected data, it was found that karate practitioners achieved higher scores in most FMS tasks compared to soccer players, with statistically significant differences in five of the seven test components (squat, hurdle step, in-line lunge, active straight leg raise, rotary stability), as well as in the overall FMS score. The overall FMS score for karate practitioners was 18.93 points, compared

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to 16.07 points for soccer players.

**Keywords:** FMS test, functional fitness, athletes, soccer, karate.



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**HIRSHFIELD SURFACE ANALYSIS OF (E)-1-(2,2-DICHLORO-1-(4-NITROPHENYL)VINYL)-2-(4-FLUOROPHENYL)DIAZINE**

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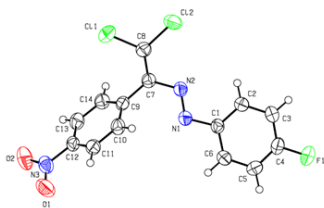
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**Abstract**

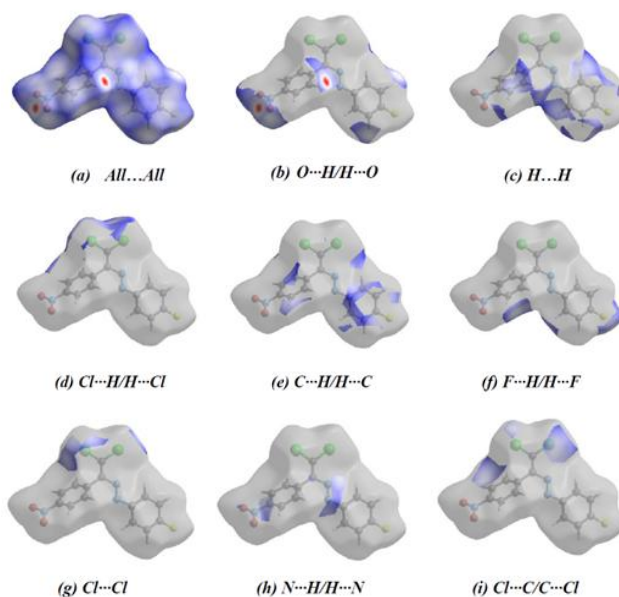
Hirshfeld surface analysis is used to investigate the intermolecular interactions in the crystal structure of each compound. The mapped surface areas on dnorm were created to measure and visualize the intermolecular interactions and to explain the observed crystal structure. While the dark red dots on the dnorm surface occur as short intermolecular interactions, other weaker intermolecular interactions appear as light red dots. With this in mind, Hirshfeld surface analysis was first performed on the crystal structure of (E)-1-(2,2-dichloro-1-(4-nitrophenyl)vinyll)-2-(4-fluorophenyl)diazine.

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Intermolecular interactions in (E)-1-(2,2-dichloro-1-(4-nitrophenyl)vinyl)-2-(4-fluorophenyl) diazine



Hirshfeld surface analysis of the crystal structure reveals that the most important effects in the formation of the crystal lattice are the interactions  $H\cdots O/O\cdots H$  (15.5%),  $H\cdots H$  (15.3%),  $Cl\cdots H/H\cdots Cl$  (13.8%),  $C\cdots H/H\cdots C$  (9.5%), and  $F\cdots H/H\cdots F$  (8.2%).

**Keywords:** dichlorodiazadienes derivatives, non-covalent interaction, hirshfeld surface analysis

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**BENZİLİDEN-2-FENİLHİDRAZİN TÖRƏMƏLƏRİNDƏN  
DİHALOGENDİAZABUTADİENLƏRİN SİNTEZİ**

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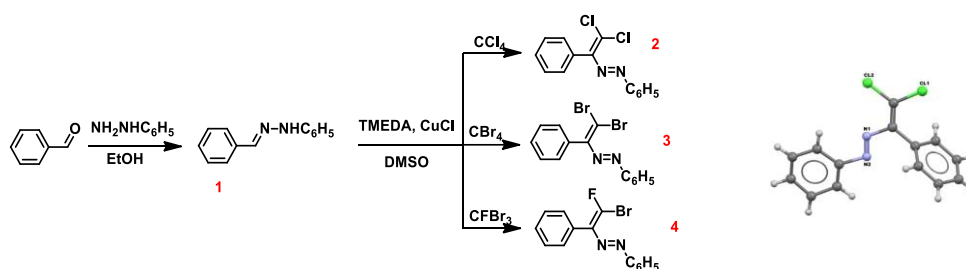
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**Abstract**

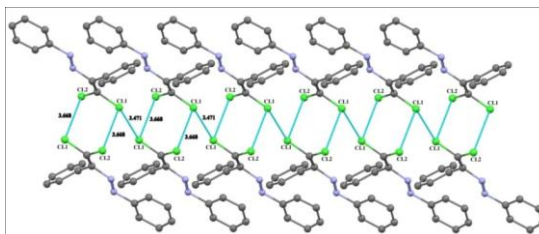
In organic synthesis, the development of effective synthesis methods for new polyfunctional compounds based on catalytic reactions is one of the urgent issues. In these syntheses, interesting transformations such as functionalization of any group in the substrate or introduction of new functional groups, intramolecular and intermolecular heterocyclization as a result of the interaction of 2 or more groups, formation of new C-C, C=C, C=N, C-N, C-Hal bonds, etc. are used. In addition, these compounds can be applied as azo dyes. The E↔Z isomerism formed in the N=N double bond gives characteristic properties to azo dyes, which once again shows how important synthons dichlorodiazabutadienes are. Therefore, first of all, the reactions of phenylhydrazone synthesized on the basis of benzoyl aldehyde in this new synthetic direction with polyhalomethanes (CCl<sub>4</sub>, CBr<sub>4</sub>, CBr<sub>3</sub>) were studied under the conditions of catalytic olefination reaction.

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In addition, 2 single crystals of (E)-1-(2,2-dichloro-1-phenylvinyl)-2-phenyldiazene were obtained and its molecular structure was confirmed again by the X-Ray method. During the RQA studies of the (E)-1-(2,2-dichloro-1-phenylvinyl)-2-phenyldiazene molecule, it was determined that non-covalent  $\text{Cl}\cdots\text{Cl}$  (3.668 Å and 3.472 Å) bonds were also involved in the crystal formation.



**Keywords:** dichlorodiazadiene derivatives, polyhalogenmethanes

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**THE EFFECT OF LINDEN EXTRACTS ON THE ANTIOXIDANT POTENTIAL OF  
ICED TEA**

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**Abstract**

This research aimed to produce iced tea enriched with *Tilia cordata* flower extracts and determine their antioxidant potential. No presence of Pb, Cd, and Ni was determined in the fresh flowers. According to the HPLC-MS analysis, ethanolic extracts had higher ( $p < 0.05$ ) phenolic acid content than the aqueous extract. Protocatechuic acid ( $1684.61 \mu\text{g}\cdot\text{g}^{-1}$  i.e.  $1738.77 \mu\text{g}\cdot\text{g}^{-1}$ ), gallic acid ( $451.07 \mu\text{g}\cdot\text{g}^{-1}$  i.e.  $586.29 \mu\text{g}\cdot\text{g}^{-1}$ ), rutin ( $359.47 \mu\text{g}\cdot\text{g}^{-1}$  i.e.  $489.36 \mu\text{g}\cdot\text{g}^{-1}$ ) and quercetin ( $191.10 \mu\text{g}\cdot\text{g}^{-1}$  i.e.  $213.95 \mu\text{g}\cdot\text{g}^{-1}$ ) had the highest values, compared to the other determined phenolic acids.

The iced teas enriched with both aqueous and ethanolic extracts exhibited significantly higher ( $p < 0.05$ ) antioxidant potential compared to the conventional linden tea control. The highest antioxidant potential was observed in the iced teas enriched with the ethanolic extract.

This research represents a novel approach to utilizing *Tilia cordata* flower extracts in the production of ready-to-drink iced tea. It offers a fresh perspective for both the beverage and food industries. The linden extracts are known for their rich chemical composition and bioactive compounds, which suggests their potential use in creating new functional food products. Furthermore, this new iced tea is free from sorbates and benzoates, which are among the most harmful artificial additives found in the food industry.

This product can be classified as a functional food because it has a beneficial impact on consumers' health. Its industrial production does not require special conditions, which gives it a significant potential and market advantage over conventionally available linden teas.

**Keywords:** Iced tea; HPLC-MS; extraction; functional beverages; *Tillia* sp.

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**January 21-28, 2025 / Havana, CUBA**

**SYNTHESIS AND BIOLOGICAL SCREENING OF AMIDES USING COUMARIN-3-  
CARBOXYLIC ACID**

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**Abstract**

Primary, secondary, and tertiary amides have been synthesized by one-pot synthesis from coumarin 3 carboxylic acid by using SOCl<sub>2</sub> and triethyl amine which have significant importance in the pharmaceutical field in the scenario of having biological activities like antimicrobial and anti-oxidants in the priority list. Reaction results are admirable at low temperature and can be pure by washing or column chromatography/preparative column chromatography. Amides are widespread in biologically active compounds with various applications in biotechnology, agriculture and medicine. Herein, Coumarin 3 Carboxylic acid based amides N-(2-hydroxyethyl)-2-oxo-2H-chromene-3-carboxamide (EACA), N-(4-fluorophenyl)-2-oxo-2H-chromene-3-carboxamide (4FCA), N-(3-ethylphenyl)-2-oxo-2H-chromene-3-carboxamide(3EACA), N-(2-chloro-5-nitrophenyl)-2-oxo-2H-chromene-3-carboxamide (2C5NCA), N-(3-fluorophenyl)-2-oxo-2H-chromene-3-carboxamide and N-(3-chloro-4-fluorophenyl)-2-oxo-2H-chromene-3-carboxamide were synthesized and characterized using spectroscopic techniques. The newly synthesized coumarin 3 carboxylic acid based amides were screened for their antibacterial and antioxidant potential. Antioxidants showed their activity by inhibiting the oxidative chain reactions that produce reactive oxygen species. The antioxidant activity showed that 2C5NCA exhibited the maximum DPPH inhibitory activity when compared with that of EACA, 4FCA, 3EACA, 3FCA, and 3C4FCA. While 3C4FCA showed maximum antibacterial activity(E.coli) as compared to other synthesized amides, while in the scenario of S aureus, 3FCA showed maximum activity as compared to 4FCA, EACA, 3EACA, 3C4FCA, and 2C5NCA. By this method, a series of novel coumarin-3-carboxamides were designed and synthesized to evaluate their biological activities.

**Keywords:** coumarin-3-carboxamides; Anti-microbial, Anti-oxidant; DFT Study; Spectroscopic Analysis.

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**SYNTHESIS AND BIOLOGICAL SCREENING OF HYDRAZONE BY USING  
CHOLIC ACID**

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**Abstract**

The hydrazone derivatives are synthesized by coupling cholic acid hydrazide depicting substituted aldehydes: m-nitro benzaldehydes, p-nitro benzaldehydes, and N,N-dimethyl benzaldehyde. Quiet of curiosity the synthesized hydrazones consist of two rotamers s-cis.E and s-trans.E. The characterization of synthesized hydrazones was done by using melting point, UV-Visible, FT-IR, and NMR spectroscopy. The synthesized compounds were screened for their biological activities like anti-bacterial, anti-fungal, and anti-oxidant. The compound 4-NBCH and 3-NBCH are highly activity against fungal strain *C. albicans* than standard Clotrimazole. In the case of the anti-bacterial strain *E. coli*, the compounds 4-NBCH and N,N-DMBCH show more activity than 3-NBCH. The compound N,N-DMBCH is more active among 4-NBCH and 3-NBCH. The highest activity was shown by 4-NBCH compound which have ZOI=24mm which was found to be highly active against Clotrimazole having ZOI=20 (containing NO<sub>2</sub> group which is a strong electron withdrawing group that creates localized electron deficient sites within molecules).

**Keywords:** Cholic acid based Hydrazones; Anti-microbial, Anti-oxidant; DFT Study; Spectroscopic Analysis.

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**January 21-28, 2025 / Havana, CUBA**

**NATURAL AND SOCIAL PARAMETERS IN THE PROCESS OF CITY  
FORMATION LESSONS FROM MEDINA**

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**Abstract:**

Rapid urbanization led to the importation of already available solution, which are very often incompatible with the local variables. This situation lead in many cases to the dissimulation of the local socio-spatial integration, which characterises the historical centres where the form constitutes a spatial expression and at the same time a testimony of all the social, geographical, cultural and economic parameters that contributed not only to its development, but also to its establishment. A testimony that has to be re-evaluated nowadays to meet the particularities of its location in time and place.

Place is considered to be the starting point from which all design for our built environment should begin, an explanation of the quality and uniqueness from urban point can only start with an understanding of the concept of place from different perspectives through the examination of tangible features like studies that focus on the physical image of the site, connection between green and grey infrastructure, the organization of public space and geometrical features and the building wealth.

In this phase, we attempted to set a complete framework that allows extracting the particular place qualities in accordance with the physical parameters of the site stressing on the importance of addressing the study of the place and its role in the place formation. Place as a matter of reason.



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**January 21-28, 2025 / Havana, CUBA**

**PARTICULARITIES OF RISKS AND THREATS TO ECONOMIC SECURITY IN  
THE BANKING SECTOR**

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**Abstract**

In the context of economic and financial services globalization, it is essential to strengthen regulatory mechanisms for the banking system, as the volume of cross-border capital flows increases. Transnational institutions (banks, insurance companies, investment funds), due to the scale of their activities, can cause irreparable damage to the global economy.

Moldova's integration into the European financial system is closely linked to the liberalization processes of the country's financial and credit system, the growth of cross-border capital flows, external borrowing, the accumulation of "toxic" debts, and more. These factors generate new threats to the economic security of the national banking system, associated with the intensifying influence of foreign banking capital, the negative consequences of refinancing external loans, and the increase in doubtful and irrecoverable debts.

Therefore, to prevent threats to the banking system, new approaches are required in monetary and credit policy, both globally and nationally. In this context, there is a need to develop an economic security concept for the national banking system, including criteria for assessing the quality of monetary and credit policy, normative values for economic security indicators of the banking system, and practical measures for implementing this policy.

It is important to highlight that, in assessing the economic security of the banking system, a micro-level approach predominates, focusing on the development and ratings of commercial banks.

**Keywords:** banking system, economic security of the national banking system, commercial banks.

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**HYBRID OFFICE TRENDS IN HO CHI MINH CITY**

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**Abstract**

The global shift towards hybrid work models has transformed the traditional office landscape, particularly in rapidly urbanizing cities such as Ho Chi Minh City, Vietnam. This paper examines the emerging trends, challenges, and implications of hybrid office models within the context of Ho Chi Minh City's unique socio-economic and cultural environment. With the rise of digitalization and changing workforce expectations post-pandemic, hybrid offices have become a focal point for businesses seeking to balance flexibility, collaboration, and productivity.

The study employs a mixed-methods approach, combining quantitative surveys and qualitative interviews with employees, employers, and industry experts. Key findings indicate that hybrid office models are characterized by a strategic blend of physical office spaces and remote working arrangements. Factors such as technological infrastructure, corporate culture, and employee preferences significantly influence the adoption and effectiveness of hybrid work setups. Moreover, this research identifies specific design trends, including flexible workstations, co-working spaces, and the integration of green and sustainable elements, that are reshaping the physical office environment.

However, the hybrid model also presents challenges, such as maintaining organizational cohesion, managing remote workforce dynamics, and addressing employee well-being. In Ho Chi Minh City, additional considerations include space limitations, cost efficiency, and the city's dynamic property market. This paper argues that a successful hybrid office model requires a tailored approach that aligns with local market conditions while embracing global best practices.

The findings of this research contribute to the growing body of knowledge on hybrid work models and provide actionable insights for policymakers, urban planners, and business leaders. By understanding the evolving needs of the workforce and leveraging innovative office designs, stakeholders can optimize the hybrid model for a more resilient and adaptable workplace in Ho Chi Minh City.

**Keywords:** Hybrid Office, Workplace Trends, Ho Chi Minh City, Flexible Work, Sustainable Design, Remote work

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**COLOR TRENDS 2025: EXPLORING THE PALETTE OF CALM AND  
VIBRANCY IN INTERIOR DESIGN**

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**Abstract**

As the field of interior design evolves, color trends play a pivotal role in shaping the aesthetics and atmosphere of spaces. This paper delves into the emerging color trends for 2025, focusing on a harmonious blend of tranquil and vibrant shades. It explores how these palettes reflect broader societal shifts towards balance, wellness, and individuality. The study analyzes the psychological impacts of various color schemes on occupants, examining their influence on mood, productivity, and overall well-being. Furthermore, the paper discusses the integration of these trends into diverse interior design contexts, offering insights into how designers can effectively leverage color to create dynamic yet soothing environments. By forecasting future developments, this research provides a comprehensive understanding of the role of color in interior design and its potential to transform spaces in 2025.

**Keywords:** color trends 2025, role of color in interior design, atmosphere of spaces, integration of these trends

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**INNOVATIVE SUSTAINABLE MATERIALS IN INTERIOR DESIGN TRENDS  
AND APPLICATIONS IN 2025**

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**Abstract**

The increasing emphasis on sustainability and environmental protection is exerting a significant influence on interior design, driving the adoption of eco-friendly materials. This paper examines the latest trends and applications of sustainable materials in interior design as projected for 2025. It underscores the advancements in products such as biodegradable composites, recycled materials, and environmentally low-impact manufacturing processes. The research further illustrates how these materials contribute to the creation of aesthetically pleasing, healthier, and more energy-efficient living environments. Additionally, the paper discusses the challenges and opportunities associated with integrating sustainable materials into mainstream design practices, including cost implications, consumer awareness, and regulatory frameworks. Through the analysis of case studies and industry developments, this study provides insights into the future trajectory of sustainable interior design, highlighting the pivotal role of innovation in achieving environmentally conscious living spaces.

**Keywords:** eco-friendly materials, sustainable materials, mainstream design practices, future trajectory of sustainable interior design, biodegradable composites, recycled materials, environmentally low-impact manufacturing processes

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**January 21-28, 2025 / Havana, CUBA**

**TECHNOPATHIES THAT INFLUENCE THE APPEARANCE OF HOOF DISEASE  
IN CATTLE FARMS ON A CONNECTED BREEDING SYSTEM**

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**Abstract**

By applying new technologies to intensive production in dairy cattle with the aim of increasing milk production per head, there are inevitable mistakes in the process of rearing, care and care of the animals themselves. The habitat in which we raise and exploit milking cows is to a large extent an important factor for the general condition of each animal. The influences of nutrition as well as typical diseases of the teats are also one of the triggers for the development of teat disease, as well as genetic predisposition. Closed stables, with a concrete floor and tied system of keeping cows contribute to a large extent to the development of various diseases of the hoofs. In the tied system, the cows are kept tied in one place for a certain period of time (it depends on the technologist), then they are moved to another barn with the same tie. As a rule, the floor in these barns is concrete with a mat. In this way of keeping, hoof injuries are common in animals, so the hygiene of facilities plays a major role in possible secondary infections of injured hoofs. We cannot completely eliminate paw diseases from the intensive production cycle, but we must do everything to prevent the excessive occurrence of diseases that we can influence, such as dermatitis digitalis and dermatitis interdigitalis. By increasing the number of technopathies on the cattle farm, there are significant losses both in production characteristics and in the economic sense. Architecturally well-designed beds, under an appropriate slope, fertilization systems, mats that are changed regularly, conscientious workers who directly take care of the cows in the barn, maintaining the hygiene of the cows themselves at a certain acceptable level, all of these are prerequisites for good and profitable production.

**Keywords:** technopathies, hoof disease, cattle

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**IMPACT OF CONSTRUCTING A TRIPARTITE MECHANICAL FREE ENERGY  
SYSTEM FOR HOME APPLIANCES THAT DOES NOT REQUIRE FUEL  
COMBUSTION**

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**Abstract**

The development of a tripartite mechanical free energy system for household appliances that eliminates the need for fuel combustion has had a major influence on academia. This cutting-edge technology has completely changed how we power our home appliances by offering a sustainable and greener substitute for conventional fuel-based systems. This system is efficient and economical since it uses sophisticated mechanical processes to produce energy without using any kind of fuel. This system's capacity to lower household carbon emissions is one of its key benefits, aiding in the worldwide fight against climate change. It contributes to a cleaner and healthier environment by reducing the amount of dangerous greenhouse gases released into the atmosphere by doing away with the need to burn fuel. Furthermore, this technology ensures a consistent and dependable energy source for household appliances because it is not dependent on finite resources. The tripartite mechanical free energy system has also shown itself to be quite adaptable, as it can be used to power a variety of household appliances, ranging from tiny ones like fans and light bulbs to bigger ones like air conditioners and refrigerators. Because of this, it is the perfect answer for both rich and developing nations, giving everyone access to sustainable energy sources. In conclusion, there is no denying the benefits of building a tripartite mechanical free energy system for household appliances that does not involve burning fuel. Its advantages and creative design have stimulated interest and study across a range of academic disciplines, opening the door to a more sustainable and greener future.

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**FEBRİL NÖTROPENİK HASTALARDA ENFEKSİYON ODAĞI VE  
ETKENLERİN İRDELENMESİ, 10 YILLIK RETROSPEKTİF ÇALIŞMA**

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**Özet**

Giriş: Etkinliği yüksek, daha seçici ve yan etki profili daralan kemoterapötik ajanların artması ile kanser ile mücadelede önemli aşamalar kaydedilmiştir. Ancak febril nötropeni (FEN), halen kemoterapi sonrası gelişen önemli bir mortalite nedenidir. Bizde bu nedenle çalışmamızda 10 yıl boyunca FEN tanısı alan hastaları enfeksiyon odakları ve etken mikroorganizmalar açısından irdelemeyi hedefledik.

Materyal ve Method: Çalışmamıza 354 adet hastaneye yatırılarak takip edilen, FEN tanısı alan hastalar dahil edildi ve iki gruba ayrıldı; Mortalite grubu (n=116), survival grup (n=238). Her iki grup enfeksiyon odakları ve saptanan etkenler açısından karşılaştırıldı ve bunların mortaliteye etkisi Cox regresyon analizi ile değerlendirildi.

Sonuçlar: Çalışmaya dahil edilen hastaların yaş ortalaması 64 (51-71) idi ve 193'ü (%54,5) erkekti. 238 (%67,2) olguda hematolojik malignite, 116 (%32,8) olguda solid tumor mevcuttu. Üretilen etkenlere bakıldığında; en sık tespit edilen patojenin *Escherichia coli* olduğu görüldü, genel olarak bakıldığında ise Enterobacteriaceae (%25,4, n=44), gram pozitif kok (%16,7, n=29), *Pseudomonas aeruginosa* (%6,3, n=11), virüs (%10,9, n=19) ve mantar (%9,2, n=16) olarak saptandı. Enfeksiyon odağı 155 katılımcıda (%43,8) belirlenememişti. Kan dolaşımı enfeksiyonları 64 hastada (%18,1), pnömoni 62 hastada (%17,5), idrar yolu enfeksiyonları 35 hastada (%9,9) ve deri ve yumuşak doku enfeksiyonları 22 hastada (%6,2) tespit edildi. Her iki grup karşılaştırıldığında Mortalite grubunda odak bulunamayan hastalar daha yüksek oranda bulunurken bu durum istatistiksel olarak anlamlı saptandı (p<0.01). Ancak regresyon analizi ile değerlendirildiğinde enfeksiyon odaklarının mortaliteye etkisi saptanmadı.

Tartışma: Çalışmamız ülkemizde FEN tanısı alan hastalarda saptanan enfeksiyon odaklarının ve etkenlerin oranını gözler önüne sermiştir. Ayrıca odak saptanabilen hastaların mortalite oranının düşük olması kaynak kontrolünün ve direkt etkili tedavinin öneminin altını çizmiştir.

**Anahtar Kelimeler: FEN, kanser, mikroorganizma**

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**INVESTIGATION OF INFECTION FOCUS AND FACTORS IN FEBRILE  
NEUTROPENIC PATIENTS, 10-YEAR RETROSPECTIVE STUDY**

**Abstract**

**Introduction:** With the increase in the use of highly effective, more selective and narrower side effect profile chemotherapeutic agents, significant progress has been made in the fight against cancer. However, febrile neutropenia (FEN) is still an important cause of mortality after chemotherapy. Therefore, in our study, we aimed to examine patients diagnosed with FEN for 10 years in terms of infection foci and causative microorganisms.

**Material and Method:** 354 patients diagnosed with FEN who were hospitalized and followed up were included in our study and divided into two groups; Mortality group (n=116), survival group (n=238). Both groups were compared in terms of infection foci and detected factors, and their effects on mortality were evaluated with Cox regression analysis.

**Results:** The mean age of the patients included in the study was 64 (51-71) and 193 (54.5%) were male. There were 238 (67.2%) cases with hematological malignancy and 116 (32.8%) cases with solid tumors. When the agents produced were examined, it was seen that the most frequently detected pathogen was *Escherichia coli*, and in general, Enterobacteriaceae (25.4%, n=44), gram-positive cocci (16.7%, n=29), *Pseudomonas aeruginosa* (6.3%, n=11), virus (10.9%, n=19) and fungi (9.2%, n=16) were detected. The focus of infection could not be determined in 155 participants (43.8%). Bloodstream infections were detected in 64 patients (18.1%), pneumonia in 62 patients (17.5%), urinary tract infections in 35 patients (9.9%) and skin and soft tissue infections in 22 patients (6.2%). When both groups were compared, patients with no focus found were found at a higher rate in the Mortality group, and this was found to be statistically significant (p<0.01). However, when evaluated with regression analysis, no effect of infection foci on mortality was detected.

**Discussion:** Our study has revealed the rate of infection foci and factors detected in patients diagnosed with FEN in our country. In addition, the low mortality rate of patients with detected foci has underlined the importance of source control and direct effective treatment.

**Keywords:** FEN, cancer, microorganisms



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**NANOFORMULATIONS OF APOMORPHINE TO ENHANCE COGNITIVE  
PROFILE**

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**Abstract**

Apomorphine, a dopamine D1/D2 agonist is effective in the treatment of Parkinson's disease; but its long term use is often associated with the dependence and addiction. The development of locomotor sensitization to psychostimulants including apomorphine is considered to be an important contributor to psychostimulant drug abuse. Previous studies have shown that long term administration of drugs of abuse increases the effectiveness of somatodendritic 5-hydroxytryptamine (5-HT)-1A receptors. Repeated administration of buspirone can also attenuate apomorphine induced sensitization. The synthesis of nanoparticles offers a transformative prospect for reshaping the therapeutic outcomes of apomorphine. Through the application of this methodology, it becomes plausible to focus on precise cerebral regions, thereby amplifying the drug's efficacy in addressing neurological disorders. In light of the latest progress in comprehending the underlying mechanisms of memory disorders, there is a growing pursuit within the pharmaceutical sector to identify fresh avenues for therapeutic interventions. A noteworthy constraint in the existing therapeutic strategies is the development of tolerance, underscoring the need for explorations into innovative and promising treatments. The present study was designed to test the hypothesis that nanoformulations of apomorphine can enhance cognitive profile with little/no side effects. Findings may help in extending therapeutics in Dementia, Alzheimer's and related disorders.

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**January 21-28, 2025 / Havana, CUBA**

**IMPLEMENTING LEAN MANAGEMENT IN A MANUFACTURING  
ORGANIZATION: SUCCESS FACTORS AND STRATEGIES FOR OVERCOMING  
CHALLENGES**

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**Abstract**

Lean management has emerged as a transformative approach for manufacturing organizations seeking to optimize processes, minimize waste, and enhance productivity. By adopting lean principles, businesses can improve operational efficiency and gain a competitive edge in the rapidly evolving industrial landscape. Despite the potential benefits, many manufacturing organizations face significant challenges in successfully implementing lean management practices. These challenges include resistance to change, insufficient employee engagement, and gaps in leadership support, which can hinder the realization of lean's full potential. Identifying critical success factors and strategies to address these barriers is essential for ensuring effective lean implementation. This qualitative study used in-depth interviews with senior service desk engineers who possess extensive experience in lean practices within a manufacturing context. Thematic analysis was applied to the interview data to identify recurring patterns and themes related to the success factors and strategies for overcoming challenges in lean implementation. The study identified several key success factors that significantly influence the effectiveness of lean management practices, which include leveraging technology, process optimization, enhancing skills and knowledge, employee engagement, variability in operations, leadership influence and resource. It also highlighted strategies to overcome challenges, including effective communication, employee engagement, phased adoption, and strong leadership support. The findings underscore the complex nature of lean implementation and provide a roadmap for organizations to adopt lean practices successfully. By emphasizing the importance of these factors and offering practical strategies, the research helps organizations overcome common barriers and sustain lean initiatives for long-term success.

**Keywords:** Lean management, Manufacturing efficiency, Success factors, Implementation challenges

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**DYNAMICS OF GENDER DISPARITY IN PERCEIVED LINGUISTIC  
COMPETENCE, ENGAGEMENT PROFILES, AND SCIENCE LEARNING  
OUTCOME AMONG 7<sup>TH</sup> STUDENTS**

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**Abstract**

Gender disparity in education remains a pressing global issue, particularly in STEM fields, where cultural norms and stereotypes often discourage girls from pursuing academic interests in science and mathematics. In Ethiopia, this issue is compounded by socio-economic factors, traditional beliefs, and limited access to resources, which can hinder both boys and girls but may disproportionately affect female students. This study focuses on 7th grade students in Ethiopia, a pivotal educational stage where foundational skills are established. Employing a cross-sectional design and multi-group structural equation modeling (MGSEM), data from 500 students revealed significant gender differences in academic performance and engagement. Findings indicate that girls exhibited higher perceived linguistic competence and emotional engagement compared to boys, with path coefficients showing statistically significant impacts ( $p < .001$ ) on science learning outcome. Girls demonstrated higher emotional and cognitive engagement levels, contributing to their enhanced academic performance compared to boys. Specifically, perceived lexical linguistic competence (PLLC) significantly predicted engagement profiles for both genders, though with a stronger effect for males ( $\beta = 0.276$ ,  $p < .001$ ) compared to females ( $\beta = 0.124$ ,  $p = .001$ ). Additionally, perceived semantic linguistic competence (PSLC) significantly influenced science learning outcomes for females ( $\beta = 0.124$ ,  $p = .013$ ) but not for males. These findings underscore the need for targeted educational interventions aimed at fostering engagement and linguistic competence to promote equity in STEM education for all students.

**Keywords:** Dynamics, Engagement profiles, Gender disparity, Perceived linguistic competence, Science learning outcomes

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**January 21-28, 2025 / Havana, CUBA**

**STUDIES ON INTEGRATED PLANT DISEASE MANAGEMENT ON *Sarocladium  
oryzae* CAUSES SHEATH ROT OF RICE (*Oryza sativa* L.)**

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**Abstract**

Sheath rot, caused by the fungal pathogen *Sarocladium oryzae*, has emerged as a significant disease affecting rice (*Oryza sativa* L.) production worldwide, particularly in regions with high humidity and intensive rice cultivation. The disease leads to considerable yield losses by affecting grain quality and quantity. This study investigates integrated disease management (IDM) strategies to control sheath rot through a combination of cultural practices, resistant varieties, biocontrol agents, and chemical treatments. Field experiments were conducted across multiple growing seasons to evaluate the efficacy of these integrated approaches. Results revealed that the combination of resistant cultivars, proper water management, timely fungicidal application, and the use of biocontrol agents such as *Trichoderma harzianum* significantly reduced disease incidence and severity. Moreover, cultural practices like proper spacing, adequate fertilization, and removal of infected plant debris further enhanced disease control efficiency. The integrated management approach not only mitigated the sheath rot incidence but also contributed to improved grain yield and quality. This study highlights the importance of adopting a holistic and sustainable approach to manage *S. oryzae*-induced sheath rot in rice cultivation systems. Further research is recommended to optimize IDM components for different agro-climatic conditions to ensure long-term disease suppression and sustainable rice production.

**Keywords:** Sheath rot, *Sarocladium oryzae*, Rice, IDM

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## YAŞLI BİREYLERDE TAI CHI EGZERSİZLERİNİN ETKİLERİ

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### Özet

Küresel yaşlı nüfusu hızla artmaktadır. 2019 yılında 60 yaş ve üzeri nüfus bir milyarı geçmişti ve 2050 yılına kadar iki milyara ulaşması beklenmektedir. Sağlıklı yaşlanmaya, genellikle “nihai koruyucu tıp” olarak atıfta bulunulmakta ve bu konuya giderek daha fazla vurgu yapılmaktadır. Fiziksel olarak, yaşlı yetişkinler sıklıkla kas atrofisi ve artrit gibi sorunlarla karşılaşırken, psikolojik olarak depresyon ve anksiyete sorunları ile sıklıkla karşılaşmaktadır. Mevcut sosyal bağlamda, birçok yaşlı birey yalnız yaşamaktadır veya huzur evlerinde yaşamaktadır ve bu durum yalnızlık duygularını artırmaktadır. Tıbbi teknolojideki ilerlemelerle birlikte hayat beklentisinin artması ile, yaşlıların yaşam kalitesi sosyal bir endişe haline gelmiştir. Bu sağlık sorunları yalnızca günlük yaşam kalitelerini etkilemekle kalmaz, aynı zamanda daha ciddi sosyal ve ekonomik yükler de yaratabilir. Bu nedenle, yaşlı yetişkinler için sağlık yönetimini etkili bir şekilde sağlamak özellikle önemlidir. Tai Chi, nazik ve akıcı hareketleri ile meditasyon özellikleri taşıyan bir aktivite olarak, zihinsel sağlığı iyileştirmeye yönelik umut verici bir tamamlayıcı ve alternatif yaklaşım olarak öne çıkmaktadır. Bu eski Çin dövüş sanatı, yavaş ve akıcı hareketleri ile derin, ritmik nefes alışıyla karakterize edilir ve bu da onu yaşlılar için uygun, düşük etkili bir egzersiz haline getirir. Tai Chi pratiği, derin nefes alarak yapılan, odaklanmış bir şekilde yavaşça gerçekleştirilen hareketlerden oluşur ve bu da fiziksel dengeyi ve zihinsel konsantrasyonu artırır. Tai Chi'nin meditasyon yönü, farkındalığı ve duygusal huzuru teşvik eder, bu da stresi yönetmek ve depresyon belirtilerini azaltmak için önemlidir. Tai Chi'nin yaşlılar için sağlık üzerindeki terapötik etkileri, denge, kemik sağlığı, uyku kalitesi, bağışıklık sistemi, bilişsel fonksiyon, metabolik göstergeler ve kardiyorespiratuar fitnessteki iyileşmelerin yanı sıra, ağrı, depresyon belirtileri, stres ve anksiyetenin hafifletilmesini de içerir. Bu çalışmada Tai Chi egzersizlerinin yaşlı bireylerde çeşitli olumlu etkilerini araştıran araştırmalar derlenmiştir ve literatür doğrultusunda Tai Chi'nin; yaşlı yetişkinler için güvenli bir egzersiz biçimi olduğu, depresyonu olan yaşlılarda depresyon belirtilerini ve yaşam kalitesini önemli ölçüde iyileştirebileceği, uyku kalitesini iyileştirebileceği ve denge, fiziksel uygunluk ve yaşam kalitesini iyileştirerek sağlıklı yaşlanmayı destekleyebileceği sonucuna varılmıştır. Bu bulgular ışığında Tai Chi'nin yaşlılarda fiziksel ve psikolojik iyi oluşu sağlayarak yaşam kalitesinin artırılması adına yeni bir bakış açısı kazandıracığını düşünmekteyiz.

**Anahtar Kelimeler:** Yaşlı bireyler, Tai Chi, yaşam kalitesi, depresyon, iyi oluş

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## THE EFFECTS OF TAI CHI EXERCISES ON ELDERLY INDIVIDUALS

### **Abstract**

The global aging population is rapidly increasing. In 2019, the population aged 60 and over surpassed one billion, and it is expected to reach two billion by 2050. Healthy aging is often referred to as the "ultimate preventive medicine," and this topic is receiving increasing emphasis. Physically, elderly adults often face issues such as muscle atrophy and arthritis, while psychologically, they frequently experience depression and anxiety problems. In the current social context, many elderly individuals live alone or reside in nursing homes, which intensifies feelings of loneliness. With advances in medical technology and the increase in life expectancy, the quality of life of the elderly has become a social concern. These health issues not only affect their daily quality of life but also create more serious social and economic burdens. Therefore, effectively managing healthcare for elderly adults is especially important. Tai Chi, with its gentle and flowing movements combined with meditation features, stands out as a promising complementary and alternative approach to improving mental health. This ancient Chinese martial art is characterized by slow and fluid movements coupled with deep, rhythmic breathing, making it a suitable low-impact exercise for elderly adults. Tai Chi practice consists of slow, focused movements performed with deep breathing, which enhances physical balance and mental concentration. The meditation aspect of Tai Chi promotes mindfulness and emotional calm, which are crucial for managing stress and reducing symptoms of depression. The therapeutic effects of Tai Chi on the elderly include improvements in balance, bone health, sleep quality, immune system function, cognitive function, metabolic indicators, and cardiopulmonary fitness, as well as the alleviation of pain, depression symptoms, stress, and anxiety. This study compiles research investigating the various positive effects of Tai Chi exercises on elderly individuals, and based on the literature, it concludes that Tai Chi is a safe form of exercise for elderly adults, can significantly improve depression symptoms and quality of life in elderly individuals with depression, improve sleep quality, and support healthy aging by enhancing balance, physical fitness, and overall quality of life. In light of these findings, we believe that Tai Chi can offer a new perspective in improving quality of life by promoting physical and psychological well-being in the elderly.

**Keywords:** Elderly Individuals, Tai Chi, quality of life, depression, well-being

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THE EIGENVALUES AND EIGENVECTORS OF NEUTROSOPHIC MATRICES

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**Abstract.** The concept of graph energy has been well-established in mathematical research and is defined as the sum of the absolute values of all eigenvalues of a graph's adjacency matrix. Various types of graph energies have been introduced over time. Recently, a real neutrosophic number was defined, which takes the form  $a + bI$ , where  $a$  and  $b$  are real numbers,  $I \in [0, 1]$  represents indeterminacy, and  $I^n = I$  for any integer  $n$ . In this representation,  $a$  is considered a certain value, while  $b$  indicates the amount of uncertainty.

In this study, the weights of graphs are considered as neutrosophic numbers. The adjacency matrix is then constructed, and its eigenvalues are determined, which exhibit unique properties. For example, for a matrix of order  $2 \times 2$ , four eigenvalues are obtained. The absolute values of these eigenvalues are calculated, and the energy of such graphs is determined.

**Keywords:** Graph energy; Adjacency matrix; Eigenvalues; Neutrosophic numbers; Energy of neutrosophic graph

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**REVAMPING HOSPITALITY: FAST FASHION'S SHIFT TOWARDS  
SUSTAINABLE SOURCING**

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**Abstract**

This abstract examines how the fast fashion and hospitality industries are interacting, with a particular emphasis on the paradigm shift toward sustainable sourcing approaches. The hotel industry is under increasing pressure to conform to environmental stewardship values as corporations and customers place a higher priority on it. This essay looks at the factors that led to this change, such as the need for ethical products from consumers and the industry's reaction to sustainability requirements. It also explores the difficulties and possibilities of using sustainable sourcing for fast fashion in the hospitality industry. This summary attempts to give a thorough overview of how these industries are changing their supply chains to satisfy the expectations of a more environmentally conscious world by examining current trends and case studies.

**Key words:** Sustainable sourcing, hospitality industry, fast fashion



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**DEVELOPMENT OF POLYETHYLENE-LIKE MATERIALS WITH BORON  
ADDITIVES IN F8BT POLYMERS: INVESTIGATION OF ELECTRONIC AND  
OPTICAL ENHANCEMENTS FOR PHOTOVOLTAIC APPLICATIONS**

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**Özet**

Fosil yakıtların nedeniyle ortaya çıkan çevre sorunları ve kaynakların yaygın olmaması sebebiyle alternatif enerji kaynaklarına olan ihtiyacı artırmıştır. Organik elektronik ve fotovoltaiik sistemler, sürdürülebilir ve verimli enerji çözümleri sunma potansiyeline sahiptir. Bu çalışma, bor katkılı F8BT polimerlerin fotovoltaiik uygulamalar için geliştirilmesi sürecinde önemli bir adım niteliğindedir. F8BT polimerine Bor katkıladığımızda elektronik ve optik özelliklerine olan etkilerini anlamak ve bu malzemelerin enerji dönüşüm verimliliğini artırma ve maliyet etkinliğini iyileştirme gibi olanaklar sağlayacağını görmek mümkündür.

DFT (Yoğunluk Fonksiyonel Teorisi) ve TD-DFT (Zaman Bağımlı Yoğunluk Fonksiyonel Teorisi) hesaplamaları kullanılarak, bu katkının polimer üzerindeki etkileri değerlendirilebilir. F8BT polimerine Bor atomu katkısının, polimerin HOMO-LUMO enerji seviyelerinde önemli değişikliklere yol açtığı belirtiliyor. Bor katkısının, geniş bant aralığı sağlayarak yapının görünür ışık bölgesinde enerji absorpsiyonu sağlaması, bu polimerin fotovoltaiik cihazlar, özellikle güneş pilleri için potansiyelini artıran bir özellik olarak öne çıkmaktadır.

F8BT polimerine 2 Bor atomu eklenmesi, polimerin geniş bant aralığına sahip olmasını ve yüksek dipol momenti ile etkin foton absorpsiyonu ve yük taşıma kapasitesini desteklemesini sağlamaktadır. Bu özellikler, güneş pillerinde verimliliği artırmaya yardımcı olabilir. Ayrıca, 3 Bor atomu eklenmesi durumunda, yapı daha yüksek reaktivite ve düşük kimyasal sertlik gibi özellikler kazanmakta, bu da polimerin farklı uygulamalarda daha esnek ve verimli bir şekilde kullanılabilmesini mümkün kılabilir.

Sonuç olarak, Bor katkısı yapılan F8BT polimeri, güneş pilleri ve diğer fotovoltaiik cihazlarda kullanım açısından çeşitli avantajlar sunmaktadır. Farklı Bor katkı seviyeleri, polimerin farklı özellikler kazanmasını sağlayarak, her bir yapının belirli uygulamalarda benzersiz avantajlar sunduğunu göstermektedir.

**Anahtar Kelimeler:** Fotovoltaiik, Yoğunluk Fonksiyonel Teoremi (DFT), Zamana Bağlı Yoğunluk Fonksiyonel Teoremi (TD-DFT), F8BT Polimeri, Bor Katkısı

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**DEVELOPMENT OF POLYETHYLENE-LIKE MATERIALS WITH BORON  
ADDITIVES IN F8BT POLYMERS: INVESTIGATION OF ELECTRONIC AND  
OPTICAL ENHANCEMENTS FOR PHOTOVOLTAIC APPLICATIONS**

**Abstract**

The environmental issues caused by fossil fuels and the limited availability of resources have increased the need for alternative energy sources. Organic electronics and photovoltaic systems have the potential to offer sustainable and efficient energy solutions. This study represents an important step in the development of boron-doped F8BT polymers for photovoltaic applications. By adding boron to the F8BT polymer, understanding its effects on the electronic and optical properties will provide opportunities to enhance energy conversion efficiency and improve the cost-effectiveness of these materials.

The effects of this addition to the polymer can be observed using DFT (Density Functional Theory) and TD-DFT (Time-Dependent Density Functional Theory) calculations.

After adding boron atoms to the F8BT polymer, significant changes were observed in its HOMO-LUMO energy levels. The boron addition resulted in a wider bandgap and showed that the structure could absorb energy in the visible light region. The modifications made to the F8BT polymer were found to notably affect its potential use in photovoltaic devices, such as solar cells. When two boron atoms were added to the F8BT polymer, its structure, wide bandgap, and high dipole moment exhibited qualities that could support effective photon absorption and charge transport. On the other hand, adding three boron atoms to the polymer resulted in characteristics such as higher reactivity and lower chemical hardness. However, each structure has the potential to offer different advantages in solar cell applications

**Keywords:** Photovoltaic, Density Functional Theory (DFT), Time-Dependent DFT (TD-DFT), F8BT Polymers, The Addition of a Boron Atom

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**THE RELATIONSHIP BETWEEN PRENATAL STRESS AND TRAUMATIC  
CHILDBIRTH PERCEPTION WITH PRENATAL ATTACHMENT IN PREGNANT  
WOMEN**

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**Özet**

Gebelikte yaşanan stres ve travmatik doğum algısı prenatal bağlanmayı olumsuz olarak etkilemektedir. Bu çalışma, gebelerde prenatal stres ve travmatik doğum algısının prenatal bağlanma ile ilişkisini incelemek amacıyla yapılmıştır. Çalışma, tanımlayıcı ve ilişki arayıcı desenedir. Çalışmaya, bir üniversite hastanesinin kadın doğum kliniğindeki 18-40 yaş aralığındaki 383 gebe dahil edilmiştir. Veriler; “Tanıtıcı Bilgi Formu”, “Prenatal Bağlanma Envanteri (PBE)”, “Travmatik Doğum Algısı Ölçeği (TDAÖ)” ve “Doğum Öncesi Algılanan Stres Ölçeği (DÖASÖ)” ile toplanmıştır. Verilerin analizinde; t testi, Varyans analizi (ANOVA), Mann Whitney U testi, Kruskall Wallis varyans analizi, Bonferroni testi, Spearman korelasyon analizi ve çoklu regresyon analizi (backward yöntemi) kullanılmıştır. Gebelerin; PBE puan ortalaması 64,02±12,25; TDAÖ puan ortalaması 58,33±33,10 ve DÖASÖ puan ortalaması 2±0,59 puandır. PBE toplam puanı ile TDAÖ toplam puanı ve DÖASÖ toplam puanının negatif yönlü ve orta derecede ilişkili olduğu görüldü (p<0,05). Çoklu regresyon analizinde TDAÖ toplam puanı, DÖASÖ toplam puanı, parite ve eş ile ilişki durumunun PBE puanına ait değişimin %40’ını açıklamıştır. Sonuç olarak; gebelerde prenatal stres ve travmatik doğum algısı düzeyleri arttıkça prenatal bağlanma düzeyleri azalmaktadır. Bu bağlamda, gebelik izlemlerinde sağlık profesyonellerinin gebeye sağlık bakımı, sağlık eğitimi ve danışmanlık hizmetlerini sunmaları önemlidir.

**Anahtar Kelimeler:** Bağlanma; Prenatal; Stres.

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**THE RELATIONSHIP BETWEEN PRENATAL STRESS AND TRAUMATIC  
CHILDBIRTH PERCEPTION WITH PRENATAL ATTACHMENT IN PREGNANT  
WOMEN**

**Abstract**

The stress and the perception of traumatic childbirth experienced during pregnancy negatively affect prenatal attachment. This study was conducted to examine the relationship between prenatal stress and traumatic childbirth perception in pregnant women with prenatal attachment. The study was descriptive and correlational design. The study included 383 pregnant women aged between 18-40 years in the gynecology and obstetrics clinic of a university hospital. Data were collected with the “Introductory Information Form”, “Prenatal Attachment Inventory (PAI)”, “Scale of Traumatic Childbirth Perception (STCP)” and “Antenatal Perceived Stress Inventory (APSI)”. In the analysis of the data; t test, analysis of variance (ANOVA), Mann Whitney U test, Kruskal Wallis analysis of variance, Bonferroni test, Spearman correlation analysis and multiple regression analysis (backward method) were used. The mean PAI score of the pregnant women was  $64.02 \pm 12.25$ ; The STCP mean score is  $58.33 \pm 33.10$  and the APSI mean score is  $2 \pm 0.59$ . It was observed that the total score of PAI and the total score of STCP and the total score of APSI were negatively and moderately correlated ( $p < 0.05$ ). In the multiple regression analysis, the total score of STCP, the total score of APSI, parity and the relationship status with the spouse explained 40% of the change in the PAI score. As a result; as the levels of prenatal stress and traumatic childbirth perception increase in pregnant women, the levels of prenatal attachment decrease. In this context, it is important for health professionals to provide care, education and counseling services to the pregnant woman during pregnancy follow-ups.

**Keywords:** Attachment; Prenatal; Stress.

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**RUH SAĞLIĞI ALANINDA METAFOR ANALİZİ**

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**Özet**

Metaforlar, tam olarak açıklanamayan bir benzerliği, yakınlığı ve ilişkiyi ifade etmek için kullanılan gelişmiş dilsel yapılarıdır. Sadece retorik veya dil alanında kullanılan metaforlar, 1980'lerden sonra bilimsel bir araştırma yöntemi olarak gündeme gelmiş ve kullanılmaya başlanmıştır. Literatürde nitel bir araştırma yöntemi olarak kullanılan metafor analizinin, bireysel veya odak grup görüşmesi, gözlem veya doküman yolu ile gerçekleştirilen nitel araştırmalara göre daha kullanışlı ve kolay olduğu belirtilmektedir. Bununla birlikte metafor analizinin bireylerin ifade etmekte zorlandıkları ve belki de farkında olmadıkları düşünce ve inançları ortaya çıkarmada etkili bir yöntem olabileceği belirtilmektedir. Metafor analizi, ruh sağlığı alanında daha çok psikoterapide kullanılmaktadır. Psikoterapi sürecinde terapistler danışanlarının sorunlarına yine danışanlarının kendi ifadeleriyle ulaşmaya çalışırlar ve onlardan metaforlar oluşturmalarını isterler. Son zamanlarda ruh sağlığı alanında yapılan araştırmalar da metafor analizinin nitel bir araştırma yöntemi olarak sıkça kullanıldığı görülmektedir. Nitel araştırmalarda metafor analizinin kullanılması, bazı bilim insanları arasında tartışma konusudur. Ancak literatürde metafor analizinin, ruh sağlığı alanında yapılacak araştırmalar için nitel bir yöntem olarak kullanılması önerilmektedir. Sonuç olarak her ne kadar nitel araştırmalarda metafor analizinin kullanılması tartışmalı bir konu olsa da örtük bilgi ve anlamları ortaya çıkarması, biliş ve kültür arasındaki etkileşimin incelenmesine olanak tanınması, nicel ve nitel yaklaşımlar arasındaki boşluğu doldurması gibi özellikleri düşünüldüğünde de metafor analizi, ruh sağlığı alanı için değerli bir araç gibi görünmektedir.

**Anahtar Kelimeler:** Metafor, metafor analizi, ruh sağlığı, nitel çalışma

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**METAPHOR ANALYSIS IN MENTAL HEALTH**

**Abstract**

Metaphors are advanced linguistic structures used to express a similarity, proximity and relationship that cannot be fully explained. Metaphors, which were used only in the rhetoric or language, came to the fore and began to be used as a scientific research method after the 1980s. It is stated that metaphor analysis, which is used as a qualitative research method in the literature, is more useful and easier than qualitative research conducted through individual or focus group interviews, observations or documents. In addition, it is stated that metaphor analysis can be an effective method in revealing thoughts and beliefs that individuals have difficulty expressing and may not be aware of. Metaphor analysis is mostly used in psychotherapy in mental health. During the psychotherapy process, therapists try to reach their clients' problems through their own expressions and ask them to create metaphors. In recent studies in mental health, metaphor analysis has been frequently used as a qualitative research method. The use of metaphor analysis in qualitative research is a matter of debate among some scientists. However, in the literature, metaphor analysis is recommended as a qualitative method for research in mental health. In conclusion, although the use of metaphor analysis in qualitative research is a controversial issue, metaphor analysis seems to be a valuable tool for mental health, considering its features such as revealing implicit knowledge and meanings, allowing the examination of the interaction between cognition and culture, and filling the gap between quantitative and qualitative approaches.

**Keywords:** Metaphor, metaphor analysis, mental health, qualitative study

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**January 21-28, 2025 / Havana, CUBA**

**TÜRKİYE YÜZYILI MAARİF MODELİ ÖĞRETİM PROGRAMLARI  
ORTAK METNİNİN OKURYAZARLIK BECERİLERİ AÇISINDAN İNCELENMESİ**

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(Sorumlu yazar)

**Özet**

Bu çalışmanın amacı, Türkiye Yüzyılı Maarif Modeli (TYMM) Öğretim Programları Ortak Metni'ni okuryazarlık becerileri açısından incelemektir. Tüm dünyada öğretim programlarının ana amaçlarından birisi yaşam boyu öğrenen bireyler yetiştirmektir. Ülkemizde lisans öncesi son program olan TYMM programlarında bu amaç bir üst ifade ile beraber “yetkin ve erdemli insan” yetiştirmek (TYMM, 2024) şeklinde belirtilmektedir. Okuryazarlık, hayat boyu öğrenen yetkin ve erdemli insan olmanın temelini oluşturmaktadır. Bu nedenle okuryazarlık tüm öğretim kademelerinde öğretim programlarının ayrılmaz bir parçasıdır. Günümüze kadar tanımı ve işlevi değişip gelişerek; çeşitleri artarak süregelen okuryazarlık becerilerinin eğitim programlarında ne düzeyde var olduğunun tespiti önemlidir. Bu çalışmada, nitel araştırma modeli doküman inceleme deseni ile TYMM öğretim programları ortak metninde okuryazarlık becerilerinin türleri ve ele alınış biçimleri incelenmektedir. Çalışmanın analiz ve değerlendirme süreci devam etmektedir. Sonuçlar kongrede sunulacaktır.

**Anahtar Kelimeler:** Türkiye Yüzyılı Maarif Modeli, öğretim programları, okuryazarlık.

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ORTAK METNİNİN OKURYAZARLIK BECERİLERİ AÇISINDAN İNCELENMESİ**

**Abstract**

The aim of this study is to examine the Turkish Century Education Model (TYMM) Curriculum Common Text in terms of literacy skills. One of the main objectives of curricula all over the world is to raise individuals who are lifelong learners. In Turkey, this aim is stated with a higher expression as raising "competent and virtuous human beings" (TYMM, 2024) in the TYMM programmes, which is the last programme before undergraduate education in our country. Literacy forms the basis of being a competent and virtuous person who is a lifelong learner. For this reason, literacy is an integral part of curricula at all levels of education. It is important to determine to what extent the literacy skills, whose definition and function have changed and developed until today and whose types have been increasing, are present in education programmes. In this study, the types of literacy skills and the way they are addressed in the common text of the TYMM curricula are examined with the qualitative research model document analysis design. The analysis and evaluation process of the study is ongoing. The results will be presented at the congress.

**Keywords:** Turkish Century Education Model, curricula, literacy.



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**SUÇ, GÖÇ VE ANOMİ İLİŞKİSİ**

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**Özet**

Suç tarihi insanlık tarihi kadar eski bir tarihe dayanan toplumsal bir olgudur. Suç geçmişte ve günümüzde önemli toplumsal sorunlar arasında yer almaktadır. Toplumda karmaşa ve toplumsal düzenin bozulmasına sebep olan suç, sosyoloji, hukuk, kriminoloji, biyoloji ve psikoloji gibi farklı disiplinlerin ilgilendiği konular arasında yer alır. Suç davranışına sosyolojik bir perspektiften bakıldığında suçlu davranışın oluşmasında etkili olan pek çok sosyal yapı faktörünün bulunduğu görülmektedir. Sosyolojik yapı teorileri bu faktörleri kurumsal yapılar, ırk, cinsiyet, yoksulluk, kentleşme, işsizlik ve göç gibi olgularla açıklamaya çalışmaktadır. Bu olgular arsında yer alan göç olgusu suçun oluşmasında önemli bir etken olarak görülmektedir. Göç, genel bir ifadeyle sosyal, ekonomik, siyasi gibi nedenlerden dolayı bir yerleşim yerinden başka bir yerleşim yerine taşınma olarak tanımlanabilir. Göç, aynı zamanda hem ülke içinde hem de uluslararası yaşanan bir hareketliliklerdir. Göç hareketi toplumsal yapıda çeşitli değişimlere sebep olmaktadır. Bu değişimler göç ile birlikte göçmenler ve göç edilen toplum arasında birtakım uyum sorunlarının oluşmasının sebep olmaktadır. Oluşan uyum sorunları da anomi durumunun ortaya çıkarmasına yol açar. Uyumsuzluk, kuralsızlık anlamlarına gelen anomi, suç davranışının oluşmasında önemli bir etkidir. 2011 yılında başlayan Suriye iç savaşıyla birlikte uluslararası bir göç hareketliliği oluşmuştur. Bu göç hareketinden coğrafi ve jeopolitik konumu sebebiyle Türkiye de etkilenmiştir. Suriye'den ülkemize doğru gerçekleşen göçler, suç ve göçe ilişkin tartışmaları da beraberinde gündeme getirmiştir. Bu çalışmada suç, göç ve anomi ilişkisi, 2011 yılından sonra gerçekleşen göç hareketliliği bağlamında incelenecektir. Çalışmamızda çeşitli literatür araştırmalarından ve istatistiksel verilerden faydalanılmıştır. 20.08.2024 göç idaresi başkanlığının basın açıklamasına göre Türkiye'de 3.099.524 geçici koruma altında bulunan Suriyeliler, 221.353'ü uluslararası koruma kapsamında bulunan yabancılar ve 1.104.353'ü ikamet izniyle kalan yabancılar olmak üzere toplam yasal kalış hakkı bulunan 4.425.230 yabancı bulunmaktadır (İç İşleri Bakanlığı, 2024).

**Anahtar Kelimeler:** Suç, Göç, Anomi, Sosyal Teori

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## RELATIONSHIP BETWEEN CRIME, MIGRATION AND ANOMIE

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### **Abstract**

Crime is a social phenomenon whose history is as old as human history. Crime is one of the most important social problems of the past and present. Crime, which causes chaos in society and disruption of social order, is among the subjects that different disciplines such as sociology, law, criminology, biology and psychology are interested in. When criminal behavior is viewed from a sociological perspective, it is seen that there are many social structure factors that are effective in the formation of criminal behavior. Sociological structure theories try to explain these factors with phenomena such as institutional structures, race, gender, poverty, urbanization, unemployment and migration. Among these phenomena, migration is seen as an important factor in the occurrence of crime. In general terms, migration can be defined as moving from one settlement to another due to social, economic and political reasons. Migration is also a mobility both within the country and internationally. Migration movement causes various changes in the social structure. These changes cause some adaptation problems between migrants and the society to which they migrate. The resulting adaptation problems lead to the emergence of anomie. Anomie, which means incompatibility and irregularity, is an important factor in the formation of criminal behavior. Starting in 2011, the Syrian civil war led to an international migration movement. Turkey has also been affected by this migration movement due to its geographical and geopolitical location. Migration from Syria to Turkey has also brought discussions on crime and migration to the agenda. In this study, the relationship between crime, migration and anomie will be examined in the context of migration mobility after 2011. In our study, various literature researches and statistical data were utilized. According to the 20.08.2024 press release of the Directorate of Migration Management, there are 4,425,230 foreigners with the legal right to stay in Turkey, including 3,099,524 Syrians under temporary protection, 221,353 foreigners under international protection and 1,104,353 foreigners with residence permits (Ministry of Interior, 2024).

**Keywords:** Crime, Migration, Anomie, Social Theory

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**IMPACT ASSESSMENT OF ACID MINE DRAINAGE ON GROUND WATER  
QUALITY OF SINGRAULI COAL FILED AREA, M.P. INDIA**

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**Abstract**

This abstract delves into the crucial task of assessing the impact of acid mine drainage (AMD) on groundwater quality in Singrauli coal filed, India, and subsequently evaluating water quality using the Water Quality Index (WQI) alongside employing statistical analyses. Singrauli, a region characterized by extensive mining activities, has raised concerns about potential groundwater contamination due to the presence of AMD (pH 2.9-3.2), prompting a comprehensive evaluation of its effects. Groundwater samples collected from various sites are analyzed for key parameters, including pH, electrical conductivity, total dissolved solid (TDS), heavy metal concentrations, and anion levels. These analyses contribute to understanding the spatial distribution of AMD-induced impacts on groundwater quality. The calculated WQI offers a quantitative assessment of overall groundwater quality, synthesizing data on various physicochemical parameters. Elevated levels of heavy metals, lowered pH values, and increased electrical conductivity characterize AMD-affected areas. In conclusion, this study offers a comprehensive framework for assessing the impact of AMD on groundwater quality in Singrauli. The combination of hydrogeochemical analyses, WQI assessment, and statistical analyses provides a comprehensive understanding of the extent of contamination and the factors contributing to it.

**Keywords:** Hydrogeochemical analyses, Water Quality Index (WQI), Acid Mine Drainage, Water pollution

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**EVALUATING THE EFFECTIVENESS OF PUBLIC-PRIVATE PARTNERSHIPS IN  
URBAN TRANSPORTATION SYSTEMS: A BUSINESS MODEL PERSPECTIVE**

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**Abstract**

Public-Private Partnerships (PPPs) have emerged as a significant mechanism for addressing the growing challenges in urban transportation systems. These partnerships combine public oversight with private sector innovation to deliver efficient, sustainable, and cost-effective solutions. This paper evaluates the effectiveness of PPPs from a business model perspective, focusing on their role in improving service delivery, financial sustainability, and user satisfaction. The study draws on case studies from various urban contexts, examining factors such as risk allocation, revenue models, and stakeholder collaboration. Findings highlight the critical role of well-structured agreements and innovative financing strategies in ensuring project success. However, the research also identifies common challenges, including regulatory barriers, misaligned incentives, and issues with transparency and accountability. The paper concludes by proposing strategies for enhancing the efficacy of PPPs, emphasising the need for adaptive business models that align with public interests and emerging technological trends. These insights aim to guide policymakers and practitioners in creating robust frameworks for urban transportation development.

**Keywords:** Public-Private Partnerships, urban transportation, business models, risk allocation, sustainability.

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**INTEGRATED MENTAL HEALTH AND PSYCHOSOCIAL SUPPORT (MHPSS)  
FRAMEWORK BY MIS/IT SPECIALIST A DIGITAL STRATEGY**

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## **Abstract**

This research paper puts together a complete framework for MHPSS services integration into major sectors through the use of digital tools for improvement in refugee well-being and community resilience in Pakistan. The international best practices provide multi-sectoral integration, capacity building, community-based interventions, and stakeholder coordination. The strategy will emphasize the role of an MIS/IT Specialist in developing and implementing the Management Information System (MIS). The main components are a centralized digital platform linking health, education, and livelihoods with MHPSS services, e-learning modules for capacity building, real-time data collection and analysis, and a knowledge hub for evidence-based practices. This monitoring and evaluation framework proposed will ensure effectiveness and scalability in MHPSS interventions. Through data-driven decision-making and collaboration with stakeholders, this framework seeks to deliver sustainable psychosocial support to Afghan refugees and host communities. Current research has revealed that incorporating MHPSS in health, education, protection, and livelihood sectors enhances overall community resilience and mental well-being. Multi-sectoral approaches are considered of paramount importance in humanitarian settings and lead to sustainable outcomes. Provide an integrated online platform within MIS that helps connect health, education, and livelihood services to MHPSS. Introduce MHPSS service directories along with referral systems within the mechanism. Capacity development for frontline professionals, including teachers and health providers, is extremely important for delivery of effective MHPSS service. Increasing emphasis is also given to trainings in PFA and trauma-informed care. Stronger community-driven approaches, peer support networks, and culturally appropriate interventions have been shown to be effective in enhancing psychosocial resilience. Appropriate coordination between UN agencies, NGOs, and governments also pave ways for the successful integration of MHPSS. Digital platforms are now widely used in facilitating collaboration. Data-based decision-making in MHPSS is on the increase with more emphasis put on both outcomes measures-quantitative (service utilization rates)-and qualitative insight-beneficiary well-being. Evidence-based practices are encouraged at international levels through bodies like WHO and UNHCR. Success stories and lessons learned enhance cross-organizational learning. Improving access to guidelines, toolkits, and research in humanitarian environments depends on information-sharing platforms. Integrating MHPSS services within key sectors through MIS System, while maximizing the strength of knowledge management and using data-informed decision-making can enhance the support programmed of Afghan refugees and host communities in Pakistan. The MIS/IT Specialist working on the SIRA World Bank Project can facilitate digital access to MHPSS interventions coordinated, evidence-driven, and scalable.

**Keywords:** integration, interventions, emphasize, resilience, psychosocial, humanitarian.

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## SAARC: AN EVALUATION OF ITS SUCCESSES, FAILURES, AND THE CALL FOR ENHANCED COOPERATION

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### **Abstract**

This paper reveals that the South Asian Association for Regional Cooperation (SAARC), established in 1985 to promote regional integration, economic growth, and social progress among its eight member states, has achieved limited success in meeting its ambitious objectives. Despite initiating notable agreements such as the South Asian Free Trade Area (SAFTA) and fostering dialogue on poverty alleviation, disaster management, and cultural exchange, SAARC's potential remains largely unfulfilled. Political tensions, particularly between India and Pakistan, have consistently hindered the organization's ability to function effectively. Limited intra-regional trade, lack of enforcement mechanisms, and overlapping memberships in other regional groupings have further weakened its relevance.

This study evaluates both the successes and failures of SAARC over the past four decades, highlighting its inability to transcend political rivalries and institutional inefficiencies. Drawing on comparative insights from other regional organizations like ASEAN, the paper emphasizes the urgent need for reforms, including depoliticizing its agenda, strengthening institutional frameworks, and fostering inclusive decision-making processes. Additionally, it identifies emerging areas such as climate change, public health, and digital connectivity as critical domains for enhanced cooperation.

The paper concludes that a reinvigorated SAARC, supported by robust political will and trust-building initiatives, could effectively address shared regional challenges. By reimagining its priorities and fostering collaboration among member states, SAARC has the potential to transform into a dynamic platform for regional progress and integration in South Asia.

**Key Words:** SAARC, Regional Integration, Political Tensions, Institutional Reform, South Asia

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**PERSONAL FINANCIAL LITERACY AMONG POST GRADUATES INDIANS**

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**Abstract**

The study examined the variability in postgraduate medical residents' understanding and management of personal finances. This research aimed to evaluate the level of financial literacy among Indian residents. A cross-sectional survey was conducted using a web-based Google Forms questionnaire with multiple-choice questions focusing on three domains: financial awareness, current financial status, and future financial plans. The survey was distributed to 400 Indian residents. Of the 400 residents, 215 (53.75%) participated in the study, comprising 80.9% men, 74.4% unmarried individuals, and 83.3% pursuing broad specialties. The findings revealed a significant lack of awareness regarding key financial topics such as stocks, specialized student/doctor loans, tax planning, life insurance, professional indemnity, and financial/tax planning. A substantial proportion of respondents expressed the view that personal finance and investment education should be incorporated into medical school or residency programs. Based on these findings, the study proposes a financial pyramid aligned with the hierarchy of needs. The study highlights a pervasive lack of financial literacy and planning among Indian medical residents. These results underscore a critical gap in the medical curriculum, emphasizing the need for formal, structured financial education during medical training.



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## VOLATILE PLANT-DERIVED COMPOUNDS AS SUSTAINABLE SOLUTIONS AGAINST *PENICILLIUM EXPANSUM*: *IN VITRO* STUDIES ANALYSIS

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### **Abstract**

*Penicillium expansum* is a significant postharvest pathogen responsible for blue mold in fruits, particularly apples, leading to economic losses and mycotoxin contamination. As synthetic fungicides face increasing restrictions due to health and environmental concerns, plant-derived volatile organic compounds (VOCs) have emerged as a promising alternative for managing *P. expansum*. This study reviews the antifungal potential of VOCs obtained from essential oils and plant extracts, focusing on their efficacy *in vitro*.

Compounds such as thymol, eugenol, citral, and carvacrol, derived from plants like thyme (*Thymus vulgaris*), clove (*Syzygium aromaticum*), lemongrass (*Cymbopogon citratus*), and oregano (*Origanum vulgare*), have demonstrated potent antifungal activity against *P. expansum*. These VOCs disrupt fungal cell membranes, inhibit spore germination, and alter metabolic processes.

The *in vitro* application of plant-derived VOCs offers a sustainable, eco-friendly approach for controlling postharvest pathogens. However, challenges remain in translating laboratory findings to practical postharvest systems. Factors such as VOC volatility, potential phytotoxicity, and the optimization of delivery systems must be addressed. This bibliographic review underscores the potential of plant-based VOCs as a viable strategy for combating *P. expansum*, supporting the transition toward greener solutions in postharvest disease management. Future research should focus on developing cost-effective, scalable technologies

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to integrate VOCs into commercial practices.

**Keywords:** Volatile Organic Compounds, Plant-Derived Antifungals, *Penicillium expansum*, Postharvest Disease Management, Sustainable Agriculture, Fungal Control

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**DEVELOPMENT OF NANUNUTRIENTS FROM MUNICIPAL WASTE  
INCINERATOR BOTTOM ASH USING ARTHOGONAL ARRAY DESIGN**

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**Abstract**

The primary target of municipal waste management was to protect the health of the population, to promote environmental quality and to provide support to economic productivity. Cheap solid municipal waste IBA was recycled and chemically treated in an acidic solution to modify its texture and chemical nature of raw IBA. The XRD analysis showed that the surface of IBA was enriched with Ca, Mg and Fe elements with chemical leaching treatment. This observation was further confirmed by FTIR spectra, where the presence of bands at 1034 cm<sup>-1</sup>, 2696 cm<sup>-1</sup> and 3770.0 cm<sup>-1</sup> in chemical leaching treatment IBA indicated that leaching reaction may have produced Ca/Mg/Fe containing minerals structures. Concentration of calcium was high as compared to magnesium and iron. Values of parameters, 1.0 ml HCl, 0.1 ml H<sub>2</sub>SO<sub>4</sub>, 1.5g pulp density at 150RPM for 150 minutes were proved as optimum values of parameters for high yield of Fe (460.0mg/dm<sup>3</sup>), Mg (2140.0 mg/dm<sup>3</sup>) and Ca (8820.0 mg/dm<sup>3</sup>). The results showed that, municipal waste was the main source of minerals especially, Ca, Fe and Mg, in bottom ash. Further treatment of this leached minerals with maize seeds showed their high efficacy as plant growth stimulators, which proved them efficient in agricultural applications for fulfilling increasing demand of food. Chemical leaching method was proved safe, easy and fast method for the modification of MW IBA. This method proved MW-IBA as a potential candidate being a catalyst support for plants growth which could be proved applicable and could be used as cheap supporter for many other industrial and agricultural application.

**Keywords:** Chemical leaching, arthogonal array design, municipal waste incinerator bottom ash, minerals, plants nutrients

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## DIGITAL HUMANITIES AMONG GHANAIAN STUDENTS: PROSPECTS AND CHALLENGES

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### **Abstract**

In the fifth generation of computers, most studies involving the assumption of the human roles by artificial intelligence through the use of robotics and automation could be considered as digital humanities. In the recent past, the world took to social distancing as part of the Covid-19 protocols of the combat of the virus through global lockdown. In view of this, the world took to virtual platforms during the crisis of the global Covid-19 pandemic with the aim to save the human family from extinction. In view of this, it often necessitated the course of exploration of the penetration of digital applications and tools within the evolving information society for the continuation of culture and tradition of socialisation within the new normal and beyond, digital humanity has the possibility to propel the preparedness of the digital citizenry towards the Fourth Industrial Revolution (4IR). Similarly, the study of digital humanities has the role to assess the strengths and weakness of the “One size fit all” syndrome of the information systems’ analysis and design without necessarily considering the diversities within the global end-users’ community of teaching, learning, research and practicum.

In an information society with greater desire to initiate digital facilities and communities with the aim to enhance the human survival as witnessed with greater enhancement in all spheres of life through the penetration of the digital tools and applications, there is the phenomenon of digital divide that should inform critical decisions in facilitating the ease of access to e-information resources on various thematic areas and disciplines of the reprographic multimedia formats often with the aim to meet the diverse end-user community’s information needs through inclusivity. In no uncertain times could one estimate the digital divide without the study of the digital humanities.

In the developing countries, the digital tools often used to facilitate human activities including provision and access of health care, education, security, agriculture, communication, industry and research among others to replace the manual interactions of the end-users. Ghana is one of the developing countries with access to some of the digital tools, to assess the information systems in order to generate report with the aim to influence the decisions on convenience of cost, time and effort through efficiencies and effective analysis of the prospects and challenges of the digital humanities. It is noted that well informed decisions could be made on the basis of the logging report of the digital humanities of all sectors including health, education, entertainment, industry, engineering and communication. In Ghana, there is still less knowledge of the assessment of the level of the digital humanities in literature as it was coined in 2004. In conclusion, the desire to conduct an empirical study of the digital humanities within the less developed economies like Ghana during and after the global economic meltdown and post-pandemic distress was of enormous benefit.

**Keywords:** digital humanities, digital divide, artificial intelligence, Covid-19, protocols.

# 9<sup>TH</sup> INTERNATIONAL CONFERENCE ON GLOBAL PRACTICE OF MULTIDISCIPLINARY SCIENTIFIC STUDIES

January 21-28, 2025 / Havana, CUBA

## GLOBAL BUSINESS MODELS AND THE ROLE OF INTERNATIONAL RELATIONS IN SHAPING HUMAN RESOURCE MANAGEMENT PRACTICES

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### **Abstract**

In this globalised world sustainability is important for each one of us to provide and think for the present and the future generations. Sustainability is based on Environmental, Economic and Social development .It is a social objective about the ability of people to synchronise to exist on the globe over a longer period. In everyday use, sustainability often focuses on countering major environmental problems. These include climate change and loss of biodiversity, loss of ecosystem , land degradation, and air and water pollution. .Strategic Human Resource management makes the most of human potential and opportunity in today's unstable climate where Human resources are being upgraded from administrative players to strategic performers . Countries having good and stable relations with each other in international relations tend to share their inventions and innovations .The technique of attracting, developing, rewarding, and retaining people for the benefit of both the employees as individuals and the organisation as a whole is known as strategic human resource management.Strategy for promoting sustainability in all activities that include the use of resources and retention of resources to fulfil the needs of the present and the next generation.As Sustainable development is a combination of environmental issues with socio-economic issues which is common for all developing countries .India over the past 2 decades has made remarkable progress in reducing extreme poverty since world bank is partnering with the government in this effort by helping strengthen policies, institutions,and investments to create a better future for the country and it's people through green resilient, and inclusive development. With the rise in geopolitical tensions India has kept itself balanced in overall development and tried to sustain during the global pandemic and also in this situation of turmoil in the global environment due to war in Russia and Ukraine, India got the opportunity to head the G20 presidency and SCO where it is getting chance to demonstrate its thought process to focus on seeking finance for sustainable development and enhancing socio -economic development through innovative, responsible and cost efficient digital public goods . India will and is encouraging collective solutions to deal with major global challenges such as food and energy security .India's 1.3 billion human capital as a large developing economy and its ambitious adaptation to climate is not only transformational for India but for the entire globe .There is a need for elaborate study of sustainable Development goals in the context of Human Resource management and it's strategic importance.

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**January 21-28, 2025 / Havana, CUBA**

**REDEFINING TEACHING: THE ROLE OF SOCIAL MEDIA IN HIGH SCHOOL  
CLASSROOMS**

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**Abstract**

The dynamic educational landscape of Lahore, Pakistan, is witnessing a growing trend in which high school educators are increasingly utilizing social media to enhance their teaching effectiveness. This study aimed to explore the experiences and perceptions of these educators regarding their professional practices influenced by social media throughout an academic term. A quantitative approach was employed, utilizing a meticulously crafted questionnaire that examined various dimensions of social media engagement among high school teachers. The sample comprised 100 high school teachers selected through a convenience sampling method, and the questionnaire consisted of 15 items. To ensure accurate and reliable measurements of the constructs, assessments of reliability and validity were conducted. Data analysis involved the application of the Pearson correlation coefficient to identify relationships between the relevant variables. The results indicated a significant positive correlation between social media usage and teaching effectiveness among high school teachers in Lahore. The majority of educators expressed confidence in their ability to leverage social networking platforms for professional purposes and believed that such tools could positively impact their teaching. The study's recommendations focus on assisting secondary school teachers in fully integrating social media into their instructional methods through targeted professional development programs tailored to their needs.

Key words: effective teaching, high school teachers, relationship, social media,

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**ON ENERGY POLICIES IN DAIRY PRODUCTION: MODERATED DIETARY  
STARCH FOR MAXIMIZED PROFITABILITY**

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**Abstract**

The specific objective of this research was to underline a pragmatic priority in dairy agriculture energy policies that demands moderated dietary starch for maximized milk production by dairy cows. It is conventionally believed that increased dietary starch can maximize milk production especially in high-merit dairy cows. However, such high-producing dairy cows may be prone to a variety of metabolic disorders that keep them from achieving their full milk production potential. Our recent large dairy herd observations have revealed that moderated dietary starch levels can help maximize milk production in high-merit dairy cows. For instance, reducing dietary cereal grains from 36-40% (DM-based) to 30-32% can accomplish the above goal. Research findings have demonstrated that cows may not necessarily respond to increased dietary cereal starch. Instead, elevated dietary starch, particularly from highly fermentable processed cereal grains, may increase the likelihood of metabolic disorders such as subacute ruminal acidosis and systemic inflammation. This can in long-term suppress cow productivity and longevity. Simply, creating problems and then finding solutions is not a wise approach. Problems must be avoided or minimized in magnitude and impact. That will save efforts, finance and time towards seeking and discerning solutions. A brief critical view of the literature will prove vainness in feeding diets with up to 40-50% barley grain. That means a minimum of 24-30% starch only from grains with ineffective fibers. Such an over-modernization in energy policies of dairy production must cease. Except for unique conditions, under standard global programs, it is not feed that pushes animal productivity, but it is rather animal physiological state and backgrounds that determine responses to feeding strategies. Contemplating the above question should provide farmers and scientists with sage advice for feeding differently processed starchy cereal grains to avoid over-modernization in energy policies of the new time's dairy agriculture. It is time to strengthen the SciTech foundations of the global dairy industry.

**Keywords:** Dairy production, Dietary starch, Milk, Metabolic disorder, Cow health, Longevity.

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**IMPACT OF FILTRATION ON THE ANTIOXIDANT AND BIOACTIVE  
PROPERTIES OF PROPOLIS**

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**Abstract**

Propolis is a complex resinous substance with a broad spectrum of bioactive compounds, including tannins, flavonoids, and phenolic acids, known for its antioxidant, antimicrobial, and anti-inflammatory properties. The chemical composition of propolis varies depending on geographic origin, climate, and environmental factors. This study, conducted during the period of 2021-2022, investigates the bioactive content and antioxidant activities of filtered and unfiltered propolis ethanolic extracts (10%) collected from two apiaries in the Polog and Porece regions of Macedonia. The average values obtained from the samples were used for statistical analysis. The results revealed that filtered propolis extracts had significantly higher flavonoid and phenolic compound content compared to unfiltered extracts ( $295 \pm 116$  mg Quer/g vs.  $257 \pm 120$  mg Quer/g, and  $176 \pm 86$  mg GAE/g vs.  $136 \pm 66$  mg GAE/g, respectively). However, no significant differences were observed in tannin content, DPPH radical scavenging activity (IC<sub>50</sub>), or ferric reducing antioxidant power (FRAP). The findings suggest that while filtration enhances the concentration of specific bioactive compounds, it does not significantly impact the overall antioxidant activity. Both filtered and unfiltered extracts demonstrated similar antioxidant properties, indicating that either extraction method can be used to preserve the bioactive potential of propolis. These results contribute to understanding how extraction methods influence the chemical composition and biological activity of propolis, which may have important implications for its use in pharmaceutical and nutraceutical applications.

**Keywords:** Propolis, bioactive compounds, antioxidant activity, filtration.



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**MONITORING AND MODELLING OF SEDIMENT TRANSPORT IN THE  
STREAMS: CASE STUDY OF MKHDACH CATCHMENT (MIDDLE ATLAS/  
MOROCCO)**

**Taoufik Ahalli , Nordine Nouyati .**

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**ABSTRACT**

The erosion process is a worldwide phenomenon which affect the land degradation, significantly impacting sustainable land management across diverse global environments. Furthermore, evaluating, and measuring the effectiveness of soil conservation activities is crucial for sound basin management. However, the assessment of a small catchment does not necessarily reflect the truth over a wide scale. For instance, in the Atlas Mountains, dynamic of sediment generation, and soil loss is clearly observed. Consequently, these processes were monitored within the Mkhdach catchment basing on Geographic Information System (GIS), and applying the Sediment Transport Index (STI) along with parameters of the Erosion and Outflow Intensity (IntErO) method. Furthermore, the studied catchment, situated within the Middle Atlas, covered an area of more than 20 km<sup>2</sup>. The STI findings revealed a significant and dynamic sediment transportation pattern. However, the annual soil loss exceeded 417.48 km<sup>2</sup>/y- 1, indicating a high and excessive soil loss due to steep slopes and land cover modification. Consequently, rainfall intensity, and the natural dynamic of land uses emerged as the primary factors controlling soil erosion and sediment generation within the studied area.

**Keywords:** Sediment transport; sediment index; annual soil loss; modelling; Mkhdach catchment; Middle Atlas

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**THE EVOLUTION AND IMPACT OF ISLAMIC ARCHITECTURE IN  
CONTEMPORARY SOCIETY**

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**Abstract**

**Problem Statement:** Preserving the natural and cultural heritage is crucial for maintaining the delicate balance between human creation and the environment. Through stunning architectural masterpieces, Islamic architecture demonstrates the ingenuity and wisdom of the ancestors in integrating natural and cultural elements.

**Research objectives:** This study aims to explore the development and influence of Islamic architecture in the context of modern life, highlighting the integration of traditional elements with contemporary design principles. It underscores the importance of cross-cultural exchange, mutual respect, and responsible stewardship of the earth, celebrating the shared procreation of heritage.

**Research method:** The research method is descriptive and analytical, incorporating case studies and examples of modern adaptations of Islamic architecture.

**Conclusion:** This study contributes to a deeper understanding of the interconnectedness of human creation and the natural world. It aims to inspire a new generation of thinkers and leaders to prioritize the preservation of heritage influenced by wisdom and the evolution of Islamic architectural principles in contemporary society.

**Keywords:** Islamic Architecture, Preserving, Cultural heritage, Modern life, wisdom

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**ETHICAL IMPLICATIONS OF ARTIFICIAL INTELLIGENCE IN EDUCATION  
AND ARCHITECTURAL DESIGN**

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**Fahim Yar Baig**

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**Abstract:**

**Necessity:** The integration of Artificial Intelligence (AI) into educational systems presents transformative opportunities alongside significant ethical challenges. As educational institutions increasingly adopt AI technologies, understanding the ethical implications becomes crucial for ensuring equitable outcomes.

**Objective:** This paper aims to explore the ethical implications of AI in education, focusing on its intersection with architectural design, particularly in the creation of learning environments that foster effective teaching and learning.

**Research Method:** The analysis includes a review of current literature on AI applications in education and architectural design, examining case studies that highlight both the benefits and ethical concerns associated with these technologies.

**Results:** The findings indicate that while AI technologies offer innovative solutions for personalized learning and administrative efficiency, they also raise critical ethical concerns, including the privacy and security of student data and the risk of algorithmic bias. Furthermore, the role of AI in designing smart classrooms and intelligent buildings is explored, revealing potential benefits in optimizing learning environments, yet also highlighting issues of surveillance and unequal access to technology.

**Conclusion:** The paper advocates for a balanced approach to the implementation of AI in education and architectural design. It emphasizes the need for ethical guidelines, inclusive practices, and continuous monitoring to ensure that AI technologies benefit all students equitably. By addressing these ethical challenges, stakeholders can harness the full potential of AI to create a more just and effective educational landscape.

POLYMERIC MEMBRANES FOR DESALINATION USING MEMBRANE  
DISTILLATION: A REVIEW

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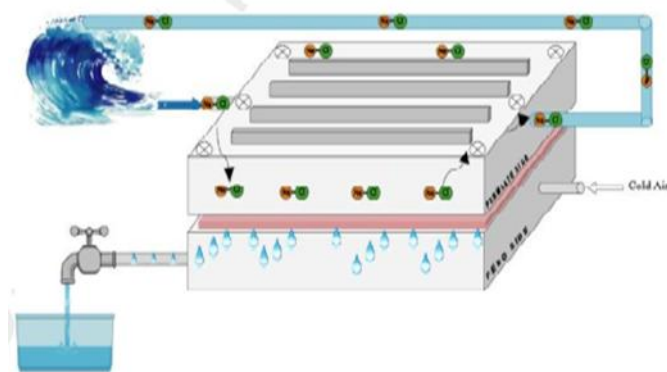
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**Abstract**

Membrane distillation (MD) is considered an emerging technology for seawater desalination. The hydrophobic polymers commonly used for this process are polytetrafluoroethylene (PTFE), polyvinylidene fluoride (PVDF), and polypropylene (PP). An ideal membrane for MD should exhibit characteristics such as high liquid entry pressure, low fouling rate, high permeability, and excellent mechanical resistance. Polymeric membranes, being more cost-effective than ceramic membranes, are considered a more affordable alternative and have dominated the research conducted so far on membrane distillation (MD). This review aims to provide a brief introduction to MD, summarize the research efforts to achieve the desired properties in polymeric membranes used in MD for desalination purposes and focus on the fabrication methods for these membranes.



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**COMPUTATIONAL ANALYSIS OF THE INHIBITORY POTENTIAL OF FLAVONE  
DERIVATIVES ON THE SARS-COV-2 PROTEIN**

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**Abstract**

**Background:** This study aims to identify potential inhibitors of SARS-CoV-2 RNA-dependent RNA polymerase (RdRp) from natural medicines derived from aromatic and medicinal plants commonly found in various foods.

**Methods:** A library of five naturally occurring flavone derivatives (4a, 4b, 4c, 4d, and 4e), along with the standard favipiravir-RTP, was evaluated using an **in silico** approach. This included (a) Lipinski's rule of five and ADMET analysis, (b) molecular docking studies, and (c) molecular dynamics (MD) simulations for 100 ns to assess stability and interaction profiles.

**Results:** The five flavone derivatives demonstrated superior pharmacological properties compared to the standard reference molecule. Among them, compounds 4d and 4e showed the strongest binding affinities of -7.036 kcal/mol and -7.141 kcal/mol, respectively, outperforming favipiravir-RTP. MD simulations confirmed the stability of these two compounds when bound to SARS-CoV-2 RdRp, exhibiting stable root mean square deviation (RMSD) trajectories and consistent interaction profiles with desirable molecular properties.

**Conclusion:** The findings suggest that flavone derivatives derived from aromatic and medicinal plants possess significant **in silico** potential as inhibitors of SARS-CoV-2 RdRp. These compounds warrant further investigation through **in vitro** and **in vivo** studies to assess their efficacy in treating COVID-19.

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**URBAN LIVING AND WOMEN'S WELL-BEING:  
A STUDY OF MENTAL HEALTH AND HEALTH BEHAVIORS IN POLISH CITIES**

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**Abstract**

This study investigates the interplay between urban living, mental condition (MC), and health behaviors among adult women in large Polish cities. Recognizing the significant impact of urbanization on well-being, we examined the associations between MC, encompassing life satisfaction, suicidal ideation, and self-assessed health, and key health behaviors: physical activity, smoking, alcohol consumption, coffee consumption, BMI, and WHR. Data were collected from 5042 economically active women residing in cities with populations exceeding 500,000. Results revealed that women with low MC were more likely to be physically inactive, smoke more cigarettes, and consume less coffee compared to their counterparts with good MC. Furthermore, women with extremely low MC exhibited lower BMI but higher waist-to-hip ratio (WHR) compared to those with stronger MC. These findings suggest that urban living may contribute to a complex interplay between mental health, health behaviors, and physical health outcomes among women. The study highlights the need for interventions that address both mental and physical health needs within the context of urban environments to improve the overall well-being of women in Polish cities.

**Keywords:** psychosocial stress, quality of life, life satisfaction, physical activity, BMI, Poland

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**TURKEY'S MENTAL HEALTH POLICY AND SERVICE DELIVERY: HUMAN  
RESOURCES MANAGEMENT AND PEOPLE-CENTERED CARE**

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**Abstract**

These days, based on the Sustainable Development Goals, there is an increasing interest in supporting, in the best way possible, the countries' mental health policies, taking into account the growing number of individuals suffering from anxiety and depression. Besides these, specialists worldwide are keen in offering a better understanding of the major factors responsible for the current situation, among which could be highlighted: the migration phenomenon; the on-going natural disasters; different forms of epidemics and pandemics, and the economic downturn. The present research focuses, on the one hand, on showing the importance of human resources management as well as people-centered care in Turkey and, on the other hand, on displaying the role played by the World Health Organization, the Ministry of Health of Turkey, and the Ministry of Family,

Labour and Social Services of Turkey in addressing two major social problems, namely: mental health and well-being. The originality of this current study comes from the following aspects: firstly, the literature review performed, since it brings to light the challenges of the topic under analysis; secondly, the ideas brought into consideration with the aid of the documents linked with the World Health Organization Global Mental Health Action Plan; and, thirdly, the emphasis placed on the case of Turkey, which is focused on creating responsible and valuable Turkish health professionals.

**Keywords:** Human Resources Management; Knowledge; Mental Well-Being; Social Inclusion; Better Health; World Health Organization; Ministry of Health of Turkey; Ministry of Family, Labour and Social Services; Mental Health; Turkey.



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**ASSESSMENT OF SOIL-TO-PLANT TRANSFER FACTORS OF NATURAL AND  
ARTIFICIAL RADIONUCLIDES IN AGRICULTURAL PRODUCTS FROM THE  
SEMI-ARID MEKNES REGION, MOROCCO**

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**Samira EL AOUIDI<sup>2</sup>**

**Radouan SAADI<sup>2</sup>**

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**Abstract**

Natural and artificial radionuclides present in agricultural crops have significant potential for health hazard through dietary intake by humans. For such an assessment of the consequence of radioactive contamination of agricultural soils, information is required on the mechanism and quantitative extent of plant uptake of radionuclides. This paper presents results on the assessment of TFs in soils for some radionuclides in the semi-arid region of Meknes, Morocco, which is situated at about 500 m above sea level. Soil and vegetable samples taken from several agricultural sites were analyzed by High-Purity Germanium gamma spectrometry and alpha spectrometry to quantify the radionuclides' activity concentrations. The investigated radionuclides were Th-234, Ra-226, Th-228, Ra-228, Pb-210, K-40, Cs-137, and Po-210. The transfer factor is the activity concentration ratio of the radionuclides in the plant tissues to that in the corresponding soils, which is indicative of the mobility and bioavailability of the radionuclide within the soil-plant system. For all measurements, standardized methodologies were used so that the data could be reliable and comparable to worldwide studies under various climatic and agricultural conditions. Results obtained showed that there was significant variation in TFs within radionuclides, which were related to soil physicochemical properties, speciation of the radionuclide, and plant species. K-40 demonstrated higher TF than actinides,

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reflecting its essential nutrient role and mobility in plants.

This work contributes to understanding the dynamics of radionuclide transfer in semi-arid agroecosystems and points out the importance of monitoring radionuclide contamination with respect to food safety. The presented results allow a first basis for the health risk assessment due to radionuclide intake by agricultural products and point out the need for mitigation strategies under conditions prone to environmental radioactive contamination. The obtained results agree with international findings and contribute to the development of improved food safety standards within the studied semi-arid context.

**Keywords:** Radionuclides, soil-to-plant transfer, gamma spectrometry, alpha spectrometry, transfer factors, semi-arid agriculture, Meknes.

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**INVESTIGATING THE CORROSION CONTROL OF *ERIOBOTRYA JAPONICA*  
(LOQUAT) SEED EXTRACT FOR CARBON STEEL PROTECTION IN ACIDIC  
MEDIUM: A SUSTAINABLE AND ECO-FRIENDLY APPROACH**

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**Prof. Driss BENMESSAOUD LEFT**

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**Abstract**

The development of green corrosion inhibitors derived from natural resources offers a sustainable solution to mitigate the degradation of carbon steel in corrosive environments. This study focuses on the inhibitory potential of *Eriobotrya japonica* (loquat) seed extract for carbon steel corrosion in an acidic medium. The extract was analyzed using UV-Vis and FTIR spectroscopy to identify bioactive compounds such as polyphenols and flavonoids that contribute to corrosion resistance. Electrochemical studies, including Tafel polarization and electrochemical impedance spectroscopy (EIS), demonstrated the extract's efficacy in reducing corrosion rates. Adsorption studies indicated a spontaneous and predominantly physical adsorption mechanism, supported by thermodynamic parameters. This work highlights the potential of *Eriobotrya japonica* seeds as a renewable and cost-effective source for corrosion inhibition, promoting environmentally friendly practices in industrial applications.

**Keywords:** *Eriobotrya japonica* seeds, green corrosion inhibitor, carbon steel, acidic medium, electrochemical studies, sustainable solutions.

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**SÜRDÜRÜLEBİLİR YAPILAR İÇİN DOĞAL TAŞ ALTERNATİFLERİNİN ENERJİ  
VERİMLİLİĞİNİN SİMÜLASYONLA ANALİZİ**

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**Özet**

Artan enerji talebi nedeniyle enerjinin en çok kullanıldığı sektörlerden biri olan yapı sektöründe, doğru malzemeler kullanılarak tasarlanmış binalar ve iklimlendirme ekipmanları sayesinde alan ısıtma ve soğutma verimliliğinde ilerleme sağlanmasına özellikle ihtiyaç duyulmaktadır. Bina kabuğunun enerji performansının iyileştirilmesi, ısıtma ve soğutma enerji yoğunluğu (toplam m<sup>2</sup> başına enerji kullanım miktarı) açısından doğru ilerlemek için kritik öneme sahiptir. Kyoto anlaşmasına göre, mekan ısıtma ve soğutmanın nihai enerji yoğunluğunun bugüne kıyasla 2030 yılında sırasıyla en az %35 ve %25 oranında yani önemli ölçüde düşmesi gerekmektedir. Bu amaçla erken tasarım aşamalarında bir binanın optimal performansı verebilecek malzemelerle tasarlanması için simülasyon programları hem hızlı hem detaylı ve doğru planlamaların yapılabilmesi açısından en faydalı yöntemlerden biridir.

Bu çalışmada, Ankara ili iklim şartlarında bir küçük işletme için yapı malzemesi olarak üç farklı doğal taş (bazalt taşı, diyabaz taşı ve granit taşı) ve sekiz farklı levha yapıda yalıtım malzemesi (mantar levha, ahşap yünlü levha, ahşap lifli levha, cam yünü, taş yünü, cüruf yünü, vermikilit ve kalsiyum silikatlı levha) kullanılarak yirmi dört farklı alternatif senaryo oluşturulmuştur. Yapı ve yalıtım malzemelerinin farklı kombinasyonları dıştan yalıtımlı duvar yapısı dikkate alınarak IES-VE simülasyon programı ile analiz edilmiştir. Yapı ve yalıtım malzemeleri sisteme dahil edilirken; yapı malzemeleri 20 cm kalınlığında ve yalıtım malzemeleri Ankara ili için ortalama optimum yalıtım kalınlığı değeri dikkate alınarak bina kabuğuna eklenmiştir. Elde edilen analiz sonuçları en enerji etkin ve en çevre kirliliğini azaltıcı malzeme kombinasyonunu belirlemek amacıyla değerlendirilmiştir. Analiz sonuçlarının Ankara ilinde binalarda enerji verimliliği, enerji ekonomisi ve sera gazlarının azaltılması konusunda çalışan karar vericilere örnek uygulama olarak sunulması hedeflenmiştir.

**Anahtar Kelimeler:** IES-VE simülasyon programı, Doğal taş, Levha yalıtım malzemesi, Binalarda enerji verimliliği, Çevre kirliliği yönetimi.

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## SIMULATION ANALYSIS OF ENERGY EFFICIENCY OF NATURAL STONE ALTERNATIVES FOR SUSTAINABLE BUILDINGS

### **Abstract**

In the construction sector, which is one of the most energy-intensive sectors due to increasing energy demand, there is a particular need for improvements in space heating and cooling efficiency through buildings and air conditioning equipment designed using the right materials. Improving the energy performance of the building envelope is critical to move forward in terms of heating and cooling energy intensity (energy use per total m<sup>2</sup> ). According to the Kyoto agreement, the final energy intensity of space heating and cooling needs to decrease significantly by at least 35% and 25% respectively by 2030 compared to today. For this purpose, simulation programs are one of the most useful methods for designing a building with materials that can provide optimal performance in the early design stages in order to make fast, detailed and accurate planning.

In this study, twenty-four different alternative scenarios were created using three different natural stones (basalt stone, diabase stone and granite stone) and eight different insulation materials (cork board, wood wool board, wood fiber board, glass wool, rock wool, slag wool, vermiculite and calcium silicate board) as building materials for a small enterprise in the climatic conditions of Ankara. Different combinations of building and insulation materials were analyzed with the IES-VE simulation program considering the externally insulated wall structure. While the building and insulation materials are included in the system; the building materials are 20 cm thick and the insulation materials are added to the building envelope considering the average optimum insulation thickness value for Ankara province. The obtained analysis results were evaluated to determine the most energy efficient and pollution reducing material combination. It is aimed to present the results of the analysis as a sample application to decision makers working on energy efficiency, energy economy and greenhouse gas reduction in buildings in Ankara province.

**Keywords:** IES-VE simulation program, Natural stone, Board insulation material, Energy efficiency in buildings, Environmental pollution management.

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**TEMİZ ÇEVRE İÇİN BİNA KABUĞUNUN ENERJİ ETKİNLİĞİNİN BÖLGESEL  
DEĞERLENDİRMESİ; İZMİR İLİ ÖRNEĞİ**

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**Özet**

Son yıllarda daha az karbon salınımı yapan çevre dostu binalar olarak adlandırılan binalar, ya yenilenebilir enerjiyi doğrudan kullanan veya elektrik enerjisi gibi tamamen karbondan arındırılabilen bir enerji kaynağına dayanan, ya da enerjiyi optimal düzeyde son derece verimli bir şekilde kullanabilecek şekilde tasarlanmış binalardır. Yüksek performanslı bina zarfı (bir binanın iç mekanını dış mekandan ayıran dış duvarlar, temeller, çatı, pencereler vb. dahil) binaların termal ihtiyaçlarını ve dolayısıyla sera gazlarını azaltmanın en etkili yoludur. Daha az karbon salınımı, hem operasyonel hem de somutlaştırılmış emisyonları içermektedir. Alternatif çözümlerle karşılaştırıldığında, bir binanın işletmesi esnasında salınan karbon miktarını azaltmak için erken tasarım aşamalarında simülasyon programları destekli olarak doğru malzemelerle tasarlanan binalar, binanın enerji verimliliğinin ve karbon salınımının düzenlenmesinde etkilidir. Kyoto yasasına uyum sağlamak için tüm ülkelerin 2030 yılına kadar konut ve konut dışı binalar için karbon miktarını belli düzeyde azaltarak enerji verimli bina alt yapısını oluşturması gerekmektedir.

Bu çalışmada, İzmir ili iklim koşullarında tasarlanan bir liman evi için farklı sıra ve boşluk sayısına sahip 30 cm genişlikte üç farklı Bims tuğla yapı malzemesi kullanılmıştır. Yapı içten ve dıştan yalıtımlı bina zarfına sahip olacak şekilde projelendirilmiştir. Dört farklı fiber yalıtım malzemesi (keten fiber, selüloz fiber, kenevir fiber, ağaç fiber) İzmir ili için belirlenen optimum yalıtım kalınlığı değeri dikkate alınarak sisteme eklenmiştir. Yapı ve yalıtım malzemelerinin farklı kombinasyonları kullanılarak toplam yirmi dört alternatif senaryoya göre bina zarfı detaylandırılmıştır. IES-VE simülasyon programı yardımıyla bütün alternatif senaryolar enerji verimliliği açısından analiz edilmiştir. Analiz sonuçlarının İzmir ilinde enerji verimli ve çevre dostu bina tasarımı ile ilgili çalışan tasarımcılar, müteahhitler ve mimarlar için değerlendirilebilir bir çalışma olması amaçlanmıştır.

**Anahtar Kelimeler:** IES-VE simülasyon programı, Doğal taş, Levha yalıtım malzemesi, Binalarda enerji verimliliği, Çevre kirliliği yönetimi.

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**REGIONAL ASSESSMENT OF ENERGY EFFICIENCY OF BUILDING  
ENVELOPE FOR CLEAN ENVIRONMENT; IZMIR PROVINCE CASE STUDY**

**Abstract**

In recent years, so-called environmentally friendly buildings that emit less carbon emissions are buildings that either use renewable energy directly or rely on a fully decarbonizable energy source, such as electricity, or are designed to use energy optimally and extremely efficiently. A high-performance building envelope (including the exterior walls, foundations, roof, windows, etc. that separate the interior of a building from the exterior) is the most effective way to reduce the thermal needs of buildings and therefore greenhouse gases. Reduced carbon emissions include both operational and embodied emissions. Compared to alternative solutions, buildings designed with the right materials, supported by simulation programs in the early design stages to reduce the amount of carbon emitted during the operation of a building, are effective in regulating the energy efficiency and carbon emissions of the building. In order to comply with the Kyoto law, all countries are required to create energy efficient building infrastructure by 2030 by reducing the amount of carbon for residential and non-residential buildings to a certain level.

In this study, three different 30 cm wide pumice brick building materials with different rows and number of gaps were used for a harbor house designed in the climatic conditions of Izmir province. The building is designed to have an internally and externally insulated building envelope. Four different fiber insulation materials (flax fiber, cellulose fiber, hemp fiber, wood fiber) were added to the system considering the optimum insulation thickness value determined for Izmir province. The building envelope was detailed according to a total of twenty-four alternative scenarios using different combinations of construction and insulation materials. All alternative scenarios were analyzed in terms of energy efficiency with the help of IES-VE simulation program. The results of the analysis are intended to be an evaluable study for designers, contractors and architects working on energy efficient and environmentally friendly building design in Izmir province.

**Keywords:** IES-VE simulation program, Energy efficiency, Environmentally friendly building, Bims brick, Fiber insulation material.

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**PİSTON AKIMLI ANAEROBİK ÇÜRÜTÜCÜDE SIĞIR GÜBRESİ VE GIDA  
ATIKLARININ BİRLİKTE ÇÜRÜTÜLMESİNİN YAŞAM DÖNGÜSÜ  
DEĞERLENDİRMESİ**

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**Özet**

Anaerobik çürütme (AÇ), biyokütleyi doğal olarak biyogaza dönüştüren ve aksi takdirde depolama alanlarına gömülmesi veya yakılması gereken atıkları azaltan biyolojik bir süreçtir. En yaygın kullanılan çürütücü tipleri, sürekli karıştırmalı tank reaktör ve piston akımlı reaktördür. Piston akımlı reaktörler, tarımsal biyogaz tesislerinin tasarımında basitlikleri, ekonomik olmaları ve maliyet etkinlikleri nedeniyle tercih edilmektedir. Geleneksel olarak, gübrenin anaerobik çürütülmesi çiftliklerde uygulanmakta olsa da, tarımsal biyogaz tesislerinde sınırlı enerji üretimi, yaygınlaşmasını engellemektedir. Benzer şekilde, sığır gübresi gibi, gıda atıkları da yeterince değerlendirilememekte ve genellikle çöp sahalarına gömülmektedir. Bu çalışma, sığır gübresinin tekil çürütülmesi ile gıda atıkları ile birlikte çürütülmesinin çevresel etkilerini değerlendirmek ve karşılaştırmak için bir yaşam döngüsü değerlendirme (YDD) modeli kullanmaktadır. Çalışmada, Van Yüzüncü Yıl Üniversitesi'ndeki bir pilot piston akımlı anaerobik çürütücünün kütle dengesi süreç verileri temel alınmış, eksik veriler literatürden tamamlanmıştır. YDD sonuçlarına göre, gıda atıkları ile birlikte çürütme, tekil çürütme ile karşılaştırıldığında iklim değişikliği etkisinde %60'lık bir azalma sağlamıştır. Birlikte çürütmenin üstün çevresel performansı, esas olarak gıda atıklarının depolama alanlarına gönderilmemesi ile ilişkilendirilen, önlenen emisyonlara dayanmaktadır. Bu durum gıda atıklarının depolama alanlarından uzaklaştırılmasıyla çevresel kredilerin elde edilmesi sayesinde mümkün olmuştur.

**Anahtar Kelimeler:** Tarımsal biyogaz tesisi, sığır gübresi, gıda atıkları, iklim değişikliği, yaşam döngüsü değerlendirmesi



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**A LIFE CYCLE ASSESSMENT OF CO-DIGESTION OF CATTLE MANURE AND  
FOOD WASTE IN A PLUG-FLOW ANAEROBIC DIGESTER**

**Abstract**

Anaerobic digestion (AD) is a biological process that naturally converts biomass into biogas while reducing waste that would otherwise need to be disposed of in landfills or incinerated. The most widely implemented types of digesters are the continuously stirred tank reactor (CSTR) and the plug-flow reactor (PFR). PFRs are particularly favored over CSTRs in the design of agricultural biogas plants due to their simplicity, affordability, and cost-effectiveness. Traditionally, the anaerobic digestion of manure has been utilized on farms; however, its limited energy production has hindered broader implementation. Similarly, as is the case with cattle manure, food waste is not being adequately utilized and is often disposed of in landfills. This study employs a life cycle assessment (LCA) model to evaluate and compare the environmental impacts of cattle manure mono-digestion and its co-digestion with food waste. The mass balance process data from a pilot PFR anaerobic digester at Van Yüzüncü Yıl University were used as the basis for the study, with any missing data supplemented from the literature. According to the LCA results, co-digestion of cattle manure with food waste resulted in a 60% reduction in climate change impact compared to mono-digestion. The superior environmental performance of co-digestion is primarily attributed to the avoided emissions associated with food waste landfilling, as environmental credits were achieved by diverting food waste from landfill disposal.

**Keywords:** Agricultural biogas plant, cattle manure, food waste, climate change, life cycle assessment

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**SÜREKLİ KARIŞTIRMALI TANK REAKTÖRÜN PERFORMANSINI GERÇEK  
ZAMANLI İZLEYEBİLEN ARDUINO TABANLI SENSÖR SİSTEMİNİN  
TASARIMI VE DEĞERLENDİRİLMESİ**

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**Özet**

Biyogaz tesisleri aracılığıyla biyokütleden yenilenebilir enerji üretimi ve organik atıkların kompost benzeri bir toprak düzenleyicisine dönüştürülmesi, karbon emisyonlarını azaltmak için oldukça talep gören çözümler arasındadır. Ancak, anaerobik sistemin etkin bir şekilde izlenmesi ve kontrol edilmesi sağlanmadığında, performansı sınırlı kalmaktadır. Ayrıca, geleneksel biyoreaktörler genellikle büyük boyutları ve yüksek maliyetleriyle öne çıkar, bu da birçok bilim insanı ve araştırma enstitüsü için erişilebilirliklerini sınırlandırır. Bu çalışma, mevcut biyoreaktörlerde mikroorganizmaların verimliliğini izlemek için düşük maliyetli ve kolayca uyarlanabilir bir çözüm sunan, kendin yap (DIY) yöntemiyle üretilmiş bir 3D baskılı anaerobik biyoreaktör sensör sisteminin geliştirilmesini tanıtmayı ve değerlendirmeyi amaçlamaktadır. Özelleştirilmiş sensör sistemi, 3D baskılı bileşenler ve elektronik parçalar kullanılarak monte edilmek üzere tasarlanmış ve bu bileşenler 3D baskılı bir muhafaza içine entegre edilmiştir. 3D baskılı bileşenlerin tasarımında Autodesk CAD yazılımı Fusion 360 kullanılmış, bileşenler ise füzyon filament fabrikasyonu (FFF) tekniğiyle üretilmiştir. Biyoreaktör sensör sistemi, Arduino tabanlı gerçek zamanlı izleme ve bulut platformlarına veri aktarımı yeteneğine sahiptir; bu da optimal organik yükleme oranı (OYO) hakkında bilgi sağlayarak gelişmiş süreç kontrolü ve optimizasyonu sağlamaktadır. Sığır gübresiyle yapılan denemeler, sistemin metan (CH<sub>4</sub>) konsantrasyonlarını, biyoreaktör sıcaklığını ve biyogaz verimini (%) başarıyla izleyip kaydettiğini göstermiştir. Elde edilen sonuçlar, mezofilik sıcaklık koşullarında literatürde rapor edilen değerlerle (%50–70 CH<sub>4</sub>) uyumlu bulunmuştur. Ön değerlendirmeler, sistemin sızdırmazlık, gaz izleme doğruluğu ve sıcaklık kontrolü gibi parametrelerini değerlendirmek için gerçekleştirilmiş ve tüm parametrelerde oldukça umut verici bir performans sergilenmiştir.

**Anahtar Kelimeler:** Arduino dijital mikrodenetleyici, manometrik yöntem, 3D baskı, anaerobik çürütme, laboratuvar ölçekli çürütücü

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## DESIGN AND EVALUATION OF AN ARDUINO-BASED REAL-TIME MONITORING SENSOR SYSTEM FOR AN ANAEROBIC CONTINUOUSLY STIRRED TANK REACTOR

### Abstract

The production of renewable energy from biomass and the transformation of organic waste into a compost-like soil conditioner through biogas plants are highly sought-after solutions for reducing carbon emissions. However, without effective monitoring and control of the anaerobic system, its performance remains constrained. Furthermore, conventional bioreactors are often characterized by their large size and significant expense, which limit their accessibility to many scientists and research institutions. This study aims to introduce and evaluate the development of a do-it-yourself (DIY) 3D-printed anaerobic bioreactor sensor system, offering a cost-effective and easily adaptable solution for monitoring the efficiency of microorganisms in existing bioreactors. The customized sensor system was designed for assembly using 3D-printed components and electronic parts, all integrated within a 3D-printed housing. Autodesk CAD software, Fusion 360, was utilized to design the 3D-printed components, which were fabricated using the fused filament fabrication (FFF) technique. The bioreactor sensor system enables Arduino-based real-time monitoring and data transmission to cloud platforms, facilitating advanced process control and optimization by offering valuable insights into the optimal organic loading rate (OLR). Trials conducted with cattle manure demonstrated that the system successfully monitored and recorded methane (CH<sub>4</sub>) concentrations, along with digester temperature and biogas yield (%). The results aligned with values reported in the literature (50–70% CH<sub>4</sub>) under mesophilic temperature conditions. Preliminary evaluations assessed the system's leak-tightness, gas monitoring accuracy, and temperature control, all of which showed highly promising performance.

**Keywords:** Arduino digital microcontroller, manometric method, 3D printing, anaerobic digestion, lab-scale digester

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**THE USE OF MACHINE LEARNING IN HIGH POWER BATTERIES FOR STATE  
OF CHARGE ESTIMATION**

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**Abstract**

Storing electrical energy has become as important as energy transmission in today's world, emerging as an indispensable element of modern life. The growing dependence on electricity has made energy storage solutions not only a technological necessity but also a strategic imperative. From industrial applications to individual use, the importance of energy storage technologies is rapidly increasing. Modern technologies such as electric vehicles, smart grids, and portable electronic devices are driving the demand for electricity and amplifying the need for advanced energy storage solutions. In areas with large-scale energy demands, such as electric vehicles, lithium-ion batteries play a critical role in extending range and improving energy efficiency. Thanks to their high energy density, these batteries enhance the performance of electric vehicles while reinforcing user trust in these technologies. The widespread adoption of Li-ion batteries has necessitated the development of integrated electronic solutions known as Battery Management Systems (BMS), which ensure the safe, efficient, and durable operation of these technologies.

BMS not only optimizes battery operating conditions but also provides users with detailed information about the battery's current status. This information is typically expressed through two key metrics: State of Charge (SoC) and State of Health (SoH). SoC indicates the amount of energy available in the battery as a percentage of its total capacity. This study aims to estimate the capacity of lithium-ion batteries under varying charge and discharge voltage conditions and to comprehensively examine how these estimations can be utilized in battery management systems.

In this study, high-power 18650 lithium-ion batteries were tested under different current values and temperatures to create a comprehensive dataset. This dataset was analyzed using machine learning techniques such as k-Nearest Neighbors (k-NN), Support Vector Machines (SVM), and Random Forest. These methods were employed to achieve higher accuracy in State of Charge (SoC) predictions, and their predictive performance was evaluated.

**Keywords:** Energy Storage, Li-ion, State of Charge, Machine Learning

**YÜKSEK GÜÇLÜ PİLLERDE ŞARJ DURUMU TAHMİNİ İÇİN MAKİNE  
ÖĞRENMESİ KULLANILMASI**

**Özet**

Elektrik enerjisini depolamak, günümüzde enerji iletimine eşdeğer bir öneme sahiptir ve modern yaşamın vazgeçilmez bir unsuru haline gelmiştir. Elektriğe olan bağımlılığın artması, enerji depolama çözümlerini yalnızca teknolojik bir gereklilik değil, aynı zamanda stratejik bir zorunluluk haline getirmiştir. Endüstriyel uygulamalardan bireysel kullanıma kadar enerji depolama teknolojilerinin önemi hızla artmaktadır. Elektrikli araçlar, akıllı şebekeler ve taşınabilir elektronik cihazlar gibi modern teknolojiler, elektrik enerjisine duyulan talebi artırmakta ve enerji depolama çözümlerine olan ihtiyacı daha da belirgin hale getirmektedir. Elektrikli araçlar gibi büyük ölçekli enerji gereksinimleri olan alanlarda, lityum iyon bataryalar, menzil artırma ve enerji verimliliği sağlama noktasında kritik bir rol oynamıştır. Bu bataryalar, yüksek enerji yoğunlukları sayesinde, elektrikli araçların performansını artırırken kullanıcıların bu teknolojilere olan güvenini pekiştirmiştir. Lityum iyon bataryaların yaygınlaşması, bu teknolojilerin daha güvenli, verimli ve uzun ömürlü bir şekilde kullanılabilmesi için Batarya Yönetim Sistemleri (BYS) adı verilen entegre elektronik çözümlerin geliştirilmesini zorunlu kılmıştır. BYS, lityum iyon bataryaların çalışma süreçlerini kontrol eder, optimize eder ve çeşitli dış etkenlerden koruyarak kullanıcılar ve sistemler için maksimum fayda sağlar.

BYS sadece bataryanın çalışma koşullarını optimize etmekle kalmaz, aynı zamanda kullanıcıya bataryanın mevcut durumu hakkında da bilgi verir. Bu bilgiler genellikle iki temel kavramla ifade edilir: Şarj durumu (State of Charge, SoC) ve sağlık durumu (State of Health, SoH). Şarj durumu (State of Charge, SoC), bataryanın toplam kapasitesine oranla ne kadar enerjiye sahip olduğunu ifade eder ve genellikle yüzde cinsinden gösterilir. Bu çalışma, lityum iyon bataryaların farklı şarj ve deşarj gerilim değerlerine göre kapasite tahminlerini gerçekleştirmeyi ve bu tahminlerin batarya yönetim sistemlerinde nasıl kullanılabileceğini kapsamlı bir şekilde incelemeyi amaçlamaktadır.

Bu çalışmada, yüksek güce sahip 18650 Li-iyon piller, farklı akım değerleri ve sıcaklıklarda test edilerek kapsamlı bir veri seti oluşturulmuştur. Oluşturulan veri seti, k-En Yakın Komşu (k-NN), Destek Vektör Makineleri (SVM) ve Rastgele Orman (Random Forest) gibi makine öğrenmesi teknikleriyle analiz edilmiştir. Bu yöntemler, Şarj Durumu (SoC) tahminlerinde daha yüksek doğruluk sağlamak amacıyla kullanılmış ve tahmin performansları değerlendirilmiştir.

**Anahtar kelimeler:** Enerji Depolama, Li-iyon, Şarj Durumu, Makine Öğrenmesi

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**January 21-28, 2025 / Havana, CUBA**

**EVALUATION OF GEOMETRIC EFFECTS ON THE IMPACT RESISTANCE OF  
LAMINATED COMPOSITE MATERIALS**

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**Özet**

Lamine kompozit malzemeler, yüksek mukavemet, elastikiyet modülü ve özelleştirilebilir özellikleri nedeniyle havacılık ve savunma sanayisi gibi pek çok alanda yaygın olarak kullanılmaktadır. Bu özellikler, kompozit malzemeleri özellikle balistik koruma uygulamaları için ideal hale getirmektedir. Bu çalışmada, kompozit malzemelerin darbe dinamikleri ve dayanımı incelenmiş, farklı yüzey tipleri ve geometrilerin performans üzerindeki etkileri değerlendirilmiştir. ANSYS/ACP ve Explicit Dynamics arayüzü kullanılarak, aynı katman, malzeme ve yönelime sahip kompozit zırh modelleri tasarlanmış ve eşit darbe yüklerine tabi tutulmuştur.

Araştırmada geometrik varyasyonların, darbe bölgesindeki gerilme dağılımı ve enerji emilimi üzerindeki etkileri detaylı bir şekilde analiz edilmiştir. Farklı tasarımların karşılaştırmalı analizleri, geometrinin balistik direnç üzerindeki kritik rolünü ortaya koymuş, belirli geometrik yapıların darbe emilimini artırarak kinetik enerji dağılımını daha etkili bir şekilde sağladığını göstermiştir.

Ayrıca, darbe sırasında meydana gelen kuvvetler incelenmiş ve kompozit malzemelerin yüksek gerinim hızlarındaki davranışları değerlendirilmeye alınmıştır. Çalışma, kompozit zırhların enerji dağılımı ve balistik tehditlere karşı koruma sağlama yeteneğini optimize etmek için geometrinin tasarımdaki önemini vurgulamaktadır. Bu bulgular, daha gelişmiş koruyucu malzemelerin tasarımına yönelik değerli bilgiler sunarak, koruma performansını artırmayı hedefleyen gelecekteki çalışmalar için temel oluşturabilir.

**Anahtar Kelimeler:** Sonlu elemanlar analizi, Darbe, Kompozit Malzeme

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**EVALUATION OF GEOMETRIC EFFECTS ON THE IMPACT RESISTANCE OF  
LAMINATED COMPOSITE MATERIALS**

**Abstract**

Laminated composite materials are widely employed in industries such as aerospace and defense due to their high strength, elastic modulus, and customizable properties. These features make them particularly suitable for ballistic protection applications. This study focuses on the impact dynamics and resistance of composite materials, analyzing the effects of different surface types and geometries on their performance under impact loads. Using ANSYS/ACP and the Explicit Dynamics interface, composite armor models with identical layers, materials, and orientations were designed and subjected to the same impact conditions.

The study evaluates the influence of geometric variations on stress distribution near the impact area and energy absorption capabilities. Comparative analyses of various designs demonstrated that geometry plays a significant role in determining the material's resistance to impact, particularly in terms of dissipating the kinetic energy of projectiles. The results revealed that specific geometric configurations enhance impact absorption, providing improved ballistic resistance.

Furthermore, the forces generated during impact were analyzed to better understand the behavior of the composite materials under high-strain-rate conditions. This research highlights the critical role of geometry in optimizing the design of composite armors for effective energy dissipation and improved protection against ballistic threats. The findings offer valuable insights into developing advanced materials for enhanced performance in protective applications.

**Keywords:** Finite Element Analysis, Impact, Composite Materials

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**MAKAM-I DANYAL CAMII'NIN YENIDEN İŞLEVLENDİRİLMESİNDE CAM  
MALZEME KULLANIMINA DAİR BİR İNCELEME**

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**Özet**

Adana ve Mersin illeri arasında sınır olup, Mersin'in Tarsus ilçesine bağlı olan bölge, zengin tarihî ve kültürel mirasıyla dikkat çekmektedir. Tarsus, birçok uygarlığa ev sahipliği yapmış olması nedeniyle inanç turizmi açısından da önemli bir destinasyon haline gelmiştir. Bu bağlamda, ilçede yer alan Makam-ı Danyal Camii, tarihî ve mimari değeriyle öne çıkan bir yapı olarak karşımıza çıkmaktadır. Makam-ı Danyal Camii, Tarsus'un merkezinde, MS 350 yıllarında inşa edilmiş olan Eski Camii'nin karşısında yer almaktadır. Caminin bulunduğu alanda, Mart 2006'da Tarsus Belediyesi tarafından abdestlik oluşturma amacıyla başlatılan çalışmalar sırasında, caminin altına inen basık tonozlu kemerli bir yapı keşfedilmiştir. Bu keşfin ardından durum, Tarsus Müze Müdürlüğü'ne bildirilmiş ve 2007 yılının Şubat ayında tamamlanan kurtarma kazıları, Müze Müdürlüğü tarafından yürütülmüştür.

Bu bildirinin amacı, Makam-ı Danyal Camii'nde yapılan kazılar sonrasında yapının yeniden işlevlendirilmesinde kullanılan cam malzemelerin kullanımına ilişkin bir literatür taraması ve alan çalışması gerçekleştirmektir. Literatürde, Makam-ı Danyal Camii'nin yeniden işlevlendirilmesine yönelik yeterli kaynağın bulunmadığı gözlemlenmiştir. Bu nedenle, çalışmanın sonuçlarıyla birlikte, cam malzemenin yapıya olan uygunluğu, kullanım biçimi ve işlevi, malzemenin uygulama yöntemleri gibi başlıklar altında elde edilen veriler literatüre kazandırılacaktır. Ayrıca, tarihî yapılarda modern cam malzeme kullanımının olumlu ve olumsuz etkileri değerlendirilecektir. Bu kapsamda, Makam-ı Danyal Camii özelinde gerçekleştirilecek analizlerin, tarihî yapıların korunması ve çağdaş müdahalelerle yeniden işlevlendirilmesi süreçlerine katkı sağlaması hedeflenmektedir.

**Anahtar Kelimeler:** Makam-ı Danyal Camii, Cam malzeme kullanımı, Tarihi yapılar ve cam malzeme



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**MAKAM-I DANYAL CAMII'NIN YENIDEN İŞLEVLENDİRİLMESİNDE CAM  
MALZEME KULLANIMINA DAİR BİR İNCELEME**

**Abstract**

The region, located between the provinces of Adana and Mersin and connected to the Tarsus district of Mersin, is notable for its rich historical and cultural heritage. Tarsus, having hosted many civilizations, has also become an important destination for faith tourism. In this context, the Makam-ı Danyal Mosque stands out as a structure of significant historical and architectural value. The Makam-ı Danyal Mosque is situated in the center of Tarsus, opposite the Old Mosque, which was constructed in 350 CE. During works initiated by the Tarsus Municipality in March 2006 to create an ablution area, a low-vaulted, arched structure descending beneath the mosque was discovered. Following this discovery, the situation was reported to the Tarsus Museum Directorate, and rescue excavations, completed in February 2007, were conducted under the supervision of the Museum Directorate. This paper aims to conduct a literature review and field study regarding the use of glass materials in the adaptive reuse of the structure following the excavations at Makam-ı Danyal Mosque. The literature review indicates a lack of sufficient resources on the adaptive reuse of the mosque. Therefore, the study seeks to contribute to the literature by presenting findings on the suitability, application methods, and functionality of glass materials in the structure. Furthermore, the positive and negative impacts of using modern glass materials in historical buildings will be evaluated. Within this scope, the analyses conducted specifically for the Makam-ı Danyal Mosque aim to contribute to the processes of preserving historical structures and refunctioning them with contemporary interventions.

**Keywords:** Makam-ı Danyal Mosque, Glass material usage, Historical buildings and glass material

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**January 21-28, 2025 / Havana, CUBA**

**APPLICATION OF DATA ENVELOPMENT ANALYSIS ON INTEGRATED CROP-  
LIVESTOCK ENTERPRISES IN KADUNA, NIGERIA**

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*Target Audience: Livestock and crop farmers, extension agents, policy makers.*

**Abstract**

The study examines the best practice in integrated crop-livestock farming system in Kaduna state, Nigeria. Primary data were obtained through structured questionnaire and interview method. A multi-stage sampling procedure was used for the study where a random selection of 8 LGAs out of 23 was carried out, 48 villages purposively selected and 242 crop-livestock enterprises were randomly selected. Descriptive statistics and Data Envelopment Analysis (DEA) were used to achieve the objective of the study. Findings from the socio-economic characteristics of integrated crop-livestock farmers indicated that approximately 76% were male, with an average age of 43 years and each farmer had an average household size of 7 individuals. The DEA findings showed that the mean total efficiency, pure efficiency, and scale efficiency were 0.72, 0.89 and 0.81, respectively. Additionally, the results indicated that the enterprises could reduce the quantity of inputs such as farm size, labour, seed, fertilizer, manure, and agrochemicals by 4.8%, 15.4%, 20.8%, 10.50%, 26.7%, and 21.8%, respectively. Moreover, the results specified that 19.4%, 29.53%, and 51.1% of farmers operated at optimal, sub-optimal, and super-optimal scales, respectively. The research indicates the importance of collaboration between crop and animal scientists, extension agents, and agricultural economists. This is suggested to address the necessity for farmers to adopt integrated crop-livestock farming practices in order to attain the optimum level of efficiency.

**Keywords:** Crop-livestock, integration, farmers, efficiency, data envelope analysis (DEA).

**JEL classification code:** C14, Q12 and Q18

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**January 21-28, 2025 / Havana, CUBA**

**THE GENETIC CHARACTERIZATION OF THE MOROCCAN CAROB TREE  
(CERATONIA SILIQUA L.) USING ISSR MARKERS.**

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**Abstract**

The carob tree (*Ceratonia siliqua* L.) is a species with significant socio-economic and ecological importance. It possesses cytotoxic, antimicrobial, antioxidant, and anti-inflammatory properties, and is used in various sectors, including pharmaceuticals, cosmetics, biotechnology, textiles, food sciences, and nutrition. It is frequently found in Morocco in different bioclimatic zones, ranging from humid to desert, with a warm and temperate climate. To establish a conservation strategy for the carob tree in Morocco, the first step towards its rational exploitation is to analyze the genetic diversity of the local genetic material. In this context, 12 populations from different regions of Morocco were analyzed using 18 ISSR molecular markers. The use of appropriate statistical analysis techniques demonstrated significant genetic diversity both within (74.20%) and between (25.80%) carob populations. The mean values of PIC and Rp is 0.47 and 3.33, respectively. In addition, hierarchical AMOVA revealed very little genetic differentiation between groups of mountain range, bioclimatic and altitudinal conditions (FCT=1.4%, FCT=5% and FCT=0.1%, respectively). The results showed that the ISSR markers used are informative and effective in detecting polymorphism and characterizing the populations of this species. Furthermore, there was very little genetic differentiation between the groups of geographic, bioclimatic, and altitudinal conditions.

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The data obtained will be useful for defining conservation strategies and breeding programs for this species.

**Keywords:** *Ceratonia siliqua*, population, polymorphism, ISSR markers, Morocco.

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**January 21-28, 2025 / Havana, CUBA**

**EXTRACTION AND CHARACTERIZATION OF ORANGE PEEL ESSENTIAL OIL  
FOR FLAVOUR AND FRAGRANCE APPLICATION**

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**Abstracts**

In the past decade, nanomaterials have attracted much attention due to their physical properties and technological applications. In this work, iron oxide nanoparticles were first synthesized via a simple co-precipitation method Using Ferrous sulphate (iron (II) Sulphate) and Ferric chloride (iron (III) chloride) as precursor and ammonia solution as precipitator. The samples were then characterized by X-ray diffraction (XRD) and Scanning electron microscope and Fourier transform infrared spectroscopy (FTIR) . XRD pattern showed that the iron oxide nanoparticles exhibited Fe<sub>2</sub>O<sub>3</sub>(hematite) structure in nanocrystals. The Fe<sub>2</sub>O<sub>3</sub> nano-powders with uniform size were prepared when the samples calcined at 300 °C, and the lowest particle size was found to be 30 nm by XRD technique . The surface morphological studies from SEM depicted sphere-like shaped particles without formation of clusters by increasing annealing temperature. The EDS spectrum showed peaks of iron and oxygen free of impurity with many elements. The antibacterial activity of chemically synthesized IONPs was assessed against pathogenic bacteria of Staphylococcus aureus and Salmonella typhi, as higher antibacterial activity was observed in staphylococcus aureus (Gram positive bacteria) taking ciprofloxacin as the control. No activity detected in S.aureus at lower concentrations. By altering the concentrations, an increase of the antibacterial activity was observed in both S.aureus and salmonella typhi.

**Keywords:** Nano particles, nanomaterials, x- ray diffraction, SEM, salmonella typhi.

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**January 21-28, 2025 / Havana, CUBA**

**AUTOMATED DETECTION OF RUST IN IMAGES USING RESNET50: A DEEP  
LEARNING APPROACH**

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**Abstract**

The early and accurate detection of rust in materials is crucial for preventing structural failures and reducing maintenance costs across industries. This study proposes a deep learning-based approach to classify images as either rust or non-rust using the ResNet50 convolutional neural network (CNN). ResNet50, a deep residual network with 50 layers, is known for its ability to extract high-level features and achieve high accuracy in image classification tasks.

The model achieved high classification accuracy, precision, and recall on the test dataset, outperforming traditional image processing methods. Qualitative analysis of the Grad-CAM visualizations confirmed that the network correctly focused on rusted regions in the images. This research demonstrates the potential of using ResNet50 for automated rust detection, which could be integrated into inspection workflows for real-time monitoring and maintenance planning.

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**A BIM-GIS FRAMEWORK FOR 3D MODELING OF INFRASTRUCTURE ASSETS**

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**Abstract**

The planning, design, and management of infrastructure projects have evolved in recent years due to the integration of Geographic Information Systems (GIS) and Building Information Modeling (BIM). This paper proposes a framework for creating 3D current status models of infrastructure projects by combining BIM and GIS. The framework provides a comprehensive and accurate representation of infrastructure assets by leveraging GIS's spatial analysis capabilities and BIM's precise 3D modeling expertise. The study details the framework's development, including methods for data integration and model validation. The results demonstrate the framework's ability to enhance project planning, monitor asset conditions, and support well-informed decision-making throughout the project lifecycle. This approach establishes a strong foundation for improving infrastructure management and fostering collaboration among stakeholders.

**Keywords:** Building Information Modelling (BIM), Geographical Information System (GIS), Industry Foundation Classes (IFC), Infrastructure, Integration.

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**SPATIAL ANALYSIS OF ROAD NETWORKS FOR ENHANCED URBAN TRAFFIC  
MANAGEMENT**

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**Abstract**

Effective urban traffic management is crucial for ensuring the safety, efficiency, and sustainability of modern cities. This study leverages spatial analysis techniques applied to road networks using Geographic Information Systems (GIS) to enhance urban traffic management. The research focuses on integrating geospatial data with advanced analytical tools to assess road network performance, identify traffic congestion and accident hotspots, and develop strategies for improving traffic flow. Key methodologies include network analysis, accessibility modeling, and spatial visualization, which enable comprehensive evaluation and informed decision-making. The findings highlight the potential of GIS-based solutions to optimize urban transportation infrastructure, reduce travel times, and support sustainable urban planning initiatives. This study provides valuable insights for policymakers and urban planners to address traffic-related challenges and improve overall urban mobility.

**Keywords:** Geographical Information System (GIS), Traffic Management, Spatial Analysis, Network analysis, Road Management.



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## MODELS OF SOIL FERTILITY ELEMENTS MANAGEMENT

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### **Abstract**

The article is concerned with the theoretical principles of soil regimes system management as well as solving problems of accurate diagnostics and balanced optimization of soil fertility elements. Much attention is directed to the problem of diagnostics and optimization of fertility elements, which is solved effectively on the theoretical principles of indicators of soil buffer properties as evaluation criteria of autoregulation of their regimes (fertility factor). Soil buffer ability in relation to biogenic elements is soil ability to resist the processes of change in the concentration of these elements in soil solution (intensity factor – IF) under the influence of increasing doses of their application and, alternatively, when removing them from the soil solution. Foremost, the subjects to diagnostics are main fertility factors and elements such as parameters of their pool, dynamics, processes of mobilization and immobilization under different conditions. On the grounds of basic data, they create graphic model of optimization with the necessarily display of limits and intervals of optimal, admissible (which is preferable) and poor fertility element agro-ecological status. Optimal parameters of each biogenic element, which are an integral part of the management model, are determined experimentally both for soils differenced with buffer properties and in relation to a specific crop or group of physiologically related crops. Methods of optimal management of main soil functions include the selection and search of the most effective options of agro-technological operations, and for this purpose, first of all, plants response to the change of the fertility elements status in soil environment is used. Optimization includes the application of group of actions aimed at changing and maintaining each element of fertility constantly in plant-optimal parameters both in spatial and temporal dimensions. Models of soil fertility management based on their intensity factors, agro-ecological parameters and indicators of buffer properties, allow us to calculate doses, make effective choice of application methods and determine the duration of aftereffects of fertilizers, ameliorants and other agro-technological processes, neutralize negative effects

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on the functioning of soil systems.

**Key words:** fertility elements, diagnostics, optimization, intensity factor, potassium buffering capacity, phosphorus buffering capacity.

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**BANACH AND HILBERT SPACES IN ECONOMIC OPTIMIZATION**

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**Abstract**

Banach and Hilbert spaces are fundamental tools in functional analysis, offering a robust framework for solving complex problems in economics. These spaces facilitate the modeling of resource allocation, market equilibrium, and optimization while providing insights into system stability. Key properties of Banach spaces, such as completeness, and Hilbert spaces, such as inner product geometry, support the analysis of multidimensional economic systems. Foundational theorems like the Hahn-Banach and Spectral theorems enable precise solutions to optimization and equilibrium problems. This integration of mathematical rigor with economic challenges advances both theoretical and practical approaches in economic decision-making.

**Keywords:** Banach space, Hilbert space, economic modeling, resource allocation, market equilibrium, optimization, stability analysis.

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**January 21-28, 2025 / Havana, CUBA**

**TEACHER-STUDENT COMMUNICATION PATTERNS IN ONLINE AND IN-  
PERSON HIGH SCHOOL ENGLISH CLASSROOMS: A COMPARATIVE  
DISCOURSE ANALYSIS**

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**Abstract**

This study explores teacher-student communication patterns in online and in-person high school English classrooms, aiming to compare how these patterns impact student engagement and participation. Through a comparative discourse analysis of classroom interactions, the research investigates how communication strategies differ between the two settings and how these differences influence student involvement. Data was collected through classroom observations, video/audio recordings, and surveys of both teachers and students. The results indicate that in-person classrooms support more immediate and dynamic communication, characterized by verbal and non-verbal interactions, fostering higher levels of engagement and participation. In contrast, online classrooms, while providing flexibility, often lead to delayed feedback and limited non-verbal communication, which affects the immediacy and interactivity of teacher-student exchanges. The study concludes that adapting communication strategies to the specific demands of each setting is essential for enhancing student participation and engagement. The findings contribute to the understanding of teacher-student communication in diverse learning environments and offer practical implications for optimizing communication in both traditional and online classrooms.

**Key words:** Teacher-Student Communication, Online Classrooms, In-person Classrooms, High School English Classrooms, Discourse Analysis

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**January 21-28, 2025 / Havana, CUBA**

**THE EFFECTIVENESS OF SPONTANEOUS FEEDBACK ON THE SPEAKING  
SKILLS OF SECONDARY SCHOOL STUDENTS**

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**Abstract**

This study investigates the effectiveness of spontaneous feedback on the speaking skills of secondary school students. The research employs a pre-test and post-test design to assess the impact of immediate corrective feedback during speaking activities, such as oral presentations and role-plays. A total of 60 grade nine students from Sadra School in Ahvaz, Iran, were randomly assigned to an experimental group receiving spontaneous feedback and a control group without treatment. The findings indicate that spontaneous feedback significantly enhances students' speaking skills, including pronunciation, vocabulary, and fluency, by allowing for quick corrections of errors and fostering an interactive learning environment. Additionally, qualitative analysis reveals positive attitudes among participants towards the use of spontaneous feedback, highlighting its role in experiential learning and the reconstruction of language use in real-world contexts. The study concludes that incorporating spontaneous feedback into English as a Foreign Language (EFL) lessons can effectively support the development of students' speaking abilities and prevent the fossilization of errors.

**Keywords:** Spontaneous feedback, Speaking skills, Secondary School, Error Correction

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**EFFICIENT REMOVAL OF DYES FROM REAL TEXTILE WASTEWATER USING  
PISTACIA LENTISCUS MATERIAL AS A SUITABLE BIO-ADSORBENT**

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**Abstract**

The global issue of water contamination underscores the urgent need for environmentally sustainable treatment methods [1]. This study investigates the use of natural Moroccan resources as effective bio-adsorbents for removing textile dyes, including crystal violet, from industrial effluents [2]. The bio-adsorbents were characterized using SEM/EDX and FT-IR techniques.

Under optimized conditions (pH 7.1, 30 mg of adsorbent, 80  $\mu\text{m}$  particle size), the adsorption process achieved a removal efficiency of 98.25% for crystal violet within 60 minutes. The adsorption followed pseudo-second-order kinetic and Freundlich isotherm models, with a maximum capacity of 93.03  $\text{mg.g}^{-1}$  at 25 °C. The process, governed by physisorption, was spontaneous and endothermic, driven by electrostatic interactions,  $\pi$ - $\pi$  stacking, and hydrogen bonding.

This research underscores the potential of *Pistacia lentiscus* leaves as an affordable and sustainable solution for treating dye-contaminated industrial wastewater, supporting global efforts to reduce environmental pollution.

**Keyword:** *Pistacia lentiscus*, Bio-adsorbent, Biomass, Crystal violet, Textile dyes, Freundlich

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model.

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**MEDIA LITERACY, POPULAR CULTURE AND NATIONAL DEVELOPMENT:  
AN EXPLORATION OF INTERSECTION**

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**Abstract**

It is a common place that culture is influenced and promoted by the media and technology as well as individual creations. Thus, this paper explores the concepts of culture, popular culture which is the culture that appeals or a culture that is easily accepted and digested by the general public. Also, the concept of media literacy was examined in view to establish the fact that it can be a good umpire in the face of rapid production and dissemination of popular culture while both concepts in the long run are building blocks for national development. Popular culture and media literacy are close and intertwined in relation to national development. Strictly speaking, popular culture and media literacy are integral parts of national development. While popular culture provides avenues for international relations, shapes individual and national identity, drives economic growth and fosters innovation; media literacy on the other hand empowers citizens to critically evaluate the media and their contents in a way to contribute to the socio-economic landscape of the nation.

**Key Words:** Popular culture, Media Literacy, National Development & Intersection



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**THEORETICAL INVESTIGATION OF NEW ORGANIC ELECTRON DONOR  
MOLECULES FOR HIGH PERFORMANCE DYE SOLAR CELLS IN THE FIELD  
OF GREEN CHEMISTRY**

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**Abstract**

The development of advanced photovoltaic technologies is extremely promising for industrial and academic applications due to their potential to generate electricity directly from sunlight, in this way contributing to green energy solutions. This research focuses on the creation and computational analysis of novel organic electron-donor molecules for organic photovoltaic cells, using time-dependent density functional theory (TD-DFT) and density functional theory (DFT) with B3LYP. We have investigated the structure, optics, electronics, reorganization energy and photovoltaic characteristics of several new molecules (MC28, MC20, MZ173, MZ175, MK162). Our study focused on global reactivity descriptors, density of states, molecular electrostatic potential (MEP), charge mobility and optical properties. Furthermore, using molecular modeling, we have identified suitable materials for the efficient assembly of dye-sensitized solar cells, particularly for green chemistry applications. By predicting the molecular electrostatic potential, boundary molecular orbitals, global reactivity descriptors and optical characteristics of the designed molecules, machine learning models provided essential information on the choice of optimal parameters for the design of substrate, dye sensitizer, semiconductor, electrolyte and catalyst. Our results suggest that all designed molecules exhibit low band gaps and excellent optical properties, paving the way for the fabrication of highly efficient dye-sensitized solar cells without the need for extensive laboratory experiments [1,2].

**Keywords:** Photovoltaics, TD-DFT, organic molecules, dye-sensitized solar cells, green chemistry, electron donor, charge mobility, green energy, agriculture.

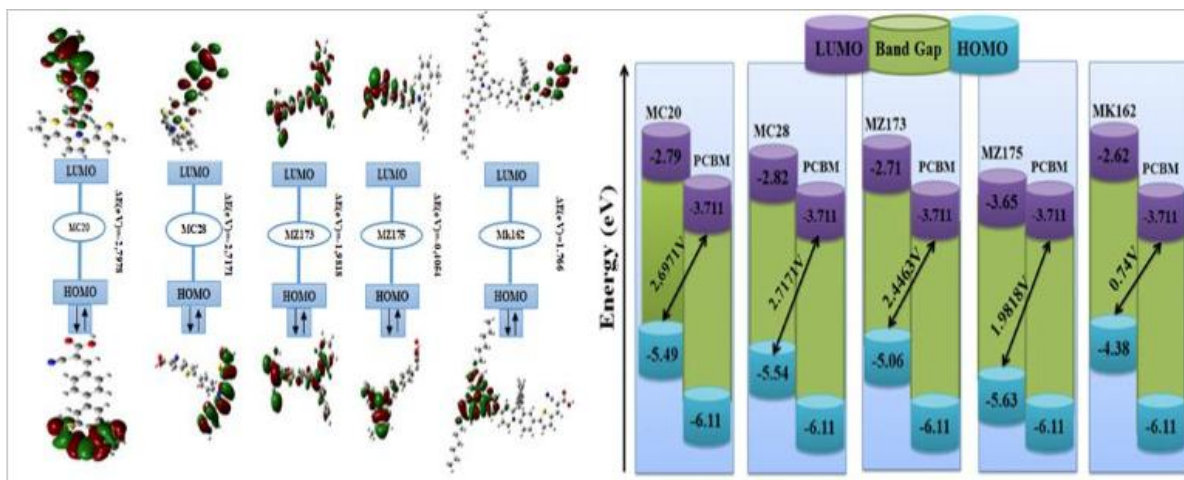


Fig. 1. The contour curves of the HOMO and LUMO orbitals of the investigated molecules.

Fig.2. Study of the open circuit voltage (Voc) of the studied donor molecules in solar cells

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**AWARENESS OF UNIVERSITY SCIENCE PRE-SERVICE TEACHERS TOWARDS  
ARTIFICIAL INTELLIGENCE CHATBOTS FOR LEARNING IN MINNA, NIGER  
STATE**

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**Abstract**

The study is to examine awareness of university science pre-service teachers towards artificial intelligence chatbots for learning in Minna, Niger state. The objectives were to determine the awareness level of university science pre-service teachers towards artificial intelligence chatbots for learning and determine the gender difference in university science pre-service teachers' awareness towards artificial intelligence chatbots for learning. The study was guided by two research questions and one hypotheses were formulated to guide the study. The research adopted the descriptive survey research. Population of the study comprise of 197 final year students from science education and educational technology. One hundred and twenty-seven (127) questionnaires were distributed base on Krejce and Morgan (1970) sample size determination. Data collected was analyzed using descriptive and inferential statistics. From the findings, pre-service teachers had high awareness. Analysis revealed that the male pre-service science teachers have a higher mean rank of 68.13 compared to the female pre-service school teachers having 55.93. The result found awareness among male and female pre-service science teachers was statistically not significant ( $U = 1459.000, p = .076$ ). Provide students with information about the benefits, functionalities, and ethical considerations associated with AI chatbot technologies, Integrate AI chatbots into the curriculum to expose students to their capabilities and encourage their usage and Ensure that students have access to clear and concise information about AI chatbots, including how they work, their limitations, and the data privacy measures in place.

**Keyword:** Artificial Intelligence Chatbots, Awareness, Accessibility & Pre-service Science Teachers

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**DOUBLE PEROVSKITES: MULTIFUNCTIONAL MATERIALS FOR  
SUSTAINABLE ENERGY AND ADVANCED TECHNOLOGIES THROUGH THEIR  
THERMAL AND ELECTRICAL PROPERTIES**

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**Abstract**

Double perovskites have emerged as a promising class of multifunctional materials due to their exceptional thermal and electrical properties. These materials are gaining increasing attention for their potential applications in diverse fields, ranging from solar energy systems to advanced electronic devices.

This study focuses on the pivotal role of double perovskites in enhancing the performance of energy systems, with particular emphasis on their application in solar panels. We investigate their optoelectronic and thermal properties, which enable improved energy conversion efficiency and optimized thermal management. Additionally, we delve into the fundamental mechanisms underlying their performance, including crystal structure engineering and bandgap tuning.

Our findings highlight the potential of double perovskites to surpass the limitations of conventional materials, paving the way for a new generation of high-performance, sustainable technologies. These advancements offer significant opportunities for the development of innovative energy and electronic devices.

**Keywords:** Double Perovskites; Thermal and Electrical Properties; Energy Conversion Efficiency; Multifunctional Materials.

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**IMPACT OF SILVER DOPING ON TITANIUM DIOXIDE NANOPOWDERS  
SYNTHESIZED BY THE CLASSICAL SOL-GEL METHOD (TiO<sub>2</sub>-C) AND  
BIOPOLYMER-BASED METHOD (TiO<sub>2</sub>-BP)**

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**Abstract**

This study examines the impact of synthesizing titanium dioxide (TiO<sub>2</sub>) via the sol-gel method, comparing the classical route (denoted TiO<sub>2</sub>-C) and the route using a biopolymer (denoted TiO<sub>2</sub>-BP), with the aim of producing a material with hierarchical porosity. Sodium alginate, a biopolymer extracted in the laboratory, was used as a surfactant. The synthesized materials were then modified by the incorporation of transition metals, notably silver (Ag<sup>+</sup>). The resulting gels were calcined at 500 °C to obtain the desired nanopowders. The characterization of Ag-TiO<sub>2</sub>-BP and Ag-TiO<sub>2</sub>-C nanopowders was performed using X-ray diffraction (XRD), ultraviolet-visible (UV-Vis) spectroscopy, Fourier-transform infrared (FTIR) spectroscopy, and Raman spectroscopy. The results show that all the nanopowders exhibit peaks corresponding to the anatase structure, with an average grain size ranging from 22 nm to 13 nm. The band gap energy varies between 3.2 eV and 1.5 eV depending on the Ag concentration. The FTIR spectra revealed characteristic peaks of TiO<sub>2</sub>, particularly the Ti-O-Ti metal bond, present in all the samples. These samples were then tested in the isopropanol decomposition reaction and evaluated for the adsorption of a cationic dye (BM).

**Keywords:** Nanoparticles, surfactant, Biopolymer, Mesoporous Materials, TiO<sub>2</sub>-C, TiO<sub>2</sub>-BP.

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**BRIDGING THE GAP: THE ROLE OF YOUTH-LED INITIATIVES IN POVERTY  
ALLEVIATION AND GENDER INEQUALITY REDUCTION IN PAKISTAN**

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**Abstract**

Youth in Pakistan are increasingly mobilizing to address social issues, particularly poverty and gender inequality. This research explores youth-led initiatives that aim to alleviate poverty and combat gender disparities, focusing on the effectiveness, scope, and impact of these programs in both rural and urban areas. By analyzing case studies of prominent youth organizations, the study highlights innovative strategies, such as microfinance programs, gender-sensitive education, and advocacy campaigns, used to empower communities and promote sustainable development. The findings will underscore the importance of empowering young leaders in fostering social change and reducing structural inequalities. The research aims to inform policy-makers and stakeholders about the potential of youth-driven solutions to address critical social challenges, contributing to a more inclusive and equitable society.

**Keywords:** Youth Empowerment, Poverty Alleviation, Gender Inequality, Social Change, Pakistan

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**UTILIZATION OF HEALTH SERVICES BY RURAL WOMEN IN DISTRICT  
MANSEHRA: CHALLENGES, ACCESSIBILITY, AND IMPACT ON MATERNAL  
HEALTH**

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**Abstract**

Rural health services play a crucial role in providing basic and maternal healthcare to rural women in Pakistan, where access to quality health services remains a challenge. This study examines the utilization of rural health centers by women in District Mansehra, focusing on the accessibility, availability, and effectiveness of maternal health services. Using qualitative and quantitative methods, the research aims to assess the challenges rural women face, including limited transportation, cultural barriers, and shortage of trained health personnel. Findings will highlight gaps in the current healthcare system and suggest strategies to improve health service delivery and maternal outcomes. By examining healthcare utilization patterns and barriers, the study offers insights into designing policies that ensure equitable access to healthcare for rural women, thereby contributing to gender equality and improved maternal health in underserved regions of Pakistan.

**Keywords:** Rural Health Services, Maternal Health, Accessibility, Gender Equality, Pakistan

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**ADSORPTION PROPERTIES OF CATIONIC DYES IN WATER BY SHEEP  
MANURE BIOCHAR**

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**Abstract**

The study explores the adsorption of methylene blue (MB) and crystal violet (CV) from aqueous solutions using biochar derived from sheep manure, prepared at 300°C. Characterization of the biochar was performed using SEM, XRD, pH<sub>pzc</sub>, DTA/TGA, and FTIR techniques. The biochar, sourced from Moroccan sheep manure (SM), demonstrated high efficiency in removing MB and CV from water. Under optimal conditions, the removal efficiencies were 96.77% for MB and 98.95% for CV, with maximum adsorption capacities of 244.08 mg/g and 295.14 mg/g, respectively. The experiments were conducted at a pH of 11, with an adsorbent dose of 0.5 g/L, a particle size of 40 µm, a contact time of 120 minutes, and a temperature of 25°C. These conditions facilitated strong interactions between the biochar surface and the dye molecules. The adsorption behavior followed the Freundlich isotherm model, indicating a heterogeneous distribution of adsorption sites on the biochar. Kinetic analysis showed that the pseudo-second-order model accurately described the process, suggesting chemisorption as the primary mechanism. Thermodynamic studies revealed that the adsorption process was spontaneous and endothermic, with enthalpy changes ( $\Delta H^\circ$ ) of 34.33 kJ/mol for MB and 31.33 kJ/mol for CV, indicating a combination of physical and chemical adsorption mechanisms. The adsorption process was driven by electrostatic interactions,  $\pi$ - $\pi$  stacking, n- $\pi$  interactions, and hydrogen bonding. Reusability tests confirmed the biochar's stability and efficiency over five regeneration cycles, highlighting its economic viability and sustainability. These findings highlight the potential of SMB<sub>300</sub> as a cost-effective and efficient



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adsorbent for removing cationic dyes, offering a promising solution for wastewater treatment applications.

**Keywords:** Crystal violet; Cationic dyes; Sheep manure biochar; methylene blue.

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**IMPACT OF DATA VISUALIZATION ON SPORTS PERFORMANCE AT SCHOOL  
AGE**

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Sports University of Tirana

**Abstract**

**Introduction**

The impact of data visualization on school-age athletic performance is a growing area of interest, especially as educational institutions increasingly use technology to enhance athletic training. The use of data visualization technology enables coaches or teachers and athletes to interpret complex performance metrics intuitively, facilitating informed decision-making. The purpose of this study is to explore how data visualization can improve training regimens and performance outcomes in school-age athletes. The use of visual tools allows coaches to more clearly communicate their strategies and responses, thereby creating an environment that fosters student development in analyzing athletic performance. Data visualization provides a comprehensive graphical representation that documents the history of a student's progress from baseline to current performance. Furthermore, this research demonstrates the relationship between visual data interpretation skills and athletic performance in school-age children. Ultimately, the goal is to create a framework for effectively integrating data visualization into sports programs for this age group.

**Methodology**

This study is based on a review of existing literature, academic journals, government reports and various publications. This study is based on a review of existing literature by collecting data from international databases such as Google Scholar, Web of Science, Research Gate, Scopus, and JSTOR etc. In addition, concrete examples of the use of data visualization in well-known educational and sports platforms have been analyzed and compared. In addition, case studies have been included to identify the effectiveness of data visualization in physical education and their impact on the development of sports skills of school-age students. The study aims to derive practical recommendations for improving sports performance through technology and data visualization, based on content analysis and findings extracted from existing sources.

**Results**

Preliminary findings indicate that athletes who utilized data visualization tools showed a significant improvement in performance metrics compared to those who did not. Specifically, participants demonstrated enhanced speed and agility scores, with an average increase of 15%

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in sprint times post-intervention. Coaches reported increased engagement during training sessions when visual aids were employed, noting that athletes were more likely to ask questions and seek clarification on strategies. Furthermore, qualitative feedback highlighted that athletes felt more confident in their abilities after visualizing their progress over time. The study also revealed that younger athletes benefited more from visual aids than older peers, suggesting a developmental aspect to data interpretation skills. Overall, the results underscore the potential of data visualization as a transformative tool in youth sports training.

### Conclusions

The integration of data visualization techniques into youth sports training has shown promising results in enhancing athletic performance among school-aged children. This study confirms that effective visual communication of performance metrics can lead to improved understanding and execution of training strategies. Coaches who adopt these tools can foster greater athlete engagement and motivation, ultimately contributing to better outcomes in sports performance. However, it is essential to consider individual differences in age and cognitive development when implementing these techniques. Future research should explore long-term effects of data visualization on athlete development and performance sustainability. The findings advocate for broader adoption of technological aids in educational sports programs to optimize training effectiveness.

**Keywords:** Data Visualization, Sports Performance, Youth Athletes, Training Techniques, Performance Metrics, Educational Sports Programs

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**VALORIZATION OF DIVERSE WASTE-DERIVED NANOCELLULOSE FOR  
MULTIFACETED APPLICATIONS: A REVIEW**

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**Abstract**

The study underscores the urgent need for sustainable waste management by focusing on circular economy principles, government regulations, and public awareness to combat ecological threats, pollution, and climate change effects. It explores extracting nanocellulose from waste streams such as textile, paper, agricultural matter, wood, animal, and food waste, providing a detailed process framework. The emphasis is on waste-derived nanocellulose as a promising material for eco-friendly products. The research evaluates the primary mechanical and thermal properties of nanocellulose from various waste sources. For instance, cotton-derived nanocellulose has a modulus of 2.04–2.71 GPa, making it flexible for lightweight applications. Most waste-derived nanocelluloses have densities between 1550 and 1650 kg/m<sup>3</sup>, offering strong, lightweight packaging support while enhancing biodegradability and moisture control. Crystallinity influences material usage: high crystallinity is ideal for packaging (e.g., softwood, hardwood), while low crystallinity suits textiles (e.g., cotton, bamboo). Nanocelluloses exhibit excellent thermal stability above 200 °C, useful for flame-retardant coatings, insulation, and polymer reinforcement. The research provides a comprehensive guide for selecting nanocellulose materials, highlighting their potential across industries like packaging, biomedical, textiles, apparel, and electronics, promoting sustainable innovation and a more eco-conscious future.

**Keywords:** Nanocellulose, Waste materials, Circular economy, Sustainable application

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**January 21-28, 2025 / Havana, CUBA**

**QUALITY EVALUATION OF RAW SOYA SEED OIL EXTRACT AND  
CORRESPONDING COMMERCIAL BRANDS**

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**R. B. Salau**

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Nigeria

**Abstract**

This study evaluated the physical and chemical quality parameters and cholesterol content of raw soya seed oil extract and branded soya oil. Twelve samples, including raw soya seed oil extract and commercial oil brands, were collected from major markets in Minna. Physicochemical properties were determined using AOAC methods. The results showed that the raw soya seed oil extract had lower moisture content ( $0.13 \pm 0.01\%$ ) and higher specific gravity ( $0.91 \pm 0.00 \text{ gcm}^{-3}$ ) compared to some branded samples. The raw oil extract was also more viscous ( $64.00 \pm 1.15 \text{ mm}^2/\text{s}$ ) due to the saturation of triglyceride chains and polymerization. Branded samples had higher acid values, indicating increased free fatty acid content. The raw oil extract had a higher cholesterol level ( $1.10 \pm 0.06 \text{ mg/kg}$ ) due to its saturated fat content. The study revealed significant differences in physicochemical properties and cholesterol content between raw and branded soya seed oil. These findings have implications for the quality control and nutritional labeling of edible oils. The results of this study can inform consumers, manufacturers, and regulatory agencies about the importance of monitoring the quality and nutritional content of edible oils.

**Keywords:** Soyabean oil, physiochemical properties, quality control, unbranded and branded edible oil.

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**January 21-28, 2025 / Havana, CUBA**

**CHINUA ACHEBE: THE NOVELIST AS CRITIC AND EDITOR**

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**Abstract**

Chinua Achebe is widely recognized as a foundational figure in modern African literature, particularly for his novels that delve into the complexities of pre- and post-colonial African experiences and explore the intersections of African life and modernity in independent Nigeria. However, his influence extends far beyond his novels as his contributions as an editor and critic have significantly shaped literary criticism and the global perception of African literature. Achebe's dual role as a novelist and the pioneering editor of the Heinemann African Writers Series, as well as the founding editor of the literary journal *Okike*, underscores his multifaceted impact on the literary world. While much scholarly attention has focused on his fiction, Achebe's editorial and critical work demands deeper examination due to its profound and enduring influence on world literature. The prominence of African writing on the global stage is largely attributable to his efforts to create a platform for African voices through both his editorial leadership and his critical essays. This paper examines Achebe's editorial work and his essays in *Morning Yet on Creation Day* and *Hopes and Impediments*, which collectively illuminate the struggles of African writers to be heard, the role of literature in post-colonial Africa, and the potential of literature to drive social and cultural transformation.

**Keywords:** Chinua Achebe, African literary criticism, post-colonial Africa, critical essays.

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**January 21-28, 2025 / Havana, CUBA**

**IMPACT OF WINTER SEEDING ON YIELD AND YIELD COMPONENTS IN  
CHICKPEA GENOTYPES**

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**Abstract**

Biodiversity and environmental sustainability play crucial roles in evaluating the thermal stress response of chickpea genotypes. A trial was conducted using a split-plot, randomized block design with three replications, two planting dates (10th October and 10th November), and 11 chickpea genotypes. The planting dates were assigned to the main plots, while the genotypes were assigned to the subplots. Measurements were taken for ecophysiological leaf characteristics (EC leaf), yield components, including the number of pods, seeds per pod, and seed weight. Analysis of variance revealed significant effects of planting dates on the number of pods, seed weight, and yield, with a notable influence on EC leaf. However, the number of nodules per plant and seeds per pod showed no significant differences. The genotype had a significant impact ( $p < 0.01$ ) on plant number, EC leaf, pods per plant, seeds per pod, seed weight, and overall yield. The highest yielding genotypes were identified, with Flip 82-150 exhibiting superior cold tolerance and overall performance compared to other genotypes, particularly in the second planting date. The GZ cultivar also demonstrated favorable results in late-season sowing.

**Keywords:** Biodiversity, environmental sustainability, chickpea genotypes, thermal stress, planting dates, yield components.

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**January 21-28, 2025 / Havana, CUBA**

**ENHANCING SEED GERMINATION IN CAPPARIS SPINOSA THROUGH  
PRECHILLING, SCARIFICATION, AND HORMONAL TREATMENTS**

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**Abstract**

*Capparis spinosa*, commonly known as Kavar or Kabar in Iran, has significant medicinal applications. However, its propagation via seeds is challenging due to both physical and chemical dormancy. This study aimed to evaluate the effects of various pre-treatments on the germination of *C. spinosa* seeds using a completely randomized design with three replications. The treatments included: (a) soaking in water for 4 hours followed by prechilling at 4°C for 24 hours, (b) acid scarification with 37% HCl for 6 hours followed by gibberellic acid (GA<sub>3</sub>) treatment at 250 ppm for 1 hour, (c) acid scarification with 98% H<sub>2</sub>SO<sub>4</sub> for 1 hour followed by GA<sub>3</sub> treatment, and (d) prechilling at -10°C for 7 days followed by GA<sub>3</sub> treatment. Germination percentage (GP), mean germination time (MGT), and germination rate index (RI) were assessed. Analysis of variance and Duncan's mean comparison revealed that the highest germination percentage (73%) was observed in treatment (d) (prechilling at -10°C for 7 days + GA<sub>3</sub>), whereas the lowest (51%) was recorded in treatment (a) (soaking in water + prechilling at 4°C). The longest MGT (8.4 days) was associated with treatment (b), while the shortest (7.21 days) was recorded in treatment (d). The highest RI was achieved in treatment (d), while treatment (a) had the lowest RI (3.64). These findings suggest that prechilling combined with plant growth regulators, particularly GA<sub>3</sub>, is effective in overcoming seed dormancy in *C. spinosa*, improving germination rates, and accelerating seedling establishment.

**Keywords:** *Capparis spinosa*, seed dormancy, germination enhancement, prechilling, scarification, gibberellic acid



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**January 21-28, 2025 / Havana, CUBA**

**DETERMINING THE CRITICAL PERIOD FOR WEED COMPETITION IN CORN  
PRODUCTION**

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**Abstract**

This study aimed to determine the critical period for effective weed control in corn by conducting an experiment using a randomized complete block design with four replications. The experiment included eight treatments, consisting of plots that were either weeded or left unweeded throughout the growing season. Each plot consisted of four rows spaced 75 cm apart and 4 meters in length. The dominant weed species observed were wheat, mallow, vetch, and amaranth. The results indicated that the most critical period for weed control occurred during the third, fourth, and fifth weeks after planting, corresponding to 30, 35, and 40 days post-planting, respectively. Prolonged weed competition led to an increase in the total dry weight of weeds and a corresponding reduction in corn yield. Conversely, extending the duration of weed control reduced the total dry weight of weeds and improved corn yield.

**Keywords:** Corn, Weed Competition, Critical Period, Yield, Weed Management

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MULTIDISCIPLINARY SCIENTIFIC STUDIES**

**January 21-28, 2025 / Havana, CUBA**

**EFFICIENCY OF NITROGEN FIXATION IN LEGUMES USING PESTICIDES**

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**Abstract**

Nitrogen (N<sub>2</sub>) constitutes the largest proportion of atmospheric gases, and despite its crucial role in enzymes, proteins, energy transporters, and other biological processes, its utilization is restricted primarily to specific bacteria. Biological Nitrogen Fixation (BNF) is the predominant method for assimilating atmospheric nitrogen, with Rhizobium, a symbiotic bacterium in legume crops, playing a key role in this process. However, the excessive and irrational use of agricultural pesticides adversely affects the efficiency of these nitrogen-fixing bacteria. The negative impact of pesticides varies across types, with herbicides, insecticides, and fungicides showing decreasing levels of inhibition. Elevated pesticide doses inhibit bacterial activity, thereby reducing the total biomass and yield of legume crops.

**Keywords:** Nitrogen Fixation, Efficiency, Legumes, Pesticides, Biological Nitrogen Fixation

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**January 21-28, 2025 / Havana, CUBA**

**EVALUATION OF PRIMARY TRITIPYRUM (*TRITICUM DURUM* × *THINOPYRUM  
BESSARABICUM*) AMPHIPLOID LINES ADAPTATION IN VAN-SARAY  
CONDITIONS, TÜRKIYE**

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**Abstract**

Transchromosomal Primary Tritipyrum is a hybrid derived from crossing durum wheat (*Triticum durum*) with *Thinopyrum bessarabicum*, a wild halophyte known for its high salt tolerance. When further crossed with bread wheat (*Triticum aestivum*), it results in Transchromosomal Secondary Tritipyrum. Due to their superior tolerance to environmental stresses compared to conventional wheat, Tritipyrum lines have gained increasing attention. This study evaluated 14 Primary Tritipyrum lines, along with 2 triticale and 4 bread wheat varieties, under the ecological conditions of Van-Saray, Türkiye. The experiment was conducted using a randomized complete block design with three replications. Several agronomic traits were assessed, including spike emergence and maturity duration, plant height, number of spikes per square meter, grain yield, thousand-grain weight, stem and spike length, spike yield, biological yield, and harvest index. The results revealed significant variation among the Tritipyrum lines: spike emergence ranged from 86 to 121 days, maturity duration from 37 to 50 days, plant height from 47 to 94 cm, number of spikes per square meter from 161 to 518, grain yield from 627 to 2,208 kg/ha, thousand-grain weight from 26 to 40.5 grams, stem length from 41 to 82 cm, spike length from 5 to 13 cm, and spike yield from 71.6 to 315.8 grams/m<sup>2</sup>.

**Keywords:** Primary tritipyrum, *Thinopyrum bessarabicum*, Transchromosomal, Triticale, Wheat, Yield, Yield components

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**January 21-28, 2025 / Havana, CUBA**

**KARYOLOGICAL EVALUATION OF NATURAL TRANSCROMOSOMAL  
PRIMARY TRITIPYRUM (*TRITICUM DURUM* × *THINOPYRUM BESSARABICUM*)  
AMPHIPLOID LINES UNDER VAN-SARAY CONDITIONS, TÜRKIYE**

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**Abstract:**

Cereals play a fundamental role in human and animal nutrition by providing essential proteins and carbohydrates. Wheat (*Triticum aestivum*), which originated through hybridization, was first cultivated in Southeastern Anatolia. However, climate change has led to a decline in genetic diversity, highlighting the need for new genetic resources. Triticale, a wheat-rye hybrid, is valued for its resilience and high yield. Tritordeum, a cross between wheat and barley, was commercially introduced in 1996. Tritipyrum, developed from durum wheat and salt-tolerant grass, shows great potential for cultivation in saline soils. In the Van region, various stress factors, including cold, drought, and salinity, significantly impact crop yields, resulting in suboptimal production outcomes for local farmers. This study aims to assess the karyological characteristics of 14 primary Tritipyrum lines cultivated under Van-Saray conditions, focusing on chromosome number, chromosome length, and chromosomal abnormalities. This evaluation may provide valuable insights into Tritipyrum's potential as an alternative crop suited to Türkiye's stress-prone environments. In mitotic metaphase engineering studies, identifying the most appropriate stage for determining euploid or aneuploid chromosome numbers is crucial. Karyological analysis revealed that all Tritipyrum lines possessed 42 chromosomes, with no abnormalities in chromosome number or structure. Chromosome length ranged from 7.22 µm (Tritipyrum 9) to 17.01 µm (Tritipyrum 5). These findings for adaptation of this new cereal, suggest that Tritipyrum could serve as a viable genetic resource for enhancing cereal production in challenging environmental conditions.

**Keywords:** Tritipyrum, Karyological Analysis, Chromosome Characteristics, Abiotic Stress Genetic Resources.

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**INVESTIGATION THE EFFECT OF USING COMBINATION OF BIO-ORGANIC  
AND CHEMICAL FERTILIZERS ON BIOLOGICAL YIELD AND YIELD  
COMPONENT OF SUNFLOWER**

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PhD Graduated, Department of Soil Science and Plant Nutrition, Faculty of Agriculture,  
Ege University, Turkey  
\*Corresponding author

**Abstract**

Sunflower (*Helianthus annuus* L.) is a vital oilseed crop, and optimizing its nutrient management can enhance yield and quality. This study investigated the effects of bio-organic and chemical fertilizers on the biological yield and yield components of two sunflower cultivars, Sunbred-262 and Albero. A field experiment was conducted using a randomized complete block design with four replications and eight fertilizer treatments, including chemical, organic, and combined applications. The results indicated a significant interaction between fertilizer treatments and cultivars, showing that the effectiveness of fertilizers depended on the cultivar. In Sunbred-262, fertilizers containing nitrogen, phosphorus, potassium, zinc, magnesium, and iron significantly reduced mean head diameter, seed weight, and seed yield per plant. However, the effect of chemical and organic fertilizers mixed with soil on seed yield and yield components in Albero was not significant. Micronutrient application notably increased seed yield and oil content in Sunbred-262. The highest yield was observed in plots treated with a combination of chemical fertilizers, manure, and micronutrients, suggesting that a balanced fertilization strategy can enhance sunflower productivity. Overall, the findings highlight that different fertilizer treatments have statistically significant effects on most agronomic traits. These findings emphasize the importance of site-specific nutrient management and cultivar selection for optimal sunflower performance. Further research is needed to refine fertilization strategies tailored to regional soil and climatic conditions.

**Keywords:** Sunflower, Chemical fertilizer, Bio-organic fertilizer, Seed yield, Micronutrients

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**January 21-28, 2025 / Havana, CUBA**

**IMPACT OF BIOFERTILIZERS AND GROWTH ENHANCERS ON YIELD TRAITS  
OF SAFFLOWER**

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**Abstract:**

Safflower (*Carthamus tinctorius* L.) is an oilseed crop with increasing industrial and agricultural significance. This study examines the effects of biofertilizers and growth enhancers on safflower yield traits, including seed number, boll number, seed weight, and oil yield. A field experiment was conducted using a split-plot randomized complete block design with three replications, testing five growth stimulants: Stimorl, Flamina, Rizamina, and Farce. Results showed that biofertilizers had significant effects on plant growth, with Flamina-treated plants producing the highest seed count (518.9 seeds per plant) compared to the control (244.3 seeds per plant). Growth stimulants also significantly increased boll number and seed weight, with the highest boll number (20.09) and seed weight (53.19 g) recorded in Rizamina and Flamina-treated plants, respectively. The highest grain yield (3,191 kg/ha) was observed in the Flamina-treated plants, whereas the lowest yield (1,366 kg/ha) was recorded in the control treatment. Also, the highest average oil yield (1,097 kg/ha) observed in the Flamina-treated plants, while the lowest (459.7 kg/ha) was recorded in the control treatment. The application of nitrogen and foliar growth stimulants played a critical role in increasing boll number per plant, supporting previous findings on their role in enhancing safflower productivity. Overall, the study demonstrates that biofertilizers and growth enhancers especially Rizamina and Flamina can significantly improve safflower yield traits, highlighting their potential in sustainable agriculture. Further research is recommended to optimize their application rates and combinations for different environmental conditions.

**Keywords:** Safflower, Biofertilizer, Growth enhancers, Yield traits, Sustainable agriculture

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January 21-28, 2025 / Havana, CUBA

ON THE INDEX DIVISORS OF CERTAIN NUMBER FIELDS OF DEGREE TEN  
DEFINED BY  $x^{10} + ax^m + b$

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Sidi Mohamed Ben Abdellah University, Graduate Normal School of Fez, Department of  
Mathematics and Computer Science, Fez-Morocco

**Abstract**

In this presentation, for any number field  $K$  generated by a root  $\alpha$  of a monic irreducible trinomial  $F(x) = x^{10} + ax^m + b \in \mathbf{Z}[x]$ , where  $1 \leq m \leq 9$  and for every rational prime  $p$ , we give sufficient conditions which guarantee that  $p$  divides the index of  $K$ . We also calculate  $v_p(i(K))$  in each case. For  $m = 1$ , we show that the index of  $K$  is either 1 or a power of 3 for every integers  $(a, b) \in \mathbf{Z}^2$ , and we characterize when 3 divides  $i(K)$ . As an application of our results, if  $i(K) \neq 1$ , then  $K$  is not monogenic.

**Keywords:** Theorem of Ore, Prime ideal factorization, Newton polygon, Index of a number field, Monogenic.

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**January 21-28, 2025 / Havana, CUBA**

**FEATURE EXTRACTION AND ANALYSIS TECHNIQUES FOR HUMAN MOTION  
UNDERSTANDING IN IMAGES AND VIDEOS**

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**Abstract**

The analysis of human motion from images and videos has emerged as a crucial area of research, with applications spanning biomechanics, surveillance, human-computer interaction, and sports science. This paper focuses on the extraction and analysis of relevant features to interpret and quantify human motion. By leveraging state-of-the-art techniques in computer vision, such as deep learning-based pose estimation, spatiotemporal feature extraction, and optical flow analysis, we aim to establish robust methodologies for motion analysis. Our approach integrates key feature detection and motion trajectory modeling to enhance accuracy and efficiency in recognizing complex human activities. Experimental results demonstrate the effectiveness of the proposed methods in real-world scenarios, paving the way for advancements in motion analysis technologies and their practical applications in diverse fields.

**Keywords:** Human Motion Analysis, Feature Extraction, Pose Estimation, Computer Vision, Video Analysis.



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**January 21-28, 2025 / Havana, CUBA**

**EXPORT NUMERATION ON GROUNDNUT CAKE BISCUITS (KULI-KULI) IN  
BIDA**

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**Abstract**

Bida is a local government area in Niger state, Nigeria and a city on the A124 highway which occupies most of the area. A Peanut/groundnut cake which has many English names but popularly known and called “Kuli-Kuli” is eaten all over West Africa. Groundnut cake is a popular Nigeria snack made from crushed peanuts. It’s made by various ethnic groups including Nupe people of Nigeria and Dagbon of Ghana. It is often eaten alone or with a mixture of garri also known as cassava flakes added with sugar and water popularly called “garri soakin” often eaten with Hausa koko, fura and kamu, and is sometimes grinded and put into salad. Pounded groundnut cake is also used for suya and kilishi. The study finds out export numeration and expenditures covered in production of groundnut cake in Bida. It health benefit contain vitamins like vitamin A, E, C B6, B12 and others helping the body system in fighting against diseases and boost immune. Daily productions of kuli-kuli are made in Bida that covered a return investment of 50% at approximately Tent million naira (#10,000,000) daily exportation. A survey research was used in collecting data from various small scale enterprises (SME) producers of kuli-kuli in Bida environ. Nevertheless, the cake or chips are exported locally and internationally as part of country foreign exchange. The study recommends the impact of women in hard working and contribution towards nation building and economy stability. Government empowerment and other related supporting hands is boosting producing of the so called.

**Keywords:** Peanut, Numeration, Export, Expenditure, Immune, Exchange

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**January 21-28, 2025 / Havana, CUBA**

**EVALUATING THE IMPLEMENTATION OF HACCP SYSTEMS IN FOOD  
ESTABLISHMENTS IN LAPU-LAPU CITY, CEBU: PATHWAYS TO ISO  
22000:2005 CERTIFICATION**

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Lapu-Lapu City College

**Dr. Ronald B. Payao**  
Cebu Institute of Technology- University

**Abstract**

This descriptive-correlational study attempted to evaluate food safety procedures based on the Hazard Analysis Critical Control Point System (HACCP) among selected food establishments in Lapu-Lapu City, Philippines. A total of ninety-six (96) respondents who belong to personnel, supervisors, and managers of the food establishments participated in the data gathering. These respondents were selected purposively since the set criteria by the researchers should be strictly followed. Weighted mean, and Chi-square were utilized to analyze the collected data using a survey questionnaire. Based on the findings, it was found that participating establishments achieved an 'outstanding' status, as evidenced by high satisfaction ratings from respondents, indicating their commitment to following HACCP as a standard protocol in meeting stakeholder expectations. Additionally, the perceptions of managers, supervisors, and personnel regarding food safety compliance were strongly aligned, highlighting a well-integrated and collaborative approach to maintaining food safety protocols. These results underscore the establishments' commitment to regulatory compliance and customer satisfaction, providing insights into their readiness for higher standards such as HACCP implementation and ISO 22000:2005 certification.

**Keywords:** Hazard Analysis Critical Control Point System (HACCP), Food Establishment, Food Safety Procedure, ISO 2200:2005, Lapu-Lapu City

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**January 21-28, 2025 / Havana, CUBA**

**THE INTERSECTION OF SCIENCE, LAW, AND PUBLIC HEALTH POLICY:  
LEGAL IMPLICATIONS AND POLICY CHALLENGES**

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**Abstract**

Since scientific discoveries are rapidly influencing public health policies and legal frameworks, the nexus of science, law, and public health policy is an important field of research. This study examines how scientific data influences public health legislation and policy, as well as the resulting legal ramifications and policy issues. How scientific research affects the creation of legislation pertaining to healthcare access, illness prevention, and risk regulation is at the heart of this conversation. It looks at the legal guidelines that control public health responses, especially in times of health emergencies like pandemics, and how to strike a balance between individual liberties and private concerns as well as public safety. The study also covers the ethical conundrums that arise at the intersection of legal regulation and scientific innovation. These include concerns about genetic testing, medical privacy, and the use of health data in policymaking. Another important topic of discussion is how to regulate new health technologies, like gene editing, AI in healthcare, and digital health tools, because these technologies raise a lot of questions about their safety, effectiveness, and how well they fit with current legal systems. The study also looks at how laws and policies might help reduce health disparities and improve health equity by looking at the social factors that affect health, like race, socioeconomic status, and access to healthcare. Finally, the study underscores the significance of judicial review in policy formulation by scrutinising how courts comprehend and apply scientific data to guide public health decisions. This paper examines how science, law, and public health policy intersect, emphasising the necessity of continuous scientific and legal developments to guarantee that public health initiatives are fair and successful while preserving individual liberties and moral principles.

**Keywords:** Science and Public Health Policy, Legal Implications, Health Equity, Emerging Health Technologies, Ethical Dilemmas in Health Law.

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**January 21-28, 2025 / Havana, CUBA**

**THE ROLE OF FORENSIC SCIENCE IN CRIMINAL JUSTICE SYSTEM: LEGAL  
IMPLICATIONS AND CHALLENGES**

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**Abstract**

As a vital instrument for establishing facts, validating testimony, and guaranteeing the correctness of verdicts, forensic science is essential to the criminal justice system. However, the intersection of forensic science and criminal law presents significant legal implications and challenges, particularly concerning the admissibility, reliability, and interpretation of forensic evidence in court proceedings. This study takes a close look at the laws that govern the use of forensic science in criminal trials. It focusses on the Daubert and Frye standards for the admissibility of forensic evidence. It examines the difficulties in guaranteeing that forensic techniques satisfy exacting scientific standards, addressing issues with the possibility of contamination, misinterpretation, and mistakes in evidence gathering that could result in erroneous convictions. The study looks at the moral and legal duties of forensic experts, focussing on issues like fairness, giving expert testimony, and how forensic evidence affects court decisions. It also looks at how cutting-edge forensic technologies like genetic analysis, digital forensics, and predictive algorithms are being used more and more. It looks at what the legal implications might be and how they make it harder to follow the rules of the law. The study also looks at the problem of erroneous convictions brought on by subpar forensic procedures and considers how forensic science may support justice reform, specifically in terms of maintaining equity, minimising prejudice, and averting further injustices. To guarantee that the use of forensic evidence in criminal processes is consistent with the values of justice, fairness, and accuracy, this study highlights the necessity for ongoing legal and scientific improvements by analysing the advantages and disadvantages of forensic science.

**Keywords:** Forensic Science, Criminal Justice, Admissibility of Evidence, Wrongful Convictions, Forensic Technology.

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**January 21-28, 2025 / Havana, CUBA**

**ENHANCING QUANTUM COMMUNICATION THROUGH AI: INTEGRATING  
MACHINE LEARNING WITH QUANTUM COMPUTING**

**Dr. Shouket Ahmad Kouchay**

Islamic University Madinah, Computer Science, Madinah Munawara, KSA.

**Abstract**

This paper investigates into the insightful associated relationship between Artificial Intelligence (AI) and Quantum Computing, exploring their mutual potential to drive groundbreaking advancements. The research begin with a concise introduction to quantum computation, providing a clear and simplified explanation of a pivotal quantum algorithm to exhibit its unique capabilities. A comprehensive review of the current applications of quantum computing within the realm of AI, highlighting areas where quantum algorithms offer significant benefits over classical approaches.

Conversely, the research highlights the role of classical machine learning (ML) techniques in enhancing quantum communication protocols. The research's focus includes the optimization of quantum key distribution, teleportation, secret sharing, and overall network performance, facilitated by ML. These enhancements lead to more secure and efficient quantum communication systems.

The research underscores the transformative potential of integrating AI and quantum technologies, driving progress in both fields. By harnessing the principles of quantum mechanics alongside the adaptability and robustness of AI, we envision a future where quantum-enhanced AI and strong quantum communication networks play a key role in a myriad of technological innovations.

**TOPICS:** Quantum Computing

**Keywords:** Quantum Computing, Artificial Intelligence, Machine Learning, Quantum Communication, Quantum Algorithms, Teleportation

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**January 21-28, 2025 / Havana, CUBA**

**FROM DATA TO DISCOVERY: UNVEILING GARLIC'S ANTIMICROBIAL AND  
ANTIVIRAL SECRETS WITH DATA SCIENCE**

**Dr. Shouket Ahmad Kouchay**

Islamic University Madinah, Computer Science, Madinah Munawara, KSA.

**Abstract**

This paper investigates into the insightful associated relationship between Artificial Intelligence (AI) and Quantum Computing, exploring their mutual potential to drive groundbreaking advancements. The research begin with a concise introduction to quantum computation, providing a clear and simplified explanation of a pivotal quantum algorithm to exhibit its unique capabilities. A comprehensive review of the current applications of quantum computing within the realm of AI, highlighting areas where quantum algorithms offer significant benefits over classical approaches.

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**TOPICS:** Quantum Computing

**Keywords:** Quantum Computing, Artificial Intelligence, Machine Learning, Quantum Communication, Quantum Algorithms, Teleportation

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**January 21-28, 2025 / Havana, CUBA**

**MODIFIED BUONGIORNO MODEL FOR MHD MICROPOLAR CASSON HYBRID  
NANOFLUID TRANSPORTATION WITH NON-LINEAR THERMAL RADIATION  
THROUGH POROUS CHANNEL**

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**Abstract**

A magnetohydrodynamic flow of hybrid based (C<sub>2</sub>H<sub>6</sub>O<sub>2</sub>-H<sub>2</sub>O) micropolar fluid with homogenous mixture of two nano species (Fe<sub>3</sub>O<sub>4</sub> and MOS<sub>2</sub>) is studied numerically. The non-Newtonian fluid dynamics is formulated as Casson flow model as well. The dynamical characteristics of heat and mass transfer are subject to be confined within a porous parallel plates channel in the existence of magnetic field and non-linear radiation heat source. A set of apposite similarity type functions is employed to yield transmuted ordinary differential form of the primary partial differential formulation. Then resulting ODEs are resolved by harnessing RK45 procedure with Matlab script. The computations are carried out to evaluate the impacts of embedded factors on the dependent physical quantities mainly concentration of nano entities, microrotation of fluid particles, hybrid fluid velocity and temperature. The temperature attains high values in case of hybrid nano fluids. The non-linear thermal radiation also adds to raise the fluid temperature.

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**January 21-28, 2025 / Havana, CUBA**

**STABILITY AND REGULARITY ANALYSIS OF NONLINEAR WAVE  
EQUATIONS WITH LOCALISED INTERNAL AND VENTCELL BOUNDARY  
CONDITIONS.**

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**Abstract**

**Introduction\*\*:** This study addresses the stability and regularity of solutions to a nonlinear wave equation with localized internal damping defined by a Carathéodory function, under Ventcel-Dirichlet boundary conditions.

**Objective\*\*:** The primary goal is to analyze the exponential decay stability and regularity properties of these solutions within the proposed framework.

**Methodology\*\*:** The stability is demonstrated through exponential decay using advanced Lyapunov functions and multiplier techniques. The influence of the boundary memory term on the solution is also thoroughly investigated, adding depth to the analysis.

**Conclusion\*\*:** The results reveal the critical role of the memory term in boundary conditions on the solution's behavior, emphasizing the importance of considering this factor in future studies.

**Keywords\*\*:** Exponential decay, stability, regularity, nonlinear wave equation, localized damping, Ventcel boundary conditions.

**References:**

Addoun, R. I., & Laoubi, K. (2024). Stability and regularity analysis of nonlinear wave equations with localised internal and Ventcell boundary conditions. *International Journal of Control*, 1–10. <https://doi.org/10.1080/00207179.2024.2368052>



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**January 21-28, 2025 / Havana, CUBA**

**ISATIN BASED HYBRID MOLECULE: A NEW ERA IN ANTICONVULSANT  
RESEARCH**

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**Abstract**

Isatin-based hybrid molecules have emerged as a promising frontier in anticonvulsant research due to their multifaceted pharmacological properties. Isatin, a heterocyclic compound, has garnered attention for its potential neuroprotective effects, including antioxidant, anti-inflammatory, and neurochemical modulation. Recent advances have led to the development of hybrid molecules, where isatin is combined with other pharmacophores to enhance anticonvulsant activity while reducing toxicity. The strategic design of such hybrid molecules allows for a synergistic approach, targeting multiple pathways involved in epilepsy, including ion channel modulation, neurotransmitter balance, and cellular signaling mechanisms. Studies have shown that isatin hybrids possess significant anticonvulsant effects in various animal models of epilepsy, often exhibiting superior efficacy compared to traditional anticonvulsant agents. These hybrids interact with GABAergic, glutamatergic, and other neurotransmitter systems, improving seizure control and offering a more comprehensive approach to managing epilepsy. Additionally, isatin-based hybrids may show promise in overcoming limitations associated with conventional antiepileptic drugs, such as drug resistance and side effects. This review explores the recent progress in the development of isatin-based hybrid molecules as anticonvulsants, discussing their chemical design, mechanisms of action, in vitro and in vivo evaluations, and potential clinical implications. The findings suggest that isatin hybrids are a promising new class of anticonvulsant agents, offering a novel direction for epilepsy therapy and potentially broadening the scope of treatment options for patients with refractory seizures. Further research is needed to optimize their pharmacological profiles and establish their clinical viability.

**Keywords:** Isatin, hybrid molecules, anticonvulsant, epilepsy, neuroprotective

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**January 21-28, 2025 / Havana, CUBA**

**VIRTUAL SCREENING AND DYNAMIC SIMULATION OF BALOXAVIR  
DERIVATIVES TARGETING EGFR, HER2, AND ERA FOR BREAST CANCER  
TREATMENT**

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**Abstract**

Breast cancer stands as one of the most prevalent malignancies affecting women globally, serving as a significant contributor to global mortality. This in-depth study addresses the pressing need for innovative and cost-effective breast cancer treatments by exploring active compounds targeting Estrogen receptor ER $\alpha$ , EGFR, and HER2. Through the evaluation of 72 Baloxavir derivatives and subsequent molecular docking using Autodock Vina in PyRx software, the research emphasizes the significance of protein-like interactions in drug development. Out of 32 compounds selected based on binding affinity, seven displayed promising ADMET characteristics. AutoDock 4.2 analysis identified six potential ER $\alpha$  and HER2 inhibitors, and three for EGFR. Validation through a 100 ns molecular dynamics simulation ensured the stability of the most promising compound, utilizing parameters like RMSD, RMSF, Radius of Gyration (RGyr), MolSA, SASA, and protein–ligand interactions. This comprehensive approach aims to contribute significantly to the development of effective and efficient breast cancer therapies, addressing current treatment limitations and complexities.

**Keywords:** Virtual Screening; ADMET; Breast Cancer; Baloxavir derivatives; Molecular Docking; Simulation Dynamic

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**January 21-28, 2025 / Havana, CUBA**

**THE EFFECT OF ADHESIVE DOSAGE ON THE PHYSICAL QUALITY OF  
PELLETED LAYING HENS' RATIONS**

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<sup>3)</sup> Department of Animal Science, Faculty of Agriculture, Mulawarman University, Samarinda, Indonesia

**Abstract**

This study aims to determine the effect of adhesive dosage on the physical quality of pelleted laying hens' rations. This study used an experimental method using a completely randomized design (CRD) with 5 treatments and 4 replications. The treatments used were: treatment A: ration without tapioca flour adhesive (control), B: ration + tapioca flour adhesive 1.5%, C: ration + tapioca flour adhesive 3.0%, D: ration + tapioca flour adhesive 4, 5% and E: ration + tapioca flour adhesive 6.0%. The variables observed were air content, pile density, pile compaction density and pile angle. The results showed that the use of different adhesive doses had a very significant effect ( $P < 0.01$ ) on air pellet content, pile density, pile compaction density and pile angle. The conclusion of this study is that the best dose of tapioca adhesive in the manufacture of laying hens ration pellets mixed is 3% with a moisture content of 10.29%, a pile density of 554.70 kg/m<sup>3</sup>, a pile compaction density of 623.26 kg/m<sup>3</sup> and a pile density of 39,43°.

**Keywords:** Dosage of Adhesive, Laying Hens Ration, Pellets, Physical Quality.

# 9<sup>TH</sup> INTERNATIONAL CONFERENCE ON GLOBAL PRACTICE OF MULTIDISCIPLINARY SCIENTIFIC STUDIES

January 21-28, 2025 / Havana, CUBA

## ENHANCEMENT OF HEAT SINK EFFICIENCY USING CYLINDRICAL FINS SUPPORTED WITH HELICAL TRAPEZOIDAL WINGS AND MHD RADIATIVE NANOFLUID

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### **Abstract**

Cooling electronic devices using heat sinks is one of the main fields in which academics are working to develop them. This manuscript presents a novel numerical study using Comsol Multiphysics to optimize heat sink performance through the strategic integration of MHD radiative nanofluid and innovative helical trapezoidal wings on cylindrical fins. The research advances the field by systematically replacing classical cylindrical fins with those provided with cylindrical wings as a first step, and with trapezoidal shapes as a second step and subsequently introducing helical trapezoidal wings instead of the aligned shape to enhance efficiency. Comsol Multiphysics 3.4 software is used to conduct the study applying finite element method. The 2D heat sink problem is modelled as a square cavity, which is equipped with 2D longitudinal section of cylindrical fins and filled with MHD radiative nanofluid. The study examined the impact of using cylindrical wings attached laterally on the cylindrical fins. Then, the efficiency of cylindrical wings is compared with trapezoidal shape. Finally, the helical trapezoidal wings are used to enhance the heat sink efficiency. The findings reveal substantial performance improvements: with nanofluid by 42.83%, enhancement with radiation by 54.19%, with cylindrical wings by 22.38%, and a superior 10.7% efficiency increase with trapezoidal wings. In addition, using helical trapezoidal wings is the optimum for the heat sink performance by 7.26 %. This work is poised to appeal to a broad readership by offering valuable insights into optimizing heat sink configurations for enhanced thermal management.

**Keywords:** Heat sink performance; Cylindrical fins; Radiative nanofluid; Helical trapezoidal wings; COMSOL Multiphysics.

# 9<sup>TH</sup> INTERNATIONAL CONFERENCE ON GLOBAL PRACTICE OF MULTIDISCIPLINARY SCIENTIFIC STUDIES

January 21-28, 2025 / Havana, CUBA

## MARINE ECOSYSTEM RECOVERY: BIOREMEDIATION AS AN ECO- FRIENDLY REMEDIATION APPROACH

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### Abstract

Nearly 1.3 million metric tons of marine pollution has been caused by petroleum hydrocarbons, which pose substantial hazards to marine ecosystems and biodiversity, while about 8 million metric tons of plastic enter seas each year. Utilizing microorganisms such as bacteria, fungi, and algae, bioremediation is a natural treatment that breaks down or eliminates contaminants. In this regard, under ideal nutritional conditions, oil-degrading bacteria like *Pseudomonas* sp. and *Alcanivorax borkumensis* can degrade hydrocarbons up to 92% in 21 days. Similar to that, it has been proven that fungi like *Aspergillus flavus* and *Penicillium* sp. can break down more than 85% of polycyclic aromatic hydrocarbons (PAHs). Microalgae such as *Chlorella vulgaris*, which exhibit 95% cadmium and 93% lead uptake in contaminated waterways, are an effective way to detoxify heavy metals. Microplastic contamination is also tackled with bioremediation; in lab settings, enzymes like PETase have been intended for breaking down polyethylene terephthalate (PET) by 50–75% in an average of weeks. In addition, genetically modified microorganisms, like *Escherichia coli*, which have been engineered to effectively degrade hydrocarbons and chelate metals, have improved pollutant degradation efficiency. The study also identifies difficulties, such as scalability for large-scale applications, unreliable degradation rates for complex contaminants, and fluctuating environmental conditions. It promotes the use of advanced molecular biology instruments to enhance bioremediation procedures. This approach offers a great deal of potential to restore the marine environment, which is in accordance with international sustainability objectives like Sustainable Development Goal 14 (Life Below Water) of the UN.

**Keywords:** Marine Pollution, Contaminants, Hydrocarbons, Microalgae, Microplastic, Sustainability.

# 9<sup>TH</sup> INTERNATIONAL CONFERENCE ON GLOBAL PRACTICE OF MULTIDISCIPLINARY SCIENTIFIC STUDIES

January 21-28, 2025 / Havana, CUBA

## ADVANCING SOLAR ENERGY: A DFT AND SLME COMPARATIVE STUDY OF LEAD-FREE DOUBLE HALIDE PEROVSKITES

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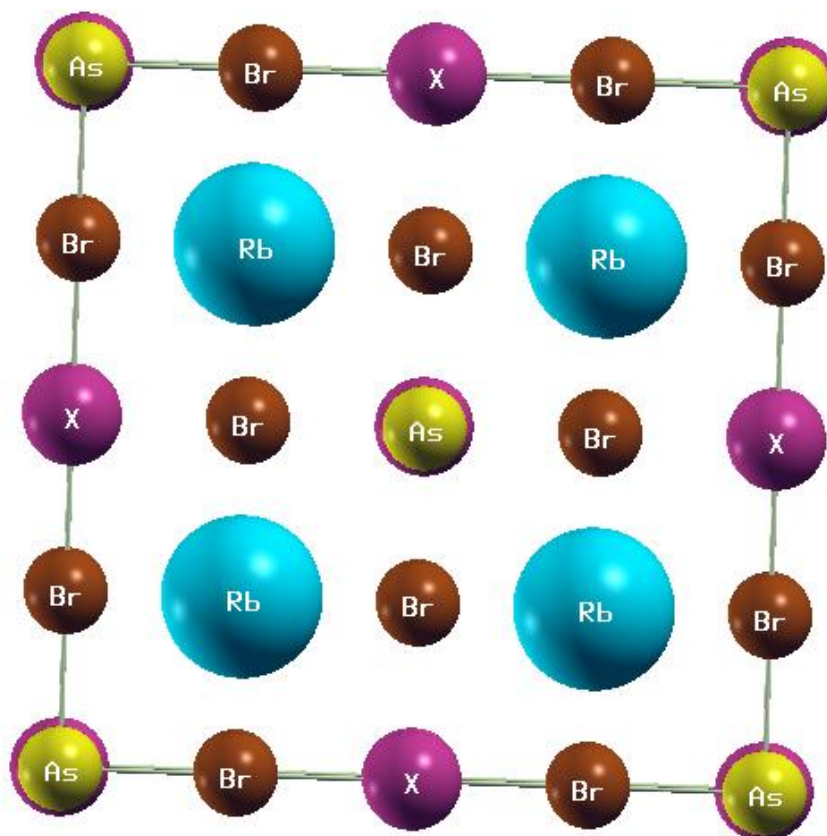
### Abstract

Recent advancements and developments in photovoltaic materials have made significant progress owing to the search for efficient and sustainable energy sources. Although lead halide perovskites have demonstrated impressive performance in solar cell applications, they face challenges such as environmental instability and lead toxicity. This study investigates several physical properties of two lead-free double halide perovskites, Rb<sub>2</sub>CuAsBr<sub>6</sub> and Rb<sub>2</sub>TlAsBr<sub>6</sub>, and evaluates their potential for solar cell applications using density functional theory (DFT) within the Wien2k code and spectroscopic limited maximum efficiency (SLME) approach. The negative formation energy and Born criteria confirm the structural stability of both perovskites in the ideal cubic structure. Optoelectronic analyses reveal that Rb<sub>2</sub>TlAsBr<sub>6</sub>, with a direct band gap of 1.51 eV, exhibits better photovoltaic characteristics compared to Rb<sub>2</sub>CuAsBr<sub>6</sub>, which has an indirect band gap of 0.60 eV. Additionally, the SLME analysis shows that Rb<sub>2</sub>TlAsBr<sub>6</sub> achieves a higher SLME of approximately 31.4 %, compared to Rb<sub>2</sub>CuAsBr<sub>6</sub> which has a SLME of 7.44%. Moreover, the calculated thermoelectric properties show that Rb<sub>2</sub>TlAsBr<sub>6</sub> exhibits enhanced thermoelectric performance compared to Rb<sub>2</sub>CuAsBr<sub>6</sub>. These findings highlight the potential of lead-free perovskites, particularly Rb<sub>2</sub>TlAsBr<sub>6</sub>, for next-generation solar cell applications..

**Keywords:** DFT · Wien2k · Rb<sub>2</sub>XAsBr<sub>6</sub> (X = Cu, Tl) · Effective masses · Perovskite solar cells

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Title: Crystal structure of  $Rb_2XAsBr_6$  ( $X = Cu, Tl$ )

<https://doi.org/10.1007/s10904-024-03330-x>

**ROBUST DEEPPFAKE DETECTION THROUGH RES-NEXT CNN AND LSTM-  
BASED RNN FUSION USING DEEP LEARNING**

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**Abstract**

Deep fake technology, powered by advancements in artificial intelligence, enables the creation of highly realistic synthetic videos, where faces or actions are manipulated to deceive viewers. These manipulations are becoming increasingly sophisticated, posing significant threats to privacy, security, and the authenticity of digital media. From spreading misinformation to committing identity fraud or blackmail, deep fakes are being used maliciously in a variety of contexts. To combat this emerging issue, we propose a robust detection system that fuses the power of Res-Next Convolutional Neural Networks (CNNs) and Long Short-Term Memory (LSTM) Recurrent Neural Networks (RNNs).

In our approach, Res-Next CNNs are employed to extract frame-level features that capture the intricate details of each frame in a video. These features are then fed into an LSTM-based RNN, which analyzes the temporal sequence of frames to detect inconsistencies caused by deep fake manipulations. This fusion of spatial and temporal analysis allows our model to effectively differentiate between real and AI-manipulated videos.

Our method is rigorously evaluated using a diverse set of benchmark datasets, including Face Forensics, the Deep Fake Detection Challenge, and Celeb-DF. Results demonstrate the high accuracy and efficiency of our approach, even in the presence of subtle manipulations. Moreover, the lightweight architecture ensures the model's suitability for real-time applications, making it a viable solution for deep fake detection in dynamic and security-critical environments. This work highlights the potential of combining state-of-the-art deep learning techniques to develop scalable, accurate, and efficient deep fake detection systems.

**Keywords:** Deep fake detection, Res-Next CNN, LSTM RNN, video manipulation, AI-generated media, temporal analysis, frame-level features, real-time detection, disinformation, synthetic media, machine learning.



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**January 21-28, 2025 / Havana, CUBA**

**EDUCATION4.0: AN ARTIFICIAL INTELLIGENCE APPROACH**

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**Abstract**

Artificial intelligence has evolved from a futuristic idea to a revolutionary force currently improving education. Teachers may personalise learning experiences, simplify administrative tasks, and give students better support by incorporating AI into learning settings. Some particular advantages that AI offers to the field of education are as follows:

Personalised learning is improved; administrative tasks are automated, learner engagement is raised; accessibility is improved; and actionable insights are obtained.

Improved Classroom Management Efficiency

Improved Security and Integrity of Assessment

Increased scalability, professional development, and ongoing lifelong learning

Benefits:

- Tailored Education

Availability Around-the-Clock

Scalability

Drawbacks:

Technology Dependency; Difficulties with Feedback and Assessment; Privacy and Security Issues

Insufficient Emotional Intelligence; Possible Inaccuracy and Bias

**Keywords:** Education 4.0, AI, emotional intelligence

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**January 21-28, 2025 / Havana, CUBA**

**THE ROLE OF NANOTECHNOLOGY IN PLANT DISEASE MANAGEMENT**

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**Abstract**

Nanotechnology offers transformative solutions for managing plant diseases, addressing challenges associated with traditional methods such as chemical resistance, environmental pollution, and low efficiency. Nanoscale materials, including nanoparticles, nanocarriers, and nanosensors, enable precise delivery of agrochemicals, enhance plant immune responses, and provide real-time disease diagnostics. Metallic nanoparticles, such as silver and zinc oxide, exhibit antimicrobial properties, effectively targeting pathogens while reducing chemical residues in the environment. Similarly, polymer-based nanocarriers ensure controlled and sustained release of fungicides and bactericides, minimizing overuse.

In this study, we highlight recent advancements in nanotechnology applications for plant disease management. We discuss the development of nanosensors for early pathogen detection and their integration into precision agriculture systems. Case studies illustrate the successful deployment of nanomaterials in mitigating fungal, bacterial, and viral diseases in key crops. Despite its immense potential, challenges remain, including scalability, cost-effectiveness, and understanding the ecological impact of nanomaterials. By addressing these challenges, nanotechnology holds the promise of revolutionizing sustainable plant disease management and contributing to global food security.

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**ELECTRONIC HEALTH RECORD USING BLOCKCHAIN**

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**Abstract**

Electronic Health Records (EHR) systems face significant challenges in data security, interoperability, and patient data ownership, compounded by increasing cyber threats and fragmented healthcare information systems. Traditional centralized EHR systems often struggle with data breaches, unauthorized access, and inefficient health information exchange between healthcare providers. However, blockchain technology presents a revolutionary approach to addressing these fundamental issues in healthcare data management. This abstract explores the implementation of blockchain technology in EHR systems, focusing on its potential to transform healthcare data security and accessibility. Blockchain-based EHR systems can provide immutable, transparent, and secure health records while enabling patients to maintain complete control over their medical data. The decentralized nature of blockchain ensures data integrity and creates an auditable trail of all transactions, significantly reducing the risk of data tampering and unauthorized access. Smart contracts can automate access control mechanisms, allowing healthcare providers to securely share patient information while maintaining compliance with healthcare regulations. Furthermore, blockchain technology enables seamless interoperability between different healthcare institutions, eliminating data silos and improving the quality of patient care through comprehensive medical history access. Overall, blockchain technology has the potential to revolutionize EHR systems by enhancing data security, improving interoperability, and empowering patients with greater control over their health information, ultimately leading to more efficient and patient-centric healthcare delivery.

**Keywords:** Decentralized Healthcare, EHR Security, Data Integrity, Healthcare Innovation, Distributed Ledger, Patient Privacy

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**SIGN LANGUAGE DETECTION**

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**Abstract**

Sign language is a vital means of communication for the deaf and hard of hearing community. However, sign language recognition systems are limited, hindering effective communication between sign language users and non-users. This study proposes DeepSign, a deep learning framework for sign language detection using Python. Our approach leverages convolutional neural networks (CNNs) and recurrent neural networks (RNNs) to recognize and classify sign language gestures.

Methods:We collected a dataset of sign language videos and preprocessed the data using techniques such as frame extraction, normalization, and data augmentation. We then trained and evaluated several deep learning models, including CNNs, RNNs, and long short-term memory (LSTM) networks, using Python libraries such as TensorFlow and Keras.

Results:Our experimental results demonstrate that the proposed DeepSign framework achieves high accuracy in sign language gesture recognition, outperforming traditional machine learning approaches. We also identify key features and patterns in sign language gestures that contribute to accurate recognition.

Conclusion:This study contributes to the development of sign language recognition systems, enabling more effective communication between sign language users and non-users. The proposed DeepSign framework offers a scalable and efficient solution for sign language detection, with potential applications in fields such as education, healthcare, and accessibility.

**Keywords:** Deep Learning, Python, CNN, RNN, LSTM, Gesture Recognition.

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**January 21-28, 2025 / Havana, CUBA**

**ADVANCES IN SUSTAINABLE WASTEWATER TREATMENT: INTEGRATING  
TECHNOLOGY, RESOURCE RECOVERY, AND ENVIRONMENTAL  
INNOVATION**

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**Abstract**

Global water scarcity, environmental pollution, and stringent regulations have prompted significant progress in wastewater treatment technologies, with a focus on improving water quality and promoting environmental sustainability. Current trends prioritize innovation in various crucial areas: A) Biological treatment enhancements, like microbial fuel cells and enzymatic bioreactors, enhance contaminant breakdown and energy efficiency. B) Chemical treatments involve advanced oxidation processes and green catalysts for efficient pollutant removal. C) Physical treatments include membrane filtration, electrocoagulation, and adsorption using sustainable materials like biochar and graphene.

The incorporation of nanotechnology has resulted in a significant advancement in the selective adsorption and degradation of toxic substances. Furthermore, biotechnology breakthroughs utilize genetically modified organisms to target particular pollutants. Another rising trend involves the utilization of machine learning and artificial intelligence to optimize processes, conduct predictive maintenance, and monitor operations in real-time. This can enhance resource allocation and decrease operational expenses. Resource recovery methods, such as nutrient extraction and biogas production, are in line with circular economy principles as they convert waste into valuable products.

Moreover, zero-liquid discharge systems and decentralized treatment models provide hopeful solutions for areas with inadequate infrastructure. Case studies spanning various industries, agriculture, and local communities showcase the effectiveness, cost-efficiency, and environmental benefits of these strategies, emphasizing their contribution to the progress of wastewater treatment methods for a more sustainable water management.

**Keyword:** Advanced Oxidation Processes, Nanotechnology, Bioreactors, Resource Recovery, Sustainable Water Management, Machine Learning.

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**STRUCTURE-BASED DRUG REPURPOSING TO INHIBIT THE DNA GYRASE OF  
*MYCOBACTERIUM TUBERCULOSIS***

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**Abstract**

**Short Introduction:**

Drug repurposing is an alternative avenue for identifying new drugs to treat tuberculosis (TB). Although TB can be cured with anti-tubercular drugs, the emergence of multidrug-resistant and extensively drug-resistant strains of *Mycobacterium tuberculosis* H37Rv (Mtb), as well as the significant death toll globally, necessitate the development of effective drugs to treat TB.

**Experiments and Key result findings:**

In this study, drug repurposing approach was employed to address this drug resistance problem by screening drugbank database to identify novel inhibitors of the Mtb target enzyme, DNA gyrase. The compounds were screened against the ATPase domain of gyrase B subunit (MtbGyrB47), and the docking results showed Echinacoside, Doxorubicin, Epirubicin, and Idarubicin possess high binding affinities against MtbGyrB47. Comprehensive assessment using fluorescence spectroscopy, SPR, and CD titration studies revealed that Echinacoside as a potent binder against MtbGyrB47. Further, ATPase, and DNA supercoiling assays exhibited IC<sub>50</sub> values of 2.1-4.7  $\mu$ M for Echinacoside, Doxorubicin, Epirubicin, and Idarubicin. Among these compounds, the least MIC<sub>90</sub> of 6.3  $\mu$ M and 12  $\mu$ M were observed for Epirubicin and Echinacoside, respectively. Hence, our findings indicate that Echinacoside and Epirubicin target mycobacterial DNA gyrase, inhibit its catalytic cycle, and retard mycobacterium growth. Further these compounds exhibits potential scaffolds for optimizing novel anti-mycobacterial agents that can act on drug-resistant strains.

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**BRIDGING THE GAP: THE ROLE OF YOUTH-LED INITIATIVES IN POVERTY  
ALLEVIATION AND GENDER INEQUALITY REDUCTION IN PAKISTAN**

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**Abstract**

Youth in Pakistan are increasingly mobilizing to address social issues, particularly poverty and gender inequality. This research explores youth-led initiatives that aim to alleviate poverty and combat gender disparities, focusing on the effectiveness, scope, and impact of these programs in both rural and urban areas. By analyzing case studies of prominent youth organizations, the study highlights innovative strategies, such as microfinance programs, gender-sensitive education, and advocacy campaigns, used to empower communities and promote sustainable development. The findings will underscore the importance of empowering young leaders in fostering social change and reducing structural inequalities. The research aims to inform policy-makers and stakeholders about the potential of youth-driven solutions to address critical social challenges, contributing to a more inclusive and equitable society.

**Keywords:** Youth Empowerment, Poverty Alleviation, Gender Inequality, Social Change, Pakistan



**DOUBLE INTEGRAL SLIDING MODE MPPT CONTROL OF PV CELL**

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**Abstract**

Double Integral Sliding Mode Control (DISMC) to improve the performance of solar panels. DISMC is used to help solar panels produce maximum power, even when sunlight and temperature change. It provides better stability and efficiency than traditional methods by reducing power fluctuations. Although DISMC can be complex to implement, it shows strong potential for increasing the effectiveness of solar energy systems. This study highlights how DISMC can make solar panels more reliable and efficient, with future improvements focused on making it easier to use in real-world applications.

**Keywords:** Double Integral Sliding Mode Control (DISMC), photovoltaic (PV) array, Boost Converter, PV cell and Maximum Power Point Tracking (MPPT).

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**THE SEARCH FOR AN END TO THE KOREAN CONFLICT: SUNSHINE POLICY**

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**Abstract**

The Korean War is recognized as the first major military confrontation of the Cold War era, a conflict that would have lasting implications for international relations. The early stages of the war ignited widespread panic and anxiety across the globe, prompting the United Nations to intervene directly in support of South Korea. Despite intense fighting and a complex military landscape, the war resulted in a stalemate, leaving the Korean Peninsula divided and without a formal peace agreement; instead, a fragile ceasefire has been in place for over seven decades. South Korea introduced the Sunshine Policy in the late 1990s to seek a lasting resolution to this enduring conflict. This innovative approach aimed to increase dialogue and enhance cooperation with North Korea, prioritizing diplomacy and engagement over isolation and hostility. By focusing on building relationships and fostering goodwill, the Sunshine Policy represented a significant shift in South Korea's strategy towards its northern neighbour. This paper delves into the historical context and evolution of the Sunshine Policy, exploring its objectives and the challenges it faced in the pursuit of peace on the Korean Peninsula.

**Keywords:** Korean War, Conflict Resolution, Sunshine Policy, Post-Cold War, Great Powers

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**KORE ÇATIŞMASININ SONUNU ARAMAK: GÜNEŞ IŞIĞI POLİTİKASI**

**Özet**

1950 ile 1953 yılları arasında Kore Savaşı, Soğuk Savaş'ın ilk önemli askeri çatışması olarak yaygın olarak kabul edilir. Bu çatışma, Kore'nin II. Dünya Savaşı sonrası iki ayrı devlete bölünmesinden kaynaklandı: Sovyetler Birliği ve Çin tarafından desteklenen komünist Kuzey ve Amerika Birleşik Devletleri ve müttefik Batılı ülkeler tarafından desteklenen demokratik Güney. Savaş, Kore Yarımadası'nda kapsamlı askeri angajmanları kapsıyordu ve uluslararası ilişkiler için derin ve kalıcı etkileri vardı. Soğuk Savaş'ın jeopolitik dinamiklerini önemli ölçüde etkileyerek, ABD dış politikasını ve küresel ittifaklarını sonraki on yıllar boyunca şekillendirdi. Kore Savaşı'nın sonuçları Kore Yarımadası'nın ötesine uzanarak askeri stratejileri ve diplomatik ilişkileri küresel olarak etkiledi.

1990'ların sonlarında Güney Kore, 1950'de başlayan Kore Savaşı'ndan kaynaklanan uzun süredir devam eden gerginliklere kalıcı bir çözüm bulmayı amaçlayan stratejik bir girişim olan Güneş Işığı Politikası'nı tanıttı. Bu savaş sadece Soğuk Savaş'ın ilk önemli askeri çatışmasını değil, aynı zamanda Kore Yarımadası'nın iki ayrı ulusa bölünmesini de sağladı: Kuzey Kore ve Güney Kore.

Güneş Işığı Politikası, Güney Kore'nin kuzey komşusuna yaklaşımında dönüştürücü bir değişimi temsil ediyor, ilişkileri geliştirmeyi ve iyi niyeti teşvik etmeyi önceliklendiriyor. Bu araştırma Güneş Işığı Politikası'nın tarihsel arka planını ve kademeli evrimini inceliyor, hedeflerini (örneğin Koreler arası diyalogu ve iş birliğini teşvik etmek) ve Kore Yarımadası'nda kalıcı barış için çabalarırken karşılaştığı zorlukları ayrıntılı bir şekilde araştırıyor. Kapsamlı bir analiz yoluyla amaç, bu politikanın karmaşıklıklarını ve bölgesel istikrar ve uzlaşmanın daha geniş bağlamındaki etkilerini ortaya çıkarmaktır.

**Anahtar Kelimeler:** Kore Savaşı, Çatışma Çözümü, Güneş Işığı Politikası, Soğuk Savaş Sonrası, Büyük Güçler

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**JONAH'S ATTITUDE AND HIS EMOTIONAL INTERFERENCE IN THE  
NINEVEH MISSION AND ITS IMPLICATION FOR SOCIAL WELFARE**

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**Abstract**

This study examines "Jonah's attitude and His emotional interference in the Nineveh Mission," a narrative rooted in the book of Jonah, which highlights significant theological and human elements in the prophetic mission. The aim of the study is to explore Jonah's emotional disposition and resistance to God's call, analyzing how personal biases and emotions interfered with the divine agenda of mercy and salvation for Nineveh. The statement of the problem revolves around the prophet's reluctance and anger at God's compassion towards a pagan city, showcasing the tension between divine purposes and human frailty. Through an exegetical and theological analysis of the text, the study found that Jonah's attitude stemmed from ethnocentric biases and a limited understanding of God's universal love and justice. His interference reflected the challenges of aligning human will with divine purposes, yet also highlighted God's patience and unrelenting commitment to His mission. The conclusion emphasizes the need for self-reflection in accepting divine mandates and the broader implications for understanding forgiveness, mercy, and the universality of God's compassion. This study contributes to discussions on human agency in divine missions and offers valuable lessons for contemporary faith practices.

**Keywords:** Emotion, Jonah, Fear, Anger, social welfare

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## ETHICS IN SUSTAINABLE DEVELOPMENT OF INDIAN ECONOMY: A STUDY

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### **Abstract**

Ethics is the integrity measures which assess the values, norms and rules that constitute the base for individual and social relationships. Ethics and economy can not be separated, the people who are working for a business should always consider how their decision affecting in society and environment. Economy made with different parts like corporate, society, government and environment etc. Today ethical behavior is very significant for sustainable growth of economy of nation. Sustainable development recognize that all development decision must consider with aspect of environment, society and corporate. This paper includes the values & ethical practices especially concerning with business, society and environment. Values give the basis for discernment about what is important for the institution to triumph in its core occupation. Values determine what is right and what is wrong and doing what is right or wrong in what we mean by ethics. To behave ethically is to behave in a manner consistent with what is right or moral. Moral code in business is form of applied ethics or professional ethics that examines ethical principles and moral or ethical problems that arise in a business environment. Ethical issues include the rights duties between a company and its employees supplier, customer and neighbours, its fiduciary responsibility to its shareholders, society and environment. The purpose of this research paper is to state the significance of ethical behaviour and the role of ethics in corporate society and environment. This paper examines the relationship among ethics and values in business, society and environment. This paper also emphasizes the need for a balance between business ethics, external market factors, and government, environment which ultimately will result into a stable and robust economy of any nation.

Ethics is important for any business, society, environment and to attain the development of any economy, this is a growing actualization in all over the world. Ethics give rise to well organized economy. Code of behaviour and profit go together in the long run. An ethically responsible company has grown a culture of caring for people and environment, a culture which flows downwards from the top manager and leaders. Ethics is the study of virtuous and virtuous choices. It emphasizes on standard rules and decorum that governs the behaviour of individuals and group. Ethics refer to the code of behaviour that advise a person while dealing in a situation, it relates to the social rules that impact people to be sincere in dealing with the other people code of conduct and the principles of behaviour is the branch of philosophy that distinguish between the right from the wrong and concerned with the rightness or wrongness, goodness or badness of human conduct. A particular action is morally good or bad for deciding this ethics provides the basis.

**Keywords:** Ethics, Values, Corporate Ethics, Environment, Society, Shareholders.

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**January 21-28, 2025 / Havana, CUBA**

**SYNTHESIS AND CHARACTERIZATION OF SILICA-CHITOSAN DECORATED  
MAGNETIC NANOSTRUCTURE FOR WASTEWATER TREATMENT**

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**Abstract**

Magnetic nanoparticles (MNPs) possess extraordinary magnetic properties and serve as effective adsorbents for heavy metals in wastewater treatment. Coating the surface of magnetic nanoparticles improves their adsorption efficiency, recyclability, and hydrophilicity. The proposed study will be focused on different ferrite magnetic nanoparticles efficiently coated with silica chitosan for the elimination of heavy metals in the treatment of wastewater. Superparamagnetic cobalt ferrite, nickel ferrite, and copper ferrite nanoparticles will be synthesized using a simple co-precipitation technique. The magnetic cores of  $\text{CoFe}_2\text{O}_4$ ,  $\text{NiFe}_2\text{O}_4$ , and  $\text{CuFe}_2\text{O}_4$  magnetic nanoparticles will be decorated with a silica shell through tetraethyl orthosilicate (TEOS) hydrolysis. Subsequently, the silica-coated ferrite magnetic nanoparticles will be further coated with chitosan. Atomic adsorption spectroscopy employed to determine the extent of metals removal from the water. The magnetic properties, structure analysis, identification of functional groups, and morphology of the prepared adsorbents analyzed before performing adsorption experiments. The kinetics and adsorption isotherms of the adsorbents examined using different chemical models.

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**DEVELOPING HUMAN SKILLS IN THE AGE OF ARTIFICIAL INTELLIGENCE:  
ALIGNING PERSONAL COMPETENCIES WITH SMART TECHNOLOGY  
ADVANCEMENTS**

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**Abstract**

This study explores the alignment of essential human skills with advancements in artificial intelligence (AI) within the context of higher education. The research focuses on a sample of 270 students from faculties of sciences in private universities in Lebanon, examining their preparedness to integrate AI-driven tools and technologies into their academic and professional journeys. Employing a descriptive research methodology, the study identifies key skills deemed crucial in the AI era, including critical thinking, digital literacy, adaptability, creativity, and emotional intelligence.

The findings reveal a significant gap between the current skill levels of students and the demands of the rapidly evolving AI landscape. While students demonstrate moderate proficiency in digital literacy and adaptability, there is a noticeable deficiency in critical thinking and creativity, which are vital for navigating complex AI applications. Additionally, the study highlights the importance of fostering emotional intelligence to enable effective collaboration between humans and AI systems.

The results underscore the necessity for educational institutions to revise curricula and adopt innovative teaching strategies that emphasize skill development in tandem with AI integration. By addressing these gaps, universities can better prepare students to meet the demands of future job markets and thrive in a technology-driven world.

**Keywords:** Artificial Intelligence, Human Skills, Higher Education, Critical Thinking, Digital Literacy, Emotional Intelligence, Descriptive Research, Lebanese Universities.

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**AIR CANVAS (Virtual Painter)**

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**Abstract**

The objective of this project is to develop an "Air Canvas Virtual Painter" that allows users to draw on a virtual canvas by tracking their hand movements using computer vision. The system will enable users to draw in the air without the need for physical drawing tools. By leveraging real-time hand tracking techniques, users can control a brush or pen to sketch, paint, or write on a digital canvas, with the option to choose colors, brush sizes, and clear the canvas.

**Hand Tracking:** Accurate detection and tracking of the user's hand movements using a webcam or any camera device, enabling the system to distinguish between drawing actions (e.g., index finger raised) and non-drawing gestures (e.g., closed fist).

**Drawing on Virtual Canvas:** Translating hand movement in 3D space into continuous, smooth strokes on a 2D canvas while minimizing latency.

**Gesture Recognition:** Recognizing specific hand gestures to switch between drawing modes, selecting different colors, changing brush sizes, or clearing the canvas.

A working virtual painter application that can detect and track hand movements through a camera. Gesture-based controls for color selection, brush size adjustment, and clearing the canvas. Ability to save drawings created on the virtual canvas.

**Keywords:** Computer vision, Air Canvas, AI, Virtual Painting



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**SPECIATION OF ARSENIC FROM FISH POND SEDIMENTS FROM TALBA  
FARM, MINNA METROPOLIS**

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**Abstract**

This study investigate the speciation of arsenic (As) from fish pond sediments (FPS) obtained from Talba farm (TF), Minna metropolis, the BCR Sequential Extraction Method was employed to determine the species of Arsenic (As) associated with four different chemical fraction of the sediments, the concentration of As species from result obtained from analysis with MP-AES gave information on the solubility and mobility of As in the FPS from each fraction (1 to 4), across the sampling location. The concentration: 3.13>1.29>1.21>1.20 of fraction 1, implies the level to which As is more soluble and easily exchangeable with carbonates, hydroxides and other clay minerals with the order of location 4>2>3>1 with location 4 and 1 having the highest and lowest concentration respectively, The concentration: 1.63>1.47>1.39>1.04 of fraction 2, implies the level to which As is more bound to Iron and Manganese with the order of location 3>1>4>2 with location 3 and 2 having the highest and lowest concentration respectively, The concentration: 1.55=1.55>1.47>1.01 of fraction 3, implies the level to which As targets metals bound to organic matter and sulfides, with the order of location 1=3>2>4 with location 1=3 and 4 as the highest and lowest concentration respectively. The concentration: 1.80>1.57>1.53>1.35 of fraction 4, implies the level to which As are bound more to silicates mineral and are therefore considered most stable and least available for biological uptake, with order of location 1 >2>4>3, the result shows that location 1 and 3 have the highest and lowest concentration respectively.

**Keywords:** BCR, MP-AES, FPS, metals, sediments, arsenic, chemical speciation, fish pond, Talba farm and solubility.

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**ASSESSMENT OF SOCIOCULTURAL PRACTICES AFFECTING THE GIRL-  
CHILD EDUCATION IN RURAL AREAS OF KATSINA STATE, NIGERIA**

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**Usman, Umar Shehu**

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**Abstract**

This study appraised the sociocultural practices, affecting the girl-child education in rural area of Katsina State, Nigeria. Five hundred and thirty four rural secondary school girl-child students were selected using stratified and purposive random sampling procedure at different stages from the three senatorial districts of Katsina State. One instrument, Students Sociocultural Practice Questionnaire (SSPQ) was used for the study. The results showed that sociocultural practices of the society: Practice of Girl-child genital mutilation (GCGM) has "Yes" to be 76.8% and "No" to be 15.7%; Preference for tattoo on the body has 'Yes' 81.3%. 'No' 15.2%; tribal marks on the body has 64%. Sociocultural practices of the society have negative effect on the rural secondary school girl-child students' attitude to and achievement in education. It is therefore recommended among others that the government should sensitize the communities on the negative impact of sociocultural practices of the society on the girl-child students' education

**Keywords:** Sociocultural Practices, Attitude, Achievement, Education, Girl-Child, Rural School

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**SIGNIFICANCE OF OPTIMUM NUTRITION DURING TRANSITION PERIOD IN  
DAIRY COWS**

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India

**Abstract**

Effective dairy cow nutrition is crucial for economic viability. Strategic feeding management during the transition period significantly influences calf health, milk production, and reproductive success. This critical phase, spanning three weeks before and after calving, is marked by profound metabolic, hormonal, and physiological shifts. To prevent complications, dairy cows require a diet meeting their optimal nutritional needs. Regulating energy intake is crucial, and common strategies include feeding high-quality forages, controlled energy diets, and negative dietary cation-anion difference (DCAD) prepartum. Research shows that feeding controlled energy diets prepartum has numerous benefits, including reduced disease incidence. Increasing energy supply through dietary carbohydrates during the prepartum period has positive effects on metabolism and performance. Controlling energy intake during the dry period enhances neutrophil function postpartum, potentially leading to improved immune function. To mitigate the risk of disorders, specific balanced feed supplements and additives are recommended. These include biotin and sulfur-containing amino acids for hoof health, rumen-protected choline and niacin for liver health, and anionic salts for calcium and phosphorus homeostasis. Yeast supplements support rumen health, carotenes promote reproductive health, and ionophores increase productivity by reducing ketosis, displaced abomasum, and methane production. Therefore, by implementing this evidence based nutritional strategies, dairy farmers can significantly enhance cow health, boost milk production, and improve reproductive performance, leading to increased profitability and improved sustainability.

**Keywords:** Transition period, Health, Nutrition, Controlled energy

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**POWER PRODUCTION FROM EXHAUST**

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**Abstract**

The current world-wide trend of increasing transportation is responsible for increasing the use of internal combustion engines. I.C engines, the devices with a high energy usage and low efficiency because roughly 75% of the energy produced during combustion is lost in the exhaust and in the coolant of the engine in the form of heat. As a huge amount of energy is lost, there is urgent need to design an advice to trap this loss. This paper proposes and implements a waste heat recovery system using a thermo electric generator (TEG) designed for four stroke I. C. engine. The system converts the waste heat from the exhaust manifold into electrical energy using a TEG. The output is then boosted by a Joule Thief converter to run the required load or to charge a battery. The experimental results demonstrate that the proposed system recovers considerable amount of waste heat which can be used to power some auxiliary automobile devices.

Internal Combustion engines have been utilized for transportation and other needs for a long time. These engines have proven to be an effective source of energy. However, a lot of the energy produced by these engines goes waste and unutilized. In today age of fuel crisis, wastage of energy produced through engines cannot be tolerated. This work aims at reclaiming energy going wasted through the silencer of engines. Using devices called Peltier Modules, the heat energy present on the silencer is converted into useful electrical energy.

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**PRICE PULSE**

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**Abstract**

Price-conscious consumers often miss out on lucrative deals due to the lack of effective tools for real-time price monitoring. Addressing this need, **Price Pulse** is a comprehensive, user-friendly platform designed to simplify price tracking for Amazon products. This MERN stack-based solution enables users to monitor price fluctuations, set personalized target prices, and receive instant email notifications whenever a product's price meets or falls below the predefined threshold. The platform emphasizes user-centric features, including secure authentication mechanisms powered by JWT, an intuitive dashboard for managing alerts, and responsive design for seamless accessibility across devices. Leveraging powerful tools such as Cheerio for web scraping and Nodemailer for email notifications, Price Pulse ensures accuracy and reliability in real-time price updates. By integrating cutting-edge web technologies and design principles, the application provides an efficient and automated alternative to manual price tracking, saving users both time and effort. Beyond its current scope, Price Pulse has the potential to revolutionize ecommerce tracking with planned future enhancements, such as incorporating historical price graphs, expanding support to other e-commerce platforms like Flipkart, and introducing a mobile application for on-the-go tracking. These features aim to empower users further, enabling data-driven purchasing decisions while ensuring affordability and convenience. By bridging the gap between affordability and accessibility, Price Pulse offers a smart solution that caters to both budgetconscious shoppers and tech-savvy users, redefining the way consumers interact with ecommerce platforms.

**Keywords:** Price Tracking, Real-Time Alerts, Web Scraping, MERN Stack, E- Commerce Tools, Automated Notifications

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**NANO-BIOCHAR A NOVEL STRATEGY FOR THE REMOVAL OF  
CONTAMINANTS FROM AGRICULTURAL SOIL**

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**Abstract**

Globally contamination in agricultural soil becomes a serious problem which is mainly caused by various anthropogenic activities such as the use of synthetic fertilizers, applications of pesticides, sewage and sludge application. Various organic amendments includes agricultural crop residues, biocompost, biochar and nano-biochar were considered as sustainable strategies for the removal of contaminants from soil ecosystem. In the present scenario nanoremediation plays a crucial role in the prevention of contaminants from environment, their remediation, detection and monitoring. Biochar in nano sizes produced from biomass via integration of pyrolysis and nanotechnology increases attraction because of its environmental friendly behaviour and improved crop productivity by providing resistance against plants pathogens. The main objective of present study is to explore the role of nano-biochar for the removal of harmful contaminants from soil. Nano-biochar applicability in soil increases the biomass of microbes, provides better environment to microbes living in soil by increasing water holding capacity, tensile strength, porosity ultimately improves the activity of soil, makes soil more suitable for the growth of microbes. Nano-biochar serves as better physico-chemical properties. With smaller size it occupies larger surface area, high cation exchange capacity, zeta potential and pore characteristics. Nano-biochar is a best alternative for synthetic fertilizers as it is a movable in soil remove toxins and pollutants from soil. Nano-biochar have the ability to supports growth of plants under stress conditions by various mechanisms. These functions includes maintaining of reactive oxygen species homeostasis, improves the ability of potassium retention and expulsion of sodium from shoot. Application of nano-biochar in agricultural becomes helpful for the sequestration of harmful contaminants from soil through enzymatic transformation, precipitation, complexation, ion exchange and adsorption mechanism furthermore reduces the loss of nutrients through leaching. Thus it can be used as a soil enhancer for green and ecofriendly agriculture.

**Keywords :** nano-biochar, novel, contaminants, agricultural soil

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**THYROID HORMONE LEVELS AND THEIR ASSOCIATION WITH PLASMA  
ZINC LEVELS AMONG ADOLESCENT AFGHAN REFUGEES; A CROSS-  
SECTIONAL STUDY**

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Demonstrator

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**Abstract**

**Introduction:** Thyroid hormones play an important role in the development and maintenance of nearly all tissues. In Pakistan, hypothyroidism and hyperthyroidism prevalence are 4.1% and 5.1%, respectively, and with increasing age, prevalence increases approximately to 10% in adults over 65 years of age. Malnutrition or nutritional deficiencies in the body can be the cause of thyroid disorders. Zinc (Zn) and copper (Cu), have important roles in regulating biological processes, maintaining normal thyroid function, and preventing thyroid diseases.

**Objective:** The objective of study was to find out levels of the thyroid hormones (TSH, T3 and T4) and its association with plasma zinc levels among adolescents Afghan refugees living in Peshawar, Pakistan.

**Methodology:**

**Study design:** Cross-sectional study

**Study setting;** It was conducted in the experimental Laboratory of Hayatabad Medical Complex, Hayatabad, Peshawar, Khyber Pakhtunkhwa (Pakistan) and University of Nottingham, England.

**Subjects:** A total of 206 adults from Khazana Afghan Refugee Camp, Peshawar were recruited and demographic details were done using a standard questionnaire.

**Methods:** We measured the patient's weight and height to calculate body mass index (BMI). Each participant blood sample was taken, so that many indicators could be measured. The concentrations of plasma zinc were measured by Inductively coupled plasma mass spectrometry (ICPMS), and TSH, T3, and T4 were done by using cobas e 601 which is a completely automated analyzer that performs immunoassay analysis using electrochemiluminescence (ECL) technology.

**Results:** Gender was equally divided into 103 females and 103 males with age group of 10-14 was (65.5%) and 15-19 was (34.5%). According to results (99.0%) participants had normal TSH levels, (79.1%) of participants had normal T3 levels, while (78.6%) of participants had normal T4 levels. T3 and T4 was low in (10.7 and 18.4 %) respectively. Serum Zinc levels in majority (65%) of participants had normal zinc levels while 35% of the participants were found to be deficient in zinc. There was significant association between gender and age group p value 0.02. A significant association was found between the gender and T3 levels. Females had more ratio of increased T3 levels. There was significant association between gender and T4 levels. However there was no significant association between thyroid hormones Zinc and other parameters.

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Conclusion: This non-significant study did not find a direct relationship between thyroid hormones and zinc levels, there is still evidence to suggest that maintaining adequate zinc levels may be important for proper thyroid function. Further research is needed to fully understand the relationship between these two factors. Keywords; malnutrition, hyperthyroidism, hypothyroidism

**Keywords:** malnutrition, hyperthyroidism, hypothyroidism

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**LIFE-CYCLE ASSESSMENT OF HYDROGEN REFUELING STATIONS  
MANUFACTURING FOR WATER DESALINATION APPLICATIONS**

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**Abstract**

The growing demand for sustainable energy solutions has led to increased interest in hydrogen as a clean energy carrier. Hydrogen refueling stations (HRS), pivotal for the hydrogen economy, are now being explored for integration with water desalination systems to produce sustainable freshwater while supporting energy transitions. A Life-Cycle Assessment (LCA) provides a comprehensive framework to evaluate the environmental impacts of manufacturing HRS infrastructure tailored for desalination applications. This analysis spans the entire lifecycle, from raw material extraction, manufacturing, and operation to end-of-life processes, identifying key contributors to the environmental footprint. LCA reveals that material selection, energy requirements, and production processes are significant drivers of environmental impact in HRS manufacturing. Incorporating renewable energy sources, such as solar or wind power, into HRS operations can substantially reduce greenhouse gas emissions. Furthermore, coupling hydrogen production with water desalination systems offers opportunities for enhanced sustainability by utilizing desalination by-products, such as brine, in hydrogen production processes. This paper evaluates the integration of HRS manufacturing and desalination systems, highlighting recent advancements in green manufacturing practices, energy efficiency, and circular economy principles. Challenges such as high capital costs, resource intensiveness, and the need for advanced material recycling technologies are addressed. By applying LCA, stakeholders can identify optimization pathways to minimize environmental impacts while fostering the adoption of hydrogen as a sustainable energy solution in water-stressed regions.

**Keywords:** Life-Cycle Assessment; Hydrogen Refueling Stations; Water Desalination; Sustainable Manufacturing; Renewable Energy Integration.

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**EVALUATION OF NEUTRON-GAMMA DISCRIMINATION APPROACHES  
USING SCINTILLATION DETECTORS**

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**Abstract**

Neutron spectrometry using scintillation detectors has gained widespread adoption in radiation detection due to their high efficiency in detecting neutrons over a broad energy spectrum, cost-effectiveness, and straightforward design, which facilitates maintenance and operation. Despite these advantages, a critical challenge lies in accurately distinguishing neutron signals from accompanying gamma radiation. Addressing this challenge, various techniques have been proposed to differentiate neutrons from gamma radiation. This work reviews neutron-gamma discrimination methods using different types of organic scintillators and compares these methods based on their accuracy and the type of detector used. Additionally, potential recommendations for the research community are provided.

**Keywords:** Neutron-gamma discrimination, Machine learning, Pulse Shape discrimination, Scintillation detectors

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**RECENT ADVANCES IN NANOTECHNOLOGY-BASED MEMBRANES FOR  
WATER DESALINATION**

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**Abstract**

The demand for desalination is steadily increasing due to the dwindling freshwater sources and the abundance of saltwater in our oceans. Among the various techniques available, membrane-based methods stand out as particularly promising. Graphene is the most studied material in recent times and is rapidly gaining traction in desalination due to its unique characteristics, including its nanopore size. This article discusses the advances in graphene-based nanomembranes for desalination, driven by the urgent need for clean water. It describes the potential of these membranes to improve the desalination process, highlighting specific research gaps related to desalination techniques, graphene-based materials, membrane casting methods, and the performance of different membranes. The article also explores the mechanics of desalination and compares the efficiency of various graphene membranes derived from distinct graphene composites. Furthermore, it addresses the challenges and future prospects of applying graphene nanomembranes to traditional desalination processes. Although graphene-based nanomembranes are still in the development phase, their substantial potential for desalination and other processes cannot be overlooked.

**Keywords:** Nanotechnology; Membranes; Water; Desalination.

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**COLD EMAIL GENERATOR & SENDER**

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**Abstract**

In the modern business environment, scaling personalized outreach through cold emails is challenging due to the time and expertise required to craft compelling, targeted messages. Manual email generation lacks consistency and adaptability to diverse audiences, which can result in poor engagement and conversion rates.

The Cold Email Generator and Sender project seeks to solve this problem by developing an AI-driven tool that automates the creation and delivery of personalized cold emails, tailored to specific audiences using Natural Language Processing (NLP) and Artificial Intelligence(AI).

Steps Involved:-

1. Extraction of relevant information needed from website (web scraping techniques) and generate email.
2. Ensuring the generated emails are coherent, contextually relevant, and personalized to the recipient's profile and industry using LLM.
3. Automating the email-sending process while maintaining a human-like tone and minimizing spam filters' impact.

The final product will allow users to input an url that contains job postings, and generate emails with personalized subject lines, body text, and follow-up strategies. This solution will provide an efficient, scalable, and data-driven approach to cold emailing, improving user productivity and increasing engagement rates

**Keywords:** LLM(Large Language Model), Email Generation, Gen AI

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**STRUCTURAL AND ELECTRONIC PROPERTIES OF  $\text{SnO}_2$ : A FIRST-  
PRINCIPLES STUDY USING DENSITY FUNCTIONAL THEORY WITH GGA,  
GGA+U ET GGA+U+V METHODS**

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**Abstract**

The accurate determination of the structural, electronic, and optical properties of  $\text{SnO}_2$  is crucial for its application in various optoelectronic devices. In this study, we employ Density Functional Theory (DFT), implemented in the Quantum ESPRESSO code, to investigate these properties using the PBE, PBE+U, and PBE+U+V methods. Ultrasoft pseudopotentials were utilized for structural and electronic property calculations, whereas norm-conserving pseudopotentials were required for the optical property simulations to ensure higher precision.

The optimized lattice parameters obtained with the PBE functional show excellent agreement with experimental results, affirming the reliability of the structural predictions. However, the electronic bandgap computed using the PBE functional is underestimated at 0.63 eV, consistent with the known limitations of standard DFT. By applying on-site corrections to the O-2p and Sn-5p orbitals through the PBE+U and PBE+U+V methods, the bandgap was significantly improved, approaching the experimental value. Additionally, these corrections yielded refractive index values and optical response curves that closely matched experimental data and the results reported by B. Thlel et al(1976).

**Keywords:** DFT; DFT+U+V; PBE ; Energy band gap;  $\text{SnO}_2$

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**January 21-28, 2025 / Havana, CUBA**

**APPROACHING ARTIFICIAL INTELLIGENCE IN DESIGNING VISUAL AIDS  
FOR TEACHING MATHEMATICS AT HIGH SCHOOLS**

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**ABSTRACT**

Today, artificial intelligence has been widely applied in many areas of society, especially in Education. AI tools, increasingly designed to be smarter, have been helpful for many teachers in their instructional tasks. This report presents some research findings on the application of AI tools in designing visual aids for teaching Mathematics at the high school level. Some ideas from the report may suggest trends in applying AI tools to the teaching process in education.

**Keywords:** Visual aids, Artificial Intelligence, Teaching Mathematics, High School.

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**REVIEW ON MINERAL COMPOSITION OF *ZINGIBERACEAE* FAMILY**

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**Abstract**

*Zingiberaceae* Family also called ginger family is a family of flowering plants made up of about 50 genera with a total of about 1600 known species of aromatic perennial herbs with creeping horizontal or tuberous rhizomes distributed throughout tropical Africa, Asia, and the Americas. Many of the family's species are important ornamental, spice, or medicinal plants. Members of the family are small to large herbaceous plants with distichous leaves with basal sheaths that overlap to form a pseudostem. The plants are either self-supporting or epiphytic. Flowers are hermaphroditic, usually strongly zygomorphic, in determinate cymose inflorescences, and subtended by conspicuous, spirally arranged bracts. The perianth is composed of two whorls, a fused tubular calyx, and a tubular corolla with one lobe larger than the other two. Flowers typically have two of their stamenoids (sterile stamens) fused to form a petaloid lip, and have only one fertile stamen. The ovary is inferior and topped by two nectaries, the stigma is funnel-shaped. This review aimed to investigate the mineral composition of *Zingiberaceae* family. The literature was gathered from several online databases such as Directory of Open Access Journals, PubMed, Scopus, Web of Science, Academic Search Complete, CORE, Research gate and Google scholar. Base on the data collected, this family revealed the content of sodium, potassium, calcium, iron, zinc, phosphorus and magnesium. This review indicated that *Zingiberaceae* Family are good source of mineral composition and could be served as guide for upcoming researches.

**Keywords:** *Zingiberaceae* Family, Mineral composition, Online database, Calcium, Sodium.

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**January 21-28, 2025 / Havana, CUBA**

**INVESTIGATING EDUCATION FOR SUSTAINABLE DEVELOPMENT:  
INSIGHTS FROM FUTURE EDUCATORS, TEACHING APPROACHES, AND  
IMPLEMENTATION CHALLENGES**

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**Abstract**

Education for Sustainable Development (ESD) is essential for tackling modern environmental, social, and economic challenges. This study examines the perspectives of prospective teachers, their teaching strategies, and the obstacles they face in implementing ESD in Pakistan. It explores educators' understanding of ESD, their approaches to embedding sustainability in teaching, and the barriers to successful implementation. Using a qualitative research design, the study involved semi-structured interviews with 12–15 prospective teachers and document analysis of teacher education curricula. Thematic analysis, based on Braun and Clarke's (2006) framework, revealed key findings. While prospective teachers acknowledge ESD's importance, their understanding is largely centered on environmental aspects, with limited consideration of social and economic dimensions. Active learning strategies, including case studies and group discussions, were commonly employed. However, challenges such as inadequate training, limited institutional support, and scarce resources hinder effective implementation. The findings highlight the need for specialized teacher training, adaptable curricula, and stronger institutional backing to equip educators with the skills to effectively integrate ESD. Addressing these challenges can promote critical thinking, problem-solving, and sustainability-focused mindsets in learners.

**Keywords:** Implementation Challenges, Pedagogical Approaches, Prospective Teachers.



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**OPTIMUM DESIGN OF REINFORCED CONCRETE CANTILEVER RETAINING  
WALLS CRICKET ALGORITHM ALGORITHM(CA)**

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**Abstract**

The CA algorithm has been employed to enhance the optimization of concrete cantilever retaining walls, and its performance has been compared with alternative methods. Results from the verification section demonstrate the robustness and superior performance of the CA algorithm relative to other techniques. Furthermore, the optimization process has a substantial impact on the cost and weight of the wall. Additionally, the study explores the effects of wall geometric shapes by analyzing two distinct wall types. Findings reveal that the conventional T-shape exhibits elevated values for cost and weight objective functions. Conversely, the T-shape wall with variable stem thickness yields the lowest values for cost and weight objective functions. The examination of stem height and soil unit weight effects shows that both objective functions exhibit increasing and decreasing trends, respectively. These variations are observed in both proposed wall types. **Keywords:** reinforcement concrete cantilever retaining wall, CA algorithm, Animal Migration optimization, sensitivity analysis, objective functions, wall cost and weight, T-shape walls.

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**DETECTION OF SUICIDAL AND DEPRESSION POSTS AND PREVENTION**

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**Abstract**

Mental health disorders, notably depression and suicide ideation, have grown more common in the digital era, with social media platforms providing channels for people to vent their emotional distress. Also, Depression is regarded as the most significant factor in worldwide disability and a major cause of suicide.

The primary goal of our research is to evaluate Reddit user posts to identify any characteristics that may disclose relevant online users' opinions toward depression. We use Natural Language Processing (NLP) techniques and machine learning methodologies to train the data and assess the effectiveness of our suggested strategy. Preprocessing techniques like tokenization, stop-word removal, and stemming are employed to refine the text data. Models such as Random Forest, Support Vector Machines (SVM), and Transformer-based architectures (e.g., BERT) are evaluated to achieve optimal accuracy in classification. We discover a vocabulary of phrases that are more commonly used in depressive reports. The findings demonstrate that our suggested strategy may greatly increase performance accuracy. The program examines user-generated material from platforms such as Reddit to find patterns, attitude changes, and language cues that are frequently related with mental health deterioration.

This project aims to provide a scalable, efficient, and socially responsible tool to assist in the early detection and mitigation of mental health crises, contributing to the broader field of public health and safety.

**Keywords:** NLP, Machine Learning, Mental Health, Depression and Suicide

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**INVESTIGATING THE EFFECT OF TEACHER- STUDENT RATIO ON  
ACADEMIC PERFORMANCE OF JSS II BASIC SCIENCE AND TECHNOLOGY IN  
JOS NORTH, PLATEAU STATE**

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**Abstract**

This study investigated the effect of teacher-student ratio on academic achievement of Basic Science and Technology in Jos North, Plateau State, Nigeria. A descriptive research survey design was used. It sought to find out the influence of teacher –student ratio, teachers’ qualifications and experience on the students’ academic achievement in Basic Science and Technology and the independent variable (teachers’ qualification and experience) and the dependent variable (student academic achievement in JSS II Basic Science and Technology students) The study’s population was made up 5 schools sampled from twenty-two (22) government junior secondary schools within the study area. The study used a sample of 18 Basic Science and Technology teachers making a total of 90 respondents. Simple random sampling technique was used to select the respondent. The Basic Science and Technology teacher’s questionnaire was used for the data collection. Three research questions and three null hypotheses guided the study. Statistical tool of mean, frequency count, and simple percentage were used in answering the research questions while the hypotheses were tested using independent sample t-test at 0.05 level of significance. The findings of the study among others revealed that, a class with low students’ ratio has a positive influence on academic achievement in Basi Science and Technology and it also revealed that a teacher’s year of experience and qualification has great influence on the academic achievement of JSS II students. It was recommended among others that, schools within Jos North in Plateau state should ensure low student-teacher ratio in classroom in schools and teachers should be giving a platform to go for in-service training for more experience and increase their qualifications.

**Keywords:** Basic Science and Technology, Achievement, student-Teacher ratio.

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## LIFE-CYCLE ASSESSMENT OF WATER DESALINATION PLANTS: A SUSTAINABLE PERSPECTIVE

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### **Abstract**

Water desalination plants play a critical role in addressing freshwater scarcity, providing a reliable source of potable water for arid and semi-arid regions. However, desalination technologies, including reverse osmosis (RO), multi-effect distillation (MED), and electrodialysis (ED), have significant environmental and economic implications. Life-cycle assessment (LCA) is a comprehensive approach to evaluating the environmental impacts of desalination plants across their entire lifecycle—from resource extraction, construction, and operation to decommissioning. LCA helps identify hotspots of environmental burden, such as high energy consumption, greenhouse gas emissions, and brine discharge, enabling the development of more sustainable desalination practices. Energy consumption is a major contributor to the environmental footprint of desalination plants, with fossil fuel-powered facilities producing significant carbon emissions. Integrating renewable energy sources, such as solar or wind power, into desalination processes can reduce these impacts. Additionally, innovative brine management techniques, including mineral recovery and zero liquid discharge systems, address the environmental challenges associated with brine disposal. This paper reviews the application of LCA to desalination technologies, focusing on identifying environmental trade-offs and optimizing system design. It highlights recent advancements in energy efficiency, material selection, and brine management that enhance sustainability. By adopting LCA, stakeholders can make informed decisions to minimize environmental impacts while ensuring water security. LCA serves as a critical tool for transitioning desalination plants toward sustainable and resilient water management solutions.

**Keywords:** Life-Cycle Assessment; Water Desalination; Environmental Sustainability; Energy Efficiency; Brine Management.

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**EXPLORATION OF THE SPECIFIC PROPERTIES OF MATERIALS  
FOR THE TECHNOLOGY INDUSTRY**

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**Özet**

Bu çalışma, ağır metallerle kirlenmiş suyun arıtımı için özel olarak tasarlanmış yenilikçi bir adsorban nanokompozitinin dikkate değer potansiyelini vurgulamaktadır. Çeşitli koşullar altında adsorpsiyon dengesi ve kinetiği üzerine kapsamlı bir analiz ile birlikte operasyonel parametrelerin optimizasyonu, deneysel verilerin hassas bir şekilde modellenmesi için sahte birinci ve sahte ikinci dereceden kinetik modellerin uygulanmasını sağlamıştır. Ayrıca, adsorpsiyon izotermi, malzemenin maksimum adsorpsiyon kapasitesinin değerlendirilmesine olanak tanıırken, temel mekanizmayı tanımlayıp açıklamak için ampirik Langmuir ve Freundlich modelleri kullanılarak modellenmiştir. Deneysel sonuçlar, hızlı bir adsorpsiyon kinetiği ve ağır metallerin giderilmesinde önemli bir verimlilik göstermektedir; optimal koşullar altında ilk 30 dakika içinde dikkate değer bir temizleme oranı gözlemlenmiştir. Ayrıca, termodinamik analiz, adsorpsiyon sürecinin kendiliğindenliği ( $\Delta G^\circ < 0$ ) doğrulamakta ve adsorban ile adsorbat arasında baskın olan fiziksel adsorpsiyonu önermektedir. Bu umut verici laboratuvar sonuçları, güçlü sanayileşme beklentileri ile birleştiğinde, bu nanokompozitin daha sürdürülebilir ve çevre dostu su arıtma çözümlerinin uygulanmasındaki kritik rolünü vurgulamakta ve böylece su kaynaklarının korunmasına ve sanayi faaliyetlerinin çevresel etkisinin azaltılmasına katkıda bulunmaktadır.

**Anahtar Kelimeler:** Nanokompozit; Adsorpsiyon; Kinetik ; İzotermi; Ağır metaller.

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**January 21-28, 2025 / Havana, CUBA**

**EXPLORATION OF THE SPECIFIC PROPERTIES OF MATERIALS  
FOR THE TECHNOLOGY INDUSTRY**

**Abstract**

This study highlights the remarkable potential of an innovative adsorbent nanocomposite specifically designed for the treatment of water contaminated by heavy metals. The optimization of operational parameters, combined with a thorough analysis of adsorption equilibrium and kinetics under various conditions, has enabled the application of pseudo-first and pseudo-second order kinetic models for precise modeling of the experimental data. Furthermore, the adsorption isotherms were modeled using empirical Langmuir and Freundlich models, allowing for the evaluation of the maximum adsorption capacity of the material while identifying and describing the underlying mechanism. Experimental results reveal a rapid adsorption kinetics and significant efficiency in the removal of heavy metals, with a notable depollution rate observed within the first 30 minutes under optimal conditions. Additionally, thermodynamic analysis confirms the spontaneity of the adsorption process ( $\Delta G^\circ < 0$ ), suggesting predominant physisorption between the adsorbent and the adsorbate. These promising laboratory results, coupled with strong industrialization prospects, underscore the crucial role of this nanocomposite in implementing more sustainable and environmentally responsible water treatment solutions, thereby contributing to the preservation of water resources and the reduction of the environmental impact of industrial activities.

**Keywords:** Nanocomposite; Adsorption; Kinetic; Isotherms; Heavy metals.

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## LIFE-CYCLE ASSESSMENT OF GREEN HYDROGEN PRODUCTION INTEGRATED WITH WATER DESALINATION: EXPLORING EMERGING TECHNOLOGIES

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### Abstract

The transition to a sustainable future requires innovative solutions that address both clean energy production and freshwater scarcity. Integrating green hydrogen production with water desalination plants represents a promising approach to achieving these goals. Green hydrogen, generated through renewable energy-powered electrolysis, relies on high-purity water, often supplied by desalination technologies such as reverse osmosis (RO) and multi-effect distillation (MED). However, the environmental and economic impacts of these integrated systems must be evaluated comprehensively. Life-Cycle Assessment (LCA) provides a critical framework for analyzing the sustainability of green hydrogen and desalination systems. By assessing resource extraction, energy consumption, greenhouse gas emissions, and waste generation across the lifecycle of these systems, LCA identifies environmental hotspots and opportunities for improvement. Emerging technologies, such as advanced electrolyzers, renewable energy integration, and hybrid systems, enhance the efficiency and scalability of this integration while minimizing environmental footprints. Innovations in brine management, including resource recovery and zero-liquid discharge methods, further enhance sustainability. Despite significant potential, challenges such as high capital costs, energy requirements, and technological complexity remain. This paper examines the life-cycle impacts of integrating green hydrogen production with water desalination, highlighting advancements in technology and strategies to overcome existing barriers. The study emphasizes the role of renewable energy and circular economy practices in making these systems viable. By leveraging LCA, stakeholders can optimize designs and operational strategies, advancing toward a low-carbon, water-secure future.

**Keywords:** Life-Cycle Assessment; Green Hydrogen; Water Desalination; Renewable Energy; Emerging Technologies.

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THE GREEN REPLACEMENT OF CONVENTIONAL PLASTICS

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**Abstract**

The diverse and ubiquitous consumption of polymers urges the necessity to make these materials easily available. However, the excessively used petrochemical-based polymers such as poly(vinyl) chloride (PVC) are nonbiodegradable, which is a motivation to modify it with “green” alternatives. In the present study, PVC ( $M_w = 48\,000\text{ g mol}^{-1}$ ) has been incorporated with cornstarch (CS) to synthesize a series of 25 samples of bioplastics in addition to blank polymer samples. The films of five various thicknesses (0.1, 0.2, 0.3, 0.5, and 1.0 mm) have been synthesized using in situ polymerization. Each sample of pure PVC film and bioplastic has been induced with different concentrations of CS in the range of 1–5 wt %. The synthesized samples were subjected to the structural characterization by using Fourier transform infrared. Thermogravimetric analysis has demonstrated the three-step degradation with the improved stability of 250 °C. The 3% concentration of CS has shown the optimum storage modulus ( $E'$ ) of 1 660 MPa from dynamic mechanical analysis and  $\tan \delta$  as 0.50. The swelling test performed using water has shown an induction of hydrophilicity in PVC up to 4%. CS-induced bioplastics can be a potential ecofriendly alternative of conventional polymers.

**Keywords:** Biomaterials; films; mechanical properties; poly(vinyl) chloride; thermogravimetric analysis



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**SYNTHESIS AND CHARACTERIZATION OF LIGHTWEIGHT GEOPOLYMER  
FOR BUILDING ENERGY SAVING**

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**Abstract**

The construction sector, one of the most energy-intensive industries, is responsible for 36% of global final energy consumption and is estimated to increase to 58% by 2040. Thus, the development of eco-friendly and energy-efficient thermal insulation materials is attracting increased interest in the housing and construction industry worldwide. Nowadays, lightweight geopolymers offer a promising solution that combines the benefits of low CO<sub>2</sub> emission and operational energy savings. In this context, this study presents an experimental investigation of metakaolin-based geopolymer foams using hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) solution as pore-forming agent. A series of mixes with varying contents of H<sub>2</sub>O<sub>2</sub> was prepared. Comprehensive characterizations were performed, including mechanical strength tests, thermal conductivity measurements, and microstructural analyses. The experimental outputs reported that the content of the pore-forming agent had a significant influence on the porous structure and the performance of geopolymer foams. In addition, the results demonstrated that the developed lightweight geopolymers exhibit excellent thermal insulation properties and sufficient mechanical strength, making them suitable for energy-saving in housing and buildings. Therefore, this research highlights the potential of geopolymer foam technology in promoting sustainable construction practices and contributing to energy-efficient building solutions.

**Keywords:** Geopolymer Foams, Red Brick Waste, Building Materials, Energy-Efficient, Thermal Insulation.

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**January 21-28, 2025 / Havana, CUBA**

**URBANIZATION, HEALTH RISKS AND POPULATION HEALTH LITERACY  
PROBLEMS**

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**Abstract**

**Introduction:** Urbanization is the population shift from rural to urban areas, the corresponding decrease in the proportion of people living in rural areas, and the ways in which societies adapt to this change. It can also mean population growth in urban areas instead of rural ones. While it offers numerous economic, social, and cultural advantages, it also brings about a wide range of challenges, particularly in the health sector.

**Aim of research:** The aim of the present study is to gain insights into the relationship between health literacy and analyses of risk factors of organizational processes, and health literacy problem of population.

**Research Methods:** Meta-Analysis, Comparative Analysis.

**Results:** The influx of people into urban centers often surpasses the capacity of existing healthcare infrastructure. Urbanization is associated with lifestyle changes, such as sedentary behavior, unhealthy diets, and increased stress levels. Urban environments often suffer from increased pollution, including air pollution, noise pollution, and inadequate waste management. Urban areas with their high population density and frequent international connections, can become epicenters for infectious disease outbreaks. Urbanization can also impact mental health due to factors like social isolation, increased stress, and reduced access to green spaces. Urbanization presents an opportunity to leverage technology in the health sector. Investments in healthcare infrastructure are crucial to meet the growing demand in urban areas. Public health campaigns, education, and lifestyle interventions can play a significant role in reducing the burden of chronic diseases in urban areas.

**Conclusion:** Health literacy is considered one key to a healthy society. Although levels of health literacy cannot be drawn on region alone, environmental factors play an important role as they interact with other associated factors. Therefore, the focus on health literacy should be emphasized not only in research but also in societies in general.

**Keywords:** Urbanization, Health Literacy

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**January 21-28, 2025 / Havana, CUBA**

**SPEECH EMOITON RECOGNITION USING MACHINE LEARNING**

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**Abstract**

Emotions play an important role in social interactions of humans and it is often said that emotions separate us from machines. Spoken words may have different interpretations depending on how they are uttered. Same sentences can have different meanings under different type of emotional states. Human brain understands different meanings by perceiving underlying emotions in speech. Finding the emotional content from speech signals is desirable because this enables us to teach emotional intelligence to computers.Speech emotion recognition is an important field of study with applications ranging from emotionally intelligent robot creation, audio surveillance, web-based E-learning, computer games, etc. The objective of this paper is to identify emotions in audio speech by using deep learning algorithms including Convolutional Neural Network (CNN) and Recurrent Neural Network (RNN) to identify different emotional states of a person. In this regard, the RADVEES dataset, Ryerson Audio-Visual database of Emotional Speech and Song, is used to study speech emotion recognition.

For experiments, we used approximately 1247 audio and song files containing eight different emotions for classification of audio data. The experimental results show that the best performing model was CNN based model with accuracy of 74.57% while RNN model only showed 55.47% accuracy which is far less in comparison. This work will be extended in future using different variants of RNNs and other DNNs like auto-encoders. Audio is a complex signal with linguistic and paralinguistic features and our future goal is to combine these features with different neural network architectures for developing improved SER systems.

**Keywords:** Convolutional Neural Network (CNN), Recurrent Neural Network (RNN), DNN

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**BUILDING A LIBERATIVE CHRISTIAN RELIGIOUS EDUCATION: A  
PERSPECTIVE ON LIBERATION PEDAGOGY**

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Universitas Kristen Indonesia<sup>1-2</sup>

**Abstract**

Christian Religious Education (CRE) holds a strategic role in shaping individuals to live according to Christian values while becoming agents of transformation in society. This article explores the concept of liberation pedagogy as an alternative approach in CRE to realize an education that liberates. Liberation pedagogy, popularized by Paulo Freire, emphasizes empowering learners through dialogue, critical reflection, and transformative actions. This approach is relevant to CRE as it aligns with biblical values that highlight justice, love, and the liberation of humanity from all forms of oppression. Through theoretical and practical analysis, this study highlights how CRE can serve as a means to address social challenges such as injustice, poverty, and discrimination by instilling values of liberation in learners. Liberative education not only develops intellectual capacities but also fosters character and inspires learners to become agents of transformation in their communities. Thus, CRE grounded in liberation pedagogy has the potential to nurture a generation with a living faith, critical awareness, and transformative action to build a more just and peaceful world.

**Keywords:** Christian Religious Education, liberation pedagogy, empowerment, transformation, Christian values.

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**January 21-28, 2025 / Havana, CUBA**

**EFFECT OF HOUSE POSSESSING ON THE ATTITUDE TOWARD THE USE OF  
PV SOLAR ENERGY: AN EXPLORATORY STUDY FROM ALGERIA**

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**Abstract**

This study seeks to assess the impact of the house possessing among respondents on the attitude toward the use of PV solar energy in Algeria. This type of research aims to examine the awareness and knowledge of consumers with the ecological environment.

The method explored in this research is quantitative through an online and face-to-face survey between March 2022 and May 2023. It should be mentioned that respondents have to live in land houses which are more suitable for installing photovoltaic solar energy. Besides, the respondents should have an income in order to cover the cost of photovoltaic solar kit purchasing. Then, the results were analyzed through SPSS software V26 by exploring the independent sample t test.

It has been found that the LEVENE test is superior to the significant level (p value:  $0.14 > 0.05$ ), which means that the variances are homogeneous. The results indicate that the independence between the attitude toward the use of PV solar energy and the gender of respondents is ensured (sig t-test: 0.353), which implies that both house possessors and those who don't possess houses are not significantly different in this issue.

**Keywords:** Consumer behavior- Green marketing- Photovoltaic solar energy- independent sample t-test-Algeria- SPSS.

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**January 21-28, 2025 / Havana, CUBA**

**ÖZEL İLETİŞİM VERGİSİNİN TARİHSEL SÜRECİ**

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**Özet**

Özel İletişim Vergisi 4481 sayılı Kanun ile 1999 yılından itibaren Türk Vergi Sistemi içerisinde uygulanmaktadır. Özel İletişim Vergisi toplumda deprem vergisi ve haberleşme vergisi isimleri ile de anılmaktadır. İnternet faturalarından, cep telefonu faturalarından, sabit telefon faturalarından, kablolu TV yayınlarından alınmaktadır. Bundan kaynaklı olarak verginin mükellefi telekomünikasyon şirketleridir. Bütün vergi gelirleri arasında oldukça küçük bir orana sahip olan ilgili vergi türünün tahakkuk tutarına bakıldığında 2007 yılından 2020 yılına kadar çok ciddi bir artış olmadığı görülmektedir. 2021 yılından itibaren artış başlamış olup 2023 yılında 2020 yılının yaklaşık dört katı tutarında bir tahakkuk değerine ulaştığı görülmektedir. 2025 yılı itibariyle ise ilk defa mobil telefon aboneliğinde, Özel İletişim Vergisi yeniden değerlendirme oranında arttırılarak 400 TL'den 570 TL'ye çıkarılmıştır. Dijitalleşmenin bu kadar önemli olduğu günümüzde yeniden değerlendirme oranındaki bir artış tartışmalara sebep olmaktadır. Yıllar içerisinde internet hizmetinden faydalanan, cep telefonu kullanan, kablolu TV yayını alan bireylerin sayısı ciddi biçimde artmasına rağmen tahakkuk eden vergi tutarının uzun yıllar boyunca artmaması vergi gelirleri için oldukça olumsuz bir durum olmakla iken bu husus telekomünikasyon şirketlerinin lehine olmuştur. Diğer bir tartışma konusu ise 1999 yılında Marmara Depremi akabinde depremin yol açtığı ekonomik kayıpları giderebilmek adına çıkarılan bir vergi türü olmasından kaynaklı olarak sadece deprem ile ilgili alanlarda harcanacağı yanlışının ortadan kaldırılması gerekliliğidir. Bu hususta kamuoyunun aydınlatılması gerekmekte ve diğer vergi türleri gibi ilgili verginin harcanabileceğinin paylaşılması gerekmektedir.

**Anahtar Kelimeler:** Vergi, Özel İletişim Vergisi, Vergi Tahakkuku

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**January 21-28, 2025 / Havana, CUBA**

**HISTORICAL PROCESS OF SPECIAL COMMUNICATION TAX**

**Abstract**

Special Communication Tax has been implemented within the Turkish Tax System since 1999 with Law No. 4481. The Special Communication Tax is also known in society as earthquake tax and communication tax. It is collected from internet bills, mobile phone bills, landline bills, and cable TV broadcasts. Therefore, the taxpayers are telecommunications companies. When the accrual amount of the relevant tax type, which has a very small share among all tax revenues, is examined, it is seen that there has not been a significant increase from 2007 to 2020. The increase has started as of 2021 and it is seen that it reached an accrual value approximately four times that of 2020 in 2023. As of 2025, for the first time, the Special Communication Tax has been increased by the revaluation rate on mobile phone subscriptions, from 400 TL to 570 TL. In today's world where digitalization is so important, an increase in the revaluation rate causes discussions. Although the number of individuals using internet services, using mobile phones and receiving cable TV broadcasts has increased significantly over the years, the fact that the accrued tax amount has not increased for many years is a very negative situation for tax revenues, and this issue has been in favor of telecommunications companies. Another topic of discussion is that since it is a type of tax that was introduced in 1999 following the Marmara Earthquake in order to compensate for the economic losses caused by the earthquake, the misconception that it will only be spent on earthquake-related areas should be eliminated. The public needs to be informed about this issue and it needs to be shared that the relevant tax can be spent like other types of taxes.

**Keywords:** Tax, Special Communication Tax, Tax Accrual

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**January 21-28, 2025 / Havana, CUBA**

**COMPARATIVE ANALYSIS OF ERA5 AND ERA5-LAND REANALYSIS DATA  
FOR DROUGHT EVALUATION USING THE STANDARDIZED  
PRECIPITATION INDEX (SPI)**

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**Abstract:** It is known that a wide variety of data sources are used in research and applications for drought evaluation. It is seen that reanalysis, remote sensing, satellite, and ground measurement data are used the most in the literature. The data sources to be selected may vary depending on the purpose, scale, drought type, data quality, and study continuity. Each data source has advantages and disadvantages compared to the others. In recent years, in many studies on hydrology, ERA 5 and ERA 5-Land data sources stand out with their superior aspects, such as easy access, suitability for global and large-scale field studies, high spatial and temporal resolutions, and long-term and continuous data provision. ERA 5-Land (9 km, ~0.1°) provides higher resolution compared to ERA 5 (31 km, 0.25°) data. It is stated that ERA 5-Land provides an advantage due to its more detailed processing feature on land surfaces. In this research study, drought analyses were performed using both data sources, and the results obtained were compared. In order to verify the obtained drought results, drought analysis results obtained from ground measurement data were used. Standardized Precipitation Index (SPI) methodology was preferred as the drought index. Analyses were carried out for the reanalysis data at specific grid points and ground observation data in Kocaeli province. Different performance metrics and the Innovative drought Classification Matrix (IDCM) were used to compare and find their differences and similarities. The results will significantly enhance the evaluation of reanalysis data, providing a foundation for more accurate and reliable drought assessments.

**Keywords:** Drought assessment, ERA5-LAND, Reanalysis, SPI, Precipitation, Kocaeli.

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**IMPACTS OF PROBABILITY DISTRIBUTION FUNCTION MODEL SELECTION  
ON DROUGHT ANALYSIS: COMPARING GAMMA AND BEST-FIT  
DISTRIBUTIONS**

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**Abstract:** In recent years, many studies have been conducted in the literature using various drought indices to monitor and evaluate drought and drought characteristics. The most well-known of these is the Standardized Precipitation Index (SPI). In SPI calculations, it is seen that the gamma probability distribution function (PDF) is often used as a reference in modeling data sets determined according to selected time scales without considering the suitability tests or only for the raw data set scale where measurements are made. Gamma cannot be the most appropriate PDF for the original data sets frequently created in arid and semiarid areas and occasionally in wetlands. Despite this, it is seen that in scientific articles, projects, and applications produced by researchers, and in free software developed using Python and R software, the gamma PDF is generally used without any suitability check, and rarely the most appropriate probability distribution models are considered. The climate of the study area, precipitation characteristics, and, in short, physical and regional conditions are effective in selecting the appropriate model. Therefore, in studies conducted on drought indices, it is critical to test different distributions for all data sets and select the most appropriate models. Within the scope of this research, the reliability of the results obtained by comparing the drought analysis results of Gamma and other PDFs like Weibull and normal functions, whose suitability was checked with the goodness of fit tests, such as the Kolmogorov-Smirnov statistical test according to 1, 3 and 12-month timescales for the observation data within the Kocaeli province and presented directly in the literature, will be evaluated.

**Keywords:** Drought assessment, PDF, Gamma, SPI, Precipitation, Kocaeli.

**Acknowledgments:** This work was supported by the research fund of The Coordinatorship of Scientific Research Projects of YTU (BAP, General Research Project Program, FBA-2024-6492). The authors would like to express their sincere gratitude to the scientific research coordination units for their financial support for the research.

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**STUDIES ON INTEGRATED PLANT DISEASE MANAGEMENT ON *Sarocladium  
oryzae* CAUSES SHEATH ROT OF RICE (*Oryza sativa* L.)**

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**Abstract**

Sheath rot, caused by the fungal pathogen *Sarocladium oryzae*, has emerged as a significant disease affecting rice (*Oryza sativa* L.) production worldwide, particularly in regions with high humidity and intensive rice cultivation. The disease leads to considerable yield losses by affecting grain quality and quantity. This study investigates integrated disease management (IDM) strategies to control sheath rot through a combination of cultural practices, resistant varieties, biocontrol agents, and chemical treatments. Field experiments were conducted across multiple growing seasons to evaluate the efficacy of these integrated approaches. Results revealed that the combination of resistant cultivars, proper water management, timely fungicidal application, and the use of biocontrol agents such as *Trichoderma harzianum* significantly reduced disease incidence and severity. Moreover, cultural practices like proper spacing, adequate fertilization, and removal of infected plant debris further enhanced disease control efficiency. The integrated management approach not only mitigated the sheath rot incidence but also contributed to improved grain yield and quality. This study highlights the importance of adopting a holistic and sustainable approach to manage *S. oryzae*-induced sheath rot in rice cultivation systems. Further research is recommended to optimize IDM components for different agro-climatic conditions to ensure long-term disease suppression and sustainable rice production.

**Key words:** Sheath rot, *Sarocladium oryzae*, Rice, IDM

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**EFFICACY OF GREEN SYNTHESIZED ZINC NANOPARTICLES ON *Pyricularia  
grisea* CAUSES BLAST IN RAGI (*Eleusine coracana* L.)**

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**Abstract**

Blast disease, caused by the fungal pathogen *Pyricularia grisea*, is one of the most devastating diseases affecting finger millet (*Eleusine coracana* L.), leading to significant yield losses. This study evaluates the efficacy of green synthesized zinc nanoparticles (ZnNPs) against *P. grisea* under *in vitro* conditions. Zinc nanoparticles were synthesized using plant extracts as reducing and stabilizing agents, ensuring an eco-friendly and sustainable approach. The antifungal activity of ZnNPs was assessed through mycelial growth inhibition assays. Results demonstrated a significant reduction in the growth and sporulation of *P. grisea* in the presence of ZnNPs, with higher concentrations showing enhanced efficacy. Scanning electron microscopy (SEM) analysis revealed structural damage to fungal hyphae, indicating the mode of action of ZnNPs. These findings suggest that green synthesized zinc nanoparticles have strong potential as an alternative to chemical fungicides for managing blast disease in finger millet. Further studies are recommended to evaluate their field efficacy and optimize application protocols for sustainable disease management.

**Key words:** Blast, *Pyricularia grisea*, Finger Millet, ZnNPs.

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**LGBTQIA+ MARRIAGE LAWS IN INDIA**

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**Abstract**

Same-sex marriages in India have not been legalised in our country to date; despite us living in the 21st century, our society still considers same-sex marriages to be an abomination of humanity or chooses to ignore it as irrelevant. Although same-sex marriages have been proven multiple times to **not cause any harm** through cultural degeneration or through the loss of legitimacy of traditional heterosexual marriages, the majority of the decision-making people of our country fail to understand or empathise with homosexual people who do not fall into the predetermined categories of husband and wife. LGBTQIA+ relationships, although having been decriminalised by the Supreme Court multiple times due to the nature of the criminalisation being unconstitutional, there has still not been any law or legislation that allows same-sex marriages to be legalised. Furthermore the 2023 case of *Supriya Chakraborty & anr. v Union of India*<sup>1</sup>, the Supreme Court failed to accommodate the Right to marry of this community as a Fundamental Right and legalise same-sex marriages. This restricts all homosexuals from enjoying their right to equality, as without any law to ensure their legalisation, society's discrimination towards them will never subside. It will further only encourage them to cause harm and violence in the name of "morality". There are multiple ways through which same-sex marriages can be legalised. This can be done by 1) interpreting the law as it stands to recognise same-gender partnership unions formally, 2) creating new legislations that provide the right to marriage of this community, 3) Amending the Special Marriages to include LGBTQIA+ marriages, 4) establishing LGBTQIA+ culture as a distinct subculture with practices that encourage relationships between people of the same gender.

**Keywords:** same-sex marriage laws, LGBTQIA+ community, discrimination, gay rights, marital relations, family law, equality, Supriya Chakraborty, Right to marry, homosexual relationships, India.

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<sup>1</sup> Supriya Chakraborty & anr. v Union of India (2023) INSC 920

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**NAVIGATING THE PARADOXES OF POLITICAL COMPETITION:  
INSTITUTIONAL MODERATION AND POVERTY DYNAMICS IN DEVELOPING  
ECONOMIES**

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**Abstract**

This study delves into the intricate nexus between political competition and poverty alleviation within the context of developing economies, foregrounding the pivotal moderating influence of political institutions. Employing an empirical framework, the study elucidates the conditional efficacy of political competition in fostering economic growth and mitigating poverty, revealing the paradoxical interplay of governance dynamics. The findings underscore that while political competition possesses transformative potential, its capacity to engender meaningful poverty reduction is inextricably linked to the structural integrity and coherence of political systems. The analysis further highlights how phenomena such as political fragmentation and institutional fragility obstruct the realization of equitable socioeconomic outcomes. By unraveling these complexities, the study advances a nuanced discourse on the political determinants of poverty, offering critical insights for reimagining governance paradigms in developing nations.

**Keywords:** Political competition, Poverty, Political institutions, Panel data, GMM

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**DECODING UNCERTAINTIES: THE INTERPLAY OF POLITICAL  
COMPETITION, INSTITUTIONAL FRAGILITY, AND POVERTY DYNAMICS IN  
DEVELOPING NATIONS THROUGH FUZZY LOGIC**

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**Abstract**

This study explores the multifaceted relationship between political competition, poverty alleviation, and decision-making processes in developing countries, incorporating fuzzy logic as an analytical lens to address inherent uncertainties. The research underscores the moderating influence of political institutions, revealing how political fragmentation and systemic fragility exacerbate poverty despite the potential economic benefits of political competition. By leveraging fuzzy logic models, the study captures the nuanced, nonlinear dynamics of political competition and institutional efficacy, offering a robust framework for evaluating conditional socioeconomic impacts. The findings demonstrate that fuzzy decision-making approaches can enhance the understanding of complex governance dynamics, providing policymakers with adaptive tools to navigate the ambiguities inherent in political and economic systems. This investigation contributes to the emerging discourse on sustainable poverty reduction strategies, emphasizing the critical interplay of political structures, economic growth, and advanced analytical methods.

**Keywords:** Political competition, Poverty, decision-making, Fuzzy Logic

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FİDEL CASTRO'NUN ÖLÜM HABERİNİN TÜRK HABER SİTELERİNE  
YANSIMASI

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**Özet**

Dünyada en uzun iktidarda kalan liderlerden biri olan Küba lideri Fidel Castro'nun vefatı dünyanın her yerinde büyük bir ilgi ile karşılandı. Birçok kez suikast girişimine maruz kalmasına rağmen 90 yaşında doğal ölüm ile yaşama veda eden Castro, dünyanın birçok noktasında günlerce gündemde kaldı ve ölümünden birkaç ay sonra devlet töreni ile Castro'ya veda edildi. Bu çalışma medyada da dile getirildiği gibi efsanevi lider Fidel Castro'nun ölüm haberinin eleştirel söylem analizi ile nasıl verildiğine odaklanmaktadır. Ölüm haberinin büyük yankı uyandırdığı 26 Kasım 2016 tarihi, çalışmada temel alınmaktadır ve Türkiye'de en çok tıklanan 10 haber sitesinde Fidel Castro'nun ölümü ile ilgili yer alan haberler başlık, fotoğraf ve haber metni içeriği bağlamında analiz edilmektedir. Haber siteleri Hürriyet, Sözcü, Mynet, Milliyet, Haber7com, Sabah, Haberler.com, Habertürk, Ensonhaber ve Cumhuriyet haber sitelerinden ibarettir. Haber siteleri 1 Ekim 2024 tarihi itibari ile en çok tıklanan haber siteleri sıralamasında ilk 10'a girenlerden seçilmiştir. Tıklanma oranına göre ilk sıradan son sıraya kadar haber sitelerinde yer alan ölüm haberleri sırasıyla değerlendirilmekte ve ayrıntılı olarak analiz edilmektedir. Analizlerde haberlerde verilen başlıklar ve metinler eleştirel söylem analizi çerçevesinde değerlendirilmekte ve diğer sitelerde verilen haberlerle kıyaslanmaktadır. Ayrıca haber başlık ve metnin uyumunun analizi ile birlikte haberlerde verilen fotoğrafların da metin ile uyumlu olup olmadığı değerlendirilmektedir.

**Anahtar Kelimeler:** İnternet Haberciliği, Fidel Castro, Haber Siteleri, Söylem Analizi, Haber Analizi



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**REFLECTION OF THE NEWS OF FIDEL CASTRO'S DEATH ON TURKISH  
NEWS SITES**

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**ABSTRACT**

The death of Cuban leader Fidel Castro, one of the longest-ruling leaders in the world, was met with great interest all over the world. Castro, who died of natural death at the age of 90 despite being subjected to assassination attempts many times, remained on the agenda for days in many parts of the world, and a few months after his death, Castro was said goodbye with a state ceremony. This study focuses on how the news of the death of the legendary leader Fidel Castro, as expressed in the media, was given through critical discourse analysis. The date of November 26, 2016, when the news of his death had great repercussions, is taken as the basis of the study, and the news about the death of Fidel Castro on the 10 most clicked news sites in Turkey are analyzed in the context of headlines, photos and news text content. News sites include Hurriyet, Sozcu, Mynet, Milliyet, Haber7com, Sabah, Haberler.com, Haberturk, Ensonhaber and Cumhuriyet news sites. News sites have been selected from the top 10 in the ranking of the most clicked news sites as of October 1, 2024. According to the click-through rate, the death news on the news sites from the first to the last place are evaluated and analyzed in detail. In the analysis, the headlines and texts given in the news are evaluated within the framework of critical discourse analysis and compared with the news given on other sites. In addition, along with the analysis of the harmony of the news headline and text, it is evaluated whether the photographs given in the news are compatible with the text.

**Keywords:** Online Journalism, Fidel Castro, News Sites, Discourse Analysis, News Analysis

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## 1. GİRİŞ

Fidel Alejandro Castro Ruz Marksist Leninist bir lider olarak Küba Devrimi'nin simgesi ve 1959'dan 2008'e kadar Küba'nın lideri olarak bilinen önemli bir figürdür. 25 Kasım 2016'da hayatını kaybeden Castro'nun ölümü, dünya genelinde olduğu gibi Türk medya organlarında da büyük yankı uyandırdı. Bu çalışma, Castro'nun ölümünün en çok tıklanan Türk haber sitelerine nasıl yansıdığını, medya dilinin ideolojik ve duygusal boyutlarıyla eleştirel söylem analizi ile incelenmesini amaçlamaktadır.

Castro'nun ölümü ülkeler arası saat farkından dolayı vefat 25 Kasım'da olmasına rağmen haber sitelerinde haber Türkiye'de 26 Kasım 2016'da verilmiştir. Vefat haberinin ilk yansımalarından başlayarak, 1 Ekim 2024 itibarıyla Türkiye'nin en çok ziyaret edilen 10 haber sitesinin (Hürriyet, Sözcü, Mynet, Milliyet, Haber7, Sabah, Haberler.com, Habertürk, Ensonhaber, Cumhuriyet) Castro'nun ölümünü nasıl sunduğu, eleştirel söylem analizi çerçevesinde değerlendirilmektedir.

Tıklanma oranına göre ilk sıradan son sıraya kadar haber sitelerinde yer alan ölüm haberleri sırasıyla değerlendirilmekte ve ayrıntılı olarak analiz edilmektedir. Analizlerde haberlerde verilen başlıklar ve metinler eleştirel söylem analizi çerçevesinde değerlendirilmekte ve diğer sitelerde verilen haberlerle kıyaslanmaktadır. Ayrıca haber başlık ve metnin uyumunun analizi ile birlikte haberlerde verilen fotoğrafların da metin ile uyumlu olup olmadığı değerlendirilmektedir. Haberlerde eleştirel söylem analizi bağlamında, haber metin ve öğelerinde sosyo-politik ve ideolojik bağlantıların yanı sıra makro ve mikro yapılar değerlendirilmektedir.

## 2. LİTERATÜR TARAMASI

Eleştirel söylem analizi, haber metinlerinin sosyo-politik ve ideolojik bağlamlarını anlamak için etkili bir yöntemdir. Bu alan, özellikle van Dijk'ın (van Dijk, 1988, 34-45; van Dijk, 2001, 96-100) makro ve mikro yapı çerçevesinde geliştirdiği modellerle ön plana çıkmaktadır. Eleştirel söylem analizi, sadece metni değil, aynı zamanda sosyal ve politik bağlamı anlamaya odaklanır. Güç ilişkilerinin söylemsel analizi, medyanın toplumsal yapıdaki rolünü sorgulayan çalışmalara öncülük etmiştir. Türkiye'de ve uluslararası alanda yapılan araştırmalar, bu yöntemin sosyal adaletsizlik ve güç dinamiklerinin açığa çıkarılmasındaki önemini vurgular. Burada özellikle tematik ve şematik yapılar üzerinden çözümlemeler yapılmaktadır. Tematik çözümleme başlıklar, haber girişleri ve olayın sunumu gibi geniş yapıları ele alırken, şematik çözümleme daha ayrıntılı bağlamsal unsurları incelemektedir. Bu yaklaşımlar, medyada ideolojik üretim, sosyal eşitsizlikler ve güç ilişkilerinin analizinde kullanılır. Benveniste (1971), Foucault (1972), Fiske (1998) ve Althusser'in söylem üzerine literatüre katkısına bakıldığında daha çok söylenen değil söylenmek istenene odaklandıkları görülmektedir (Akt., Mutlu, 2012, s.281-282). Tematik çözümlemede haberin başlıkları, ana olayın tanımlanması, bağlam ve ardalan bilgileri gibi geniş anlamda haberin yapı taşları yer alır. Bu, okuyucunun algısını yönlendiren temel unsurların analizine olanak tanır. Şematik çözümlemede ise bağlamda kullanılan dilin, haber kaynaklarının ve görsel unsurların incelenmesi esas alınmaktadır. Örneğin, olayların sunum şekli, kullanılan görseller ve retorik araçlar, söylemin ideolojik temellerini anlamayı kolaylaştırır (van Dijk, 1988, 34; Wodak ve Meyer, 2009, 259). Eleştirel söylem analizi bağlamında birçok yerli ve yabancı kaynak ulaşmak mümkündür. Van Dijk'ın sosyo-bilişsel yaklaşımı, özellikle medya söyleminde ideolojik üretimi ve gücün kötüye kullanımını incelemek için kullanılmıştır (van Dijk, 1988, s. 34-45; van Dijk, 2001, s. 96-100). Fairclough ve Wodak (1997, 259-261) söylemin tarihsel ve sosyo-kültürel

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bağlamlarını analiz ederek, dilin sosyal eşitsizliklerin nasıl üretildiğini göstermektedir. Wodak'ın (2009, 15-20) eleştirel söylem çözümlemesi, sosyal eşitsizliklerin söylem üzerinden nasıl yapılandırıldığını ele alır. Özellikle, toplumsal güç ilişkilerinin dildeki yansımaları üzerine analizleri dikkat çekicidir (Wodak, 2014, s. 302).

Türkiye'deki çalışmalar arasında, Özer ve Şahin'in (2024, 1152-1154) Van Dijk'ın makro-mikro çözümleme modeliyle gerçekleştirdiği analizleri öne çıkmaktadır. Yardım ve Doğruel'in (2019, 140-143) Pippa Bacca cinayet haberleri üzerine çalışması, tematik ve şematik çözümlemenin gücünü göstermektedir. Dilbilimci S. Nalan Büyükkantarcıoğlu ve Nükhet Elpeze Ergeç gibi akademisyenler, Türkiye'deki medya metinlerini eleştirel perspektiften analiz ederek sosyal eşitsizlik ve güç ilişkilerine dikkat çekmiştir (Özer ve Şahin, 2024). **Çelik ve Köse (2021) Türkiye-Yunanistan sınırındaki mülteci krizinin söylem analizini** karşılaştırmalı bir değerlendirme yaparak Hürriyet ve Kathimerini gazetelerindeki söylemlerin üzerinden ideolojik ve tematik farklılıklar açısından nasıl yapıldığını analiz etmişlerdir. Ayrıca Çelik'in (2021, 53) pandemi ile ilgili haberlerde söylem analizi üzerine odaklanan araştırmasında, Türkiye'de en çok tıklanan üç haber sitesindeki pandemi içeriklerinin Teun A. Van Dijk'in söylem analizi modeliyle incelendiği görülmektedir.

### 3. YÖNTEM VE BULGULAR

Araştırmanın yöntemi, Teun Van Dijk'in Söylem Çözümlemesi modeli kullanılarak Fidel Castro'nun ölüm haberi ile ilgili haberlerin söylem analizinde makro yapı üzerinden değerlendirilmesinden ibarettir. Söylem analizinde makro yapı değerlendirilirken; aşağıdaki tablodan da aktarıldığı gibi başlık, haber girişi, fotoğraf gibi öğeler tematik yapıyı oluştururken, şematik (semantik) yapıda ise olay durum ve yorum bilgisi değerlendirilmektedir.

**Tablo 1:** Teun Van Dijk'in Söylem Çözümlemesinde Makro Yapı, Çelik (2021, 53)

Söylem Analizinde Makro Yapı
1) Tematik Yapı
a) Başlık
b) Haber Girişi: Spotlar/Haber girişleri (spot yoksa)
c) Fotoğraf
2) Semantik Yapı
a) Durum: Ana olayın girişi/Sonuçlar/Ardalan bilgisi/Bağlam bilgisi
b) Yorum: Haber kaynakları/Haber yorumları

Castro'nun ölüm haberi 26 Kasım 2016 tarihi itibarı ile Türk medyasında yer almaya başlamıştır. Bu çalışma kapsamında 1 Ekim 2024 tarihi itibarı en çok tıklanan ilk 10 haber sitesi seçilmiştir (B2Press, 2024). Fidel Castro'nun ölümü ile ilgili bu sitelerde yer alan haberler başlık, fotoğraf ve haber metni içeriği bağlamında Van Dijk'ın tematik yapı modeli kullanılarak analiz edilmektedir. Analize tabi tutulan haber siteleri Hürriyet, Sözcü, Mynet, Milliyet, Haber7com, Sabah, Haberler.com, Habertürk, Ensonhaber ve Cumhuriyet haber siteleridir.

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**Tablo 2.** Tıklanma Sırasına Göre 1’den 10’a Kadar Haber Sitelerinde Castro’nun Ölümü İle İlgili Verilen Haber Başlıkları

Haber Sitesi	Haber Başlığı
Hürriyet	Efsane devrimci lider Castro’nun unutulmaz fotoğrafları
Sözcü	Fidel Castro kimdir? Hayatını kaybeden Fidel Castro kaç yaşındaydı?
Mynet	Fidel Castro hayatını kaybetti
Milliyet	Son dakika haberi: Küba’nın efsane lideri Fidel Castro öldü
Haber7com	Fidel Castro hayatını kaybetti
Sabah	Fidel Castro hayatını kaybetti
Haberler.com	Fidel Castro Kimdir? Fidel Castro Öldü mü? Fidel Castro'nun Hayatı!
Habertürk	Fidel Castro hayatını kaybetti
Ensonhaber	Fidel Castro hayatını kaybetti
Cumhuriyet	Küba’nın efsane lideri Fidel Castro yaşamını yitirdi

Haber sitelerinde yer alan haber başlıklarında 10 haber sitesinden 7’sinin Castro’nun hayatını kaybettiğine vurgu yaptığı görülmektedir. Hürriyet, Milliyet ve Cumhuriyet haberlerinde Castro’nun devrimci ve efsane lider olduğuna vurgu yapmaktadır. Haberler.com Fidel Castro öldü mü? sorusu ile Sözcü ise hayatını kaybeden Fidel Castro kaç yaşındaydı? sorusu ile dikkat çekme yolunu tercih etmektedir.

Haber spotları ve metinlerine bakıldığında ise Fidel Castro’nun ölümü üzerine yayımlanan haberlerin, kullanılan dilin içerdiği ideolojik göndermeler ve okuyucuya sunulan çerçeveleme biçimleri açısından dikkat çekicidir. Spotların ve metinlerin söylem analizinde olayın nasıl tanımlandığı, liderin hangi yönlerinin öne çıkarıldığı ve okuyucuya verilen duygusal mesajlar, ana olayın girişi, arda alan bilgisi, bağlam bilgisi ve yorumlar bağlamında incelenmektedir. Elde edilen bulgular bağlamında kahramanlaştırıcı ve romantize edici, tarafsız ve bilgilendirici, eleştirel çerçevelemeler, tıklama çekmeye yönelik söylemler gibi spot ve metinlerin olduğu görülmektedir.

### **3.1. Kahramanlaştırıcı, Romantize Edici Metin ve Başlıklar**

**Hürriyet:** *"Efsane devrimci lider Castro'nun unutulmaz fotoğrafları"* başlıklı haberin spot ve sonrasında haber metninde, Fidel Castro’yu “efsane devrimci lider” olarak tanımlayarak, liderin tarihsel önemini ve halk üzerindeki etkisini yüceltmektedir. (Hürriyet, 2016). Romantize edici bir dil kullanılmakta ve Castro’nun sadece olumlu yanlarını ele alarak eleştirel bir perspektif sunmamaktadır. Bu söylem, okuyucuyu liderin başarısına odaklarken, tarihsel bağlamdaki tartışmalı yönlerini görmezden gelmektedir.

**Cumhuriyet:** *"Küba'nın efsane lideri Fidel Castro yaşamını yitirdi"* başlıklı haberin spot ve metin içeriğinde, benzer bir şekilde, “efsane lider” tanımlamasıyla Castro, tarihe geçen bir kahraman olarak sunulmaktadır (Cumhuriyet, 2016). Ancak bu dil, Castro’ya yönelik eleştiriler ve yönetim tarzıyla ilgili daha geniş bir bağlam sunmaktan kaçınılmaktadır.

### 3.2. Tarafsız ve Bilgilendirici Spotlar

**Mynet:** “Fidel Castro hayatını kaybetti” başlıklı haberin spot ve metninde, olayın yalnızca ölüm haberini vererek tarafsız bir çerçeve sunmaktadır (Mynet, 2016). Herhangi bir sıfat ya da ek bilgi verilmemesi, okuyucuya liderin kimliği ve önemi hakkında yorum yapma fırsatı bırakmaktadır. Bununla birlikte, nötr tonlama liderin tarihsel bağlamını ya da tartışmalı yönlerini yansıtmadığı için eksik kalabilmektedir.

**Habertürk:** “Fidel Castro hayatını kaybetti” başlıklı haberin spot ve metninde, Habertürk’ün benzer şekilde olay odaklı olduğu ve duygusal ya da ideolojik bir yargı içermeyen (Habertürk, 2016) haberi verdiği görülmektedir.

**Ensonhaber:** “Fidel Castro hayatını kaybetti” başlıklı haberin spot ve metninde Ensonhaber, olayı nötr bir dilde sunarak okuyucuyu içeriğe yönlendirme niyeti göstermektedir (Ensonhaber, 2016). Ancak liderin olumlu ya da olumsuz yönlerine dair herhangi bir ipucu vermemesi, haberin yüzeysel bir değerlendirme sunduğunu göstermektedir.

### 3.3. Eleştirel Çerçeveler

**Sözcü:** “Fidel Castro kimdir? Hayatını kaybeden Fidel Castro kaç yaşındaydı?” başlıklı haber spot ve metninde Castro’nun kimliğini ve tarihsel bağlamını sorgulamayı hedefleyen bir ton taşıdığı görülmektedir (Sözcü, 2016). Ancak “kimdir?” sorusu, liderin mirası üzerinde denge kurmaya çalışsa da okuyucuya yalnızca bir merak unsuru sunabilmektedir. Sözcü’nün bu haberi, genel okuyucu kitlesi için anlaşılır ve erişilebilir bir dil kullanmasına rağmen, daha geniş ve eleştirel bir bağlam sunma açısından eksik kalmaktadır. Liderin mirasını farklı perspektiflerden tartışmak yerine, yalnızca yaşam hikâyesini sunmak, okuyucuya olayın bütüncül bir resmini vermekte yetersiz kalabilmektedir.

**Haber7.com:** “Fidel Castro hayatını kaybetti” başlıklı haberin spot ve metninde Haber7, nötr bir spot sunmuş gibi görünse de içerikte Castro’nun insan hakları ihlalleri ve otoriter yönetim tarzını vurguladığı görülmektedir (Haber7, 2016). Bu, liderin mirasını daha eleştirel bir perspektifle değerlendirme eğiliminde olan bir söylem ortaya koymaktadır.

**Sabah:** “Fidel Castro hayatını kaybetti” başlıklı haberin spot ve metninde Sabah’ın spotu, benzer şekilde sade bir dil kullanmakla birlikte, içeriklerinde Castro’nun otoriterliğine ve Küba’daki sorunlara vurgu yapmaktadır (Sabah, 2016). Dolaylı bir eleştiriyle, Sabah haberinde liderin mirasını olumsuz bir çerçevede sunmaktadır.

### 3.4. Tıklama Çekmeye Yönelik Söylemler

**Haberler.com:** “Fidel Castro kimdir? Fidel Castro öldü mü?” başlıklı haberin spot ve metnine bakıldığında, Haberler.com bu tür bir spotla, okuyucuda merak uyandırarak etkileşim sağlamayı amaçladıkları (Haberler.com, 2016) görülmektedir. Ancak bu dil, liderin karmaşık mirasını sorgulamaktan çok, okuyucuyu haberin içine çekmeyi hedeflemektedir.

**Milliyet:** “Son dakika haberi: Küba’nın efsane lideri Fidel Castro öldü” başlıklı haberin spot ve metninde Milliyet, online gazetecilikte tıklanmayı arttırmak için sıklıkla kullanılan “Son dakika” vurgusunu başlıkta tercih etmektedir. Bu durum haberin önemini ve aciliyetini artırırken, “efsane lider” ifadesi liderin romantize edildiğini göstermektedir (Milliyet, 2016). Spot ve metin içeriğinde liderin tarihsel tartışmalarını ya da eleştirel yanlarını yansıtmaktan uzak bir söylem inşa edildiği görülmektedir.

### 3.5. Haberlerde Yer Alan Fotoğrafların Temsili

Fidel Castro'nun görsel temsilinde, fotoğraflar genellikle Castro'nun liderlik dönemini ve Küba Devrimi'ni öne çıkaran sahneleri içermektedir. Örneğin, Castro'nun konuşma yaparken veya halk arasında görülmesi, onun karizmatik bir lider olduğu algısını güçlendirmek için seçilmiş algısı yaratmaktadır. Fotoğraf seçimlerinin ideolojik etkisi bağlamında, bu tür görseller Castro'yu romantize etme veya liderlik niteliklerini yüceltme eğiliminde olabilmektedir. Özellikle Hürriyet ve Cumhuriyet gibi kaynaklarda Castro'nun devrimci liderliği vurgulanırken, liderlik figürü ikonik bir kahraman gibi sunulmaktadır. Duygusal etki bağlamında, Sözcü veya Milliyet'teki fotoğraflar, Castro'nun ölümünün duygusal etkisini pekiştirmek için yas atmosferini vurgulayan karelerden oluşmaktadır. Nostaljik ve tarihsel bağlamda Hürriyet'in galerisindeki fotoğraflar, Castro'nun hayatına dair nostaljik bir bakış sunmakta ve liderin tarihsel önemine vurgu yapmaktadır.

Simgeleştirme bağlamında haberlerde kullanılan görseller, Castro'nun devrimci bir lider olarak ideolojik simgesini güçlendirebilir. Örneğin, halkla iç içe olduğu anların ya da üniformasıyla resmi pozlarının kullanılması, onu "halkın lideri" veya "askeri devrimci" olarak yeniden üretmektedir. Görsellerde eksik temsil bağlamında, Castro'nun yalnızca olumlu yönlerini yansıtırken, onun tartışmalı politikalarına veya eleştirilen yönlerine dair görsellerin nadiren sunulduğu görülmektedir. Batı karşıtlığı ve direniş ikonu olma bağlamında özellikle Sabah ve Ensonhaber gibi kaynaklarda Castro'nun anti-emperyalist duruşunu destekleyen görsel seçimler yapılırken, Hürriyet Castro'nun liderlik anılarına odaklanan ikonik fotoğraflar kullanarak devrimci figürün pozitif temsiline ağırlık vermektedir. Sözcü ise daha biyografik ve ölüm haberine odaklanan görseller sunarak Castro'nun kişisel yaşamına dair daha az bilgi sunmakta ve liderlik mirasını daha yüzeysel bir şekilde ele almaktadır. Sabah ve Haber7 de daha duygusal bir atmosfer yaratmak amacıyla yas ve kayıp temalarını görseller aracılığıyla ön plana çıkarmaktadır.

### 4. SONUÇ VE DEĞERLENDİRME

Fidel Castro'nun ölüm haberinin Türk medyasına yansımaları, aynı zamanda medya organlarının ideolojik ve dilsel tercihlerinin bir yansıması olarak da değerlendirilmektedir. Bu süreçte kullanılan dil, medyanın söylem biçimini ve haberin okuyucu üzerindeki etkisini büyük ölçüde şekillendirmektedir. Örneğin, sol eğilimli haber siteleri Castro'yu bir devrimci lider olarak yüceltirken, diğer siteler, daha dengeli bir bakış açısı ile hem onun tarihsel mirasını hem de iktidarındaki tartışmalı yönleri dile getirmektedirler. Bu durum, haberin sunuluş biçiminin sadece bilgi aktarmakla kalmadığını, aynı zamanda toplumsal ideolojik yapıları pekiştiren bir işlev gördüğünü de göstermektedir.

Haber başlık, spot ve metinlerinde özellikle kahramanlaştırıcı, romantize edici, tarafsız ve bilgilendirici, eleştirel çerçeveleme tekniği, tıklama çekmeye yönelik söylemler gibi birçok teknik ve usul kullanılmıştır. Kullanılan görsellerde yine çoğunlukla fotoğrafların büyük kısmında Castro'yu tarihsel bir figürden ziyade, ideolojik bir simge olarak yüceltme eğilimi olduğu görülmektedir. Fidel Castro'nun ölümüne dair Türk haber sitelerinde yer alan haberlerin eleştirel söylem analizi bağlamında ilk kez ele alınması çalışma açısından önemlidir. Bu yönü ile çalışmanın medyada liderlik temsilinin nasıl yer aldığına dair sunduğu veriler akademik çalışmalara kaynak olmayı hedeflemektedir.

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TÜRKİYE'DE YAYILIŞ GÖSTEREN *SILENE* L. (CARYOPHYLLACEAE)  
TAKSONLARI ÜZERİNE TAKSONOMİK KATKILAR

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**Özet**

*Silene* L., (Nakil) yeryüzünde yaklaşık 870 türü, Türkiye Florası'nda ise 145 türü (167 takson) bulunan bir cinstir. Gen merkezi Anadolu ve çevresi olan *Silene* cinsi üzerine taksonomik bir çalışma yapılmıştır. Bu çalışma kapsamında, Türkiye'nin tamamını kapsayan arazi çalışmaları yapılmış ve *Silene* türlerine ait bitki örnekleri toplanmıştır. Cinsine ait daha önce toplanmış bitki örnekleri 28 Türkiye'den ve 6 Türkiye dışından herbaryumlar ile 11 online sitede detaylı olarak incelenmiştir. Sahip olduğumuz örnekler bütün dünya örnekleriyle karşılaştırılmış ve taksonomik durumları açıklığa kavuşturulmuştur. Türlerin taksonomik durumlarının açıklığa kavuşturulması amacıyla bitki örneklerinin betimleri (deskripsiyonları) genişletilmiş, yine bu amaçla türlere ait tohumlar ve polenler mikromorfolojik bakımdan taramalı elektron mikroskobu (SEM) ile incelenmiştir. Yaptığımız araştırmalar ile türlerin (taksonların) sinonim olup-olmadığı, tespit edilen yeni tür (yeni alttür veya varyeteler), Türkiye Florası'nda da varlığı teyit edilen yeni kayıt türler, bazı türlerin kategorilerindeki taksonomik değişiklikler, endemizm durumları ortaya çıkarılmıştır. Çalışma sonunda, 29 taksonun sinonim (*S.amana*, *S.eminentis*, *S.aydosensis*, *S.brevicalyx*, *S.cirpicii*, *S.goksuensis*, *S.inclinata*, *S.koycegizensis*, *S.ispartensis*, *S.yildirimlii*, *S.olympica* var.*erciyesdaghensis*, *S.kucukodukii*, *S.sipylea*, *S.caramanica* var.*idaea*, *S.bitlisensis*, *S.konuralpiae*, *S.apetala*, *S.bithynica*, *S.bocquetiana*, *S.magenta*, *S.guerbuezii*, *S.karakotchanensis*, *S.pompeiopolitana*, *S.sangaria*, *S.sumbiliana*, *S.trinervia*, *S.choruhensis*, *S.confertiflora* subsp.*thiebautii*, *S.atropurpurea*), 11 taksonun yeni tür yada yeni kayıt (*S.kemahensis*, *S.nemrutensis*, vd.), 26 taksonun statü değişikliği ve sinonim olduğu (*S.aegyptiaca* subsp.*ruderalis*, *S.araratica* subsp.*davisii*, vd.), 2 türün (*S.fuscata*, *S.fabaroides*) ise Türkiye Florası'nda olmadığı belirlenmiştir.

**Anahtar Kelimeler:** Flora, *Silene*, Türkiye, Tohum, Polen, Taksonomi.

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TAXONOMIC CONTRIBUTIONS ON *SILENE* L. (CARYOPHYLLACEAE) TAXA  
DISTRIBUTED IN TÜRKİYE

**Abstract**

*Silene* L. (bladder campion and catchfly) is a genus with approximately 870 species worldwide and 145 species (167 taxa) in the Flora of Türkiye. A comprehensive taxonomic study was conducted on the *Silene* genus, whose gene center is Anatolia and its surroundings. This study involved extensive fieldwork across Türkiye, during which plant specimens of *Silene* species were collected. Previously collected specimens were meticulously examined in 28 herbaria within Türkiye, 6 herbaria outside Türkiye, and 11 online databases. These specimens were compared with global collections to clarify their taxonomic status.

To further elucidate the taxonomic status of the species, detailed descriptions of the plant specimens were expanded. Additionally, seeds and pollen were examined micromorphologically using a scanning electron microscope (SEM). Our research identified synonyms, new species (including new subspecies or varieties), newly recorded species confirmed in the Flora of Türkiye, taxonomic changes in some species categories, and endemism status.

At the conclusion of the study, 29 taxa were identified as synonyms (e.g., *S. amana*, *S. eminentis*, *S. aydosensis*, *S. brevicalyx*, *S. cirpicii*, *S. gokuensis*, *S. inclinata*, *S. koycegizensis*, *S. ispartensis*, *S. yildirimlii*, *S. olympica* var. *erciyedaghensis*, *S. kucukodukii*, *S. sipylea*, *S. caramanica* var. *idaea*, *S. bitlisensis*, *S. konuralpiae*, *S. apetala*, *S. bithynica*, *S. bocquetiana*, *S. magenta*, *S. guerbuezii*, *S. karakotchanensis*, *S. pompeiopolitana*, *S. sangaria*, *S. sumbiliana*, *S. trinervia*, *S. choruhensis*, *S. confertiflora* subsp. *thiebautii*, *S. atropurpurea*). Eleven new species or new records (e.g., *S. kemahensis*, *S. nemrutensis*) were identified, 26 taxa had their status changed and became synonyms (e.g., *S. aegyptiaca* subsp. *ruderalis*, *S. araratica* subsp. *davisii*), and 2 species (*S. fuscata*, *S. fabaroides*) were determined not to be part of the Flora of Türkiye.

**Keywords:** Flora, *Silene*, Türkiye, Seed, Pollen, Taxonomy.

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## Introduction

There are approximately 850 species of *Silene* globally (Hernández-Ledesma et al., 2015), but according to the Plants of the World Online (POWO) database, there are 904 species (source: POWO). Historical records indicate that the Flora of Türkiye includes 135 species (154 taxa) of *Silene* (Coode and Cullen, 1967; Davis et al., 1988; Tan and Vural, 2000; Yıldız, 2012). Yıldız (2012) prepared a checklist of *Silene* species in Türkiye.

Over the years, studies on *Silene* taxa have introduced new taxa to the scientific world, expanded the distribution areas of some taxa, and altered the statuses of others. Recent research indicates that the Flora of Türkiye is home to 145 species (20 subspecies, 2 varieties) and a total of 167 taxa of *Silene*, with 44% being endemic. These findings are supported by numerous studies (Aydin et al. 2014a, Aytaç et al. 2015, Güner & Duman 2016, Fırat & Yıldız 2016a, Fırat & Yıldız 2016b, Yıldız et al. 2017, Toprak & Yıldız 2022; Chowdhuri 1957, Melzheimer 1977, Yıldız & Çırpıcı 1998, Yıldız 2002 and 2006, Kılıç & Özçelik 2008). Molecular phylogenetic studies have also provided significant taxonomic insights (Lazkov 1996, 2003, 2012; Lazkov & Sennikov 2021; Oxelman et al. 2013; Jafari et al. 2020; Oxelman & Lidén 1995; Desfeux & Lejeune 1996; Oxelman et al. 1997, 2001; Eggens et al. 2007; Rautenberg et al. 2012; Aydin et al. 2014a; Jafari et al. 2019).

The aim of this study is to present the taxonomic changes identified in recent research on the *Silene* genus in the Flora of Türkiye.

## Materials and Methods

Studies on the growing taxa of a genus involve the intensive collection of plants from the research area, evaluation of previously collected specimens, and review of floristic-taxonomic publications on the subject. In this context, *Silene* samples collected and housed in herbaria (CBAH, E) and various works on the Flora of Türkiye were utilized (Coode & Cullen, 1967). Plant identification was carried out at the Department of Biology, Faculty of Arts and Sciences, Celal Bayar University. The primary references for identification were the "Flora of Türkiye," floras of Europe and neighboring countries, and various sources on *Silene*.

Various domestic and international herbaria were employed for the identification and evaluation of collected samples and the examination of other *Silene* species globally. The herbaria consulted include: From Türkiye: ADO, AEF, AIBU, AKDE, AKDU, ANK, ATA, BOZOK, BULU, CBAH, EDTU, EGE, ERCH, ESSE, GUL, HUB, ISTE, ISTF, ISTO, IZ, IZEF, KATO, KNYA, MARE, MUFE, NGBB, TARI, VANF. From abroad: Geneva (G), Edinburgh (E) and Kew (K), Berlin (B), Leiden (L). Online databases used include "The World Flora Online," "The International Plant Names Index," "Plants of The World Online," "The Global Plants Database," "Tropicos," "Encyclopedia of Life," "Catalogue of Life," "World Checklist of Selected Plant Families," "Virtual Herbaria," "Europeana Collections," "The Linnaean Herbarium," and others. Approximately ten thousand *Silene* samples were examined from these herbaria and databases. Seed and pollen examinations were conducted at the Dokuz Eylül University Technology Research and Application Center using a "LEO 440 Computer Controlled Digital" brand electron microscope (SEM). Seeds and pollen were placed on a metal carrier (stub) with adhesive tape on both sides and coated with gold to make them conductive for imaging on the SEM screen. Many microphotographs were obtained. Seed morphological features were evaluated according to Prentice (1978) and Stearn (1992), and pollen according to Punt et al. (2007).

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**Findings and Discussion** (Tables 1-8, Figures Şekil 1-7).

**SILENE** L., Sp. Pl. 1: 416 (1753), [kor. ad / nom. cons.]. / NAKIL (TURKISH NAME).

**Type species:** *S. anglica* L.

**Synonyms:** *Lychnis* L., Sp. Pl. 1: 436 (1753). *Coronaria* Guett., Hist. Acad. R. Sci. Par. 1750, Mem. 229 (1754). *Behen* Hill, Veg. Syst. 4: 41 (1762). *Atocion* Adans. Fam. Pl. (Adanson) 2: 254. 1763 (1763). *Viscaria* Bernh., Syst. Verz. (Bernhardi) 261 (1800). *Melandrium* Röhl., Deutschl. Fl. (Röhling), ed. 2, Phanerog. Gew. 274 (1812). *Melandyrum* Rchb., Handb. Nat. Pfl.-Syst. 298 (1837). *Eudianthe* Rchb., Deut. Bot. Herb.-Buch 206 (1841). *Gastrolychnis* (Fenzl) Rchb., Deut. Bot. Herb.-Buch 206 (1841). *Heliosperma* Rchb., Deut. Bot. Herb.-Buch 206 (1841). *Uebelinia* Hochst., Flora 24(2): 664 (1841). *Gastrocalyx* Schischkin, Bull. Mus. Cauc., Tiflis 12: 200 (1919). *Charesia* E.A. Busch, Trudy Bot. Muz. 19: 183 (1926). *Schischkiniella* Steenis, Blumea xv: 145 (1967). *Minjaevia* Tzvelev, Novosti Sist. Vyssh. Rast. 33: 102 (2001).

## Examples from the species examined

### 1. Synonym

***Silene amana*** Boiss. (commonly known as kıyışak) was first described by Boissier in 1867 from the Hatay region, specifically the Amanos Mountains and Belen Plateau. This species is recognized as valid in the Floras of Türkiye by Coode and Cullen (1967).

### Reviews:

A large number of plant samples thought to belong to the species *Silene amana* were examined. These samples are: G-BOIS, G 001500007!-*S. amana* type sample; M. Haradjian 404 (G!); Y. Akman 240 (ANK!); M.Y. Dadandı and K. Yıldız 0139 (E 00623626!; MUFE 12311!); M.Y. Dadandı and K. Yıldız 0177 (CBAH!; MUFE 12385!); M.Y. Dadandı and K. Yıldız 0142 (M. Celal Bayar Univ. Herb.!; MUFE 12316!); M. Kuh n.y. (CBAH!).

In a molecular study (Du-Pasquier et al., 2017), it was stated that *S. amana* is a synonym of *S. italica* (yuğuşyüreği).

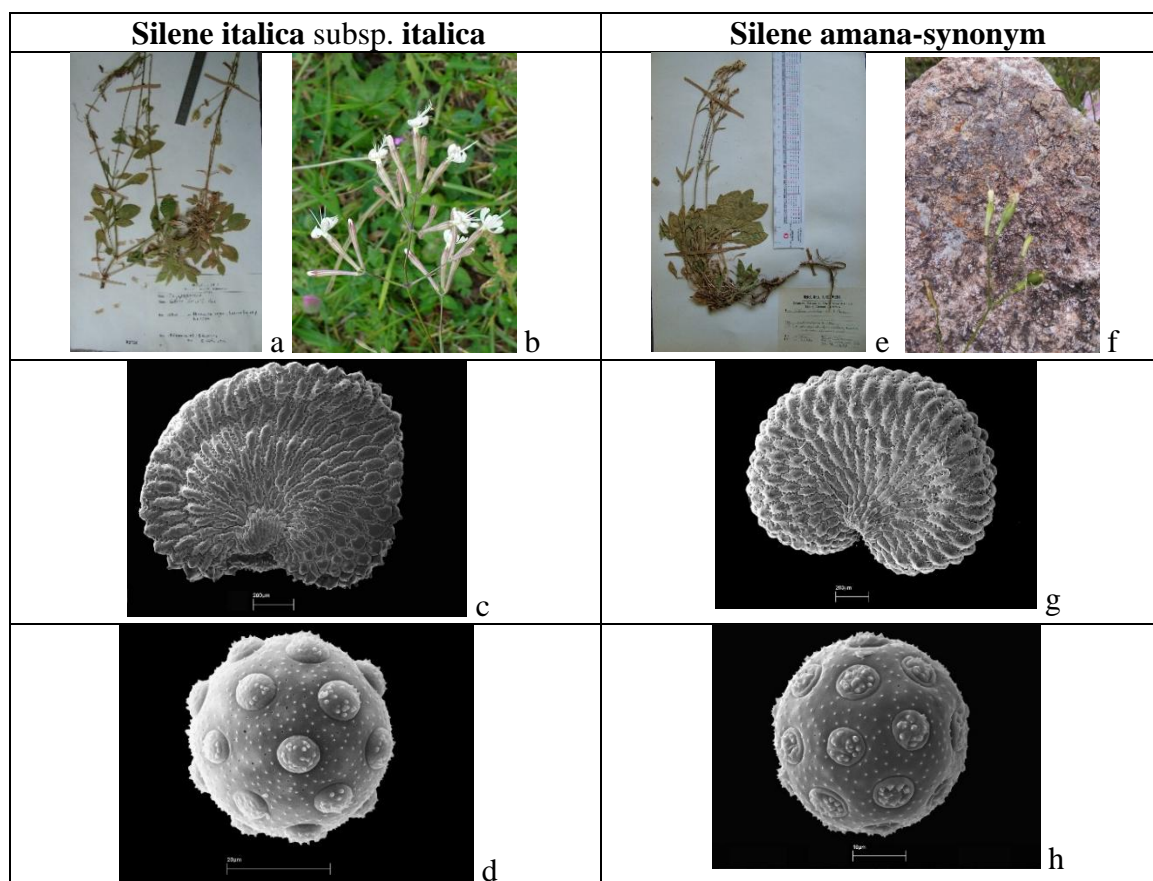
In the Flora of Spain (Talavera, 1990), the species was reported as a synonym of *S. viridiflora* (tongue-tipped nakil). Additionally, it is noted that *S. amana* is similar to *S. viridiflora* and *S. italica* in the Flora of Türkiye. The evaluations regarding *S. viridiflora* were found to be incorrect, particularly concerning anthophore and calyx characteristics. Focusing on the assessments of Pierre-Emmanuel Du Pasquier et al. (2017), samples were collected and re-examined in 2018 from the area where the type specimen of *S. amana* (kıyışak) was originally found. Minor differences in *S. amana*, such as length, were attributed to ecological conditions. As a result of these investigations, it was concluded that *S. amana* is a synonym of *S. italica* subsp. *italica* (Figure 1, Table 1).

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**Table 1.** Comparison of *Silene italica* subsp. *italica* and *Silene amana* species (Figure 1).

	<i>Silene italica</i> subsp. <i>italica</i>	<i>Silene amana</i> – synonym
<b>Plant</b>	20-80 cm tall, perennial and biennial. simple hairy	50-80 cm tall, perennial, sometimes biennial, simple hairy
<b>Basal leaves</b>	30-80 x 3-20 mm, spathulate, obovate-lanceolate	35-85 x 10-22 mm, ± elliptic-spathulate
<b>Stem leaves</b>	20-67 x 0.5-10 mm, narrow, linear, lanceolate, spathulate, sessile	25-43 x 9-15 mm, ovoid-cordate twice as long as wide, sessile
<b>Inflorescence</b>	Loose panicle	Loose panicle
<b>Calyx</b>	15-21 (-25) mm long, glandular hairy	13-20 mm long, glandular hairy
<b>Petal</b>	17-23 mm long, palmate lobes 4-5 mm long	17-20 mm long, palmate lobes 2.5-4 mm long
<b>Anthophore</b>	7-12 mm long	10-11 mm long
<b>Capsule</b>	9-13 x 4-5 mm, in calyx	9-12 x 4-6 mm, in calyx
<b>Seed</b>	1-1.6 x 0.7-1.1 mm, reniform	1.3-1.4 x 0.9-1.0 mm, reniform



**Figure 1.** *S. italica* subsp. *italica* (a-d) and *S. amana* (e-h). a, e.: Herbarium specimens, b, f.: Habit c, g: seed, d, h.: pollen (SEM microphotographs of seed and pollen).

**Systematic status of *Silene amana***

*Silene italica* (L.) Pers., Syn. Pl. 1: 498 (1805). Subsp. *italica* / **Yuğuşyüreği**, Türk. Bitkileri Liste., p. 360 (2012). (Figure 1, Table 1).

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**Synonym:** *Cucubalus italicus* L., Syst. Nat., ed. 10, 2: 1030 (1759).

*Silene pilosa* (Willd.) Spreng., Syst. Veg., ed. 16, 2: 411 (1825).

*Silene papillifolia* F.N.Williams, J. Linn. Soc., Bot. 32: 91 (1896).

**Silene amana** Boiss., Fl. Orient. 1: 634 (1867).

## 2. Synonym

*Silene koycegizensis* Dönmez & Vural is a species that was published in 2002 (Dönmez & Vural, 2002).

### Reviews

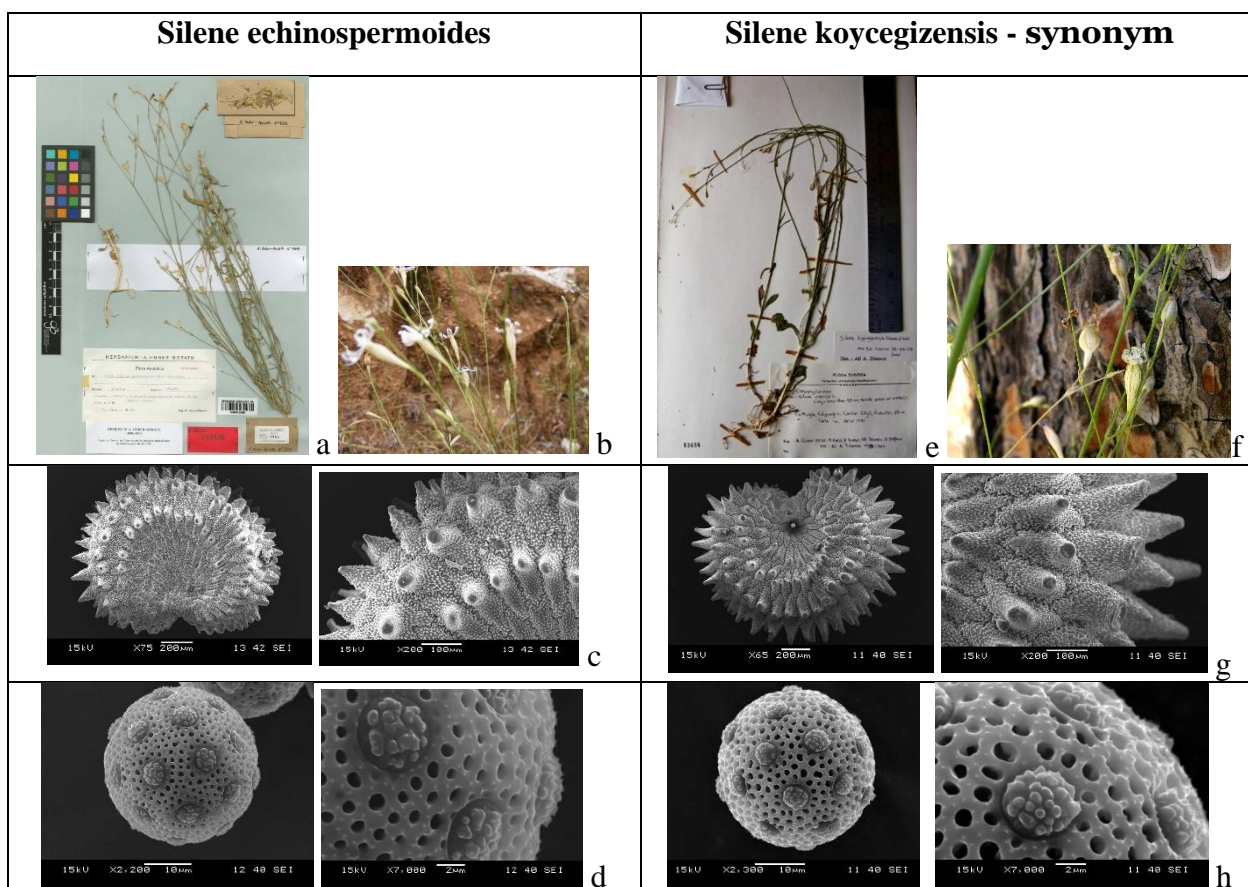
In our reviews, it was determined that *Silene koycegizensis* is very similar to *Silene echinospermoides* (Ege nakılı). When we compared *S. koycegizensis* and *S. echinospermoides* morphologically, it was found that almost all characters were intertwined and there was no significant difference except for petal length (Table 2).

In our reviews, the ligules at the base of the petals of the samples that were initially identified as different species showed some variation. For example, in the CBAH herbarium, the petal base is bifid in the samples K. Yıldız 255, 85-1, 95-1, 88-1, 93, 259. The petal base is also bifid in the samples K. Yıldız 89-2, K. Yıldız 263-2, and K. Yıldız 85-2, MUFE 0767 and K. Yıldız 256 (Table 2).

According to these data, the species *S. koycegizensis* is a synonym of the species *S. echinospermoides* (ege nakılı).

**Table 2.** Comparison of the species *S. echinospermoides* and *S. koycegizensis* (Figure 2).

	<b><i>Silene echinospermoides</i></b>	<b><i>Silene koycegizensis</i>- synonym</b>
<b>Plant</b>	50-90 cm long, annual, herbaceous, slender, erect, loosely branched, simply hairy, upper parts glabrous	50-95 cm, annual herbaceous, erect, simple or branched at base, simply hairy, upper parts glabrous
<b>Basal leaves</b>	20-50 x 5-10 mm, oblanceolate spatulate (reverse lanceolate-spatulate)	20-70 x 6-18 mm, spatulate
<b>Inflorescence</b>	dicasiacal (loosely many-flowered)	dicasiacal (loosely many-flowered)
<b>Calyx</b>	10-15 mm, membranous, veins weakly reticulate	10-14 membranous, veins weakly reticulate
<b>Petal</b>	white 15-20 mm long, ligules at base of the leaf 1.5-2 mm.	10-12 mm, white, ligules at base of palm 1-2 mm.
<b>Anthophore</b>	7-8 mm long	4-6 mm long
<b>Capsules</b>	7-8 x 4-6 mm	4-7 x 4-6 mm
<b>Seed</b>	1,2-1,6 mm, reniform, papillate	1-1,2 mm, reniform, papillate
<b>Pollen</b>	Reticulate	Reticulate



**Figure 2.** *Silene echinospermoides* (a-d) and *Silene koycegizensis* (e-h). a, e: Herbarium specimens, c, g: Seed; d, h: Pollen (SEM microphotographs of seed and pollen).

### Systematic status of *Silene koycegizensis*

***Silene echinospermoides*** Hub.-Mor., Notes Roy. Bot. Gard. Edinburgh 28: 7 (1967). / Ege Nakılı, Turkish. Plants List., p. 359 (2012). Figure 2, Table 2.

**Synonym:** *Silene juncea* Sm., Fl. Graec. Prodr. 1: 295 (1809)! [Roth.'unki (1797) Değil / non Roth. (1797)].

***Silene koycegizensis*** Dönmez & Vural, Ann. Bot. Fenn. 39(2): 154 (2002).

### 3. Synonym

***Silene brevicealyx*** Hartvig & Strid species was published in 1987 (Hartvig & Strid, 1987).

#### Reviews

A large number of samples belonging to *Silene tunicoides* and *S. brevicealyx* species were examined. *S. brevicealyx* (elegant nakıl, Turkish synonym) is the same as *S. tunicoides* (milas nakılı) in terms of plant height, stem leaves, and all characteristics of the inflorescence. In the samples collected from the *S. brevicealyx* type area, the calyx length in the flower is not 2.2-2.6 mm as in the type record, but 5 mm; in the fruit, it is 2-2.5 mm. The capsule has exceeded the calyx, and the petal blade and anthophore length are the same as *S. tunicoides* (milas nakılı). The holotype specimen of *S. brevicealyx* was examined, and it was understood that the specimen was a late fruiting specimen of the vegetation period and that some of its dimensions showed differences due to the ecological conditions in areas above 1200 meters. Therefore, **S.**

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*brevicalyx* was given as a synonym.

**Table 3.** Comparison of *Silene tunicoides* and *Silene brevicalyx* species (Figure 3).

	<b>Silene tunicoides</b>	<b>Silene brevicalyx- Synonym</b>
<b>Leaves</b>	10-15 mm x c. 1 mm, usually in bundles, subulate-linear	10-14 x c. 0.4 mm, subulate, in many pairs from the same point
<b>Calyx</b>	2-5 mm long	5 mm in flower (not 2.2-2.6 mm as in type record), 2-2.5 mm in fruit
<b>Petal</b>	5-6.5 mm long. Lamina undivided or emarginate	3-3.4 mm long, Lamina entire, undivided
<b>Capsule</b>	not protruding beyond calyx or protruding only slightly.	distinctly protruding from calyx.
<b>Seed</b>	1, 1.06-1.2 mm, oblong, reniform	1.1-1.4 mm, oblong, reniform

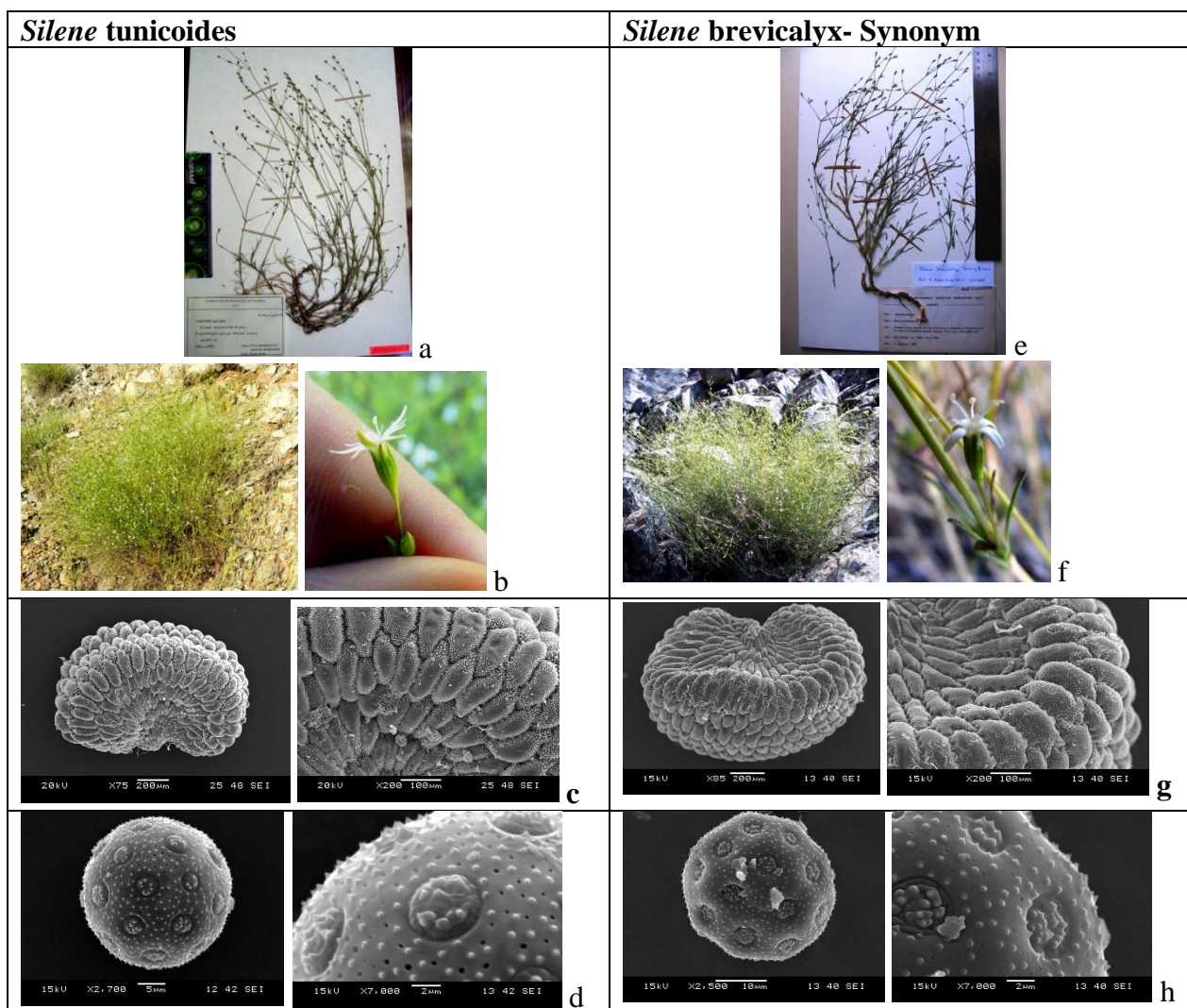


Figure 3. *Silene tunicoides* (a-d) and *Silene brevicalyx* (e-h). a, e: Herbarium samples, b, f: Habit c, g: Seed, d, h: Pollen. (SEM microphotographs of seed and pollen).



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**Systematic status of *Silene brevicalyx***

*Silene tunicoides* Boiss., Diagn. Pl. Orient. ser. 1, 1: 34 (1843). / Milas nakılı, Turkish. Plants List., p. 364 (2012). Figure 3, Table 3.

**Synonym:** *Silene brevicalyx* Hartvig & Strid, Bot. Jahrb. Syst. 108(2-3): 323 (1987). / Zarif nakılı (Turkish homonym) Turkish. Plants List., p. 356 (2012).

Aegean Section; Antalya Region.

**4. Synonym**

*Silene inclinata* Hub.-Mor. Notes Roy. Bot. Gard. Edinburgh 28: 4 (1967). / yamaç nakılı, Türkiye Bitkileri Listesi, 360 (2012).

**Reviews:**

It sounds like a thorough study was conducted on the species *S. leptoclada* and *S. inclinata*. The main findings indicate that *S. leptoclada* is similar to *S. flavascens* but can be distinguished by its longer body, sparse glandular hairs on its calyx and pedicel, and a hairless, longer anthophore.

The study aimed to differentiate *S. inclinata* and *S. leptoclada* as described in the Flora of Türkiye. Initially, *S. inclinata* was thought to differ from *S. leptoclada* by having simple hairy pedicels and calyx, and lanceolate-acuminate calyx teeth. However, upon examining various specimens from different regions, it was found that these differences were not consistent. Both species showed similar morphological features, including seed characteristics and pollen surface.

Ultimately, the study concluded that all examined samples were *S. leptoclada*, making *S. inclinata* a synonym of *S. leptoclada*. This means that what was previously thought to be two distinct species are now considered the same.

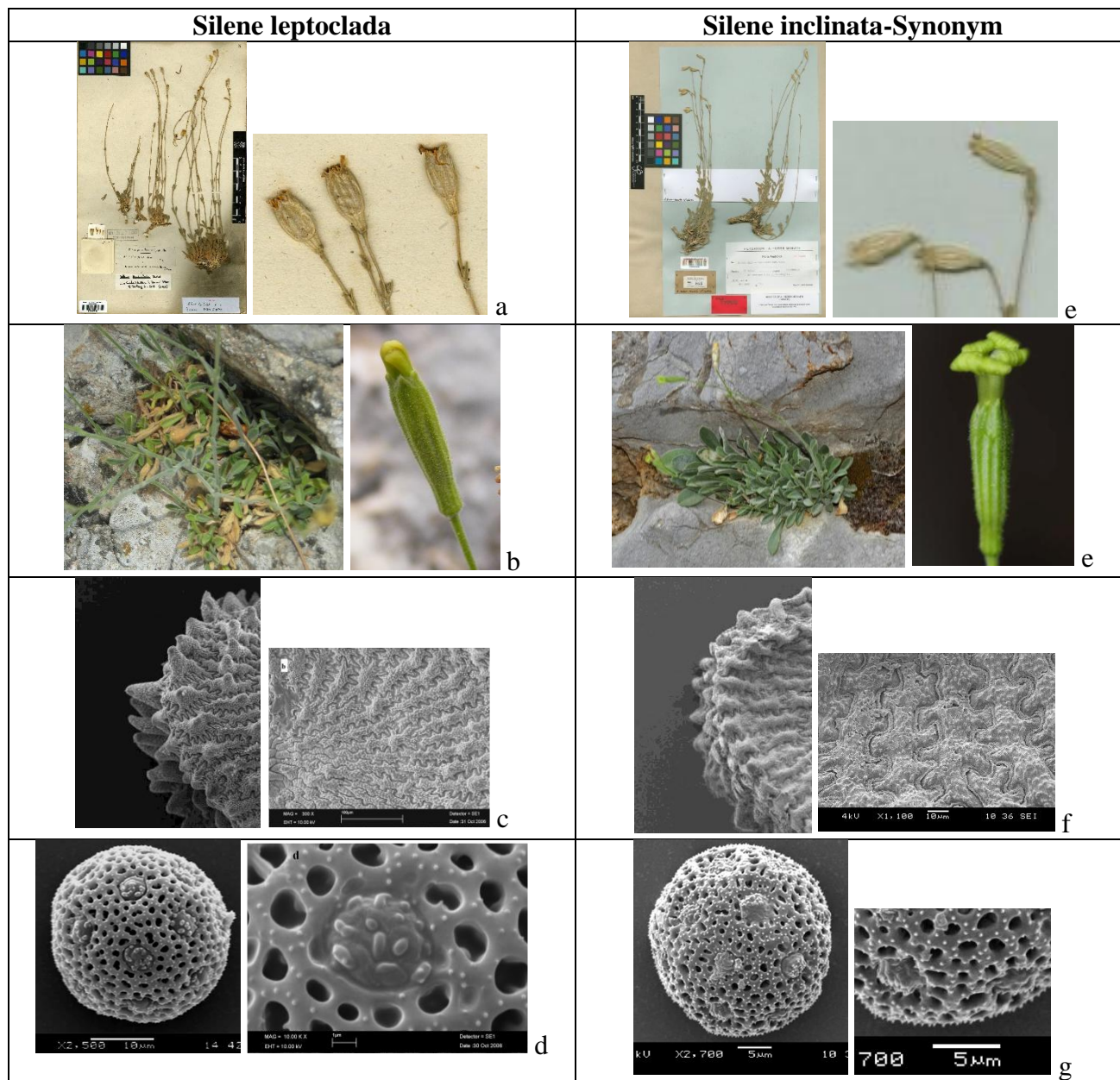
**S. leptoclada** is similar to **S. flavascens** but has distinct features like a longer body and sparse glandular hairs. **S. inclinata** was initially thought to differ from **S. leptoclada** due to its simple hairy pedicels and calyx, and lanceolate-acuminate calyx teeth. Specimens from various locations (Adana, Antalya, Hatay) were examined, showing no significant morphological differences except for some geographical variations. Both species share almost identical seed features, pollen surface, and other characters. Hairiness differences were not consistent across samples. Ultimately, all examined samples were identified as **S. leptoclada**, making **S. inclinata** a synonym of **S. leptoclada**.

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**Table 4.** Comparison of *Silene leptoclada* and *Silene inclinata* species (Figure 4).

	<b>Silene leptoclada</b>	<b>Silene inclinata - Synonym</b>
<b>Plant</b>	10-38 cm tall, perennial, numerous erect stems from the base, simple short widespread hairs.	20-40 cm tall, perennial, numerous erect stems from the base, simple covering hairs
<b>Basal leaves</b>	15-60 × 3-10 mm, rosette-shaped mass, reverse lanceolate, reverse ovate-spoular.	20-50 × 3-10 mm; rosette-shaped mass, lanceolate-spoular in shape.
<b>Stem leaves</b>	3-30 × 1-5 mm, narrowly elliptical, narrowly reverse lanceolate, all leaves sparsely simple hairs, dense and silky hairs	12-33 × 1.2-3.5 (-6) mm; (I saw 6 mm in Morath's sample) lanceolate; simple rather dense hairs.
<b>Inflorescence</b>	usually dichasium	compound dichasium
<b>Calyx</b>	8-15 mm, sparsely glandular and simple hairy	10-16 mm, sparsely glandular, simple hairy
<b>Petal</b>	Lamina divided into two up to 1/2, 3-7.5 mm long, two very tiny ligules at the base of the lamina	Lamina divided into two up to 1/2, 2-3.5 mm long, two very tiny ligules at the base of the lamina
<b>Anthophore</b>	2-3.5 mm, glabrous	2-4 mm; simple hairy glabrous
<b>Fruit</b>	7-12.5 mm, oblong; slightly protruding from the calyx	6.8-10.5 × 2.2-4.2 mm; oblong; slightly protruded from calyx
<b>Seed</b>	0.7-1.2 × 0.6-0.9 mm, reniform, light brown	0.5-1.2 × 0.2-1.0 mm, reniform, dark brown
<b>Pollen</b>	Reticulate	Reticulate



**Figure 4.** *Silene leptoclada* (a-d) and *Silene inclinata* (e-g). a, e: Herbarium specimens; b, e: Habit; c, f: Seed; d, g: Pollen (SEM microphotographs of seed and pollen).

**Systematic status of *Silene inclinata***

***Silene leptoclada*** Boiss., Fl. Orient. 1: 647 (1867). / Kaya nakılı, Türk. Bitkileri Listesi., p. 361 (2012). Figure 4, Table 4.

**Synonym:** *Silene inclinata* Hub.-Mor. Notes Roy. Bot. Gard. Edinburgh 28: 4 (1967). / yamaç nakılı, Türkiye Bitkileri Listesi, 360 (2012).

### 5. Synonym

#### Reviews

*Silene gokuensis* was indeed described as a new species in 2018 by Budak, Hamzaoglu, and Koç (2018).

*Silene capillipes*, first described in 1856, is also native to Türkiye and shares similar habitats and morphological traits.

This species is a perennial plant, typically 15-35 cm tall, with distinct characteristics such as being hairy on the lower part and hairless on the upper part. The basal leaves are spatulate, measuring 5-18 × 3-10 mm, while the upper stem leaves are similar but smaller. The inflorescence is branched, and the calyx is 6-8 mm long and short-hairy. The petal blade is 4-5 mm, divided into ¼ parts, with lobes close to 1 mm long and two ligules at the base of the blade, 0.5-3 mm long. The anthophore length is 3.5-4 mm.

Recent studies suggest that *Silene gokuensis* might be a synonym of *Silene capillipes* due to their overlapping characteristics.

**Table 5.** Comparison of *Silene capillipes* and *Silene gokuensis* species (Figure 5).

	<b><i>Silene capillipes</i></b>	<b><i>Silene gokuensis</i>- Synonym</b>
<b>Plant</b>	Perennial, 10-35 cm tall, delicate, slender erect stem, lower stem more or less pubescent, upper glabrous	15-35 cm tall, delicate, slender erect stem, lower stem more or less pubescent, upper glabrous.
<b>Leaves</b>	Basal leaves 10-16 x 5-9 mm, spatulate; Stem leaves ± lanceolate or reverse lanceolate), smaller than basal leaves	Basal leaves 5-18 × 3-10 mm, reverse lanceolate-spouted, Casule leaves similar but smaller and ± sessile
<b>Inflorescence</b>	Loose, compound dichasium	Loose, compound dichasium
<b>Calyx</b>	6-9 mm long, shortly pubescent or ± glabrous	. 6-8 mm long, glabrous, teeth acute
<b>Petal</b>	white or pale pink, blade 4-5 mm long, split to 1/4-1/6	white; blade 4-5 mm long, split to 1/4
<b>Anthophore</b>	4-6 mm long, glabrous	3.5-4 mm long, glabrous
<b>Capsule</b>	6-8 mm long, ovoid, mostly as long as the calyx, sometimes very slightly swollen	4-4.5 mm long, ovoid, as long as the calyx
<b>Seed</b>	0.5-0.9 mm, reniform-rectangular, slightly scorpionoid	1-1.2 mm, orbicular
<b>Habitat</b>	cave mouths, rock cavities	rock cavities

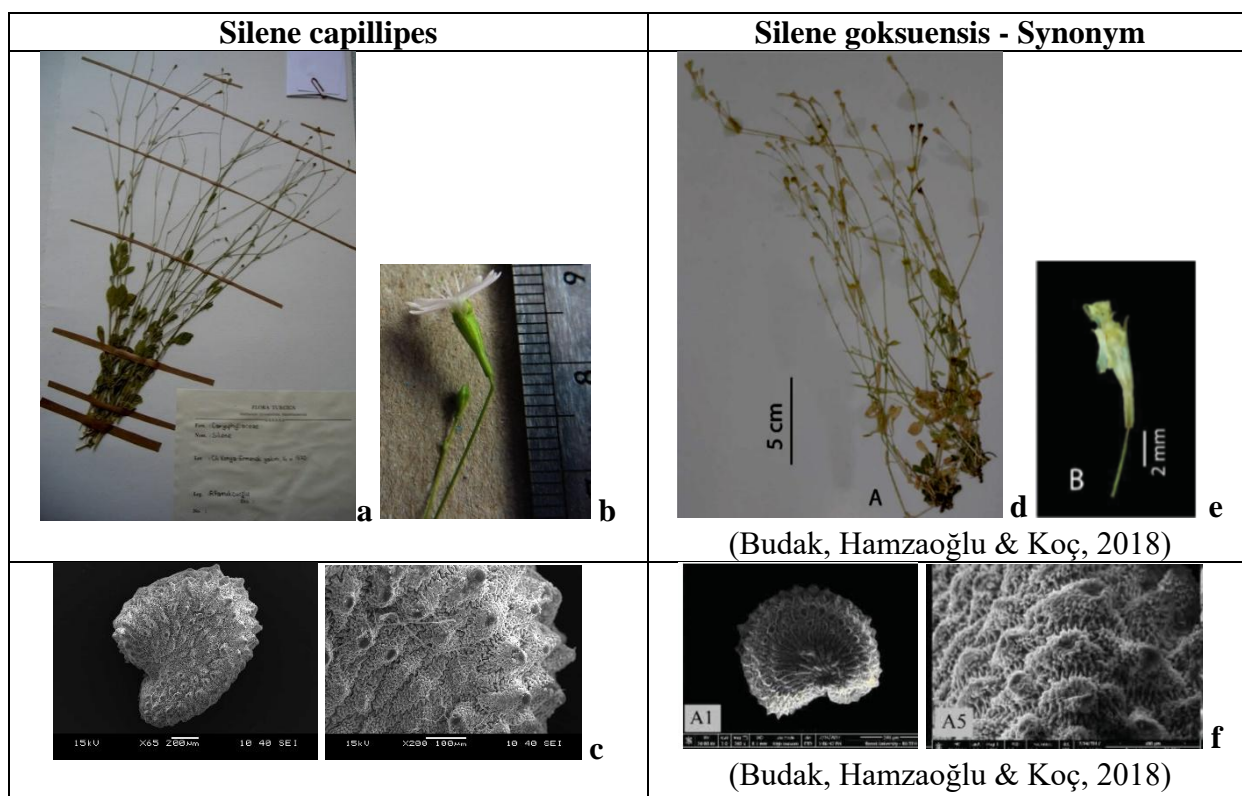


Figure 5. *Silene capillipes* (a-c) and *Silene gokuensis* (d-f) figures. a, b, e, f. Herb. sample (HUB), c, d. Seed (SEM) (Table 5).

#### Systematic status of *Silene gokuensis*

*Silene capillipes* Boiss. & Heldr., Diagn. Pl. Orient. ser. 2, 5: 55 (1856). / İn nakılı, Türk. Bitkileri Listesi., p. 356 (2012). Figure 5, table 5.

**Synonym:** *Silene gokuensis* Budak, Hamzaoğlu & Koç, Phytotaxa 345(2), 170–174 (2018). Türkiye: Konya Department. **Endemic.**

#### 6. Synonym

*Silene eminentis* was described as a new species by H. Özçelik in 2002 (Özçelik, H, 2002).

#### Reviews:

This species was distinguished from *Silene peduncularis* and *Silene sipylea*. However, *S. sipylea* is considered a synonym of *S. idaea*. *S. eminentis* and *S. idaea* differ significantly, particularly in their inflorescence and calyx length.

*S. eminentis* also shows differences from *S. peduncularis*. For instance, while *S. peduncularis* flowers are cream-colored, *S. eminentis* flowers are not. Additionally, the anthophore length in *S. peduncularis* found in Türkiye ranges from 4 to 8.5 mm, and the capsule length is 9-14 mm. Recent studies suggest that *S. eminentis* might be the same species as *S. armena* (Figure 6, Table 6).

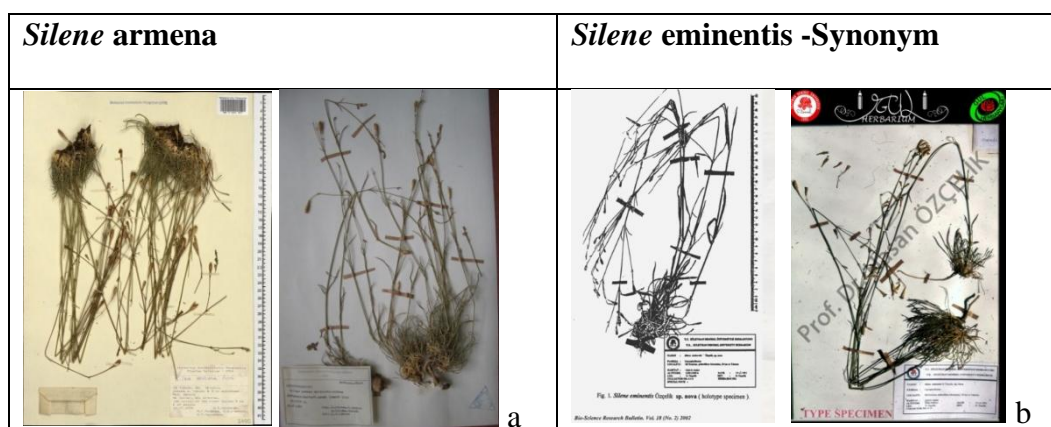
Although *S. armena* var. *armena* was initially considered endemic to Türkiye (Coode and Cullen, 1967), it has also been reported in the Caucasus (Komarov and Schischkin 1936, p. 488). Therefore, it is not strictly endemic to Türkiye.

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**Table 6.** Comparison of *Silene armena* and *S. eminentis* species (Figure 6).

	<b><i>Silene armena</i> var. <i>armena</i></b>	<b><i>Silene eminentis</i> - Synonym</b>
<b>Plant</b>	Woody at base, branched from base, perennial, up to 70 cm, glabrous.	45-70 (-80) tall, branched from base, perennial, glabrous.
<b>Basal leaves</b>	20 - 75 x 1 - 2 mm, linear-opposite lanceolate, stem leaves similar	(5-) 8-13 (16) cm x 1-3 (-4)mm, narrowly linear; stem leaves, similar
<b>Inflorescence</b>	Raceme, sometimes paniculate	Dicasium or panicle
<b>Calyx</b>	13-20 mm long, glabrous	15-19 mm, glabrous
<b>Petal</b>	18-25 mm, whitish and yellowish green, divided up to ½ of the lamina	(16-) 19-23 mm, yellowish or greenish white, divided to ½ of the base of the leg.
<b>Anthophore</b>	(4-)5-9 mm, glabrous	5 -9 mm, glabrous
<b>Capsule</b>	9-15 x 5-6 mm, oblong-ovoid	10-15x4-6 mm, oblong-cylindrical
<b>Seed</b>	1.5-2.3 mm, reniform	approx. 1-1.5 mm, reniform



**Figure 6.** Herbarium specimens of *Silene armena* var. *armena* (a) and *Silene eminentis* (b).

#### **Systematic status of *Silene eminentis***

***Silene armena*** Boiss., Diagn. Pl. Orient. ser. 1, 1: 29 (1843). var. **armena** / Çığıştak, Türk. Bitkileri Liste., p. 355 (2012). (Figure 6, Table 6).

**Synonym:** *Silene dianthifolia* Gay, Asie Min. Bot. [Tchihat.] 1: 193 (1860).

*Silene scabridula* Boiss., Fl. Orient. 1: 643 (1867).

*Silene tenuicaulis* Freyn & Sinonimt., Öst. Bot. Zeitschr. 40: 12 (1890).

*Silene filipes* Freyn & Sinonimt., Bull. Herb. Boiss. 3:98 (1895).

*Silene amassiensis* (Freyn) Bornm., Feddes Rep. Beih. 89(1): 116 (1936).

*Silene lycica* Chowdhuri, Notes Roy. Bot. Gard. Edinburgh 22: 256 (1957).

*Silene eminentis* H. Özçelik, Bio-Science Research Bulletin. 18(2): 121-129 (2002).

#### **7. Synonym**

*Silene aydosensis* was described as a new species by Yıldız and Erik in 2010 (Yıldız and Erik, 2010).

#### **Reviews**

Initially, it was separated from ***S. caramanica*** and ***S. doganii*** based on the Flora of Türkiye and surrounding regions (Coode and Cullen, 1967). However, it was later found that the

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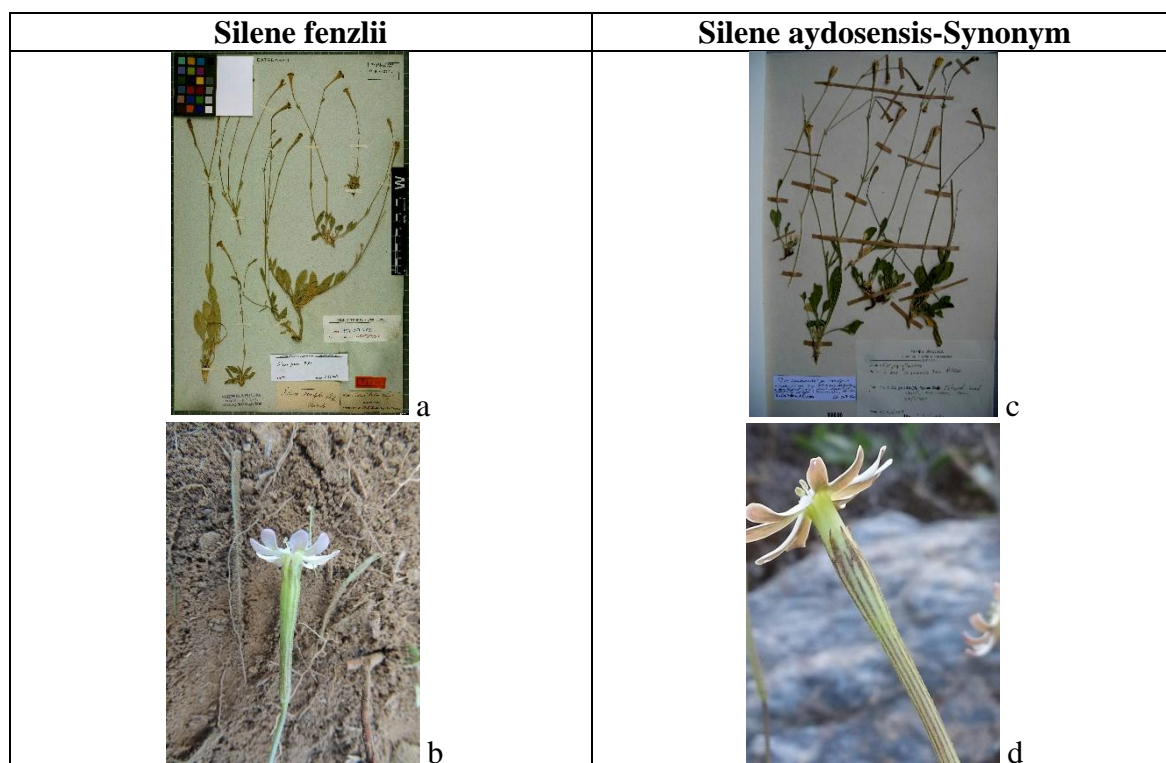
assignment of **S. aydosensis** was erroneous due to inadequate descriptions in the Flora of Türkiye.

Recent studies have shown that samples collected from the same region, including those by K. Yıldız and H. Özçelik, were actually **S. fenzlii** (GÜL!). When comparing **S. aydosensis** and **S. fenzlii**, the main differences noted were the hairiness of the plant parts and the presence of wings on the petals. However, these differences were attributed to the plant's late period and were not sufficient for species distinction.

Therefore, it has been concluded that **S. aydosensis** is a synonym of **S. fenzlii** according to the principle of priority.

**Table 7.** Comparison of *Silene fenzlii* and *Silene aydosensis* species (Figure 7).

	<b>Silene fenzlii</b>	<b>Silene aydosensis - Synonym</b>
<b>Plant</b>	10-36 cm, perennial, stem simply hairy	18-30 cm, perennial, stem erect simply hairy
<b>Basal leaves</b>	11-60 x 2.5-12 mm, linear-spathulate	28-65 mm long, spatulate
<b>Stem leaves</b>	3-50 mm long, triangular-lanceolate	5-25 mm long, linear
<b>Inflorescence</b>	1 (-2) flowered	usually 2-3 flowered, sometimes solitary
<b>Calyx</b>	23-35 mm long, simple short soft hairy	25-32 mm glabrous
<b>Petal</b>	½ divided in two	½ divided in two
<b>Anthophore</b>	15-23 mm, glabrous	15-20 mm, glabrous
<b>Capsule</b>	10-15 mm	10-12 mm



**Figure 7.** *Silene fenzlii* (a, b) and *Silene aydosensis* (c, d). a, c: Herbarium specimens, b, d: Photographs taken from the field.

**Systematic status of *Silene aydosensis***

*Silene fenzlii* Boiss. & Balansa, Diagn. Pl. Orient. ser. 2, 6: 30 (1859). / Bolkar nakılı, Türk. Bitkileri Listesi., p. 359 (2012) (Figure 7, Table 7).

**Synonym:** *Silene aydosensis* K. Yıldız & Erik, Ann. Bot. Fenn. 47(2): 152 (2010). / Türk. Bitkileri Listesi., 359 (2012).



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**Conclusion and Recommendations**

**Table 8.** New species (taxa), new registration, change of taxonomic status, synonyms, valid new species, new records and species not in Flora of Türkiye.

	<i>Silene</i> species (taxa) accepted to exist to date (Flora orientalis 1867, Flora of Türkiye 1967 and other works, articles)	
<b>A</b>	<b>Valid Species (Taxa)</b>	<b>Synonyms</b>
<b>1</b>	<i>Silene italica</i> (L.) Pers., Syn. Pl. 1: 498 (1805). Subsp. <i>italica</i> / <b>Yuğuşyüreği</b> , Türk. Bitkileri List., s. 360 (2012). Şekil 1, Tablo 1.	<i>Silene amana</i> Boiss., Fl. Orient. 1: 634 (1867).
<b>2</b>	<i>S. echinospermoides</i> Hub.-Mor., Notes Roy. Bot. Gard. Edinburgh 28: 7 (1967). / <b>Ege nakılı</b> , Türk. Bitkileri List., s. 359 (2012).	<i>S. koycegizensis</i> Dönmez & Vural, Ann. Bot. Fenn. 39(2): 154 (2002).
<b>3</b>	<i>S. tunicoides</i> Boiss., Diagn. Pl. Orient. ser. 1, 1: 34 (1843). / <b>Milas nakılı</b> , Türk. Bitkileri List., s. 364 (2012).	<i>S. brevicealyx</i> Hartvig & Strid, Bot. Jahrb. Syst. 108(2-3): 323 (1987). / <b>Zarif nakıl</b> (Türkçe eşad) Türk. Bitkileri List., s. 356 (2012).
<b>4</b>	<i>S. leptoclada</i> Boiss., Fl. Orient. 1: 647 (1867). / <b>Kaya nakılı</b>	<i>S. inclinata</i> Hub.-Mor. Notes Roy. Bot. Gard. Edinburgh 28: 4 (1967).
<b>5</b>	<i>S. capillipes</i> Boiss. & Heldr., Diagn. Pl. Orient. ser. 2, 5: 55 (1856). / <b>İn nakılı</b> , Türk. Bitkileri List., s. 356 (2012). <b>Endemic</b>	<i>S. goksuensis</i> Budak, Hamzaoglu & Koç, Phytotaxa 345(2), 170–174 (2018)
<b>6</b>	<i>S. armena</i> Boiss., Diagn. Pl. Orient. ser. 1, 1: 29 (1843). var. <i>armena</i> / <b>Çığıştak</b> , Türk. Bitkileri List., s. 355 (2012). <b>Endemic</b>	<i>S. eminentis</i> H. Özçelik, Bio-Science Research Bulletin. 18(2): 121-129 (2002)
<b>7</b>	<i>S. fenzlii</i> Boiss. & Balansa, Diagn. Pl. Orient. ser. 2, 6: 30 (1859). / <b>Bolkar nakılı</b> , Türk. Bitkileri List., s. 359 (2012). <b>Endemic</b>	<i>S. aydosensis</i> K. Yıldız & Erik, Ann. Bot. Fenn. 47(2): 152 (2010). ( <b>aydos nakılı</b> , Türkçe eşad: Türk. Bitkileri List., 359, 2012).
<b>8</b>	<i>S. birandiana</i> Ekim, Notes Roy. Bot. Gard. Edinburgh 42(1): 85 (1984). / <b>Bey nakılı</b> . Türk. Bitkileri List., s. 356 (2012). <b>Endemic</b>	<i>S. cirpicii</i> K. Yıldız & Dadandı, Ann Bot Fenn, 46: 464-468 (2009).
<b>9</b>	<i>S. phrygia</i> Boiss. Fl. Or. 1: 644 (1867). / <b>Midas nakılı, Endemic</b>	<i>S. ispartensis</i> Ghazanfar, Notes Roy. Bot. Gard. Edinburgh 41: 97, t. 1 (1983).
<b>10</b>	<i>S. erciyesdaghensis</i> Aksoy & Hamzaoglu, Bot. J. Linn. Soc. 158: 730 (2008). / <b>Kayseri nakılı</b>	<i>S. yildirimlii</i> Dinç, Ot sis 19:1, 21 (2012).
<b>11</b>	<i>S. erciyesdaghensis</i> Aksoy & Hamzaoglu, Bot. J. Linn. Soc. 158: 730 (2008). / <b>Kayseri nakılı</b>	<i>S. olympica</i> Boiss., var. <i>erciyesdaghensis</i> (Aksoy & Hamzaoglu) K.Yıldız & Çırpıcı, Türkiye Bitkileri List. 362 (2012).
<b>12</b>	<i>S. caramanica</i> Boiss. & Heldr., Diagn. Pl. Orient. ser. 1, 8: 90 (1849). var. <i>caramanica</i> Boiss. & Heldr. / <b>Karaman nakılı, Endemic</b>	<i>S. kucukodukii</i> Y. Bağcı & Uysal in Nord. J. Bot. 25: 306-310 (2007)
<b>13</b>	<i>S. idaea</i> Hausskn. Mitth. Thüring. Bot. Vereins 5: 49 (1893). / <b>Kazdağ nakılı, End.</b>	<i>S. sipylea</i> O. Schwarz, Feddes Rep. 36: 80 (1934)
<b>14</b>	<i>S. idaea</i> Hausskn. Mitth. Thüring. Bot. Vereins 5: 49 (1893). / <b>Kazdağ nakılı, Endemic</b>	<i>S. caramanica</i> var. <i>idaea</i> (Hausskn.) K.Yıldız & A.Çırpıcı, Türkiye Bitkileri List. 356. (2012).
<b>15</b>	<i>S. sclerophylla</i> Chowdhuri, Notes Roy. Bot. Gard. Edinburgh 22: 261 (1957). / <b>Parlak nakıl, End.</b>	<i>S. bitlisensis</i> O.Tugay & Ertugrul in Bot. J. Linn. Soc. 156: 463-466 (2008).
<b>16</b>	<i>S. porphyrantha</i> Schischk. Vestn. Tiflissk. Bot. Sada 50: 28 (1920). / <b>Yayla nakılı, End.</b>	<i>S. konuralpiae</i> Fırat & K.Yıldız, Phytotaxa 288: 215. (2016)
<b>17</b>	<i>S. nocturna</i> L., Sp. Pl. 1: 416 (1753). / <b>Göz nakılı</b> , Türk. Bitkileri List., s. 362 (2012).	<i>S. apetala</i> Willd. (İspanya Florası'nda Sinonim)
<b>18</b>	<i>S. pendula</i> L., Sp. Pl. 1: 418 (1753). / <b>Nakıl</b> , Türk. Bitkileri List., s. 362 (2012).	<i>S. bithynica</i> Post, Bull. Herb. Boiss. 7: 152 (1899).

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19	<b>S. stenobotrys</b> Boiss. & Hausskn., Fl. Orient. 1: 611 (1867). / <b>Maraş nakılı</b> , Türk. Bitkileri List., s. 364 (2012).	<b>S. bocquetiana</b> Yıld. ve Kılıç OT Sistemantik Botanik Dergisi 26(2). 59-72 (2019).
20	<b>S. viscaria</b> (L.) Borkh. subsp. <b>hamzaoglu</b> (Budak) K.Yıldız, yeni düz. ve st. / comb. et stat. nov. / <b>Yağız nakıl</b> , Türk. Bitkileri List., s. 360 (2012).	<b>S. magenta</b> Yıld. & Kılıç, OT Sistemantik Botanik Dergisi, 24, 2, 1-8, (2017)
21	<b>S. microsperma</b> Fenzl, Pugillus 27:9 (1842). subsp. <b>microsperma</b> / <b>Deniz nakılı</b> , Türk. Bitkileri List., s. 360 (2012).	<b>S. guerbuezii</b> H. Özçelik, Bio-Science Research Bulletin, 18(2): 121-129 (2002).
22	<b>S. conica</b> L., Sp. Pl. 1: 418 (1753). / <b>Sivri nakıl</b> , Türk. Bitkileri List., s. 358 (2012).	<b>S. karakotchanensis</b> Yıld. ve Kılıç OT Sistemantik Botanik Dergisi 26(2). 59-72 (2019).
23	<b>S. discolor</b> Sibth. & Sm., Fl. Graec. Prodr. 1(2): 292 (1809). / <b>Kıyı nakılı</b> , Türk. Bitkileri List., s. 359 (2012).	<b>S. pompeipolitana</b> J. Gay ex Boiss., Fl. Orient. 1: 595 (1867).
24	<b>S. thymifolia</b> Sibth. & Sm., Fl. Graec. Prodr. 1(2): 292. (1809). / <b>Istranca nakılı</b> , Türk. Bitkileri List., s. 364 (2012).	<b>S. sangaria</b> Coode & Cullen, Notes Roy. Bot. Gard. Edinburgh 28: 2 (1967).
25	<b>S. cryptoneura</b> Stapf, Denkschr. Akad. Wien 2 (1886). / <b>Özge nakıl</b> , Türk. Bitkileri List., s. 358 (2012). <b>Endemic</b>	<b>S. sumbiliana</b> I.G. Deniz & O.D. Düşen, Ann. Bot. Fenn. 41: 293 (2004).
26	<b>S. gallinyi</b> Heuffel ex Reichenb. Fl. Germ. Excurs.: 815 (1832). / <b>Trakya nakılı</b> .	<b>S. trinervia</b> Sebast.& Mauri. Fl. Roman. Prodr.: 152 (1818). Ic. Fiori, Ic. Fl. Ital. 1: t. 1190 (1899).
27	<b>S. armeria</b> L., Sp. Pl. 1: 420 (1753). / <b>Horozpipiği</b> , Türk. Bitkileri List., s. 355 (2012).	<b>S. choruhensis</b> Hamzaoglu, Turk. J. Bot. 36: 4 (2012). Türkçe sin.: İspir nakılı, Türk. Bitkileri List., s. 357 (2012) [S. choruhensis Hamzaoglu'nun Türkçe adı].
28	<b>S. confertiflora</b> Chowdhuri, Notes Roy. Bot. Gard. Edinburgh 22: 264 (1957). / <b>Gıncıpancar</b> , Türk. Bitkileri List., s. 358 (2012).	<b>S. confertiflora</b> subsp. <b>thiebautii</b> Du Pasquier ( <b>Amanos Gıncıpancarı</b> ), Thèse de doctorat: Univ. Genève, no. Sc. 5042, 235-253 (2016). Cenevre. Identifiers.DOI: 10.13097/archive-ouverte/unige:92871
29	<b>S. viscaria</b> (L.) Borkh., Rhein. Mag. Enweit. Naturk. 1: 520 (1793). / <b>Gül nakıl</b> , Türk. Bitkileri List., s. 364 (2012).	<b>S. atropurpurea</b> (Griseb.) Greuter & Burdet, Willdenowia 12(2): 189 (1982).
		<b>29 taxa</b>
<b>B</b>	New species (taxa) - new registration-status change-valid new species and new records	
1	<b>S. kemahensis</b> Aytaç & Kandemir, Bağbahçe Bilim Dergisi, 2(1) 2015: 37-42. / <b>Kemah nakılı. Endemic</b>	+NEW SPECIES
2	<b>S. nemrutensis</b> K. Yıldız, Phytotaxa 292 (2): 189–195 (2017). / <b>Nemrut nakılı</b> .	+NEW SPECIES
3	<b>S. bilgili</b> E. Doğan & H. Duman, Phytotaxa 246 (4): 293–299 (2016). / <b>Balıkesir nakılı</b>	+NEW SPECIES
4	<b>S. miksensis</b> Fırat & K. Yıldız, Phytotaxa 273 (4): 283–292, 2016. / <b>Müküs nakılı Endemic</b>	+NEW SPECIES
5	<b>S. arszuzensis</b> Özbek & Uzunh. Phytotaxa, 397 (1): 074–082 (2019). / <b>Arsuz nakılı</b> , Phytotaxa, 397 (1): 77 (2019).	+NEW SPECIES
6	<b>S. marschallii</b> C.A.Mey. Subsp. <b>anaması</b> K. Yıldız & Dadandı, Nordic J. Bot. 28(3): 336 (2010). / <b>Anamas salkımı</b> , Türk. Bitkileri List., s. 361 (2012).	+NEW SUBSPECIES

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7	<b>S. acaulis</b> L. Sp. pi. ed. 2, 603 (1762). Subsp. <b>vanensis</b> Özgökçe & Kit Tan, Ann. Bot. Fennici, 42: 143-149 (2005). / <b>Bodur sinekkapan</b> . Şekil 000, harita 000.	+NEW SUBSPECIES
8	<b>S. vivianii</b> Steud., Nomencl. Bot. ed. 2, 2: 588 (1841) Subsp. <b>viscida</b> (Boiss.) Boulos. Fl. Egypt Checklist : 14 (1995) / <b>Cizre nakılı</b>	+NEW RECORDS
9	<b>S. marschallii</b> C.A.Mey. Subsp. <b>propinqua</b> (Schischk.) Nersesian, Phytom, Horn, Austria, Vol. 36: 43-52 (1996). / <b>Doğusalkımı</b>	+NEW RECORDS
10	<b>S. bornmuelleri</b> Freyn, Oesterr. Bot. Z. 41: 363 (1891). / <b>Yıldız nakılı</b>	+NEW RECORDS
11	<b>S. exsudans</b> Boiss. & Heldr., Diagn. Pl. Orient. 8: 76 (1849) / <b>Kumul nakılı</b>	+NEW RECORDS
	11 (6) Taxa	<b>11 taxa</b>
<b>C</b>	<b>Valid species (Taxa)</b>	<b>Change of taxonomic status and Synonyms</b>
1	<b>S. assyriaca</b> Hausskn. & Bornm. ex Lazkov, Bot. Zhurn. (Moscow & Leningrad) 89(7): 1181 (2004). / <b>Kaba ballica, aktarma ad</b> [adı aktarılan: <i>S. aegyptiaca</i> subsp. <i>ruderalis</i> Coode ve Cullen	<b>S. aegyptiaca</b> (L.) L. Fil. subsp. <b>ruderalis</b> Coode & Cullen, Notes R.B.G. Edinburgh, 28: 8 (1967).
2	<b>S. araratica</b> Schischkin, Ber. Tomsk. Staats. Univ. 77: 292 (1927). / <b>Ağrı nakılı</b> , Türk. Bitkileri List., s. 355 (2012).	<b>S. araratica</b> Schischk. subsp. <b>davisii</b> (Chowdh.) Ghazanfar, Notes R.B.G., 41: 103 (1983). / Türkçe eşad: Çölemerik nakılı, Türk. Bitkileri List., 355 (2012).
3	<b>S. argentea</b> Ledeb., Fl. Ross. 1(2): 311 (1842). / <b>Boz nakıl</b> , Türk. Bitkileri List., s. 355 (2012).	<b>S. cappadocica</b> Boiss. & Heldr., Diagn. Pl. Orient. ser. 1 (8): 86 (1849).
4	<b>S. cserei</b> Baumg., Enum. Stirp. Transsilv. 3: 345 (-346) (1817) / <b>Has nakıl</b>	<b>S. cserei</b> subsp. <b>aeoniopsis</b> (Bornm.) Chowdhuri (1957).
5	<b>S. balansae</b> Boiss. subsp. <b>balansae</b> subsp. <b>demirizii</b> (K. Yıldız & Cırpıcı) K. Yıldız, comb. et stat. nov. / <b>Demiriz nakılı -Endemic</b>	<b>S. demirizii</b> K. Yıldız ve Cırpıcı, Nordic J Bot, 28: 332-340 (2010).
6	<b>S. delicatula</b> Boiss., Diagn. Pl. Orient. ser. 1, 1: 41 (1843). / <b>Alaca nakıl - Endemic</b>	<b>S. delicatula</b> Boiss. subsp. <b>delicatula</b>
7	<b>S. atocioides</b> Boiss. Diagn. Pl. Or. Nov. Ser. 1,5: 83 (1844) / <b>Gebiz nakılı, aktarma ad</b> [adı aktarılan: <i>S. delicatula</i> Boiss. subsp. <i>pisidica</i> Coode & Cullen, Türk. Bitkileri List., s. 358 (2012)].	<b>S. delicatula</b> Boiss. subsp. <b>pisidica</b> Coode & Cullen, Notes Roy. Bot. Gard. Edinburgh 28: 7 (1967). / gebiz nakılı
8	<b>S. goniocaula</b> Boiss., Diagn. Pl. Or. Nov. Ser. 1,1: 31 (1843). / <b>Kulaklı nakıl</b> , aktarma ad [adı aktarılan: <i>S. erimicana</i> Stapf, Türk. Bitkileri List., s. 359 (2012)].	<b>S. erimicana</b> Stapf, Denkschr. Acad. Wiss. Wien, Math.-Nat. Kl. 51: 284 (1886).
9	<b>S. viscaria</b> (L.) Jess subsp. <b>hamzaogluui</b> (Budak) K. Yıldız, comb. et stat. nova. / <b>Yağız nakıl</b> , Türk. Bitkileri List., s. 360 (2012).	<b>S. hamzaogluui</b> Budak Turk J Bot, 35 (2011) 285-289 (2011).
10	<b>S. microsperma</b> Fenzl, Pugillus 27:9 (1842). subsp. <b>microsperma</b> / <b>Deniz nakılı</b> , Türk. Bitkileri List., s. 360 (2012).	<b>S. kotschyi</b> Boiss. var. <b>kotschyi</b> <i>Silene kotschyi</i> Boiss., Diagn. Pl. Orient. ser. 1, 1: 40 (1843). (G!).
11	<b>S. microsperma</b> Fenzl, Pugillus 27:9 (1842). subsp. <b>maritima</b> (Fenzl) F. Eggens & B. Oxelman. PhytoKeys 159: 1-34 (2020) / <b>Sahil nakılı</b> .	<b>S. kotschyi</b> Boiss. var. <b>maritima</b> Boiss., Flora Orientalis, vol. 1 (1867).
12	<b>S. simsii</b> F. Jafari, Rabeler & Oxelman, Phytotaxa 425(1): 41 (2019). / <b>İbişgıyış</b> , Türk. Bitkileri List., s. 361 (2012).	<b>S. multifida</b> Rohrb Rohrb., Monogr. <i>Silene</i> 88 (1869).

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13	<b>S. portensis</b> L., Sp. Pl. 1: 420 (1753) <b>subsp. rigidula</b> Greuter & Burdet, Willdenowia, 12: 190 (1982). / <b>Güzel nakıl</b>	<b>S. rigidula</b> Sibth. & Sm., Fl. Graec. Prodr. 1(2): 299 (1809).
14	<b>S. conica</b> subsp. <b>subconica</b> (Friv.) Gavioli Nom. ref.: Sched. Fl. Ital. Exsicc. ser. 3, 16: 363 (1927). / <b>Mahruti nakıl</b> , Türk. Bitkileri List., s. 364 (2012).	<b>S. subconica</b> Friv., Flora 18(1): 334 (1835).
15	<b>S. compacta</b> Fisch. ex Hornem., Hort. Bot. Hafn. 1: 417 (1813). / <b>Kanlıbasıra otu</b> , Türk. Bitkileri List., s. 358 (2012).	<b>Atocion compactum</b> (Fisch. ex Hornem.) Tzvelev, Novosti Sist. Vÿssh. Rast. 33: 97 (2001).
16	<b>S. armeria</b> L., Sp. Pl. 1: 420 (1753). / <b>Horozpipiği</b> , Türk. Bitkileri List., s. 355 (2012).	<b>Atocion armeria</b> (L.) Raf., Autik. Bot.: 29 (1840).
17	<b>S. scythicina</b> Coode & Cullen, Notes Roy. Bot. Gard. Edinburgh 28: 6 (1967). / <b>Rize nakılı</b> , Türk. Bitkileri List., s. 363 (2012). <b>Endemic</b>	<b>Atocion scythicinum</b> (Coode & Cullen) Frajman in Taxon 58: 822. (2009)
18	<b>S. davrazensis</b> K. Yıldız nom. Nova / <b>Sakız nakılı</b> , <b>aktarma ad</b> [adı aktarılan: <i>Silene lucida</i> Chowdh. subsp. <i>glandulosa</i> Ekim. Türk. Bitkileri List., s. 361 (2012)].	<b>S. lucida</b> Chowdh. subsp. <b>glandulosa</b> Ekim
19	<b>S. manissadjianii</b> Freyn, Herb. Boissier 3: 83 (1895) var. <b>manissadjianii</b> / <b>Amasya nakılı</b> , Türk. Bitkileri List., s. 361 (2012). <b>Endemic</b> .	<b>S. manissadjianii</b> Freyn
20	<b>S. vulgaris</b> (Moench) Garcke <b>subsp. vulgaris</b> / <b>Ecibücü</b>	<b>S. vulgaris</b> (Moench) Garcke var. <b>vulgaris -İsp-Slovakya</b>
21	<b>S. vulgaris</b> subsp. <b>commutata</b> (Guss.) Hayek, Repert. Spec. Nov. Regni Veg. Beih. 30 (1): 258. (1924) / <b>Tepeli nakıl</b>	<b>S. vulgaris</b> var. <b>commutata -İsp-Slovakya</b>
22	<b>S. vulgaris</b> subsp. <b>macrocarpa</b> Turrill Hook., Pl. Tab. 3551 (1956). / <b>İri nakıl</b> .	<b>S. vulgaris</b> var. <b>macrocarpa -İsp-Slovakya</b>
23	<b>S. lucida</b> Chowdhuri, Notes Roy. Bot. Gard. Edinburgh 22: 271 (1957). / <b>Cilo nakılı</b> , Türk. Bitkileri List., s. 361 (2012). <b>Endemic</b>	<b>S. lucida</b> Chowdh. subsp. <b>lucida</b>
24	<b>S. euxina</b> Rupr., Fl. Caucasi 184 (1869). / <b>Yalı nakılı</b> , Türk. Bitkileri List., s. 359 (2012).	<b>S. dichotoma</b> subsp. <b>euxina</b> (Rupr.) Coode & Cullen, Notes Roy. Bot. Gard. Edinburgh 28: 8 (1967).
25	<b>S. colorata</b> Poirer var. <b>colorata</b> / <b>Kum nakılı</b>	<b>S. colorata</b> Poir., Voy. Barbarie 2. 163 (1789).
26	<b>S. conica</b> L., Sp. Pl. 1: 418 (1753) subsp. <b>conica</b> . Türk. Bitkileri List., s. 358 (2012). / <b>Sivri nakıl</b>	<b>S. conica</b> L. L., Sp. Pl. 1: 418 (1753).
C	<b>26 TAXA</b>	
1	<b>Not in Türkiye</b>	<b>S. fuscata</b> Link ex Brot.
2	<b>Not in Türkiye</b>	<b>S. fabaroides</b> Hausskn
	<b>SİLENE, CURRENTLY VALID SPECIES (Taxa) in the Flora of Türkiye:</b> <b>145 species (+20 subsp. +2 varieties): Total taxa: 167</b>	<b>Studied taxa (in Türkiye):</b> <b>approximately 200, and modified taxon: 69</b>

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**TÜRKİYE YÜZYILI MAARİF MODELİ VE OKUL ÖNCESİ EĞİTİM:  
ÖĞRETMENLERİN GÖRÜŞLERİYLE BİR YOL HARİTASI**

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Education, Ankara-Türkiye

**Özet**

Bu çalışma, Türkiye Yüzyılı Maarif Modeli kapsamında hazırlanan okul öncesi eğitim programının öğretmenler perspektifinden değerlendirilmesini amaçlamaktadır. Araştırma, öğretmenlerin programla ilgili görüşlerini, güçlü ve geliştirilmesi gereken yönlerini, uygulamada karşılaşılan zorlukları ve önerilerini ele almaktadır. Araştırmanın çalışma grubunu 2024-2025 eğitim öğretim yılı güz döneminde Bayburt ili içerisinde yer alan Millî Eğitim Bakanlığı bünyesindeki okul öncesi eğitim kurumlarında görev yapmakta olan 10 okul öncesi öğretmeni oluşturmuştur. Araştırma, öğretmenlerin var olan programı derinlemesine incelemeleri amacıyla nitel araştırma yöntemlerinden fenomenoloji yöntemiyle gerçekleştirilmiştir. Araştırmada veri toplama amacıyla “Türkiye Yüzyılı Maarif Modeli Okul Öncesi Eğitim Programı Öğretmen Görüşme Formu” kullanılmıştır. Görüşme soruları, “Türkiye Yüzyılı Maarif Modeli Okul Öncesi Eğitim Programının” temel bileşenleri doğrultusunda oluşturulmuş ve uzman görüşleriyle revize edilmiştir. Görüşmeler öğretmenlerin izinleri dahilinde ses kaydı alınarak ve notlar tutularak kayıt altına alınmıştır. Görüşmeler ortalama 30 dakika sürmüştür. Elde edilen veriler, içerik analizi yöntemiyle incelenmiş ve temalar oluşturularak raporlanmıştır. Bulgular, programın beceri temelli yaklaşımı, sosyal-duygusal öğrenme becerileri, değerler eğitimi, aile katılımı ve değerlendirme süreçleri gibi temel bileşenlerin etkinliği öğretmenlerin deneyimleri ışığında incelenmiştir. Araştırma sonuçları, programın sahadaki uygulanabilirliğine dair önemli ipuçları sunarak, eğitim politikalarının geliştirilmesine yönelik somut öneriler ortaya koymaktadır.

**Anahtar Kelimeler:** Okul öncesi, Türkiye Yüzyılı Maarif Modeli, okul öncesi eğitim programı, öğretmen görüşleri.

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**January 21-28, 2025 / Havana, CUBA**

**THE CENTURY OF TÜRKİYE EDUCATION MODEL AND PRESCHOOL  
EDUCATION: A ROUTE MAP WITH THE PERSPECTIVES OF TEACHERS**

**Abstract**

This study aims to evaluate the preschool education program prepared within the scope of the Century of Türkiye Education Model from the perspective of teachers. The research addresses teachers' views on the program, its strengths and aspects that need to be developed, the difficulties encountered in implementation, and their suggestions. The study group of the research consisted of 10 preschool teachers working in preschool education institutions within the Ministry of National Education in Bayburt province in the fall semester of the 2024-2025 academic year. The research was conducted with the phenomenology method, one of the qualitative research methods, in order to enable teachers to examine the existing program in depth. "Century of the Century of Türkiye Education Model Preschool Education Program Teacher Interview Form" was used for data collection. The interview questions were created in line with the basic components of the "Century of Türkiye Education Model Preschool Education Program" and revised with expert opinions. The interviews were recorded with the permission of the teachers by audio recording and taking notes. The interviews lasted an average of 30 minutes. The data obtained were analyzed by content analysis method and reported by creating themes. The findings examined the effectiveness of the basic components of the program such as skills-based approach, social-emotional learning skills, values education, family involvement and evaluation processes in the light of teachers' experiences. The results of the research provide important clues about the applicability of the program in the field and provide concrete suggestions for the development of educational policies.

**Keywords:** Preschool, The Century of Türkiye Education Model, preschool education program, teacher opinions.

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## **Introduction**

Taking teachers' perspectives into account in the development of educational programs is important from both theoretical and practical perspectives. Teachers are the main stakeholders who evaluate the applicability of programs in the field and directly observe their effects. Research in the field of early childhood education reveals that teachers' feedback is critical for creating a quality learning environment (Katz, 1994). In the development of educational programs, teachers' feedback based on their experiences is essential for understanding the impact of the program in the field. Research has shown that teachers play critical roles in pedagogical leadership, individual child development and classroom interactions (Fonsén et al., 2023). Moreover, identifying the challenges and strengths teachers face in practice contributes directly to program development processes (Hyson et al., 2009).

In studies evaluating the impact of training programs in the field, it has been reported that teachers' field-specific feedback is insufficient (Chen & Chang, 2006). It has been emphasized that teachers' views should be further examined in the development of educational approaches appropriate to the individual needs of children (Dayan & Ziv, 2012). It has also been reported that teachers' feedback on curriculum policies is lacking and this creates gaps in curriculum development processes (Boyd & Boyd, 2020). This study aims to examine teachers' feedback to understand the impact and applicability of the Century of Türkiye Education Model preschool education program in the field. By filling these gaps in the literature, it aims to provide suggestions on how teachers' opinions can be used more effectively in program development processes. In this context, the study aims to evaluate the preschool education program prepared within the scope of the Century of Türkiye Education Model from the perspective of teachers.

## **Materials and Methods**

### ***Research Design***

This study is based on qualitative research methodology. Qualitative research is an approach that aims to understand the experiences, perceptions and opinions of individuals and focuses on in-depth data collection. For the purpose of the study, phenomenology model (phenomenology) was adopted. Phenomenology is a qualitative research design that aims to understand and interpret individuals' experiences of a particular phenomenon (Creswell, 2013).

### ***Participants***

The study group consisted of 10 preschool teachers with different years of professional service. The participants were selected by purposive sampling method. This type of sampling aims to collect more in-depth data by selecting individuals with certain characteristics in line with the purpose of the research (Patton, 2002). All of the teachers were selected from the teachers who implemented the preschool education program within the scope of the Century of Türkiye Education Model.

All of the teachers were female. When the age groups of the teachers participating in the study are examined, it is seen that there is one teacher (10%) in the 25-30 age range, four teachers (40%) in the 31-35 age range, three teachers (30%) in the 36-40 age range, and two teachers (20%) in the 41 and over age group. Teachers' years of professional service ranged between 3 years and 24 years, with an average of 13.1 years of professional service.

### ***Data Collection Tool***

The data collection tool used in the study was the "Century of Türkiye Education Model Preschool Education Program Teacher Interview Form". There are a total of 8 questions in the

interview form. The questions in the form were structured to cover preschool teachers' general evaluations about the Century of Türkiye Education Model, the applicability of the program, its skill-based structure, family and community involvement, evaluation processes and suggestions.

#### **Data Collection and Analysis**

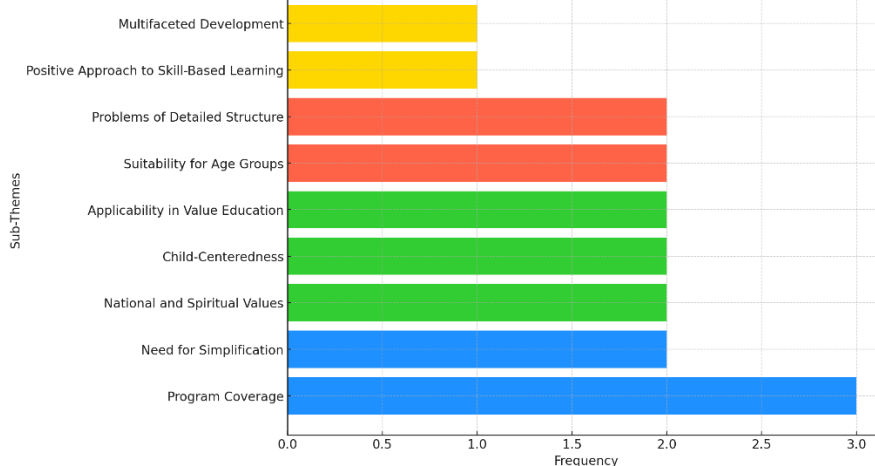
The interview form was used in one-to-one semi-structured interviews with teachers to collect data. The interviews were audio-recorded and notes were taken with the permission of the teachers and subjected to thematic analysis. During the interviews, a flexible environment was provided for teachers to express their thoughts freely. The interviews lasted an average of 30 minutes.

The data obtained in the study were evaluated using the thematic analysis method. This method reveals the common and different views of the participants in a systematic way by extracting meaningful themes and sub-themes from the data (Braun & Clarke, 2006). In the study, the identities of the teachers were hidden by assigning codes such as T1, T2, T3... to the teachers. This coding method aims to protect the confidentiality of the participants' identities and to perform a more systematic analysis. In addition to the codes, the length of teachers' professional experience was also given in parentheses. This approach contributed to deepening the analysis by classifying teachers' views according to their professional experience.

#### **Findings and Discussion**

##### **Teachers' General Evaluations on the Century of Türkiye Education Model Preschool Education Program**

Teachers' opinions about the Century of Türkiye Education Model Preschool Education Program were divided into 4 themes: “The general structure of the program, values and sub-goals, applicability of the program, and skill-based and multifaceted development”.



**Figure 1.** General Evaluations of the Program

The first theme for teachers' opinions about the Century of Türkiye Education Model Preschool Education Program is “*General Structure of the Program*”. While the majority of teachers expressed their opinions on the comprehensiveness of the program, some teachers expressed their opinions on the simplification of the program. The opinions of some teachers on this theme are as follows: “*The program is generally well designed, past and present are tried to be combined, and it is aimed to raise children in accordance with certain values.*” (T2, 16 years). “*It is a good education program if fully implemented. It is a program that supports the multidimensional development of children in terms of mental, social, emotional, physical and*

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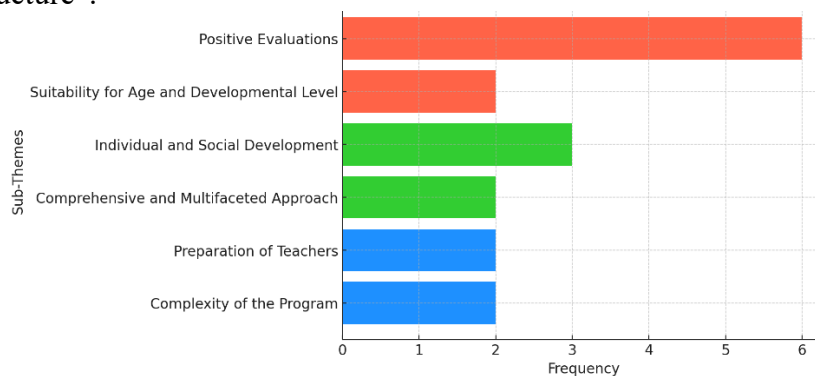
*moral aspects.*” (T8, 7 years). ”.....*It makes me pessimistic that a program that is in favor of simplification is overwhelmed with so much detail. For this section, which is the most basic part of education, so much detail seems unnecessary to me. Simplification is important.*“ (T5, 3 years).

The theme of “Values and Objectives” emphasized by the teachers about the curriculum was divided into three sub-themes: “national and spiritual values, the child being at the center and the applicability of values education”. Some of the teachers' statements on this theme are as follows: *“The fact that the program was shaped according to the virtue, morality and spiritual values on which it is based has enabled the program to gain depth.”* (T4, 10 years). *“It will reveal positive results in terms of putting the child at the center in education and including play-based activities....”* (T6, 19 years).

Some teachers expressed opinions on the theme of “Applicability of the Program”. A remarkable statement about this is as follows: ”.....*While the purpose of preschool is simple and accessible, such as providing children with good habits and ensuring that they use Turkish well, strange expressions and explanations in the details of the program seem very inaccessible to me. The preschool age is ideal for making friends, socializing in an environment where there is equal opportunity, and at the same time getting used to the school climate, and it already fulfills this. I think it has become crowded so that the child can do this and learn that and be aware of this.*” (T5, 3 years). In addition, it was determined that two teachers made positive evaluations in terms of the program providing *“Skill-Based and Multidimensional Development”*.

## **Teachers' Opinions on Skill-Based Program**

It was determined that teachers' opinions on the skill-based nature of the Century of Türkiye Education Model Preschool Education Program were divided into 3 themes: “The suitability of the skill-based structure, the strengths of the skill-based structure, and the difficulties of the skill-based structure”.



**Figure 2.** Opinions on the Skill-Based Program

When Figure 2 was examined, it was found that the majority of the teachers expressed opinions on the suitability of the skills-based program in terms of *“positive evaluations and suitability for children's age and developmental level.”* Some of the statements related to this are as follows: *“I think it supports their self-development and is appropriate.”* (T4, 10 years). *“It is good that it is skill-based, we were already progressing skill-based for our department. It is good that it is emphasized by being aware of this.”* (T5, 3 years). *“The fact that the program is skill-based puts the child, family and society at the center. I think this structure is suitable for the developmental characteristics of children because it includes not only skills for a certain field but also the national and spiritual values of the society and cultural accumulations.”* (T7,



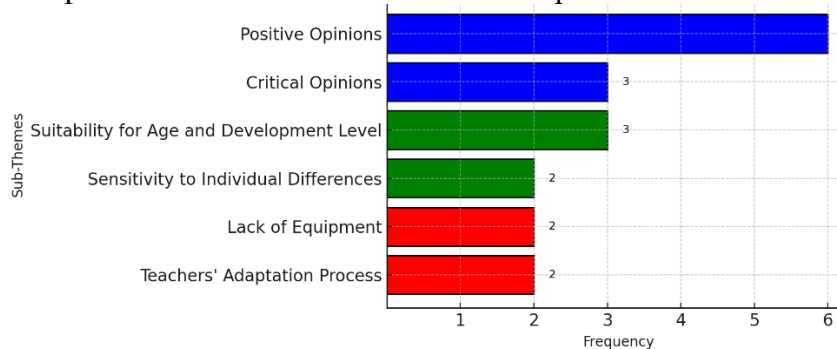
16 years).

Some teachers emphasized the sub-themes of “Individual and social development and comprehensive and multifaceted approach” for the theme of *“Strengths of Skill-Based Structure”*. Some of the statements related to this are as follows: *“It will have positive results in terms of helping children develop their creativity, problem solving skills and communication skills. This will enable the child to become successful individuals in the society in accordance with their abilities. The child's sense of self-confidence will improve.”* (T6, 19 years). *“The program has a skills-based approach that allows children to discover and develop their individual talents. This can contribute to children's cognitive, social and motor development, especially when supported by play-based learning processes.”* (T9, 11 years).

The last theme *“Challenges of Skill-Based Structure”* emphasized by the teachers regarding the skill-based curriculum is divided into two sub-themes. These sub-themes are *“Teachers' preparation and the complexity of the program.”* Some of the statements related to this are as follows: *“.....I do not think that sustainability literacy, which is a sub-branch of literacy skill, is suitable for preschool period. It is not suitable for the age group and development.”* (T8, 7 years). *“Children's acquisition of creative, analytical and problem-solving skills at an early age forms the basis of lifelong learning skills. It is important in this respect. However, it is critical that teachers are well prepared for skills-based education. Without adequate guidance, it may be difficult for children to fully benefit from this structure.”* (T10, 17 years).

**Teachers' Opinions on Learning and Sub-Learning Outcomes**

It was determined that teachers' opinions on the learning and sub-learning outcomes in the Century of Türkiye Education Model Preschool Education Program were divided into 3 themes: “General Evaluation of Learning and Sub-Learning Outcomes, Compliance with Children's Developmental Level and Problems in the Implementation Process”.



**Figure 3. Opinions on Learning and Sub-Learning Outcomes**

When Figure 3 is examined, it is found that some teachers have positive views towards learning and sub-learning outcomes, while some teachers have a critical perspective towards learning and sub-learning outcomes. Some of the teacher statements regarding this are as follows: *“It is very good because it targets the holistic development of children.”* (T8, 7 years). *“The clear definition of learning and sub-learning outcomes makes it easier for the teacher to focus on concrete goals. However, the fact that the outcomes are so standardized that individual differences are ignored may create difficulties for children with different developmental rates.”* (T10, 17 years).

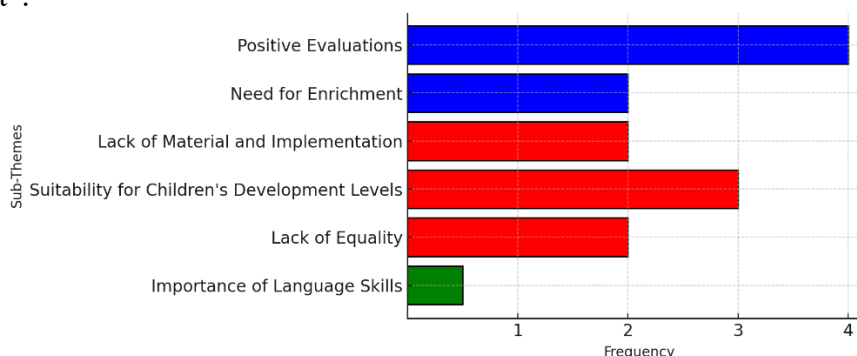
The theme of “Appropriateness to Children's Developmental Level” emphasized by teachers for learning and sub-learning outcomes is divided into two sub-themes: “Appropriateness to age and developmental level and sensitivity to individual differences”. Some of the statements

regarding these are as follows: *"Suitability to the individual differences of children is quite sufficient."* (T1, 24 years). *"I liked the new learning and sub-learning outcomes."* (T9, 11 years).

The last theme emphasized by the teachers regarding learning and sub-learning outcomes, "Problems in the Implementation Process", is divided into two sub-themes: "Lack of equipment and teachers' adaptation process". Some of the statements related to these are as follows: *"MTIC.1. Being able to imitate the sounds they hear with the instrument. MTB.1.a. Imitates the sounds he/she hears from nature/environment/objects by using instruments made of leftover materials/Orff instruments. MTB.2.a. Chooses the instrument to play among the options of instruments made of leftover materials/Orff instruments presented to him/her. MLB.2.b. Says the name/characteristics of the instrument made of leftover materials/Orff instrument he/she chooses. For example, in order to reach this skill, first of all, we do not have the necessary equipment to reach this skill in our class."* (T2, 16 years). *"The old one was easier to understand, this one seemed complicated while practicing, but I think I will get used to it as I practice it."* (T4, 10 years).

#### **Teachers' Opinions about Domain Skills**

It was determined that teachers' opinions on the content area skills in the Century of Türkiye Education Model Preschool Education Program were divided into three themes: "Adequacy of Content of Content Area Skills, Applicability Problems, and Turkish and Language Development".



**Figure 4.** Opinions on Domain Skills

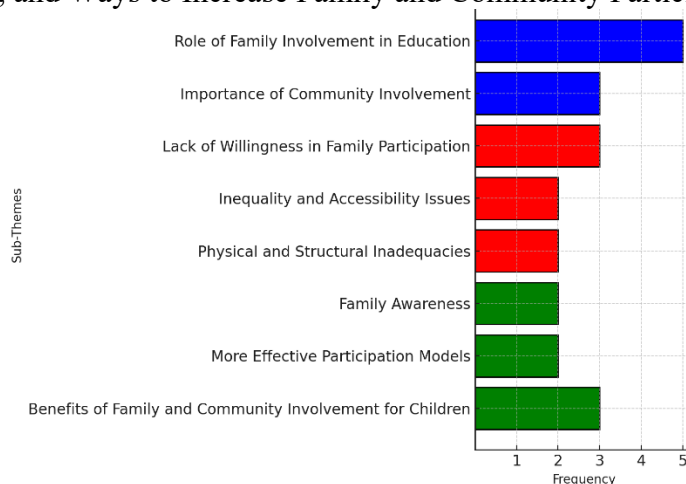
When Figure 4 was analyzed, it was found that some teachers made positive evaluations on the theme of "Adequacy of Content of Field Skills". Some of the related teacher statements are as follows: *"All domain skills are detailed and sufficient."* (T1, 24 years). *"Especially the fact that the movement and health area has been introduced instead of the playground and that health is included in this area, I think that children will have a pre-cognition for healthy living at an early age and they will be more sensitive to this in their later lives."* (T4, 10 years).

It was concluded that some teachers expressed opinions on the sub-themes of "Lack of material and application, suitability to children's developmental level and lack of equality" in the "Applicability Problems" theme regarding the field skills in the program. Some statements related to this are as follows: *"The applicable ones were the ones we used to apply in the past. As I said, I cannot visualize the new outputs. I do not know how to transfer them."* (T5, 3 years). *"I think that the content of mathematics content area skills and science content area skills are slightly above the developmental level of children."* (T7, 16 years). *"The fact that the curriculum includes Turkish, mathematics, science, social, movement and health, art and music provides a comprehensive structure to support children's well-rounded development. Not*

addressing each area equally may lead to some areas being neglected. For example, emphasizing academic skills such as Turkish and mathematics may cause creative areas such as art or music to remain in the background.” (T10, 17 years).

#### **Teachers' Opinions on Family/Community Involvement**

It was determined that teachers' opinions on family/community participation in the Century of Türkiye Education Model Preschool Education Program were divided into three themes: “The Importance of Family and Community Participation, Difficulties Encountered in Implementation, and Ways to Increase Family and Community Participation”.



**Figure 5.** Opinions on Family/Community Involvement

When Figure 5 is analyzed, it is concluded that some teachers expressed opinions on the sub-themes of “The role of family involvement in education and the importance of community involvement” in the theme of “The Importance of Family and Community Participation”. Some of the statements related to this are as follows: *“I think that increasing family participation in education is more beneficial for the child.”* (T3, 8 years). *“I think that education can never be done in isolation from the family and society. For years, education has always been given the example of a triple hairpin and the family has been thought to be a part of education. The family should be made aware and the achievements of the child should be made permanent in the family and society. If a behavior acquired at school does not continue at home (if the child is taught at school that lying is wrong and the parents set an example by lying at home), this behavior acquired will not be permanent. It would be a wasted effort.”* (T6, 19 years).

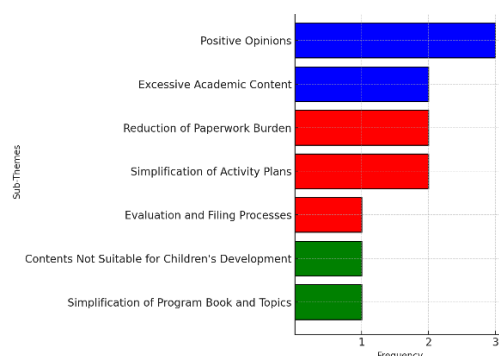
It was found that some teachers emphasized the sub-themes of “Lack of desire in the participation of families, inequality and accessibility problems, and physical and structural inadequacies” in the theme of “Difficulties Encountered in Practice” for family/community participation. Some of the statements related to this are as follows: *“We are asked to gain so many skills, we don't have equipment in our classrooms, we don't have auxiliary staff, we don't have interns, we don't have the right to recess, we have a lot of paperwork to fill out, and unfortunately, we can't take the family to school every day. Our families are not very eager to come to school anyway.”* (T2, 16 years). *“I have never been able to do community participation. I continue with family participation.”* (T5, 3 years). *“Encouraging families to actively participate in children's learning processes ensures that children are supported at home, because it is important that the education we provide continues at home. This increases children's motivation to learn and strengthens our cooperation with families. Unfortunately, activities to increase family engagement do not reach all families equally due to socioeconomic*

differences. Unfortunately, the way families are included in education is also superficial. For example, they should be more actively involved in curriculum development and decision-making processes instead of just being invited to activities.” (T10, 17 years).

Some teachers, on the other hand, expressed opinions on family/community involvement under the theme “Ways to Increase Family and Community Involvement” on the topics of “raising family awareness, more effective participation models, and the benefits of family and community involvement for children”. One of the teacher statements is as follows: “Family participation contributes positively to the development of the child. It benefits the child's emotional and social development, especially intellectual development. It provides the child with the opportunity to get to know the culture, social life and professions in which the child lives. It makes the child feel safe in the school.” (T8, 7 years).

### **Topics That Teachers Want to be Changed or Removed from The Curriculum**

It was determined that the opinions of the teachers about the issues they wanted to be changed or removed in the Century of Türkiye Education Model Preschool Education Program were divided into 3 themes: “General Evaluation of Content, Paperwork and Time Management, and Compliance with Age and Development Level”.



**Figure 6.** Opinions on the Topics They Want to be Changed/Removed in the Program

When Figure 6 was analyzed, it was found that some teachers expressed opinions on the sub-themes of “Positive opinions and excess of academically oriented content” in the theme of “General Evaluation of Content”. Some teacher statements related to this are as follows: “All the content is very good.” (T1, 24 years). “Preschool period is a period in which children should develop through play-based learning. There are learning outcomes in the program that are too academic-oriented (e.g., intensive Turkish or mathematics content aimed at increasing academic performance at an early age), which can negatively affect children's natural learning processes....” (T10, 17 years).

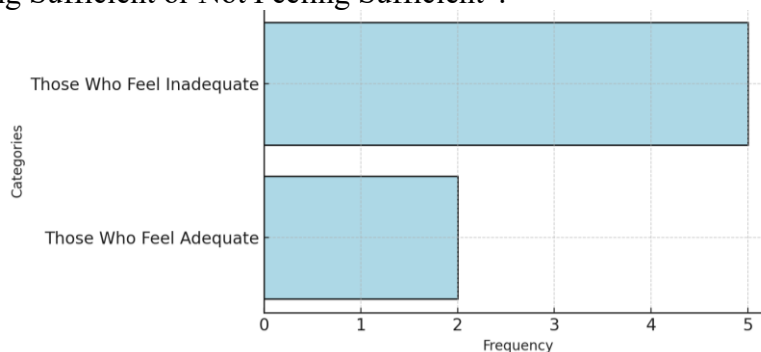
Some teachers expressed opinions on the sub-theme of “Reducing Paperwork Burden, Simplifying Activity Plans, and Evaluation and Filing Procedures” for the theme of “Paperwork Burden and Time Management”. Some of the statements related to this are as follows: “Paperwork should be reduced and teachers should be given some breathing space.” (T2, 16 years). “The filing and evaluation part should be simplified.” (T3, 8 years) “.....But I think it is negative in terms of time and workload for the teacher to do 50 minutes of training without any break and to increase the paperwork load.” (T6, 19 years). “.....The fact that the activity plans are too detailed causes teachers to spend more time than necessary in the planning phase. This takes their energy and attention away from interacting with children. Detailed plans put us under an unnecessary burden in daily practice. It is sufficient for daily activity plans to provide a general framework to guide teachers. The details should be left to

*the teacher's discretion and should be adaptable to children's interests. Each activity plan should include only the main outcomes and implementation steps, and unnecessary details (e.g. a structure in which every second is planned) should be removed. The planning process can be accelerated by using digital tools and ready-made templates. This allows teachers to save more time.*" (T10, 17 years).

It was concluded that some teachers emphasized the sub-theme of "Content that is not suitable for children's development and simplification of the curriculum book and subjects" in the theme of "Appropriateness to Age and Development Level" regarding the subjects they wanted to be changed/removed in the curriculum. Some teacher statements related to this are as follows: *"Sustainability literacy. I don't think it is suitable for children's age and development."* (T8, 7 years). *"Not in terms of adding it, but the preparation of activity plans is very time-consuming, we write too many learning outcomes and sub-learning outcomes in activity plans. Then they ask us to write these things again in the process. This is very time consuming. Also, the program book is too long and too complicated. It should be simplified and the topics should be ordered more systematically."* (T9, 11 years).

#### **Teachers' Efficacy Beliefs about the Program**

According to the opinions of the teachers, it was determined that the efficacy beliefs of the Century of Türkiye Education Model Preschool Education Program were divided into the theme of "Feeling Sufficient or Not Feeling Sufficient".



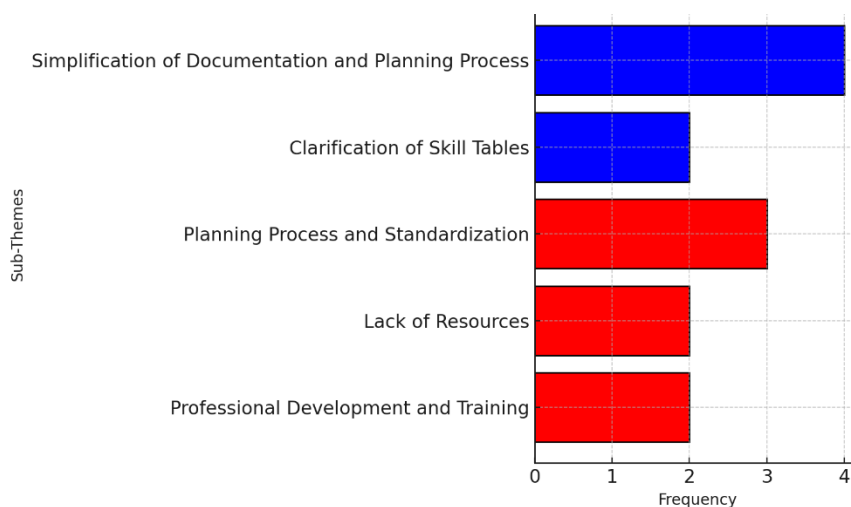
**Figure 7.** Teachers' Efficacy Beliefs about the Program

When Figure 7 is examined, it is concluded that the majority of teachers do not feel themselves sufficient for the program. Some statements related to this are as follows: *"I am not sufficient, of course, because I still have not fully grasped the program. It will be possible to fully grasp it with practices."* (T2, 16 years). *"Of course, I have deficiencies because the program is still new."* (T3, 8 years). *"No, I couldn't understand the program. I couldn't understand what it wants, how it wants it, how I will give it, how I will observe the output in the child."* (T5, 3 years).

On the other hand, it was determined that a small number of teachers felt themselves adequate for the Century of Türkiye Education Model Preschool Education Program. The statements of some teachers about this are as follows: *"Yes, I feel adequate."* (T4, 10 years). *"Of course, I had difficulties in the process of getting information about the new program. But I try to adapt to the program change as in every new situation."* (T7, 16 years).

#### **Teachers' Recommendations for the Program**

It was determined that teachers' suggestions for the Century of Türkiye Education Model Preschool Education Program were divided into two themes: "Simplification of the Program and Suggestions for the Implementation Process".



**Figure 8.** Recommendations for the Program

When Figure 8 was examined, it was concluded that the teachers expressed opinions on the sub-theme “Simplifying the document and planning process and clarifying the skill tables” in the theme of “Simplifying the Curriculum”. Some teacher statements related to this are as follows: *“Minimization of documents.”* (T1, 24 years). *“I think that the program is very comprehensive in general and its contents are effective. I just think that there are too many details, for example, in preparing daily plans, and I would prefer more simplification.”* (T3, 8 years). *“It is very good that children are included in the program not only academically but also in terms of values, morals, patriotic aspects, but it would be better if the skill tables were clearer and more understandable, especially system literacy, sustainable literacy.”* (T8, 7 years).

It was also found that some teachers expressed opinions on the sub-theme of “Planning process and standardization, lack of resources, and professional development and trainings” in the theme of “Suggestions for the Implementation Process” for the Century of Türkiye Education Model Preschool Education Program. Some teacher statements related to this are as follows: *“..... Trainings should be increased.”* (T9, 11 years). *“There was a very fast transition to the implementation process. I don't think we were adequately prepared. Also, schools were not provided with enough resources.”* (T10, 17 years).

### **Conclusion and Recommendations**

When the general evaluations of the teachers about the Century of Türkiye Education Model Preschool Education Program were examined, most of the teachers stated that the program was comprehensive and had a strong foundation in terms of values and goals. The child being at the center and the inclusion of national and spiritual values in education were evaluated positively.

On the other hand, the excessive details of the program and the need for simplification were frequently emphasized. Teachers stated that some concepts were too complex and created problems in terms of applicability.

The skills-based structure was found positive in terms of developing children's creative, problem-solving and social skills. In addition, the fact that it provides a community and family-centered structure was evaluated positively. Teachers expressed that they had difficulties especially in terms of the complexity of the program and lack of teacher preparation. It was stated that some skills were not appropriate for age and developmental level.

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Learning outcomes facilitated focusing on concrete goals and supported the holistic development of children. It was criticized that standardized outcomes ignored individual differences and that some skills were not appropriate for children's developmental level. Lack of equipment and difficulties in the adaptation process of teachers were seen as important obstacles in the implementation process.

It was stated that the content area skills were adequate and supported children's all-round development. It was emphasized that mathematics and science skills exceeded children's developmental level and that creative areas such as art and music remained in the background. The positive effects of family involvement on children's development were frequently mentioned. However, reluctance of families to participate, socioeconomic inequalities and lack of infrastructure were among the major problems. It was stated that families should be made aware and more effective participation models should be developed.

The vast majority of teachers did not feel adequate for the program. The fact that it was a new program and that there was not enough training made it difficult for teachers to adapt to the program. For example, "No, I did not understand the program. I do not know what it wants, how it wants it, how to give it, how to observe it in children" (T5, 3 years). A few teachers stated that they felt adequate for the program and that they were trying to adapt to the process. It was emphasized that the document load should be reduced, activity plans should be simplified and skill tables should be made more descriptive. It was stated that more resources should be provided to schools and teachers' training processes should be increased.

When the results are evaluated in general, although the program has a comprehensive and strong structure, the need for applicability and simplification stands out. While the skills-based structure contributes to children's development, teacher preparation and the complexity of the program create significant problems. Family and community engagement is seen as critical to the success of education, but current models of engagement are inadequate. Evaluation and planning processes place additional burden on teachers and need to be simplified. In this context, it is important to simplify the details in the curriculum, especially to make concepts more understandable. Planning processes and document burden should be reduced. Teachers should be given comprehensive trainings on the implementation of the program. In addition, guidance materials should be provided for the effective implementation of the skills-based structure. Material and infrastructure support should be provided to schools and equipment deficiencies should be eliminated. Awareness-raising activities should be carried out to increase the participation of families in education and participation models should be made more effective. In order to increase the applicability of the program, feedback should be received from teachers and revisions should be made accordingly.

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**TEKNOLOJİ TABANLI UYGULAMALARIN EĞİTİME ENTEGRASYONU: WEB,  
VR VE AG ARAÇLARI ÜZERİNE BİR ANALİZ**

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**Özet**

Teknolojinin eğitime entegrasyonu, öğrenme süreçlerini zenginleştirme ve çocukların motivasyonunu artırma potansiyeliyle giderek daha fazla önem kazanmaktadır. Bu çalışma, okul öncesi eğitimde kullanılan web tabanlı araçlar, sanal gerçeklik (VR) ve artırılmış gerçeklik (AG) teknolojilerine yönelik yapılan araştırmaların sistematik bir tarama ile incelemeyi hedeflemektedir. PRISMA protokolü çerçevesinde yürütülen çalışmada, Web of Science, Scopus, ERIC, Google Scholar ve PubMed veri tabanlarındaki araştırmalarda, okul öncesi eğitimde kullanılan teknoloji tabanlı uygulamaların eğitim süreçlerine entegrasyonu, uygulamaların potansiyel faydaları, kullanım düzeyleri ve karşılaşılan zorluklar üzerine odaklanılmıştır. Analiz sonuçları, web tabanlı araçların kolay erişilebilirliği ve maliyet etkinliği nedeniyle öğretmenler tarafından daha yaygın kullanıldığını göstermektedir. Bu araçlar, öğrenme materyallerini kişiselleştirme ve sınıf içinde aktif katılımı artırma konusunda etkili bulunmuştur. AG ve VR teknolojileri ise soyut kavramların somutlaştırılması, yaratıcılığın geliştirilmesi ve çocukların öğrenmeye olan motivasyonunun artırılması gibi alanlarda dikkat çekmektedir. Ancak, bu teknolojilerin daha az yaygın kullanıldığı ve genellikle teknik altyapı eksiklikleri ve yüksek maliyetler nedeniyle sınırlı kaldığı belirlenmiştir. Literatürde, teknik altyapı eksiklikleri, öğretmenlerin teknolojiye adaptasyon sürecindeki yetersizlikleri ve maliyet engelleri, bu araçların eğitime entegrasyonunda karşılaşılan temel zorluklar olarak öne çıkmaktadır. Bunun yanı sıra, AG ve VR gibi yenilikçi teknolojilerin pedagojik uygulamaları hakkında daha fazla rehberliğe ihtiyaç duyulmaktadır. Sonuç olarak, teknoloji tabanlı araçların okul öncesi eğitimde öğrenme süreçlerini destekleme potansiyelini ortaya koyarken, bu araçların etkin entegrasyonu için teknik altyapının iyileştirilmesi, eğitim programlarının geliştirilmesi ve maliyetlerin düşürülmesi gerektiğini vurgulamaktadır. Çalışma, teknoloji temelli eğitim araçlarının etkili kullanımını destekleyecek stratejilerin belirlenmesine katkı sağlamaktadır.

**Anahtar Kelimeler:** Sanal gerçeklik gözlükleri, artırılmış gerçeklik, web tabanlı araçlar, okul öncesi, teknoloji temelli uygulamalar

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**INTEGRATION OF TECHNOLOGY-BASED APPLICATIONS INTO EDUCATION:  
AN ANALYSIS ON WEB, VR AND AR TOOLS**

**Abstract**

The integration of technology into education is becoming increasingly important with the potential to enrich learning processes and increase children's motivation. This study aims to conduct a systematic review of research on web-based tools, virtual reality (VR) and augmented reality (AR) technologies used in preschool education. The study, which was conducted within the framework of the PRISMA protocol, focused on the integration of technology-based applications used in preschool education into educational processes, potential benefits of applications, usage levels and challenges encountered in the research in Web of Science, Scopus, ERIC, Google Scholar and PubMed databases. The results of the analysis show that web-based tools are more widely used by teachers due to their easy accessibility and cost-effectiveness. These tools were found to be effective in personalizing learning materials and increasing active participation in the classroom. AR and VR technologies, on the other hand, attract attention in areas such as concretizing abstract concepts, enhancing creativity and increasing children's motivation to learn. However, these technologies have been found to be less widely used and often limited due to lack of technical infrastructure and high costs. In the literature, lack of technical infrastructure, teachers' inability to adapt to technology and cost barriers stand out as the main challenges faced in the integration of these tools into education. In addition, there is a need for more guidance on the pedagogical applications of innovative technologies such as AR and VR. In conclusion, while the study reveals the potential of technology-based tools to support learning processes in preschool education, it emphasizes the need to improve technical infrastructure, develop training programs and reduce costs for the effective integration of these tools. The study contributes to the identification of strategies to support the effective use of technology-based educational tools.

**Keywords:** Virtual reality glasses, augmented reality, web-based tools, preschool, technology-based applications

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## 1. Introduction

The integration of technology into education is becoming increasingly important with the potential to enrich learning processes and increase children's motivation. Technology-based applications enrich learning processes, especially through innovative tools such as augmented reality (AR), virtual reality (VR), and mixed reality (MR). These tools have a strong potential to enhance teachers' digital competencies and promote child engagement (Wang & Li, 2024). For example, the capacity of AR to visualize learning materials through gamification has been identified as an important factor in increasing children's interest (Lampropoulos et al., 2022). Studies on the pedagogical effects of VR and AR tools show that they facilitate children's understanding of abstract concepts and improve their problem-solving skills (Zhang et al., 2022). For example, a systematic review on the impact of VR in anatomical education revealed that it accelerated children's learning processes (Uruthiralingam & Rea, 2020). Combining VR with gamification in language learning increased children's motivation to learn and led to better results (Pinto et al., 2021). However, teachers' lack of adequate training and technical support for these technologies constitutes a significant barrier to implementation (Wang & Li, 2024). The main obstacles encountered in the dissemination of technology-based applications include hardware costs, lack of technical infrastructure, and limited knowledge of teachers (Albishri & Blackmore, 2024; Familoni & Onyebuchi, 2024). In this context, this study aims to conduct a systematic review of the research on web-based tools, VR and AR technologies used in education and to focus on the integration of technology-based applications into educational processes, their potential benefits, usage levels and challenges.

## 2. Method

### 2.1. Research Design

The model of this study is a systematic review, which aims to examine the research on web-based tools, VR and AR technologies used in preschool education. A systematic review is a research model used to summarize and analyze the data collected by systematically reviewing the existing literature on a specific topic. This method is ideal for identifying knowledge gaps in the literature and future research areas by providing a holistic assessment of research findings (Gough et al., 2017; Thomas & Harden, 2008).

### 2.2. Data Collection and Analysis

This study adopted a systematic review method to examine the impact of technology-based applications (VR, AR, and web-based tools) used in preschool education. Data were collected within the framework of the PRISMA protocol. This process included the following steps: (1) Literature Review: The search was conducted in Web of Science, Scopus, ERIC, Google Scholar, and PubMed databases using keywords such as "preschool education", "technology-based practices", "VR", "AR", and "web-based tools". After title and abstract evaluation, 150 studies were included. In this process, studies that were outside the scope of the study and those with inappropriate methodologies were excluded. After full-text review, 50 studies that met certain criteria were evaluated in detail. At this stage, studies with missing data or out of context were excluded from the analysis. As a result, 20 studies that met the research questions and met certain methodological standards were included in the review. These studies reveal the main themes in the literature on the use of technology-based applications in education (Table 1).

The inclusion criteria for the studies were as follows: (a) published between 2010 and 2024, (b) in English or Turkish, (c) addressing the use of technology in education. Inclusion and

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Exclusion Criteria: (a) The study included only studies that analyzed technology-based practices in the preschool context. (b) Studies that did not focus on technology use or addressed only general pedagogical approaches were excluded. (c) Meta-analyses, systematic reviews, and experimental studies were preferred. Selection Process: Screened studies were evaluated using the PRISMA flowchart (Moher et al., 2009) and selected according to appropriate criteria. The articles identified as a result of the initial screening were examined on the basis of title and abstract; those found appropriate were included in the full-text review.

The collected data were analyzed using thematic content analysis method. This method is an appropriate approach to identify common themes related to technology-based practices and to reveal trends in the literature (Braun & Clarke, 2006). The analysis process proceeded as follows: (1) Coding and Theme Identification: The data obtained from the studies were coded using qualitative data analysis software. (2) Three main themes were identified: Teachers' Attitudes, Technology Use Levels and Challenges. (3) Data Validation: The reliability of the coding process was tested by comparisons between independent coders. (4) Presentation of Results: The results of the analysis were supported with graphs and tables to visualize the findings.

### **3. Findings and Discussion**

Table 1 presents the studies covered in the scope of the research.

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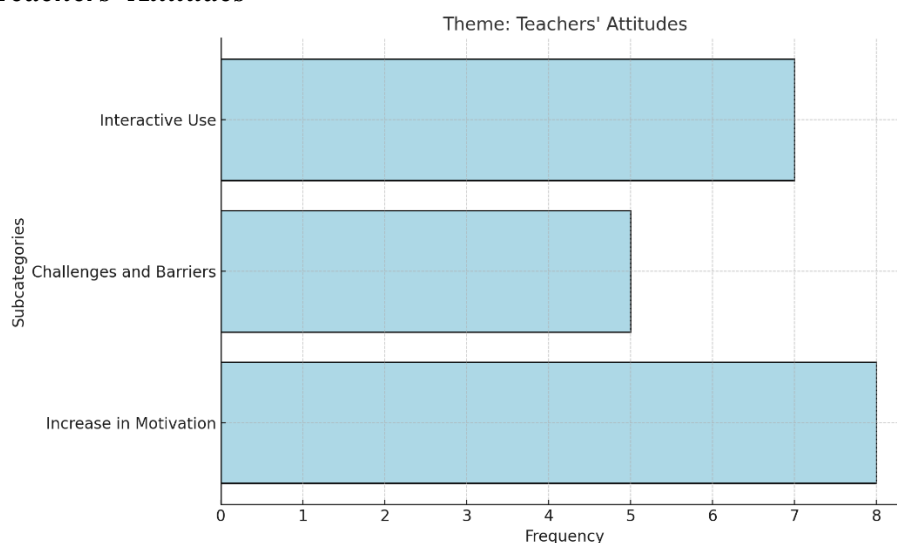
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**Table 1. Systematic review studies**

Order	Title of Study	Year of Publication	Main Theme
1	How virtual reality, augmented reality and mixed reality facilitate teacher education: A systematic review	2024	Teacher training and XR technologies (VR, AR, MR)
2	Evaluation of the Use of Augmented Reality tools in the Education Field	2017	The use of AR tools in education
3	A Review on Augmented Reality Authoring Toolkits for Education	2022	Pedagogical use of AR tools and accessibility
4	Learning Strategies Using Augmented Reality Technology in Education: Meta-Analysis	2020	Learning strategies with AR
5	Virtual and Augmented Reality in K–12 Education	2020	Pedagogical implications of VR and AR
6	Augmented Reality and Gamification in Education: A Systematic Literature Review	2022	AR and gamification
7	A Systematic Review of the Design of Augmented Reality Applications for Young Children	2022	AR application design
8	Using Virtual Learning Objects in Educational Content	2022	Virtual learning objects
9	Foreign Language Learning Gamification Using Virtual Reality—A Systematic Review of Empirical Research	2021	Language learning with VR and gamification
10	Educational Software based on Augmented Reality: A Systematic Literature Review	2021	AR-based educational software
11	Virtual, augmented, and mixed reality-based learning systems: personalisation framework	2016	VR/AR/MR personalization framework
12	Augmented and virtual reality in anatomical education—a systematic review	2020	VR and AR in anatomical education
13	A Review of Extended Reality (XR) Technologies in the Future of Human Education	2022	XR technologies and human education
14	The virtual challenge: Virtual reality tools for intervention in children with developmental coordination disorder	2021	Intervention with VR tools
15	Virtual reality platform for teacher training on classroom climate management: evaluating user acceptance	2024	VR for teacher training
16	Virtual and Augmented Reality versus Traditional Methods for Teaching Physiotherapy	2022	VR and AR in physiotherapy education
17	Augmented Reality in E-Learning Review of Prototype Designs for Usability Evaluation	2015	AR and e-learning
18	A Systematic Literature Review on Augmented Reality in Game-Based Learning for English as a Second Language	2024	AR and game-based language learning
19	Virtual, Augmented and Mixed Reality in K–12 Education: A Review of the Literature	2020	XR technologies in K-12 education
20	Augmented Reality and Gamification in Education: A Systematic Literature Review	2022	AR and gamification

According to the findings obtained from the data analysis, the studies (Table 1) were analyzed under three themes. These include (1) preschool teachers' attitudes towards technology-based practices, (2) their level of use, and (3) the difficulties encountered.

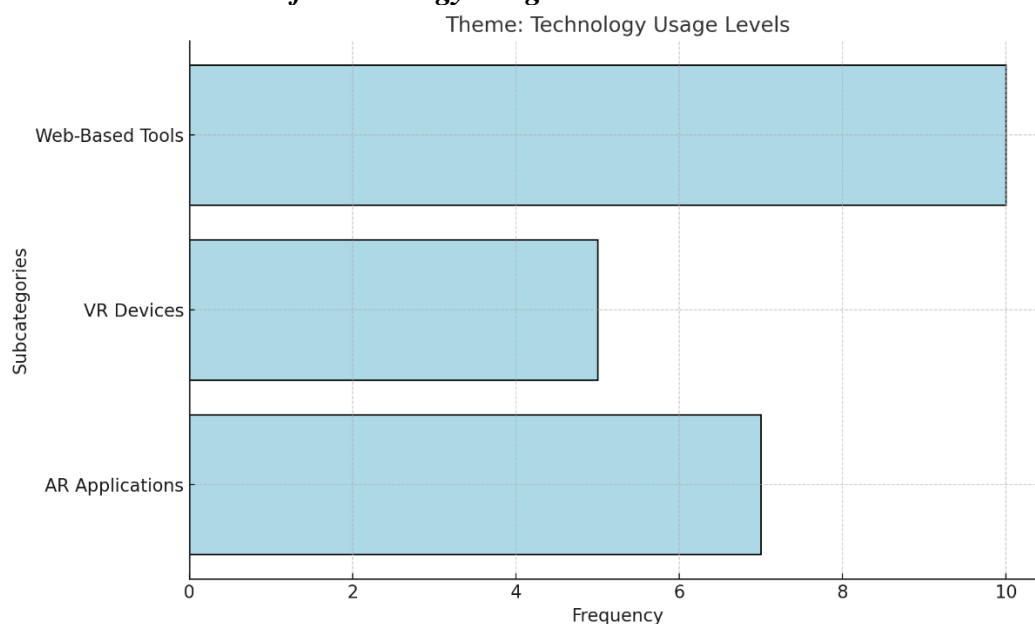
*Theme 1: Teachers' Attitudes*



**Figure 1.** Teacher Attitudes

When Figure 1 is analyzed, most teachers stated that VR and AR technologies make the learning processes in their classrooms more interactive. In particular, these technologies are effective in attracting children's attention and increasing their motivation to learn. For example, Wang and Li (2024) emphasize that teachers see XR (Extended Reality) technologies as a tool that supports children's active learning processes (Wang & Li, 2024). However, some of the teachers stated that implementing these technologies was time-consuming and challenging. In particular, the lack of technical knowledge and limited user manuals when using AR applications prevent teachers from making full use of these technologies. In addition, the findings that virtual reality tools are particularly effective in language learning and increase motivation and child engagement are also noteworthy. da Silva et al. (2017) reported that teachers observed improved problem solving and creativity in children with the use of VR (da Silva et al., 2017).

*Theme 2: Teachers' Level of Technology Usage*

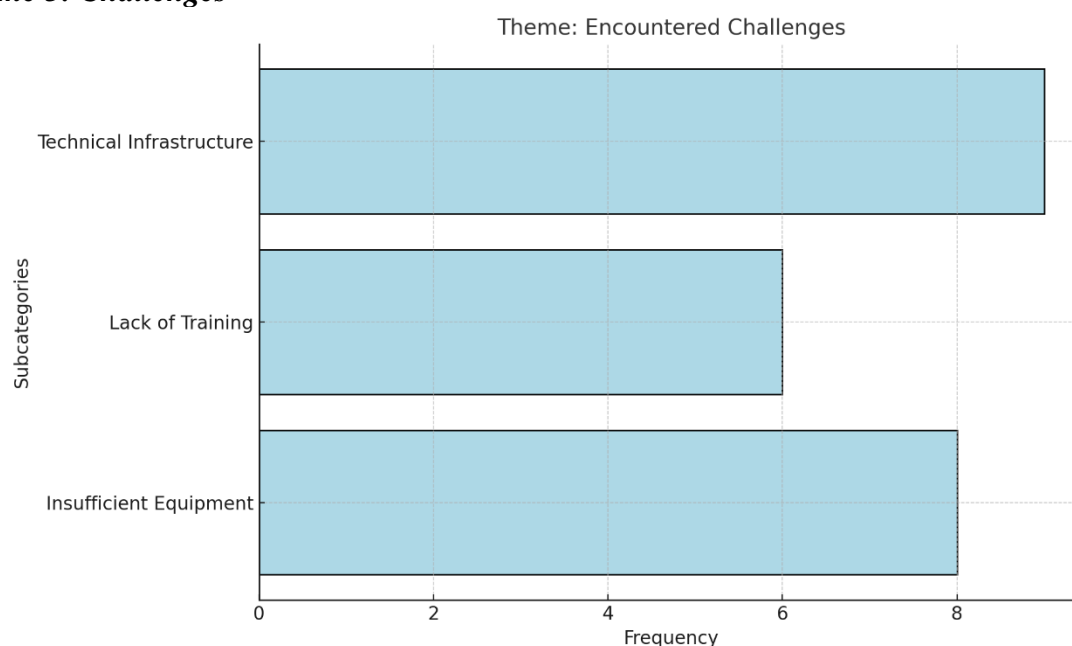


**Figure 2.** Teachers' Level of Technology Usage

The findings in Figure 2 reveal how preschool teachers use technology-based applications in the classroom. Web-based tools (e.g., Wordwall) were found to be more common than other technologies. This is mainly because these tools are easily accessible and affordable. However, the level of use of expensive hardware such as VR devices is low. Fotaris et al. (2017) systematic review showed that teachers use AR tools more frequently in language learning and game-based activities (Fotaris et al., 2017).

Teachers reported that augmented reality applications were particularly effective in concretizing abstract concepts and improved children's conceptual understanding. Hanid et al. (2020) meta-analysis emphasizes the contribution of augmented reality tools to visual learning and shows that they support educational gamification in classroom activities (Hanid et al., 2020).

**Theme 3: Challenges**



**Figure 3.** Theme 3: Challenges

When the difficulties encountered in Figure 3 are analyzed, it is seen that the lack of technical infrastructure is one of the most frequently reported problems. In particular, inadequate internet connection, outdated hardware and inaccessibility of AR/VR devices prevent teachers from using these technologies effectively in their classrooms. Dvareckienė et al. (2016) suggest that teachers would use AR and VR tools more widely if the technical infrastructure were improved (Dvareckienė et al., 2016).

Another important challenge is teachers' lack of training on these technologies. Zhang et al. (2022) reported that the majority of teachers did not receive adequate guidance on how to implement VR and AR technologies in the classroom (Zhang et al., 2022). It was also reported that teachers were unable to fully experience these tools due to lack of equipment (e.g., inadequate VR goggles). Alalwan et al. (2020) state that this deficiency is more prevalent among teachers, especially in rural areas (Alalwan et al., 2020).

**4. Conclusion and Recommendations**

This systematic review has comprehensively addressed how technology-based applications in preschool education are perceived by teachers, their level of use and the challenges encountered. The results of the analysis show that VR and AR technologies make children's learning processes more interactive and improve their motivation and problem-solving skills in particular. However, web-based tools were found to be more widely preferred due to their ease of use and accessibility. In addition, although teachers' attitudes towards VR, AR and web-based tools are generally positive, their level of use of technology in the classroom varies depending on experience and technical knowledge. However, some of the teachers are distant from these technologies because they face difficulties in the process of using the technology and do not receive adequate support. Teachers' positive attitudes towards technology-based applications may enable more widespread and effective use of these tools. However, factors that negatively affect attitudes, such as lack of infrastructure and inadequate training, limit technology adoption. Teachers' attitudes towards technology directly shape their pedagogical



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practices and support innovative approaches to classroom practice. Regular training and mentoring programs should be organized to increase teachers' positive attitudes towards technology. These programs should provide hands-on content to highlight the benefits of technology tools and teach their applicability in the classroom. In addition, platforms should be established where teachers can share successful technology applications with each other.

Web-based tools stand out as the most widely used technology-based applications among teachers due to their accessibility and economic advantages. In contrast, VR and AR technologies are used in a limited way due to high costs and lack of technical knowledge. In particular, web-based tools facilitate teachers in material development and gamification processes. The widespread use of web-based tools is due to their economic and logistical accessibility. In contrast, the classroom use of more innovative technologies such as VR and AR is less preferred despite their potential to enrich educational processes. This highlights the importance of support mechanisms for the effective integration of technological innovations. Low-cost solutions should be developed to encourage the use of web-based tools as well as AR and VR technologies, and these tools should be made more easily accessible. Modular training contents should be prepared and hands-on workshops should be organized for teachers to learn how to use VR and AR technologies.

Teachers mostly face difficulties such as lack of technical infrastructure, internet connection problems and lack of devices when using technology-based applications. In addition, teachers' lack of adequate training and guidance on these technologies prevents them from using technology effectively in the classroom. These challenges are particularly pronounced in rural areas. In this context, the lack of technical infrastructure and guidance limits the effective use of technological tools in the classroom. Addressing these shortcomings is critical to the success of digital transformation in education. Without technical infrastructure and pedagogical support, the applicability of innovative tools will remain limited. State-funded projects should be implemented to strengthen technical infrastructure in rural and disadvantaged areas. In addition, teacher training programs for technology-based practices should be regularized. These trainings should cover technical knowledge and pedagogical practices, as well as economic support for access to devices.

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**THE ROLE OF PHYSIOTHERAPY IN PROSTATE CANCER: A SYSTEMATIC  
REVIEW**

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**Abstract**

Prostate cancer is one of the most common malignancies among men worldwide, with its treatment often associated with side effects such as fatigue, muscle weakness, urinary incontinence, sexual dysfunction, and reduced quality of life. Physiotherapy plays a critical role in managing these side effects, offering evidence-based interventions that improve functional capacity, reduce symptom burden, and enhance overall well-being.

This systematic review examines the effectiveness of physiotherapy interventions in prostate cancer patients, focusing on exercise therapy, pelvic floor muscle training, and rehabilitation programs. Studies highlight that exercise, particularly aerobic and resistance training, can alleviate cancer-related fatigue, improve muscle strength, and promote cardiovascular health. These benefits are crucial for patients undergoing androgen deprivation therapy, which is associated with significant muscle loss and metabolic changes.

It is anticipated that early implementation of pelvic floor muscle training may accelerate recovery and restore continence more effectively. Additionally, physiotherapy interventions addressing pain and mobility limitations, such as manual therapy or balance training, further support patients in regaining independence and improving their quality of life. Physiotherapy not only addresses physical challenges but also contributes to psychological well-being by empowering patients through active participation in their care. This review underscores the need for individualized physiotherapy programs tailored to the unique needs of prostate cancer patients at different stages of their treatment journey. Future research should focus on long-term outcomes and the integration of physiotherapy into multidisciplinary cancer care.

In conclusion, physiotherapy interventions are integral to prostate cancer management, providing significant benefits in terms of functional recovery, symptom relief, and quality of life enhancement.

**Keywords:** Prostate cancer, physiotherapy, rehabilitation, exercise therapy

**FİZYOTERAPİNİN PROSTAT KANSERİNDEKİ ROLÜ: SİSTEMATİK BİR  
DERLEME**

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Bölümü, Fizyoterapi Programı, Konya, Türkiye

**Özet**

Prostat kanseri, dünya çapında erkekler arasında en yaygın kanserlerden biridir ve tedavisi genellikle yorgunluk, kas zayıflığı, idrar kaçırma, cinsel fonksiyon bozukluğu ve yaşam kalitesinde azalma gibi yan etkilerle ilişkilidir. Fizyoterapi, bu yan etkilerin yönetilmesinde kritik bir rol oynar, fonksiyonel kapasiteyi iyileştiren, semptom yükünü azaltan ve genel iyilik halini artıran kanıta dayalı müdahaleler sunar.

Bu sistematik derleme, prostat kanseri hastalarında fizyoterapi müdahalelerinin etkinliğini incelemekte olup, egzersiz terapisi, pelvik taban kası eğitimi ve rehabilitasyon programlarına odaklanmaktadır. Çalışmalar, özellikle aerobik ve direnç antrenmanlarının kanserle ilişkili yorgunluğu hafifletebileceğini, kas gücünü artırabileceğini ve kardiyovasküler sağlığı teşvik edebileceğini vurgulamaktadır. Bu faydalar, önemli kas kaybı ve metabolik değişikliklerle ilişkili olan androjen deprivasyonu tedavisi gören hastalar için hayati önem taşımaktadır.

Pelvik taban kası eğitiminin erken dönemde uygulanmasının iyileşmeyi hızlandırabileceği ve kontinans daha etkili bir şekilde geri kazandırabileceği öngörülmektedir. Ayrıca, ağrı ve hareketlilik sınırlamaları üzerine yapılan fizyoterapi müdahaleleri, manuel terapi veya denge eğitimi gibi, hastaların bağımsızlıklarını yeniden kazanmasını ve yaşam kalitelerini artırmasını desteklemektedir. Fizyoterapi, sadece fiziksel zorlukları ele almakla kalmaz, aynı zamanda hastaların bakım süreçlerine aktif katılımını sağlayarak psikolojik iyilik hallerine de katkıda bulunur. Bu derleme, prostat kanseri hastalarının tedavi yolculuklarının farklı aşamalarında ihtiyaçlarına özel olarak uyarlanmış fizyoterapi programlarının gerekliliğini vurgulamaktadır. Gelecekteki araştırmalar, uzun vadeli sonuçlar ve fizyoterapinin multidisipliner kanser bakımına entegrasyonu üzerine odaklanmalıdır.

Sonuç olarak, fizyoterapi müdahaleleri, prostat kanseri yönetiminin ayrılmaz bir parçasıdır ve fonksiyonel iyileşme, semptomların hafifletilmesi ve yaşam kalitesinin artırılması açısından önemli faydalar sağlamaktadır.

**Anahtar Kelimeler:** Prostat kanseri, fizyoterapi, rehabilitasyon, egzersiz terapisi

## GİRİŞ

Prostat kanseri erkeklerde akciğer kanserinde sonra en sık görülen kötü huylu kanser türleri arasında ikinci sırada yer alır. Yaşın artışına paralel olarak görülme sıklığında da artış gösterir. Prostat kanseri erken evrede asemptomatik olabilir (Bray et al., 2018). Afro-amerikan erkeklerde görülme sıklığının beyaz erkeklerde görülme sıklığından fazla olduğu bildirilmiştir. (Panigrahi et al., 2019). Genellikle yavaş bir progresyon gösterir. Patolojinin temel semptomları arasında idrar yapmada zorluk, artan sıklık ve nokturidir; bunların hepsi prostat hipertrofisinden de kaynaklanabilir. Hastalığın daha ileri evresinde, aksis iskelet kemikleri metastatik hastalığın en yaygın yeri olduğundan, idrar retansiyonu ve sırt ağrısı görülebilir (Rawla, 2019).

Prostat kanseri, Orta Doğu'da giderek önemli bir sağlık sorunu haline gelmiş, ancak bu bölgede kapsamlı kanser kayıtlarının eksikliği nedeniyle yeterince araştırılmamıştır. Avrupa ve Kuzey Amerika'da prostat kanseri üzerine yapılan kapsamlı çalışmaların aksine, Orta Doğu'da çoğu hasta, rutin PSA taramalarından ziyade semptomlarla başvurduktan sonra teşhis almaktadır. Türkiye, Lübnan, Irak, Suriye, Bahreyn ve Ürdün'ü kapsayan bir çalışmada, hastaların önemli bir kısmına ileri evre hastalık tanısı konulmuştur (Sayan, Langoe, et al., 2024). Bu durum, bölgedeki prostat kanseri farkındalığının düşük seviyelerde olmasıyla daha da kötüleşmekte, ölüm oranlarının Avrupa ve Kuzey Amerika'ya kıyasla ciddi şekilde yüksek olmasına neden olmaktadır. Suudi Arabistan'da yapılan bir çalışma, prostat kanseri hakkında bilgi düzeyinin oldukça düşük olduğunu göstermiştir. Bu eksiklikler, erken teşhis ve etkili tedaviye yönelik stratejilerin geliştirilmesini acil bir ihtiyaç haline getirmekte ve bölge genelinde sağlık hizmeti sonuçlarını iyileştirme açısından önemli bir hedef oluşturmaktadır (Sayan, Eren, et al., 2024). Prostat kanseri gelişiminde kalıtsal faktörler önemli bir rol oynarken, eksternal faktörler de riski artırabilir. Birinci derece akrabalarda hastalık varsa risk artar, birden fazla akrabanın etkilenmesi veya erken başlangıçlı hastalık durumunda risk daha da yükselir. Gerçek kalıtsal prostat kanseri, genellikle üç veya daha fazla akrabanın etkilenmesiyle tanımlanır (Grönberg et al., 1996).

Tümörlerin sınıflandırılmasında TNM sistemi (Uluslararası Kanser Kontrol Birliği (UICC) 2002 TNM sınıflandırması olarak ifade edilir. Bu sistem, tümörün boyutu (T), lenf nodu tutulumu (N) ve metastaz durumu (M) için kullanılır) (SchrlSder et al., 1992), derecelendirilmesinde ise Gleason skoru kullanılır. Bu skor, tümörün agresifliğini 2 ile 10 arasında değerlendirir ve biyopsi örneğinde %5'ten fazla görülen tümör desenlerine dayanır (Gleason & Mellinger, 1974).

## PROSTAT KANSERİ TEDAVİSİNDE KLİNİK YAKLAŞIMLAR

Avrupa Üroloji Derneği'nin prostat kanseri ile ilgili 2007 sunduğu ve 2013 yeniden güncellediği kılavuzlarında ve ESMO klinik uygulama kılavuzunda tedavi için sunduğu bazı seçenekler şu şekildedir (Aus et al., 2005; Heidenreich et al., 2008; Heidenreich et al., 2014; Parker et al., 2020):

- Aktif Gözetim: Hastalığın ilerleme riski düşük olan prostat kanseri hastalarının tedaviyi erteleyerek yakından takip edildiği bir stratejidir.
- Radikal Prostatektomi: Prostat kanserinde cerrahi olarak prostatın tamamen çıkarıldığı ve yaşam kalitesini artırmaya yönelik bir tedavi yöntemidir.
- Radyasyon Tedavisi: Prostat kanserinde düşük, orta ve yüksek riskli hastalar için belirlenen dozlarla uygulanan, sağkalım oranlarını iyileştiren bir tedavi yöntemidir.

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- Transperineal Brakiterapi: Prostat kanserinde düşük dozlu radyasyon kaynaklarının doğrudan prostata yerleştirildiği, belirli kriterlere sahip hastalarda etkili bir tedavi yaklaşımıdır.
- Adjuvan Harici Işın Radyasyon Tedavisi: Cerrahi sonrası prostat kanseri hastalarında tekrarlamayı önlemek amacıyla uygulanan radyoterapidir.
- Prostat Kanserinin Alternatif Lokal Tedavi Seçenekleri: Prostat kanseri için cerrahi ve radyoterapiye alternatif olarak kriyocerrahi ve yüksek yoğunluklu odaklanmış ultrason gibi tedavi yöntemleridir.
- Hormonal Tedavi: Prostat kanserinin büyümesini tetikleyen androjen hormonlarını baskılamak amacıyla uygulanan tedavi yöntemidir.
- Kemoterapi: Prostat kanseri ilerlediğinde hormon tedavisine direnç gösteren hastalarda kullanılan, kanser hücrelerini yok etmeyi hedefleyen ilaç tedavisidir.
- İmmünoterapi: Bağışıklık sisteminin prostat kanseri hücrelerini tanımasını ve yok etmesini sağlayan bir tedavi yaklaşımıdır.
- Radyoaktif Tedaviler: Prostat kanserinde radyoaktif maddelerin metastatik kanser hücrelerine ulaşarak onları hedef aldığı bir tedavi yöntemidir.
- Kombine Tedavi Stratejileri: Prostat kanseri tedavisinde cerrahi, radyoterapi, hormonal tedavi ve kemoterapi gibi yöntemlerin birlikte kullanılarak hastalığın kontrol altına alınmasını hedefleyen yaklaşımlardır.
- Yaşam Tarzı ve Destekleyici Tedaviler: Prostat kanseri hastalarının yaşam kalitesini artırmak için fiziksel aktivite, diyet ve psikososyal destek gibi yaşam tarzı değişikliklerini içeren yaklaşımlardır.

## PROSTAT KANSERİ TEDAVİSİNDE FİZYOTERAPİ YAKLAŞIMLARI

Kanser rehabilitasyonu, hastaların kısıtlamalarını en aza indirerek en üst düzeyde fonksiyonelliğe ulaşmalarını hedefleyen bir süreçtir. Dietz sınıflamasına (Fukushima et al., 2021) göre rehabilitasyon; koruyucu, restoratif, destekleyici ve palyatif olarak dört ana gruba ayrılır:

Koruyucu rehabilitasyon, kanserin tanısından itibaren tüm süreçlerde yan etkileri ve komorbid hastalık risklerini azaltmayı amaçlar. Restoratif rehabilitasyon, kalıcı fiziksel kaybı olsun ya da olmasın, mevcut fonksiyonları en üst seviyeye çıkarmayı hedefler. Destekleyici rehabilitasyon, özbakım ve hareketliliği artırmaya rehberlik ederken kas atrofisi ve kontraktür gibi sorunları önlemeye yönelik çözümler sunar. Palyatif rehabilitasyon, yaşam beklentisi sınırlı hastalarda semptomları yöneterek yaşam kalitesini artırmayı amaçlar (Danış, 2023).

Prostat kanseri tedavisi cerrahi, radyoterapi, kemoterapi veya hormonoterapi gibi yöntemlerle gerçekleştirilir. Ancak özellikle androjen baskılayıcı tedavi; osteoporoz, kas atrofisi, fiziksel uygunlukta azalma, fonksiyonel kapasite kaybı, kırık riski artışı ve metabolik sendrom gibi olumsuz etkiler yaratabilir. Bu hastalar, yorgunluk, ağrı, inkontinans, cinsel işlev kaybı ve kas-iskelet problemleri gibi yan etkilerle başa çıkmakta zorlanır. Bu durumlar yaşam kalitesini olumsuz etkilerken, uygun rehabilitasyon yaklaşımlarıyla semptomların yönetimi, fiziksel aktivitenin korunması ve yaşam kalitesinin iyileştirilmesi sağlanabilir. Bazı çalışmalar, rehabilitasyonun kanserin tekrarlama riskini ve kansere bağlı ölümleri azaltabileceğini göstermektedir (Danış, 2023; Keilani et al., 2017).

Bourke ve ark. yaptıkları meta-analizde, prostat kanseri olan 1574 erkeği içeren 16 çalışmayı incelemişlerdir. Buna göre; egzersiz müdahalelerinin kansere özgü yaşam kalitesi, kansere özgü yorgunluk ve egzersiz kapasitesini iyileştirmede etkili olduğu gösterilmiştir. Özellikle, egzersiz müdahaleleri 6 aya kadar olumlu etkiler sağlamakta, bu etki orta düzeyde faydalı

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olarak değerlendirilmektedir. Ayrıca, egzersize bağlı ölüm raporlanmamış ve egzersizin kardiyovasküler sağlık üzerinde bir etkisi bulunmamıştır. Egzersiz sonucu bazı küçük kas-iskelet yaralanmaları (burkulmalar ve zorlanmalar) gibi yan etkiler görülebilir, ancak bu etkiler uygun şekilde uyarlanmış egzersiz programları ile azaltılabilir. Egzersizin fiziksel işlevselliği iyileştirdiği ve kaşeksi gibi ileri evre kanserle ilişkili fizyolojik değişikliklere olumlu etkilerde bulunduğu belirtilmiştir (Bourke et al., 2016; Maddocks et al., 2012). Cinsel aktivite üzerine etkisi ise sınırlı sayıda denemeden dolayı dikkatli değerlendirilmelidir. Bu bulgulara dayalı olarak, prostat kanseri olan erkeklerde egzersiz müdahalelerinin faydalarını savunmak ve uygulamak için klinik rehberlerin ve tedavi eden klinisyenlerin farkında olmaları gerektiği vurgulanmıştır. Ayrıca, egzersiz programları bireysel olarak düzenlenmeli ve gerektiğinde davranış değişikliği desteği sunulmalıdır (Bourke et al., 2016).

Egzersiz, obezitenin prostat kanseri üzerindeki olumsuz etkilerini engelleyerek dolaylı yoldan fayda sağlayabilir. Obezite, vücutta kanserojen maddelerin depolanmasına neden olarak prostat kanseri riskini artırabilir. Ayrıca, obezite testosteron bağlayan serum proteinlerini azaltarak serbest hormon seviyelerini artırabilir, bu da kanser riskini yükseltebilir. Egzersiz sırasında artan metabolik talep, oksijen serbest radikallerinin üretimini tetikleyebilir, ancak düzenli egzersiz yapan bireylerde bu oksidatif strese karşı koruyucu enzimlerin (örneğin süperoksit dismutaz) üretimi artar. Bu enzimler, kansere karşı koruma sağladığı gibi, güçlü ve sürekli egzersizin prostat kanserine karşı koruyucu etkisini açıklayabilir (Larson et al., 2023; Torti & Matheson, 2004).

Prostat kanseri tedavisinde kullanılan androjen yoksunluğu tedavisinin olumsuz etkilerinden biri, sekonder osteoporoz ve kemik mineral kaybıdır. Androjen yoksunluğu tedavisinin ilk yıllarında kemik mineral yoğunluğu kaybı yıllık %3-5 arasında olup, kırık riski artmaktadır. Egzersizin bu konuda menopoz sonrası kadınlarda kemik kaybını önlediği gösterilmiş ve prostat kanseri tedavisi gören erkeklerde de kalsiyum ve kolekalsiferol takviyeleriyle birlikte egzersiz önerilmiştir. Bu bulgular, egzersizin yalnızca prostat kanseri riskini azaltmada değil, tedavi sürecinin olumsuz etkilerini iyileştirmede de önemli bir rol oynayabileceğini göstermektedir (Daniell, 2001; Torti & Matheson, 2004).

Jamrasi ve ark. yaptıkları çalışmada, prostat kanseri hastalarının androjen yoksunluğu tedavisi (ADT) sonrasında düşme riskinin arttığı vurgulanmıştır. Direnç bandı ile güç ve denge eğitimi verilen hastalar kemik sağlığı, fonksiyonel performans, denge ve yaşam kalitesi açısından değerlendirilmiştir. Sonuçlar, uygulanan fizyoterapi programının kemik mineral yoğunluğu, fonksiyonellik, geriye doğru yürüme ve zamanlı kalk ve yürü testleri ile yorgunluk ve yaşam kalitesi parametrelerinde iyileşmeler olduğunu göstermiştir (Jamrasi et al., 2020).

Prostat kanseri olan erkeklerde cinsel fonksiyon ve yaşam kalitesini iyileştirmeye yönelik çeşitli tedavi yöntemlerini inceleyen bir sistematik çalışmada pelvik taban kas eğitimi, biyofeedback, penis vibratörü, elektrostimülasyon, şok dalgası tedavisi, aerobik, direnç ve esneklik egzersizleri ve vakum ereksiyon cihazı gibi tedavi yöntemleri incelenmiştir. Tüm çalışmalar, cinsel fonksiyonu değerlendirmiş ve müdahale gruplarında iyileşmeler bildirilmiştir; ancak çalışmaların çoğunda gruplar arasında anlamlı bir fark bulunmamıştır. Şok dalgası tedavisini içeren çalışmalarda, seksüel disfonksiyon ile ilgili iyileşmeler rapor edilmiş ancak bu değişikliklerin klinik olarak anlamlı olmadığı belirtilmiştir. Çalışma, konservatif tedavilerin prostat kanseri olan erkeklerde cinsel fonksiyon ve yaşam kalitesini iyileştirmede diğer tedavilere göre daha etkili olduğunu öne sürmüştür. Ancak, bu tedavilerin istenmeyen etkilerini değerlendirmek için daha fazla araştırmaya ihtiyaç olduğu vurgulanmıştır (da Fonseca Pedroso et al., 2024).



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Prostat kanseri hastalarına idrar ve dışkı tutamamanın önlenmesi için Kegel egzersizleri eğitimi öneren çalışmalar mevcuttur. Literatürde, kegel egzersizlerinin radyoterapi gören prostat kanseri hastalarında yaşam kalitesini iyileştirebileceğini ve idrar tutamama riskini azaltabileceğini iddia eden çalışmalar vardır. Pelvik taban kas eğitiminin de inkontinans sorunlarını azalttığı, ancak bu etkilerin her zaman anlamlı olmadığı gözlemlenmediği rapor edilmiştir. Ek olarak, bazı çalışmalar pelvik taban kas eğitiminin ya da elektrik stimülasyonunun idrar kontinansını etkilemediğini belirtmiştir (Milios et al., 2019; Urveylioglu et al., 2021).

Avrupa Üroloji Derneği, hastaya özgü uygulanan pelvik taban kas egzersizlerinin, prostat ameliyatından sonra idrar kaçırmanın iyileşmesini hızlandırmak için en etkili konservatif tedavi olduğunu belirtmiştir. Filocamo ve arkadaşlarının 2300 erkekle yaptıkları randomize çalışmada, pelvik taban kas egzersizleri uygulanan grubun, herhangi bir tedavi almayan kontrol grubuna göre daha fazla iyileşme sağladığını göstermektedir (Filocamo et al., 2005). Overgard ve arkadaşlarının çalışması da, pelvik taban rehabilitasyonunda uzmanlaşmış fizyoterapistlerin uyguladığı pelvik taban kas egzersizlerinin, idrar kaçırma oranını önemli ölçüde azalttığını belirtmiştir. Ancak, bu çalışma 12 ay sonra yapılan ped testi sonuçlarında tutarsızlık göstermiştir (Overgård et al., 2008). Moore ve arkadaşlarının çalışmasında, elektrik stimülasyonu ile yapılan pelvik taban kas egzersizlerinin idrar kaçırmayı daha hızlı iyileştirmede bulunmuş; Kakihara ve arkadaşlarının çalışmasında ise elektrik stimülasyonunun ek fayda sağlamadığı görülmüştür (Kakihara et al., 2007; Moore et al., 1999). Pelvik taban kas egzersizlerinin, özellikle ameliyattan hemen sonra başlanması durumunda, radikal prostatektomi sonrası idrar kaçırma tedavisinde etkili olabileceği ancak elektrik stimülasyonunun ek fayda sağlamadığı belirtilmektedir (Zaidan & Silva, 2016).

### SONUÇ

Sonuç olarak, prostat kanseri risk faktörleri, araştırmalar ve klinik prognoz konusunda fizyoterapistlerin bilgi sahibi olmaları önemlidir. Prostat kanseri için predispozan ve risk faktörleri arasında, aşırı terleme, düşük egzersiz toleransı, pelvik bölgeye yayılan poliartralji, addüktör ve hamstring kaslarda sertlik, spinal kasların spazmı gibi olması gibi klinik bulgular yer almaktadır (Subramanian, 2022). Düşük yükte yapılan germe ve güçlendirme egzersizleri, kanser hastalarının rehabilitasyonunda önemli bir rol oynar. Ayrıca, bu egzersizler ile hastaların fiziksel kapasiteleri artırılabilir. Aerobik egzersizler ve yaşam tarzı değişiklikleri, genel sağlığı iyileştirebilir ve hastaların enerji seviyelerini yükseltebilir. Kanserin evresine göre egzersiz toleransı kademeli olarak artırılmalı ve dirençli egzersizler dikkatle planlanmalıdır. Manuel terapi ise temel rehberlere uygun şekilde yapılmalı, yüksek hızdaki tekniklerden kaçınılmalıdır (Huri et al., 2016). Kor kasları güçlendirme egzersizleri, özellikle lumbal bölge ve alt sırt ile lumbo-pelvik bölgenin güçlendirilmesi için faydalıdır. Ayrıca, solunum kapasitesinin artırılması amacıyla spirometre kullanımı da önerilebilir.

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**HEMINGWAY'S NOVEL 'THE SNOWS OF KLIMANJARO' ACCORDING TO  
EMILE BENVENISTE'S THEORY OF ENCHANTING**

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**Abstract**

Ernest Hemingway is one of the most powerful novelists not only in American literature but also in our time. Born on July 21, 1899 in Oak Park, Chicago, Ernest Miller Hemingway grew up with a close interest in hunting, fishing, football and boxing and had a very active life. He is a writer who has managed to convey the power of his pen to generations with his mastery in symbolically combining the images that his life has given him since his childhood with reality and dreams, and with the Nobel and Pulitzer awards he has received. Hemingway, the son of a doctor, started working as a journalist after finishing secondary school. The writer, who volunteered for World War I, left the army when he was wounded while serving in the Italian army and settled in Paris. He is the author of many famous works such as *The Sun Rises*, *A Farewell to Arms*, *Green Hills of Africa*, *For Whom the Bell Tolls*, *The Old Fisherman and the Sea*, *The Snows of Kilimanjaro*, *Being and Nothingness*, *Paris is a Festival*. The author, whose life ended in 1961 as a result of being shot with a shotgun, is still unknown whether his death was accidental or suicide. According to Hemingway, whose works often show traces of the great battles between life and death, life is a constant war. One of Hemingway's works, where traces and images from his real life can be seen reflected in the perceptions of character and place in his works, is *The Snows of Kilimanjaro*, where he plainly displays the alienation of the individual in the battle of life, his inner distress, emotions, passions and desires. *The Snows of Kilimanjaro* consists of a selection of ten of the author's most admired short stories. In this study, an evaluation of enunciation, whose existence has been accepted in linguistics since Aristotle's *Poetics*, will be made according to the enunciation theory of Benveniste from the French school. Accordingly, by going beyond just phonetic, morphological and syntactic examination, the dimensions of the speaker, space and time will also be illuminated in context with semantic analysis along with the enunciation dimension.

**Keywords:** Enunciation Theory, Hemingway, *The Snows of Kilimanjaro*

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EMİLE BENVENİSTE’NİN SÖZCELEME KURAMINA GÖRE HEMINGWAY’İN  
‘KLİMANJARO’NUN KARLARI’ ADLI ESERİ

**Özet**

Ernest Hemingway sadece Amerikan edebiyatının değil çağımızın en güçlü romancılarından biridir. 21 Temmuz 1899’da Chicago Oak Park’ta doğan Ernest Miller Hemingway, avlanma, balık tutma, futbol ve boksla da yakından alakalı bir şekilde büyümüş ve oldukça hareketli bir yaşam geçirmiştir. Çocukluğundan itibaren yaşamının ona kattığı imgeleri, gerçeklik ve hayallerle sembolik olarak birleştirmedeki ustalığı, aldığı Nobel ve Pulitzer ödülleriyle kaleminin gücünü kuşaklara duyurmayı başarmış bir yazardır. Doktor bir babanın oğlu olan Hemingway, ortaokulu bitirdikten sonra gazetecilik yapmaya başlamıştır. Birinci Dünya Savaşı’na gönüllü olarak katılan yazar, İtalyan ordusunda görev yaptığı dönemde yaralanınca ordudan ayrılmış ve Paris’e yerleşmiştir. Güneş Doğar, Silahlara Veda, Afrika’nın Yeşil Tepeleri, Çanlar Kimin İçin Çalıyor, İhtiyar Balıkçı ve Deniz, Klimanjaro’nun Karları, Varlık ve Yokluk, Paris Bir Şenliktir gibi pek çok ünlü eserin yazarıdır. Hayatı 1961 yılında av tüfeğiyle vurulması sonucu biten yazarın, ölümünün kaza mı intihar mı olduğu hala bilinmemektedir.

Ölümlerle yaşam arasındaki büyük savaşların izlerinin eserlerinde sık görüldüğü Hemingway’ye göre yaşam daimi bir savaştır. Gerçek hayatından izlerin ve imgelerin eserlerinde karakter ve mekân algılarına yansıdığı görülebilen Hemingway’in, yaşam savaşının içindeki bireyin, kendine yabancılaşması, iç bunaltıları, duyguları, tutkuları ve arzularını bütün yalınlığıyla sergilediği eserlerinden biri de Klimanjaro’nun Karları adlı eseridir. Klimanjaro’nun Karları yazarın çok beğenilen on kısa öyküsünün seçkisinden oluşmaktadır. Bu çalışmada varlığı dilbilimde Aristo’nun Poetika adlı eserinden beri kabul edilen sözcelemenin Fransız ekolünden Benveniste’nin sözceleme kuramına göre bir değerlendirmesi yapılacaktır. Buna göre sadece fonetik, morfolojik ve sentaktik inceleme aşılarda, sözceleme boyutuyla beraber semantik analizle bağlam içinde, konuşucu, uzam ve zaman boyutları da aydınlatılmış olacaktır.

**Anahtar Kelimeler:** Sözceleme Kuramı, Hemingway, Klimanjaro’nun Karları

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## Giriş

Emile Benveniste'nin sözceleme kuramı dilin yalnızca iletişimsellik boyutuyla ilgilenen dilbilim kuramlarına yeni bir soluk getirmiştir. Dilin yalnızca işlevsel olarak, ileti- kod- alıcı gibi boyutlarıyla, fonetik, morfolojik, sentaktik veya semantik yönleriyle ilgilenmenin de dışına çıkarak, dilin iletişim esnasında alıcı ve iletilen arasındaki iletişimsellik boyutunda öznenin işlevselliğini ve etkinliğini de ortaya koymayı amaçlamıştır. Benveniste, dilin sadece morfolojik veya sentaktik yönden incelemelerinin yeterli olmayacağı, bu incelemenin dilin yalnızca belli bir boyutunu ortaya koyabileceği görüşünden hareketle, dilde iletişimi sağlayan alıcı ve gönderici arasında iletişimin öznenin etkinliğinin ortaya konması bakımından da önem taşımaktadır. Dilin alt birimleri sırasıyla fonetikten başlayarak, morfolojik, sentaktik ve semantik olarak ilerleme gösterir. Sözceleme boyutunu irdeledikten sonra ise, dilin; konuşucu, bağlam, uzam, zaman, kişiler ve kişilere ses aracılığıyla iletilen ses boyutuna ilaveten, söylem boyutu da devreye girecektir. Benveniste'nin kuramının ortaya koyduğu çözümlemeye ilaveten yapılacak bir gramatik tahlille beraber dil içi söylemin bütün boyutları aydınlatılmış olacaktır. Bir sözcelemede değişmeyen sabit öğeler vardır, bunlar özne ve bağlamdır. Konuşucunun söylem içinde aktardığı boyut ise söylemin biçimsel boyutunu ifade eder ki bu boyut değişkenlik göstermektedir. Biçimsel öğeler bağlama göre, zaman, uzam ve diğer öznel ifadeler olarak sıralanabilir.

Sözcelemin sabit öğeleri

-Özne

-Bağlam

Sözcelemin Değişkenlik Gösteren Öğeleri

-Adıllar

-Zaman ve Uzam, Ulaçlar, Belirteçler vs.

Emile Benveniste'nin sözceleme kuramına göre bir sözceleme ya da söylemi incelemek için o sözce grubunun ilk olarak adıllarını sonra kipliklerini, daha sonra sıfatlarını, sonraki aşamada anlatı ya da söylem karşılaştırmasını, en son aşamada ise aktarılan söylemin türünü belirlemek gerekecektir. Benveniste'nin sözceleme kuramına göre aktarılan söylemin türleri şöyle sıralanabilir:

-Dolaysız Serbest Aktarılan Söylem

-Dolaysız Aktarılan Söylem

- 'Ki' Bağlacı ile Dolaysız Aktarılan Söylem

-Dolaylı Aktarılan Söylem

- 'Ki' bağlaçsız Dolaylı Aktarılan Söylem

-Ara Tümce ile Dolaylı Aktarılan Söylem

-Dolaylı Serbest Aktarılan Söylem

-Anlatısal Dolaylı Aktarılan Söylem

Dilbilimin alt dallarının fonetikten başlayarak morfolojik sentaktik ve semantik analizlerle devam ettiğini söylemek mümkündür. 19. asırda dilbilimin sistematik bir biçimde ilerlemesi Ferdinand de Saussure'ün gösterge kuramıyla yön bulmuştur. İşlevsel dilbilim ve üretici dönüşümlü dil bilgisinin gösterge düzeyinden başlayarak söz dizimsel ve semantik analizleri Metin düzeyinde bağlam çerçevesinde analizlerin yapılması ihtiyacını doğurmuştur. Bu incelemelerde metin, bağlam ve dil dışı unsurlar da anlamı açıklamada devreye girince bu tip çözümlemeler edim bilim ile yaygın bir analiz yöntemi haline gelmiştir. Dil bilimcilerce edim bilim ve sözceleme kuramları ve edim bilimi ayıran nokta edim bilimde dil öğretimi ve ön varsayımlar da analizlerde dikkate alınmasıyla açıklanabilir. Sözceleme kuramlarına göre gramer araştırmasına ek olarak Kim?, Kiminle?, Nerede?, Ne zaman?, Nasıl?, Ne konuşuyor? Sorularının yanıtları da analize dâhil edilmektedir( Kıran&Kıran, 2022, s.257). Öznenin

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bağlamdaki etkinliğini ortaya koymaya çalışan çözümleme tekniği sözcelemin çözümlenmesidir. Sözcelemin incelenmesinde başlıca unsurlar kişi adları, özne, zaman ve uzam belirteçleridir (Kıran&Kıran, 2022, s. 260).

Emile Benveniste'nin sözcelem kuramına göre sözceleme söylemin sorumluluğunu üzerine almaktır (Kıran&Kıran, 2022, s. 260). Sözceleme kuramında biçimsel öğeler ve sabit öğeler vardır. Özne ve bağlam sabit öğelerdir. Biçimsel öğeler ise özne, kişi adları, zaman ve uzam belirteçleridir. Kiplikler sözcelemin çözümlenmesinde diğer önemli unsurlardandır. Kiplikler, sözceleme öznellik katan dil içi unsurlardır. Kiplikler, söylemde bazen açık bazen örtük olabilir. Örtük kipliklere çoğunlukla öznel söylemlerde veya sıfat içeren söylemlerde rastlanmaktadır. Sözceleme kuramında diğer önemli analiz unsuru aktarılan söylemin türünü belirlemektir. Aktarılan söylem anlatsal olabileceği gibi dolaylı ya da dolaysız olarak aktarılan söylem olabilmektedir (Kıran&Kıran, 2022, s. 276).

Hemingway'in Klimanjarro'nun Karları adlı eseri onun Kübadan Klimanjarro'ya Afrika'ya gittiği dönemde yazdığı ve o dönemi içinde anlatıcı yazar konumunda anlattığı bir eserdir. Bu eserinde hasta olduğu dönemi alkol sorunlarını yoluna koyamadığı erkek kadın ilişkilerini intihar fikrinin ilk izlerini avcılığı balıkçılığı ve doğa tutkusunu yansıttığı bir eserdir. Bu eserde anlatsal söylem az kullanılmış daha çok dolaysız serbest aktarılan söylem türünün izlerini görmek mümkündür. Bu eserin bir başka önemi bu eserde topladığı öykülerinde Türkiyeden izleri görmek mümkündür. Edirne, İstanbul ve İzmir'de bulunmuş olan yazar gazetecilik döneminde savaş muhabiri olarak gönderildiği ülkemizden izlenimlerini de yer yer öykülerin arasına serpiştirmiştir. Bunları da ağırlıklı olarak dolaysız aktarılan söylem türünde anlatmıştır.

Klimanjarro Dağı Hemingway'in gözünden eserde şöyle aktarılmıştır:

'Klimanjarro, karla kaplı, 6500 metre yüksekliğinde bir dağ. Afrika'nın en yüksek dağı olduğunu söylerler. Masal dilinde bu dağın Batı doruğuna Nğaje Nigai, senin benim anlayacağım dildeyse 'Tanrı'nın Evi' diyenler var. Batı doruğuna yakın bir yerde, kurumuş donmuş bir leopar iskeleti olduğu söylenir. Söylenir de kimse kalkıp bu leoparın, o yükseklikte ne aradığını açıklayamaz...' (Hemingway: 1999, s.7).

Aktarılan Söylem Türleri:

'İşin en güzel yanı, acısız olması.' Adam durdu, sonra devam etti: 'Başladığımı da böyle anlıyorsun zaten.' s.7 Dolaysız Serbest Aktarılan Söylem

'Sahiden mi' s.7 Dolaysız Serbest Aktarılan Söylem

'Elbette. Bu koku için tabii, çok özür dilerim. Mideni kaldırıyor herhalde.' S.7 Dolaysız Serbest Aktarılan Söylem

'Şunlara bak! Adam iç geçirdi: 'Ne çekiyor bunları buraya? Koku mu yoksa görüntü mü?' s.7 Dolaysız Serbest Aktarılan Söylem

'Adamın yattığı sedyeden bozma karyola, mimoza ağacının gölgesine kurulmuştu. Gölgenin ötesine baktı, açık saçıklığın doruğunda, insana salt bacak aralarını anımsatan bir kayalığın dibinde, üç kocaman kuş, gagalarından salyalar damlatarak bakıyorlardı. Bir alay kadarı da daireler çizerek gökyüzünü parselleme kavgasındaydı.' s.8 Anlatsal Söylem

'Belki de hiçbir zaman yazamayacaktın, onun için bunca yıl oyaladın durdun kalemini, diye geçirdi içinden. Kimbilir? Artık öğrenecek zaman da kalmamıştı.' s. 11 Dolaylı Serbest Aktarılan Ara Tümceli Söylem

'Sen iyiyken dedim bunu. Ama şimdi nefret ediyorum. Bacağına böyle bir şey niye oldu anlamıyorum. Ne günah işledik de başımıza böyle bir şey geldi?' s.12 Dolaysız Serbest Aktarılan Söylem



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‘İçme şunu. Sevgilim, yalvarırım içme artık. Elimizden gelen her şeyi yapmak zorundayız.’

S.13 Dolaysız Serbest Aktarılan Söylem

‘Kar yolları kesince, bir hafta Madlener-Haus’da kalmış, tipi şiddetini arttırdıkça onlar da teselliyi iskambilde aramış, gaz lambalarının titrek alevinde avuçlarıyla fişleri yeşil çuhaya küreklemiş, Herr Lent herkesten fazla kaybetmişti. Sonunda nesi var nesi yok yitirdi. Her şeyini kayak okulunun yıllık kârını, o mevsimin bütün kazancını sonunda da sermayesini. Gözünün öünde canlanıverdi birden: upuzun burnuyla, kağıtları toplayıp alan elleriyle ‘sans voir’ diyen titrek sesiyle.O zamanlar hep kumar vardı. Kar yağmadı mı kumara; fazla yağdı mı gene kumara. Kumar masalarında geçirdiği uzun bitip tükenmek bilmeyen günlerini düşündü.’ s.15

Anlatisal Söylem

Ernest Miller Hemingway, 1899’da Chicago Oak’da dünyaya gelmiştir. Babası doktor olan Hemingway’in annesinin onu daha çok nazik bir kız çocuğu gibi yetiştirme çabasından dolayı erkeksi olan alanlara daha yoğun bir ilgi ve heves duymuştur. Boks, balık tutma, beyzbol, avlanma, orduya katılıp savaşlarda gönüllü asker olarak yer alma gibi durumların temelinde bu duruma tepki olarak içten gelen dürtüleri onu şekillendirmiştir denebilir. Kansas City Star gazetesinde çalışmaya başlamıştır. Birinci Dünya Savaşı’na gönüllü olarak katılmış ve İtalyan cephesinde savaşmıştır (Perkins:1985, s.1150). Savaşta yaralandıktan sonra Paris’e yerleşmiştir. Daha sonra savaş muhabiri olarak çalışmaya devam etmiş ve bu sırada en değerli eserlerini yayımlamaya başlamıştır. Güneş de Doğar, Silahlara Veda, Afrika’nın Yeşil Tepeleri gibi eserlerini bu yıllarda yazmıştır. İspanya iç savaşına katılan dönemin Hemingway en ünlü eseri ‘Çanlar Kimin İçin Çalıyor’ adlı eserini bu yıllarda kaleme aldı ve çok büyük bir şöhret kazandı. 1952 yılında yazdığı ‘Yaşlı Adam ve Balıkçı’ adlı eserini 1953 yılında Nobel Edebiyat Ödülü izledi. 1961 yılında ise av tüfeğiyle vurulması sonucu hayatını kaybetti (Hook:1983, s. 116).

### Sonuç

Hayata yaşam ve ölümün iki uç noktasından tutkuyla asılmış olan Hemingway yaşama olan tutkusunu eserlerine ve karakterlerine yansıtmıştır. Savaş, aşk, doğa, avcılık, mücadele, hırs, hayata bağlılık, bezginlik, iç bunalımları, kadın erkek ilişkileri, bilinçaltı psikolojik çözümlenmeleri eserlerinde dikkati çeken başlıca unsurlardır. Yaşamın her anına her noktasına tutkuyla bağlı olan Hemingway, bu tutkudan kaynaklı olarak yaşamı daima bir mücadele halinde yaşamıştır. Yaşamın en tatlı yönlerini aşkı, evlilikleri, Floridita’daki dost meclisleri, sevgileri, öfkeleri, iç bunlatıları, ölümü düşlemesi, savaşlara katılması, gazetecilik ve insan ilişkileriyle ilgili her alanda, spora, beyzbola, boksa olan merakı onu yaşama sıkı sıkı bağlayan etkenlerden olmuştur. Hayatı daima doruklarda yaşayan Heminway, aynı anda düştüğü buhranlarda ilerleyen yaşlarda yaşadığı sağlık sorunları, içki ve av tutkusuyla beraber taşıdığı savaşın ağır izlerinin de etkisiyle kimi zaman duygusal manada diplere de inmiştir. Savaş onun için aynı zamanda yaşam demektir. Deniz tutkusu onun için hayattaki alma verme dengesi, kazanç mücadele, hırs ve başarı demektir. Deniz aynı zamanda onun hayalinde bir kadın gibidir. Bütün bu tutkularını eserlerine başarıyla metaforlarla nakş eden Hemingway’in en sevilen eserlerinden biri de Kilmanjaro’nun Karları adlı eseridir. Bu eserinde, ilişkilerini, yaşadığı sağlık sorunlarını, çok sevdiği tutkularından uzak kalınca düştüğü bunalımları anlatıcı yazar olarak romanda geri dönüş teknikleriyle beraber de okura aktarmıştır. Bu öyküsünde, karısıyla karşılıklı diyalogların sık olarak kullanılması sözcelem incelemesine uygun bir teknikle kaleme alınması bakımından araştırma açısından elverişli bir zemin teşkil etmiştir. Zira sözcelemede esas olan söylemdeki öznenin etkinliği, söylemin türü ve sözcelemede, kim, kiminle, ne zaman, nerede, ne konuşuyor sorularının yanıtlarını bulmak için uygun bir tekniğe

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sahiptir. Çok sevdiği avcılıktan, denizlerden ve sosyal hayatından uzaklaşmış, sağlık sorunlarının da etkisiyle bir buhran geçirmekte olan yaşlı bir adamın karısıyla olan yaşamından bir kesit eserin belkemiğini oluşturmuştur. Flash back tekniği ile zamanda geri ve sonrasında ileriye sıçramalarla okura geçirdiği merhaleleri, yaşamda hangi noktalarda yenik düştüğü, hafızasına kazınan dönüm noktalarını aktarmıştır. Bunlar arasında Hemingway'in gerçek hayatta da deneyimlemiş olduğu, Paris dönemi ve İstanbul, Trakya yılları bu eserin içinde okuyucuya anlatsal söylem türünde yansıtılmıştır. Klimanjaro'nun Karları eserinde yapılan sözceleme taramaları sonucunda en sık dolaysız aktarılan söylem türüne rastlanmıştır. Örnekleme konu olan tümceler şöyle sıralanabilir:

The marvelous thing is that it's painless," he said. "That's how you know when it starts." "Is it really?"

"Absolutely. I'm awfully sorry about the odor though. That must bother you." "Don't! Please don't."

"Look at them," he said. "Now is it sight or is it scent that brings them like that?"

The cot the man lay on was in the wide shade of a mimosa tree and as he looked out past the shade onto the glare of the plain there were three of the big birds squatted obscenely, while in the sky a dozen more sailed, making quick-moving shadows as they passed.

"They've been there since the day the truck broke down," he said. "Today's the first time any have lit on the ground. I watched the way they sailed very carefully at first in case I ever wanted to use them in a story. That's funny now.

"I wish you wouldn't," she said.

"I'm only talking," he said. "It's much easier if I talk. But I don't want to bother you."

"You know it doesn't bother me," she said. "It's that I've gotten so very nervous not being able to do anything. I think we might make it as easy as we can until the plane comes."

"Or until the plane doesn't come."

"Please tell me what I can do. There must be something I can do."

"You can take the leg off and that might stop it, though I doubt it. Or you can shoot me. You're a good shot now. I taught you to shoot, didn't I?"

"Please don't talk that way. Couldn't I read to you?" "Read what?"

"Anything in the book that we haven't read."

"I can't listen to it," he said. "Talking is the easiest. We quarrel and that makes the time pass."

"I don't quarrel. I never want to quarrel. Let's not quarrel any more. No matter how nervous we get. Maybe they will be back with another truck today. Maybe the plane will come."

"I don't want to move," the man said. "There is no sense in moving now except to make it easier for you."

"That's cowardly."

"Can't you let a man die as comfortably as he can without calling him names? What's the use of clanging me?"

"You're not going to die."

"Don't be silly. I'm dying now. Ask those bastards." He looked over to where the huge, filthy birds sat, their naked heads sunk in the hunched feathers. A fourth planed down, to run quick-legged and then waddle slowly toward the others.

"They are around every camp. You never notice them. You can't die if you don't give up."

"Where did you read that? You're such a bloody fool."

"You might think about some one else."

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"For Christ's sake," he said, "that's been my trade."

He lay then and was quiet for a while and looked across the heat shimmer of the plain to the edge of the bush. There were a few Tommies that showed minute and white against the yellow and, far off, he saw a herd of zebra, white against the green of the bush. This was a pleasant camp under big trees against a hill, with good water, and close by, a nearly dry water hole where sand grouse flighted in the mornings.

"Wouldn't you like me to read?" she asked. She was sitting on a canvas chair beside his cot.

"There's a breeze coming up.

"No thanks."

"Maybe the truck will come."

"I don't give a damn about the truck." "I do."

"You give a damn about so many things that I don't."

"Not so many, Harry." "What about a drink?"

"It's supposed to be bad for you. It said in Black's to avoid all alcohol. You shouldn't drink."

"Molo!" he shouted. "Yes Bwana."

"Bring whiskey-soda." "Yes Bwana."

"You shouldn't," she said. "That's what I mean by giving up. It says it's bad for you. I know it's bad for you."

"No," he said. "It's good for me."

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**TATAR ŞAİRİ SİBGAT HEKİM'İN SANATINDA VATAN KAVRAMI**

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**Özet**

Tataristan'ın halk şairi, Abdullah Tukay ödülü sahibi Sibgat Hekim (1911-1986), geçen yüzyıl Tatar edebiyatında kendi ekolünü kurmuş ve klasik eserleriyle derin izler bırakmış ünlü söz ustasıdır. İlk şiirlerinde daha çok köylü insanların düşünce ve duyguları, onların özverili hizmeti, gençlik ve aşk gibi konular ele alınmış olup doğup büyüdüğü toprağa sevgi ve Sovyetlerin içinde bir bütün olarak yaşayan çeşitli halkların dostluğu gibi konular da şairin ilgisini hep çekmiştir. Aynı zamanda şiirlerinde kendisi de katıldığı 1941-1945 Büyük Vatan Savaşı konusu da önem kazanmıştır. Fakat Sibgat Hekim'in hayatı boyunca sanatına eşlik eden en önemli konu, vatana olan sevgi ve özlemdir.

Vatan kavramına Sibgat Hekim'in şiirlerinde çeşitli duygular yüklenir. Ayrıca vatan, sanatında çeşitlilik de gösterir. Vatan, onun için doğal olarak her şeyden önce doğup büyüdüğü topraktır. Şair, günümüz Tataristan Cumhuriyeti'nin Mari El Cumhuriyeti sınırında bulunan Küllê Kimê köyünde doğar. Burası, "Kazan Ardı" olarak anılan ve verimli kara toprağa, karanlık ormanlarında yoğun yetişen ladin ve beyaz gövdeli kayın/huş ağaçlarına zengin ve balta ustaları, dericileri, kuyumcuları, genel olarak çalışkan insanlarıyla ünlü bölgedir. Şair için "Kazan Ardı" aynı zamanda Şehabetdin Mercani, Abdünnasır Kursavi, Abdullah Tukay, Aliasker Kamal, Ömer Beşirov ünlü Tatar şahısların dünyaya geldiği Arça (Arsk) toprağıdır. Çünkü Sibgat Hekim'in doğduğu köy o zamanlar Arça ilçesine dâhildi. Fakat zamanla bu coğrafya şairin sanatında daha bir genişler ve Tatar Türklerinin eskiden yaşayıp İdil Boyu Bulgar ve Altın Orda gibi şanlı devletler kurduğu topraklar da vatan kavramı içinde yer almaya başlar. Doğal olarak vatan, 1917 Devrimi sonrası oluşan Tataristan özerk Cumhuriyeti ve daha geniş bir şekilde Sovyetler Birliği olarak da algılanır. Bazı şiirlerinde Sibgat Hekim, vatan kavramı içine yaşadığı Dünya gezegenini de dâhil eder.

**Anahtar Kelimeler:** Kazan Tatar edebiyatı, Sibgat Hekim, şiir, vatan, Arça.

THE CONCEPT OF HOMELAND IN THE POETRY OF SIBGAT HEKIM

**Abstract**

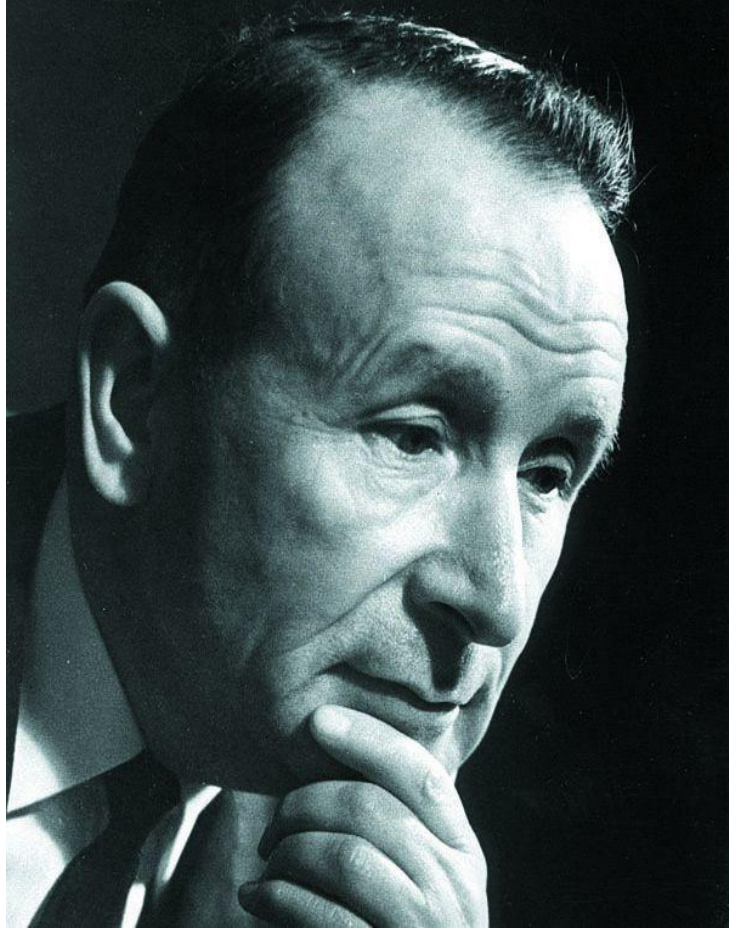
People's poet of the Republic of Tatarstan, laureate of the Gabdulla Tukay Prize Sibgat Hekim (1911-1986), a famous master of words, who founded his own school in Tatar poetry in the last century and left a deep mark on it. In his first poems, such themes as the thoughts and feelings of peasants, selfless service to the people, youth and love were in the foreground. Topics such as love for the native land and friendship of peoples living within the Soviet Union also always attracted the attention of the poet. At the same time, the theme of the Great Patriotic War of 1941-1945, in which he personally participated, also gained importance in his poetry. But the most important theme that accompanied the work of Sibgat Hekim throughout his life was love and longing for the Motherland.

The concept of the Motherland in the poems of Sibgat Hekim is revealed in various aspects. For him, his homeland is, naturally, first of all, the land where he was born and raised. The poet was born in the village of Kulle Kime, located on the border of the Republic of Tatarstan with the Republic of Mari El. This region, also known as "Zakazanie", rich in fertile black soil, spruce and white-trunked birches growing densely in dark forests, is also widely known for its master carpenters, tanners, jewelers and generally hardworking people. On the other hand, the poet's homeland is the land of Archa (Arsk), where such famous Tatar writers and religious figures as Shekhabetdin Merjani, Abdunnasyr Kursavi, Abdulla Tukay, Aliasker Kamal, Gumer Bashirov were born. However, in the poet's work, this geography expands and the concept of the poet's homeland includes the lands on which the Turkic Tatars lived in the past and founded such glorious states as the Volga Bulgaria and the Golden Horde. Naturally, the Autonomous Republic of Tatarstan, formed after the 1917 revolution, and, more broadly, the Soviet Union are perceived as their homeland. In some of his poems, Sibgat Hekim includes in the concept of the Motherland and the planet Earth on which he lives.

**Key words:** Tatar literature, Sibgat Hekim, poem, homeland, Arsk.

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**GİRİŞ**

Tataristan'ın halk şairi ve gazeteci Sibgat Hekim, 20. yüzyıl Tatar edebiyatında kendi ekolünü oluşturmuş ve klasik eserleriyle son yüzyılın şiirinde derin izler bırakmış bir söz ustasıdır. Sanatının ilk döneminde, daha çok köylü insanların düşünceleri, duyguları, özverili hizmeti, gençlik ve aşk gibi konuları ele almıştır. Yıllar geçtikçe şiirlerinde bu konular genişleyip daha bir gelişmiştir. Doğup büyüdüğü toprağa sevgi ve Sovyetlerin içinde bir bütün olarak yaşayan çeşitli halkların dostluğu gibi konular ise şairin ilgisini hayatının sonuna kadar çekmiştir.

Sibgat Hekim (Sibgat Taci oğlu Hekimov) Rusya İmparatorluğu döneminde 4 Aralık 1911 yılında günümüz Tataristan Cumhuriyeti'nin Mari El Cumhuriyetine çıkan sınırında bulunan Küllê Kimê köyünde doğar. Şairin balta ustası olan babası, İdil-Ural bölgesinde yaşanan şiddetli açlık yılında ailesini geçindirebilmek için iş bulma umuduyla büyük oğlunu da yanına alıp 1921'de Ukrayna topraklarına gider ve orada ikisi de açlıktan ölür. Annesi Gazze Hanım, elinde kalan dokuz çocuğu yalnız başına büyütür. Sibgat Hekim, yedi yıllık okuldan mezun olunca on dokuz yaşına kadar köyde kalır. Önce okulda öncü öğretmen olur, el yazması dergi çıkarır ve edebiyat kursu yönetir. 1931 yılında Kazan'a gelen Sibgat Hekim, çalışan köylü çocukları üniversite ve enstitüye hazırlayan Tatrabfak'ta okumaya başlar. İkinci yıldan itibaren Kazan Devlet Pedagoj Enstitüsü'nde eğitim görür ve buradan 1937'de mezun olunca Tataristan Kitap Neşriyatında, ardından da Sovyet Edebiyatı (günümüzde Kazan Utları) dergisinin yazı işleri bürosunda çalışır. 1941-1945 Büyük Vatan Savaşı başlamasından sonra hemen orduya katılır, savaşın başından sonuna kadar cephede savaşır ve 1946 yılının mayıs ayına kadar

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orduda görev yapar. Ordudan dönünce Sovyet Edebiyatı dergisinin yazı işleri bürosunda çalışmaya devam eder.

1950 yılından itibaren 3 Temmuz 1986 yılında vefat edene kadar sadece yazarlıkla uğraşan Sibgat Hekim, Tataristan'da edebiyat ve sanat alanında en büyük ödül olan Abdullah Tukay ödülüne layık bulundu. Ayrıca şair, Rusya Federasyonu çapında verilen Maksim Gorki Devlet Ödülünü de aldı. 16 Haziran 1986'da çok uluslu Sovyet edebiyatının geliştirilmesindeki büyük hizmetlerinden dolayı Tataristan ÖSSC Yüksek Konseyi Başkanlığı Kararnamesi ile "Tataristan ÖSSC Halk Şairi" fahri unvanına da layık bulundu (Remiyev, 2001: 265). 26 Ocak 1981'de doğumunun 70. yıldönümünde doğup büyüdüğü Küllê Kimê köyünde şairin hayatı ve sanatıyla ilgili önemli eşyalardan ve geniş bilgiden oluşan bir müze de açıldı (URL1).

Sibgat Hekim ilk şiirlerini okul öğrencisiyken yazmaya başlar. Ünlü Tatar şairi Adil Kutuy'un kız kardeşi, Küllê Kimê köyüne misafir gelir ve Sibgat Hekim'in şiir denemelerini duyunca onu Kazan'a davet eder (URL3). Şiirleri 1931'de Ataka, Sovyet Edebiyatı dergilerinde ve Kızıl Yaşlêk gazetesinde yayınlanır. Her şeyden önce Tatar halkının binyıllık sözlü edebiyatından, özellikle de türkülerinden ("Арча" (Arça), "Сарман" (Sarman), "Сибелә чәчәк" (Serpiliyör Çiçek), "Кара урман" (Karanlık Orman) vb.) güç ve ilham alarak yazdı. 1940'lı yıllara kadar yazdığı lirik şiirleri *Bêrênçê Cırlar* (İlk Şarkılar) adlı kitabında yayınlandı. Katıldığı 1941-1945 Büyük Vatan Savaşı konusu da sanatında önem kazandı. *Kursk Dugası* (Kursk Arkı), *Duga* (Ark), *Kır Cırı* (Tarla Şarkısı), *Kükyözê* (Gökyüzü) vb. şiirleri buna en güzel örnektir. Fakat Sibgat Hekim'in hayatı boyunca sanatına eşlik eden en önemli konu, şüphesiz, vatana olan sevgi ve özlemdir.

### ARAŞTIRMA ve BULGULAR

Vatan kavramı Sibgat Hekim'in şiirlerinde çok yönlüdür. Doğal olarak her şeyden önce doğup büyüdüğü toprak Kazan Ardı ve bu bölgede bulunan Küllê Kimê köyüdür. Şairin sanatında köyünün doğası ve bu köyde yaşayan yufka yürekli hamarat hemşerileri çok özel tasvir ve tanımlamalarla anlatılır. Diğer taraftan vatan, Kazan Ardı bölgesinin en önemli ilçesi, ünlü Tatar şair, yazar ve düşünürlerin dünyaya geldiği Arça (Arsk) toprağıdır. Tatar Türklerinin bir zamanlar kurduğu şanlı İdil Boyu Bulgar devleti, Altın Orda ve Kazan Hanlığı toprakları da Sibgat Hekim için mutlaka vatan kavramı içinde yer alır. Ayrıca vatan, 1917 Devrimi sonrası oluşan Tataristan özerk Cumhuriyeti ve daha geniş bir şekilde Sovyetler Birliği olarak da görünür. Bazı şiirlerinde ise şair, kendini yaşadığı gezegenin bir parçası olarak tanır ve vatan kavramı içine yaşadığı Dünya'yı da dâhil eder.

Sibgat Hekim tarafından bir hazine sandığına benzetilen memleketi, "Kazan Ardı" şeklinde anılan Kazan'ın iç bölgesidir. Karanlık ormanlarında yoğun yetişen ladin ve beyaz gövdeli kayın ağaçlarına zengin, balta ustaları, dericileri, kuyumcuları, genel olarak çalışkan insanlarıyla ünlüdür bu topraklar. Sibgat Hekim'in soyağacı da büyük emeklerle ormanı temizleyerek buldukları arazide darı yetiştiren Mamka adında yaşlı bir adamla başlar. Yukarıda anıldığı gibi, şairin babası da balta ustası olmuştur. Sanatının ilk döneminde yazdığı "Гомер яңа башлана" (Hayat Yeni Başlıyor), "Югалган эзләр" (Kaybolan İzler) ve "Жәйге таң" (Yaz Tanı) gibi şiirlerinde lirik kahraman için doğup büyüdüğü köy, hayatın zorluklarından sığındığı sıcak bir yuva olarak algılanır. "Әй, мәктәбем!" (Ah Okulum), "Үрләреңне менгәч" (Tepelerine Çıkınca) ve "Башка берни дә кирәкми" (Başka Hiçbir Şeye Gerek Yok) gibi şiirlerinde de şair, memleketinin gönlüne en yakın, en kutsal yer olduğunun altını çizer:

*Башка берни дә кирәкми...*

*Başka hiçbir şeye gerek yok,*

*Туып-үскән шушы җирнең ямен*

*Doğup büyüdüğüm yerin huzurunu*



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*Алыштырмый икән һичнәрсәң.  
“Башка берни дә кирәкми”*

*Vermiyormuş başka hiçbir şey.\*  
(Başka Hiçbir Şeye Gerek Yok)*

Hiç şüphe yok ki, her insan için memleketi, aziz ve değerlidir. Çünkü yeryüzüne ilk ayak bastığı andan ömrünün son günlerine kadar insan, gücünü doğup büyüdüğü topraktan alır. Ayrıca, aitlik hissi ile güzellik kavramı da ilk kez memleketin toprağında aşılır. Bu yüzden Sibgat Hekim için de en güzel yaz, köyünde yaşanan yazdır; en hoş kokulu çiçekler, köyünün kır, orman ve çayırlarında yetişen çiçeklerdir; en güzel ağaçlar, evinin önünde yetiştiği ve çocukluğundan beri sadece gözlerini değil gönlünü de okşadığı üvez ve kayın ağaçlarıdır; en leziz yiyecekler de köyünde tattığı, Tatar mutfak kültürünün başköşesinde yer alan çavdar ekmeği ile sütlü çaydır. Şair, kendisini bu değerlerden başka asla düşünemez. Ona özgürlük veren ve uzaklara uçmak için kanatlar takan da memleketidir. “Әй, язмыш, язмыш” (Ey Kader Kader) adlı şiiri de buna en güzel delildir:

<i>Әй, язмыш, язмыш, Туган җиремнең Тугач та кәргән Миңа үз төсө. Кая барсам да Мин шат канатлы, Ирекле, азат, Һаман үз кеше. Әй, язмыш, язмыш, Теләмим башка, Башка бер җәһне — Мин үз җәемнән. Аерма мине Туган илемнән, Кара икмәгем, Сөтле чәемнән. Әй, язмыш, язмыш, Ташлама читкә, Читтә сулырмын Кайгыдан, моңнан. Аерма мине Өй түрөмдәге Миләшләремнән, Каеннарымнан.</i>	<i>Ey kader kader, Öz vatanımın Doğunca sinmiş Bana öz rengi. Nereye gitsem Ben mutlu, mesut Özgürüm, hürüm, Daima kendim. Ey kader kader, İstemem senden Başka bir yazı Kendi yazımdan. Ayırma beni Öz toprağımdan, Çavdar ekmeğim, Sütlü çayımdan. Ey kader kader, Elde solarım Susuz gül gibi Dertten kaygıdan. Ayırma beni Ev önümdeki Üvezlerimden, Kayınlarımdan.</i>
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Savaşta vatan için mücadele verirken yaranan ve hayatın zorluklarından yorgun düşen şairin iyileşmesi için de köyünün temiz havasına, kır ve çayırlarda yetişen bitkilerin kokusuna ve köyünün etrafında akan pınarlara ihtiyacı vardır:

<i>Авыруыма табиб кирәк түгел, Йөрәгемнең беләм дәвасын: Һәр ел саен кайтып иснәп киләм Авылымның чиста һавасын. “Авылым минем” (Köyüm Benim);</i>	<i>Şifa için tabip lazım değil, Biliyorum kalbin devasını: Mutlak her yıl soluyorum gidip Köyümüzün temiz havasını.</i>
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\* Makalede şiir çevirileri bize aittir (Ç.ZÇ).

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Башка берни дә кирәкми,  
Үзем чапкан печәннәрне  
Бер туйганчы иснәсәм.  
Миңа гына шулай тоела микән  
Бөтен рәхәтләре соң аның?  
Башка берни дә кирәкми,  
Үзем тапкан чиммәләрнең  
Ятып эчсәм суларын.

“Башка берни дә кирәкми” (Başka Hiçbir Şeye Gerek Yok);

Төрлесе булды тормышта,  
Сугышып жаным арса,  
Кыйналып яки хаксызга,  
Нахакка жәберләнсә...  
Качып, мин сиңа егылдым.  
Кайттым, сіндә савыктым,  
Шатландым һәрчак эчемнән,  
Йөрәгемдә сау утым.

Тыкрыкка кергәндә һәр тал  
Кул бирде, дәште танып,  
Барсы да сіндә дәвалый,  
Барсы да сіндә табиб.

“Башка берни дә кирәкми.” (Başka Hiçbir Şeye Gerek Yok).

Başkurt ve Tatar şairi Nacar Necmi'nin de yazdığı gibi, “Sibgat Hekim'in bütün varlığı -ruhu, akli, gözleri, konuşması, yürüyüşü, gülümsemesi- memleketine, tepelere, yollara, ormanlara, pınarlara uzanır.” Savaşta hasta dönünce Sibgat Hekim her yıl bir aylığına memleketine gidip dinlenmeyi güzel bir gelenek yapar. Köyde büyüyen herkes gibi o da çocukluğunun geçtiği çayır ve ormanlarda çilek, mantar ve çiçekler toplayıp biçilmesini bekleyen gür otların içine uzanarak uzun uzun bulutlara bakar. Böylece, köyünde yorgun bedenine ve canına güç katar, şiirleri için ilham bulur:

Язар өчен илһам эзлә, диләр,  
Урын эзлә, диләр, ямьләрәк.  
Никтер минем шигъри хисләремә  
Арышларның, исе тәмләрәк!

“Авылым минем” (Köyüm Benim);

Исәнме, жанга газиз жүр,  
Илһамым – туган ягым!

“Туган як” (Memleket);

Туган як – сандык, хәзинә.  
Жырга мин нәкъ ач кеше,  
Ачам теләгән вакытта,  
Үз кулымда ачкычы.

“Туган як – сандык...” (Memleket, Sandık...).

Şair, çiftçi soyundan gelmesi ve toprağa olan yakınlığıyla gurur duyar, köklerinin de ekinler misali toprakta olup ruhunu beslediğini yazar:

Бөтенләем белән Жирнеке мин,  
Минем барлык нәсел-нәсәбем –

Başka hiçbir şeye gerek yok,  
Biçtiğim otu, çiçeği

Doya doya koklarsam!

Tek beni mi sarıp sarmalıyor

Böyle huzur, böyle bir rahat?

Başka hiçbir şeye gerek yok,

Bulduğum o pınarların

Eğilip suyunu içersem!

Her şeye tanık oldum ben,

Yorulunca savaştan,

Dövülüp ya da haksıza

Azarlandığım zaman

Ben sana döndüm memleket,

Şifayı sende buldum.

İçim içime sığmadı,

Senle ayakta kaldım.

Köye girince söğütler

Seslendiler el verip.

Hepsi şifa dağıtıyor,

Senin her şeyin tabip.

Yazmak için ilham ara derler,

Güzel yerleri ziyaret et.

Gönlüm ise çavdar kokusundan

İlham alır, hep ona hasret!

Merhaba, aziz toprağım,

İlhamım, memleketim!

Memleket sandık, hazine.

Ben ise türküye aç!

Açıyorum acıkınca,

Anahtarı elimde.

Tamamen Toprakta gelmekteyim,

Soyum çiftçi, soyum emektar.

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*Игенчеләр. Жирдән төртөн чыга  
Һәрбер юлым, һәрберем әсәрем.*

*Иген уңса – жыр да тиз язылды...*

*“Бөтенләем белән Жирнеке мин...”* (Tamamen Topraktan Gelmekteyim);

*Миңа бит һәрнәрсә бу жирдә*

*Яшарга, язарга булыша.*

*“Монда да язмасаң: куаклар...”* (Burada Yazmazsan, Çalılar...).

Sibgat Hekim'in şiirlerinde Tatar Türklerinin yaşadığı coğrafya en ufak ayrıntılarıyla anlatılır. Örneğin ladin, çam, kayın, meşe, söğüt gibi ağaçların, şifalı bitki ve çileklerin yetiştiği, Tatar masallarında sıkça anılan *kara urman* ya da *karurman* (karanlık orman) (“*Hu сөйли урман...*” (Ne Söylüyor Orman), “*Урманнарға керсәң, сызгырып кер...*” (Ormanlara Islık Çalarak Gir...) vb.), düğünçiçeği, çan çiçeği, papatya ve karabuğday çiçeği gibi çeşit çeşit hoş kokulu kır çiçekleri ve biçilmiş otlarla nefes alan kır ve çayırlar, saman yığınlarının bulunduğu harman yeri, sürülmüş ve çavdar, buğday, karabuğday, günebakan, keten, yulaf gibi tahılların ekilip olgunlaştığı tarlalar (“*Бу кырлар, бу үзәннәрдә...*” (Bu Kırlarda, Bu Çayırlarda), “*Давыл чәчәкләре*” (Düğünçiçekleri), “*Басуга туры*” (Tarlaya Doğru), “*Баушак чаңы*” (Başak Çanı) vb.), dağın eteklerinden kaynayan pınarlar, sabahtan pınarların etrafına çöken sis vb., bunlar hepsi şiirlerinin temelini oluşturur:

*Урманнарға керсәң, сызгырып кер,*

*Селкенмәгән агач калмасын;*

*Сукмакларын уят, аланнарын,*

*Кошчыкларын уят аннан соң...*

*Онтымасын өчен кошлар монда*

*Һәр агачка жырын уйгандыр...*

*Калын урман, купне күргән урман,*

*Уйландыра алсаң, уйландыр.*

*“Урманнарға керсәң, сызгырып кер...”* (Ormanlara Islık Çalarak Gir...);

*Арыш шаулап серкә очырганда,*

*Хисләрем дә бергә уйнаган.*

*“Бу кырлар, бу үзәннәрдә...”* (Bu Kırlarda, Bu Çayırlarda);

*Печән жіткән, мин болында йөрм,*

*Тугайларга күңлем табынды.*

*Озын, сары давил чәчәкләре*

*Көтеп утыра кебек давилны.*

*“Давыл чәчәкләре”* (Düğünçiçekleri);

*Ромашкалар төшеп килә үрдән,*

*Бәрелеп-бәрелеп кала жіләкләр.*

*“Һавада сөт исе, жып-жылы сөт...”* (Havada Süt Kokusu, Sıcacık Süt);

*Карабодай чәчәгенә*

*Йогар кояш сарысы...*

*“Тукта, бер үткән гомерне...”* (Dur, Geçen Hayatı Bir...);

*Арыштан аерым кем күргән*

*Арышның күк чәчәген?*

*“Баш куеп искән жілләргә...”* (Baş Koyup Esen Yellere...);

*Жил генә алып килгәндер,*

*Кырлардан искән жілдер:*

*Her bir yolum, her eserim benim*

*Bu topraktan filizlenmekte.*

*Mahsul bol olunca tez yazıldı şiir...*

*Bana her şey bu toprakta*

*Yaşam, sanat kaynağı.*

*Yaşam, sanat kaynağı.*

*Yaşam, sanat kaynağı.*

*Ormanlara ıslık çalarak gir,  
Sallanmayan ağaç kalmasın;  
Yol ve alanları uyandır sen,  
Kurt kuşları bile uyansın.  
Unutulmasın diye kuşlar burada  
Her ağaca şarkı örmüştür.  
Kalın orman, çok şey gören orman,  
Düşündürebilsen düşündür.  
Çavdar polen uçururken  
Duygular da uçuşmuş.  
Otlar olgunlaşmış. Ben, çayırdā.  
Togaylara taptım gönülden.  
Uzun sarı düğünçiçekleri  
Fırtınayı sanki beklerler.  
Papatyalar tepelerden iner,  
Papuçuma çarpar çilekler.  
Karabuğday çiçeğine  
Geçer güneşin sarısı...  
Çavdardan ayrı kim görmüş  
Çavdarın gök çiçeğini?  
Ancak rüzgar getirmiştir;  
Rüzgar, tarladan esen;*

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Үсә тәрәзәм каршында

Үсә бер бөртек киндер.

“Үсә бакчамда киндер...” (Keten Biter Bahçemde);

Житлегеп килгән игеннәр

Үзенә дәшә.

Тоташып ерак офыкка,

Тирбәлә рәшә.

Ятам кырда салам кибәнәндә,

Йөзне куеп көзгә кояшка.

Бүген мин дә жанҗаллардан азат,

Ятам, аста арыш саламы.

“Көз” (Güz);

Арыш өлгергән көннәрдә,

Түзмим, житми чыдамым,

Чыгам кырга, тыңлыым арыш

Башагының чыңлавын.

“Башак чаңы” (Başak Çanı);

Якын, бик якын печәнгә

Без таңда төшкән болын,

Кунычын капиый итекнең

Сукмакта үскән солың.

“Туган як” (Memleket);

Солы кыры... Уйлар, уйлар...

Солылар күк чорналдылар.

Алтын-сары кыңгыраулар

Чыңладылар, чыңладылар.

“Солы кыры... Уйлар, уйлар...” (Yulaf Tarlası... Düşünceler...);

Бер тауда ун чишмә,

Тынмыйлар бер кич тә,

Чәчәкле жәй әле,

Атлы һәм жәяүле

Юлыгыр...

Бер тауда ун чишмә,

Юлларын син кисмә;

Агышы ун төрле,

Тавышы ун төрле,

Моң башка...

“Бер тауда ун чишмә” (Bir Dağda On Çeşme).

Sibgat Hekim'in verdiği bilgiye göre, doğup büyüdüğü köyün çevresinde ondan fazla pınar varmış (Harras, 1991: 7). Bu yüzden şair defalarca pınar imgesine atıfta bulunarak onları birçok eserinin şiirsel dokusuna dokumuştur (“Фазыл чишмәсе” (Fazıl Pınarı), “Башка берни дә кирәкми” (Başka Hiçbir Şeye Gerek Yok), “Чишмәсе бар” (Pınarı Var) vb.).

On dokuz yaşına kadar köyde toprağı sürüp eken ve biçen şair, memleketine olan duygularını aktarıırken ancak köye özgü manzaraları da şiirlerine en güzel şekilde dokur. Bunlar, ekinlerin üzerinde uçuşan tarla kuşları, geceleri at nöbeti esnasında kırdan yanan ateşler, oynayıp koşturan kulunlar, sürüyü otlaklara doğru kovalayan çobanlar, sürü döndüğünde köye yayılan süt

Penceremin tam önünde

Bitmiş bir tane keten.

Olgunlaşan ekinler

Çağırır bizi.

Bitişip ufukla

Sallanır ufkun sisi.

Uzanmışım saman yığınınna,

Yüzü okşar güzün güneşi.

Bütün kavgalardan azat bugün,

Altımdaysa çavdar samanı.

Çavdarlar olgunlaşırken

Kimler dizginler canımı!

Tarlaya gider dinlerim

Çavdar başağının çanını.

Yakın, çok yakın biçilen ota

Tanda gidilen çayır.

Çizmeleri yoklamakta

Yolda yetişen yulaf.

Yulaf tarlası... Düşünceler

Yulaf gibi sarıldılar.

Altın sarısı çan çiçekleri

Durmadan çingirdadılar.

Bir dağda on pınar,

Susmadan akarlar,

Çiçekli yaz şimdi,

Atlı da yaya da

Her uğrar...

Bir dağda on pınar,

Aksınlar pınarlar;

Akması on türlü,

Sesi de on türlü,

Hüznü de on türlü...

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kokusu, etrafı kamışlarla çevrili kuğulu göller, tarlada yaban kazlarından ya da gölde kuğulardan kalan beyaz tüyler vb.:

*Тугайларга барсам, тургай кебек*

*Жырым очар төсле пырхылдап.*

*“Тургай сайрый, дартле, моңлы сайрый...” (Turgay Öter, Hüzünlenip Öter...);*

*Июнь печәнәнә күмелеп,*

*Ярсып чапкан колынның*

*Көттем каршыма чыкканын;*

*Болында эш, кырда эш,*

*Чаба, бернидә гаме юк,*

*Башы – сары көнбагыш.*

*“Июнь мине сүзсез итә...” (Haziran Sessiz Bırakır);*

*Һавада сөт исе, жып-жылы сөт,*

*Иң куесы сөтнең, иң шәбе;*

*Башын арыш сөткә мана төсле,*

*Агарырга, ахыры, исәбе.*

*“Һавада сөт исе, жып-жылы сөт...” (Havada Süt Kokusu, Sıcacık Süt...);*

*Монда да язмасаң: ал да яз,*

*Тирәмдә сибелгән каурыйлар...*

*“Монда да язмасаң...” (Burada Yazmazsan...);*

*Пар аккошлар очкан бергә-бергә,*

*Матур күлләр тагын бар, диләр.*

*Вагьдәләрне безнең, әй, беркетер өчен*

*Ак каурыйлар калган, каурыйлар.*

*“Бөтенләйгә инде ерак-ерак...” (Ebediyen Artık Uzaklara...).*

*Togaylarda tarla kuşu gibi*

*Türküm ürker, uçar göklere.*

*Haziran otuna gömülüp*

*Delice koşan kuluna*

*Denk gelmek istedim;*

*Çayırda tarlada işin yok bitesi,*

*Kulunsa koşuyor tasasız,*

*Ay çiçeğine benzer başı.*

*Havada süt kokusu, sıcakık süt,*

*En yoğun süt ve en lezzetli;*

*Çavdar başağını süte banmış...*

*Ağarmak mı yoksa niyeti?*

*Burada yazmazsan: al da yaz*

*Etrafa serpilmiş kuş tüyü...*

*Çift kuğular bir arada uçan*

*Güzel göller daha var, derler.*

*Sözümüze imza atmak için*

*Apak tüyler kalmış, ak tüyler.*

Sibgat Hekim'in şiirlerinde Kazan Tatarlarının doya doya yaşadığı tüm dört mevsimi de görmek mümkün. Kış mevsiminde yer alan soğuk kış tipleri, memleketinin soğuk kışından sıcak diyarlara sığınan ama baharda mutlaka yuvalarına dönen kuşların sesi, nehirlerin çayların kalın buzun altında uyuklayıp baharda coşarak akması, karın bağrından güneşe doğru delip çıkan ilk çiçekler, haziran ayının sevecen ve şefkatli yeli, sonbaharda etrafa hüzün yayarak dökülen yapraklar, şairin umut, hüzün ve özlem gibi ruh hali ve duygularını bildirmek için kullanılan bütün bu manzaralar okuyucunun hafızasına kazınmakta:

*Шаулар елгалар, елгада сулар,*

*Тиздән чәчәкләр, чәчәкләр чыгар.*

*Безнең бакчага сандугач килер.*

*“Бишек жыры” (Ninni);*

*Кошлар кайта безгә, син һаман юк,*

*Син һаман юк, никтер килмисең.*

*“Юксыну” (Özlem);*

*Мин беренче чәчәкләрне жыйган*

*Урыннарга барам яз саен.*

*“Мин беренче чәчәкләрне эзлим...” (Arıyorum İlk Çiçekleri);*

*Уяна кошлар тирәктә,*

*Жәйге жыл куя исең;*

*“Таң атканда” (Tan Ağarırken);*

*Coşar nehirler, nehirde sular,*

*Yakında artık açar çiçekler;*

*Bahçemize de döner bülbüller.*

*Kuşlar döner ama sen hep eksik.*

*Sen hâlâ yok, hâlâ dönmedin.*

*İlk çiçeği derlediğim yere*

*Her baharda uğrar oldum ben.*

*Uyanıyor kuşlar çalılıkta,*

*İlki yaz rüzgarı esiyor.*

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*Юктыр, июнь эжилләрэдәй*

*Yoktur haziranın yeli kadar*

*Ягымлы һәм шәфкатле.*

*Ilık ve şefkatli diğer bir yel.*

*“Баи куеп искән эжилләрә...” (Baş Koyup Esen Yellere...);*

*Син килмәдең, көзге эжилләр инде*

*Sen gelmedin, güz rüzgârı artık*

*Яфракларын эжиргә сиптеләр.*

*Yaprakları döktü yerlere.*

*“Юксыну” (Özlem).*

Sibgat Hekim'in bazı şiirlerinde doğa, halkın başına gelenleri aktarmaya da yardımcı olur. Yani şiirlerinde, halkın yaşadığı tarihî olaylar da yer alır:

*Арышлар уйный эжилләрдә,*

*Çavdarlar sallanır rüzgarda,*

*Дулкыннар кара-кучкыл.*

*Dalgalar siyaha çalmakta.*

*Әйтерсең, үткән сугышның*

*Küllere benzerler, savaştan*

*Калган көле кушылган;*

*Kaldığı küllere.*

*Кушылган сагыш аларга,*

*Hüzünle yoğrulmuş çavdarlar;*

*Шуңа кара-кучкыллар.*

*Bu yüzden siyaha çalarlar.*

*Төшәләр түбән дулкыннар,*

*Eğilir başaklar. Beklerim*

*Көтәм чыкканын шуннан;*

*Yeniden kalksınlar başaklar.*

*Калкалар – ерак елларның*

*Kalktılar, yaşanmış yılların*

*Кара сыртлары сыман.*

*Karanlık sırtını andırıp.*

*“Кырларда давил, кырларга...” (Kırlarda Fırtına, Kırlara...).*

Fakat yine de doğa tasviri, daha çok şairin gönül dünyasında olup bitenlere eşlik eder. Örneğin, saçları ağarıp yaşlanmaya başlayan şair, her ne kadar gençliğini özlese de doğanın kanununa uyarak haletine uygun tasviri yine köyünün doğasında bulur. Başka bir tabirle, içindeki hüzne köyünün tarlasında yetişen çavdar ve karabuğday ile Tatar köylerinin nehir kenarlarını süsleyen söğütleri de ortak eder:

*Яшьлек, синең дә бу эжирдә*

*Gençlik, senin de hayatta*

*Бар иде бит бар чагың.*

*Vardı var olduğun an.*

*Елыйсы килә шул кырда*

*Ağlayasım var tarlada*

*Кочып арыш башагын.*

*Kucaklayıp çavdar başağını.*

*“Башак чыңы” (Başak Çanı);*

*Арышның саргылт серкәсе Çavdarın sarı poleni*

*Ябышкан да арышка,*

*Yapışmış da çavdara*

*Селкенә иртәнге эжилдә,*

*Sallanır sabah yelinde*

*Күнеп көткән язмышка.*

*Boyun eğip kadere.*

*Мин дә бу эжирнең вакытлы*

*Ben de dünyanın süreli*

*Кунагы, иркәсе күк;*

*Konuğu, kıymetlisi,*

*Торам әз генә эләген,*

*Düşer gibi duruyorum*

*Арышның серкәсе күк.*

*Çavdar poleni gibi.*

*“Арышның саргылт серкәсе...” (Çavdarın Sarı Poleni...);*

*Сезгә эндәшми мин кемгә*

*Size değil de kimlere*

*Эндәшим өянкеләр?*

*Sesleneyim söğütler?*

*Житте минем дә сезнең күк*

*Geldi çattı sizin gibi*

*Картайдым, дияр көннәр.*

*Yaşlandığım o günler.*

*Күбәйде миндә дә тутлар*

*Çoğaldı bende de çiller*

*Сездәге тутлар кебек,*

*Sizdeki çiller gibi,*

*Ул тутлар учакта сүнеп*

*O çiller ateşte sönüp*

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*Бетмәгән утлар кебек.*

*Bitmeyen alev gibi.*

“Минем таныш өянкеләр...” (Tanıdık Söğütlerim...);

*Ахрысы, якты бу дөнья*

*Aydınlık dünyadan artık*

*Бездән дә кала бугай,*

*Ayrılır günüm geldi.*

*Офыклар артына батып*

*Karabuğday da gömülüp*

*Бара күк карабодай.*

*Kaybolmakta ufukta.*

“Тукта, бер үткән гомерне...” (Dur, Geçen Ömrü Bir...);

*Үрдә юллар... Житмеш яшьлек гомер...*

*Tepedeki yollar... Yetmiş yaşlık ömür...*

*Укучылар нидер көтә күк.*

*Okuyucu şiir bekler gibi.*

*Камыл исе, төчкелт арыш исе,*

*Anız koktu, acı çavdar koktu,*

*Ятам кырда суккан көлтә күк.*

*Ben, dövülmüş harman misali...*

“Көз” (Güz).

Sibgat Hekim, türküleri ve Şehabetdin Mercani, Abdünnasır Kursavi, Abdullah Tukay, Aliasker Kamal, Ömer Beşirov gibi Tatar halkının maarifi ve medeniyetinin gelişmesinde kilit rol oynayan büyük şahıslarıyla ün alan Kazan Ardi'nda Arça (Arsk) ilçesinde doğup büyümüşür:

*Миңа бу олы тәхетне*

*Bana bu yüce tahtı*

*Калдырган Курсавилар.*

*Bırakmış Kursaviler.*

*Мәржәни анда утырган,*

*Mercani oturmuş onda,*

*Тукайлар булган шаһы.*

*Tukaylar olmuş şahı.*

“Кайтамын туган ягыма...” (Dönüyorum Memlekete);

*Кыр эжилләре иркәләде килеп,*

*Tarla yeli sevip sarmaladı,*

*Тукай моңы ерактан тартты.*

*Tukay hüznü çekti uzaktan.*

“Атым минем үргә менгән саен...” (Atım Benim Yokuş Çıkarken Hep...);

*Арча — данлы Тукай-Кырлай ягы.*

*Arça, şanlı Tukay-Kırlay bölgesi.*

“Арчалылар, без бит Арчалар” (Arçalıyız Biz, Arçalı).

Küllê Kimê köyü, 1990 yılına kadar Arça ilçesine bağlı olur. Bu tarihten sonra Etne, Arça ilçesinden ayrılıp kendi başına bir ilçe statüsü kazanınca şairin doğup büyüdüğü köy, Etne ilçesi sınırları içinde kalır. Ancak Sibgat Hekim'in bütün şiirlerinde doğal olarak memleket, Kazan Ardi'nda yer alan Arça'dır:

*Ватанымның якты бер почмагы син,*

*Vatanımın aydın bir köşesi,*

*Казан арты, әй, Казан арты.*

*Kazan Ardı, ey Kazan Ardı!*

*Гел кояшка карый тәрәзләрең,*

*Hep güneşe bakar pencerelerin*

*Казан арты, әй, Казан арты.*

*Kazan Ardı, ey Kazan Ardı!*

“Атым минем үргә менгән саен...” (Atım Yokuşu Çıkarken Hep...);

*Арча, Арча,*

*Arça Arça,*

*Бөтен дөнья сокланыр як,*

*Dünya hayran kalan topraksın sen,*

*Син йөрәктә, минем эңырым төсле,*

*Kalbimdesin, tıpkı türküme gibi.*

*Мәңге изге эңирең.*

*Ebediyen azizdir bu toprak.*

*Арча, Арча, ятим калыр идем,*

*Arça Arça, yetim kalırdım ben*

*Синнән мине аерып алсалар.*

*Senden beni bir gün ayırsalar.*

*Арча, Арча, синдә минем нигез.*

*Arça Arça, sende olduğum ev,*

*Сиңа кайтсам, гүя юк кайгым.*

*Sana döndüğümde derdim biter.*

“Син йөрәктә минем, Арча” (Kalbimdesin Arça).

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Kazan Ardı'nda bulunan Arça ilçesinin bereketli toprağından Sibgat Hekim'den sonra da Arif Ahunov, Muhammet Mehdiyev, Dias Veliyev, Rafael Töhfetullin ve daha birçok ünlü şair ve yazar çıkmıştır.

Yıllar geçtikçe Sibgat Hekim'in şiirlerinde vatan kavramı, sadece orman tarlalarla kaplı ve Tatar halkının önemli şahıslarının beşiğı olan ünlü Kazan Ardı ve Arça ile de sınırlı kalmıyor. Bilgi biriktikçe vatan, halkın şanlı geçmişine tanıklık eden Bulgar Devleti, Altın Orda ve Kazan Hanlığı topraklarını da kapsamaya başlar. Şair 1974 yılında "Дәверләр капкасы" (Devirler Kapısı) adlı poem yazar. Bu eserin temeline alınan konu, 1969'da Tataristan'da Kama (Çulman) nehri kıyısında bulunan Yarçallı (Neberejniyi Çelni) şehrinde sadece ağır taşıt üretiminde uzmanlaşacak ve KAMAZ (Kamskiy Avtomobilniy Zavod Kama Otomobil Fabrikası) adını alacak otomobillerin üretiminin başlamasıdır. Bu faaliyet Sibgat Hekim'e mevcut topraklarda kurulan Bulgar devletini ve halkının şanlı geçmişini hatırlatır:

Атып читкә бөтен чүп-чарын,  
Аерып КамАЗ Болгар туфрагын,  
Бодай үскән кара туфрагын,  
Кара туфрак - дала туфрагын  
Өйде бергә... Чаллы чал булды,  
Тарихының өстен салдырды.  
Терелде күк Чаллы туфрагы,  
Шаулады күк Болгар базарлары,  
Кайнады күк корыч казаннары,  
Дулкыннарын ярга какты сулар,  
Тимерчеләр, оста бакырчылар...

"Дәверләр капкасы" (Devirler Kapısı).

Sovyet döneminde Rus halkı hariç diğer halkların kadim tarihini düşünmek yasak olsa da Sibgat Hekim bu şiirinde atalarının kurduğu şanlı Bulgar Devleti'ni en önemli ayrıntılarıyla (birçok ülke ile ticaret yapması, demir işlemesi, bakırcılarıyla ün alması vb.) anlatmayı başarmıştır. Ayrıca, Bulgar devleti, Altın Orda ve Kazan Hanlığı anılan şiirlerde şanlı geçmişle gurur duymanın yanında kaybedilen devletlere karşı duyulan hüznü de belirlemekte.

Başka bir şiirinde ise şair, yaşadığı Kazan şehriden yola çıkarak ünlü Kazan Hanlığına da dikkat çeker:

Әй, Казан, бабамнар йорты,  
Тарихым узган сіндә,  
Данлы һәм шанлы булып сін  
Яшәрсең бездән соң да.  
Әй, Казан,, шагыйрьләр йорты,  
Иң якты эзләр сіндә,  
Данлы һәм шанлы булып  
Яшәрсең бездән соң да.

"Әй, Казан..." (Ey Kazan).

Kendisini tanımaya başlaması 1917 Devrimi sonrası Sovyetler dönemine denk gelen ve bu dönemde çiftçi ve işçi sınıfı için yapılan bütün imkânlardan yararlanarak refah hayata kavuşan bir birey olarak Sibgat Hekim, tarihin izini sürerek vatan kavramı içine Sovyet döneminde oluşturulan ve doğal gaz, petrol gibi zengin doğal kaynaklarıyla sadece kendi ülkesinin değil

Atarak bir kenara çöpleri,  
Ayıklayıp KamAz Bulgar toprağını,  
Buğday biten kara toprağı,  
Kara toprak bozkır toprağını  
Yığıdı bir araya... Çallı yaşlandı,  
Tarihinin üst katmanını attı.  
Sanki canlandı Çallı toprağı,  
Gürültüsü geldi güya Bulgar pazarının,  
Kaynadı sanki demir kazanları,  
Nehirler de dalgaları vurdu sahile  
Demirciler, usta bakırcılar...

Ey Kazan, atalarımın yurdu,  
Tarihim geçmiş senden.  
Ünlü ve şanlı olup sen  
Yaşarsın ebediyen.  
Ey Kazan, şairler yurdu,  
En parlak izler sende.  
Ünlü ve şanlı olup sen  
Yaşarsın ebediyen.



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diğer ülkelerin ekonomisine de büyük katkıda bulunan Tataristan Özerk Sovyet Sosyalist Cumhuriyeti'ni de dâhil eder:

— Сез кайдан? - дин сорыйсыз.

— Без Казаннан. Казанны

Идел кичкән — шул белер.

Урамнары ак ташлы,

Жырлый Сәйдәш, Такташны —

Татарстан шул булыр.

Бер горуурлык хисе яна миндә,

Эчтән бәрәп яна битләрдә.

Сөйләр идем аны дөньядагы

Барлык-барлык парламентларда.

Кирәк булса, дөнья картасыннан

Кырык илне эзләп табармын.

Мин яшәгән Татарстан менә,

Күр, кайларга илтә товарын...

Керосины да юк, көндездән ул

Телеп куя иде чырасын.

Кем юрады икән нефть төяп

Океаннарга аның чыгасын?!

Карындыклы иде тәрәзәсе,

Яба, яга иде саламың.

Хәзер аңа дөнья базарында

Зур дәүләтләр бирә сәламен.

Нигезләрен биек итеп сала

Яңа Куба, яңа Вьетнам.

Күтәрелә бөтен бер Африка, —

Кимсетелгән, ачтан боеккан.

Татарстан үсте, үзе булыша

Ул элекке колонияләргә...

“Бер горуурлык хисе...” (Bir Gururluk Hissi).

Son olarak, Sibgat Hekim'in birçok şiirinde vatan düşünce evrensel boyut kazanarak genel olarak tüm yeryüzünü -Dünya gezegenini- de kapsar:

Мин гашиыйкмын, Жиргә гашиыйкмын.

Ben aşığım, Dünya 'ya âşık.

“Исәнмесез, гөлләр...” (Merhaba, Güller...)

Yukarıda da anıldığı üzere, Sibgat Hekim için vatan, atalardan kalan aziz topraklar ve bu topraklarda yaşayan yetenekli, yaratıcı halkının şanlı tarihidir. Bütün bunların bütünü, şairin yaratıcılığının kapsamını genişletip eserlerini yüksek yurttaşlık duygusuyla zenginleştirmekte. Ünlü Avar şairi Resul Gamzatov “Vatan sevgisi açlık gibidir, söndürülemez.” demiştir. Bu sözler, Sibgat Hekim için de geçerlidir. Nerede olursa olsun, şair memleketini özler (URL4). Özlem ise her şeyden önce susama imgesiyle anlatılır ve “Сусама” (Susama) şiiri, buna ne güzel örnektir. Mecazi anlamda bu şiirde “susama” kelimesi, doğup büyüdüğü toprağı, köyü özlemek ve her zaman ona ihtiyaç duymak anlamına gelir. Şair için memleket hasreti o kadar kuvvetli bir duygu ki o, köyüne gittiğinde tarlalarda esen rüzgârlara tapar ve pınarların önünde diz çöker:

Sorarsanız “Neredensin?” diye,

Biz, Kazanlı. Bizim Kazan'ı

İdil nehrini geçenler bilir.

Caddeleri şehrin ak taştan,

Bahsedilir Seydaş ve Taktaş'tan,

Tataristan işte bu olur.

Bir gururluk hissi var kalbimde,

İçten yanıp vurur yüzüme.

İsterdim söylemek dünyadaki

Parlamentoların hepsinde.

Gerekirse haritaya bakıp

Kırk ülkeyi arar bulurum.

Yaşadığım Tataristan işte,

Bak nereye satar ürününü.

Gazı yoktu, günün ışığında

Akşam için yaktı çırağı.

Kim fal açtı petrol yükleyerek

Okyanusa alır yol diye?

Zardan olan penceresi ile

Çatısı da yakıtı da saman...

Şimdi ise dünya pazarında

Büyük devletlerden alır selam!

Temelini yüksek kurmaktadır

Yeni Küba, yeni Vietnam.

Kalkınmakta artık tüm Afrika,

Zulüm görmüş, bitmiş açlıktan.

Tataristan artık yardım eli

Uzatmakta kolonilere...

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Күңелгә минем, туган як,  
Бигрәк тә якын шул син.  
Кырларың өстеннән искән  
Жилләргә хәтле сусыйм.  
Тезләнем чиймәләреңә,  
Бетми тик сусау гына.  
Мин бәхетле бары тик син  
Бәхетле булсаң гына.  
Ник болай сагышылы иттең,  
Бу кадәр мине соң син?!

Аерылып бер көн дә узмый,  
Яңадан сиңа сусыйм.  
“Сусау” (Susama).

Yukarıda gösterilen örneklerden de görüldüğü üzere, mutluluk duygusu da şair için memleketinden ve hemşerilerden ayrı asla düşünülemez. Çünkü şaire göre insan, ancak doğup büyüdüğü toprakta küçüklüğünden itibaren tanıdığı, bütün zorluklara birlikte göğüs gerdiği insanlarla ancak mutlu olabilir:

Чыпчык та үз чытырманым дигән,  
Туган эңир тик булсын чытырман,  
Аермасын сине язмышың шул  
Чытырманда торган йортыңнан.  
Кайгысы да эңиңел уза монда,  
Икмәге дә ертмый тамакны,  
Кай тарафка таба йөз тотсаң да,  
Син бәхетле һаман, канатлы.  
“Чыпчык та үз чытырманым дигән...” (Serçe De “Yurt” Demiş Çalığa...);  
Мин синеке, авыл, мин синеке,  
Мин синеке туган көнемнән;  
Мин шытканмын гуя яңгырыңнан  
Шыкландырган нарат төбеннән.  
“Ява яңгыр” (Yağıyor Yağmur);

Ayrıca, mutluluk duygusuyla yan yana insanın saygı ve değeri de daha çok öz vatanında gördüğüne vurgu yapılır:

Кадер дә, хермәт тә сиңа  
Тик туган эңирдә икән.  
“Сез һаман бергә икән” (Siz Hâlâ Berabermiş).

Sibgat Hekim’in şiirlerinde vatan kavramı, yıllar geçtikçe her ne kadar genişlese de hayatının sonuna doğru yine daralıp doğup büyüdüğü köyüyle son bulur. Yani en küçük coğrafyadan başlayıp gezegen boyutuna ulaşan vatan, şair için hayatının sonunda yine doğup büyüdüğü topraktan başkası değildir. Belki de bu yüzden, hayatının büyük kısmını Tataristan’ın başkenti Kazan’da yaşasa da Sibgat Hekim, vefat edince köyünün mezarlığında toprağa verilmek ister. Yani öldükten sonra bile memleketinin sıcaklığına muhtaç olacağını dile getirir:

Кире китәм, кайтарыгыз мине  
Киме зиратына, Кимегә.  
“Васьять” (Vasiyet);

Kalbimde doğduğum toprak!  
Çok değer veriyorum.  
Kır tarlalarından esen  
Yellere susuyorum.  
Diz çöktüm pınar karşında,  
Bitmez ama susamam!  
Mutluyum ancak seni de  
Mutlu gördüğüm zaman.  
Neden böyle hüznün saldın  
Sen benim yüreğime?  
Tek bir gün ayrı kalınca  
Susarım sana yine.

Serçe de “yurt” demiş çalığa.  
O çalılık olsa da vatan,  
Yeter ki kaderin ayırmasın  
Çalılıkta olan yuvandan.  
Derdine de derman ancak burada  
Ekmeği de yırtmaz damağı.  
Hangi yöne çevirsen de yüzün  
Sen hep mutlu, sen hep kanatlı.  
Ben seninim köyüm, ben seninim,  
Bu böyledir doğduğum günden.  
Güya bittim senin yağmurundan  
Koruyan o çamın dibinden.

Değer de hürmet de sana  
Ancak doğduğun yerde.

Gidiyorum, götürün siz beni  
Kimê kabristanına, Kimê’ye.

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Бар жылысын тоеп ятармын күк

Үлгәч тә мин синең туфракның.

“Үрләреңне менгәч” (Тепелерине Çıkınca).

Sıcağını hissederim gibi

Ölünce de senin toprağının.

**SONUÇ**

Edebiyata 1930’lu yıllarda gelen Sibgat Hekim, 1980’li yıllara -vefatına- kadar Tatar şiirinin ön saflarında yer aldı. Onun tüm hayatı ve sanatı, doğup büyüdüğü Kazan Ardı’na olan bitmez tükenmez sevgi ve özlemle doluydu. Başka hiç bir Tatar şairi memleket konusunu bu kadar içten, derin ve geniş bir şekilde işlemedi. Doğup büyüdüğü köyüne olan duygular, Sibgat Hekim’in sanatında hatta sevgi ve özlemin de ötesi bir tutku olarak belirir. Şair, nereye giderse gitsin köyünün tepelerine, ladin ve kayınla dolu ormanlarına, dağın eteğinde kaynayan pınarlarına, söğütlerin yetiştiği sokaklarına ve harman yerini saran saman kokusuna “susar” (hasret kalır). Halkının gönlünde yaşayan duyguları bu kadar güzel bir şekilde dile getirdiğinden dolayı Sibgat Hekim’in onlarca şiiri Sara Sadiykova (“Cycay” (Susama), “Әй, язмыш, язмыш” (Ey Kader Kader), Şakir Mecitov (“Юксыну” (Özlem), Mansur Muzzafarov (“Башка берни дә кирәкми” (Başka Hiçbir Şeye Gerek Yok) vb.) gibi ünlü Tatar bestecileri tarafından bestelenerek halkına şarkı olup dönerek büyük ilgi gördü ve görmeye devam ediyor. Sibgat Hekim’in sanatında yukarıda örnek gösterilen şiirlerde en yakın, en kutsal yer olarak anılan vatan kavramı çok yönlüdür. Her şeyden önce vatan, yeryüzüne ilk ayak bastığı andan ömrünün son günlerine kadar ona sürekli güç ve ilham veren doğup büyüdüğü topraktır. 1941-1945 Büyük Vatan Savaşı’nda vatan için mücadele ederken yaralanan ve sonraki yıllarda hayatın sınavlarından yorgun düşen şairi iyileştirmek için de köyünün temiz havasını teneffüs etmek, çayırlarında yetişen bitkilerin kokusunu içe çekmek ve köyünün etrafındaki pınarlardan akan suyu kana kana içmek yeterlidir. Çiftçi soyundan gelmesi ve toprağa olan yakınlığıyla gurur duyan şair, köklerinin de ekinler gibi toprakta olup ruhunu beslemesinden söz eder. Ancak Sibgat Hekim’e göre “vatan” kavramı sadece orman tarlalarla kaplı ve ünlü şahısları veren Kazan Ardı ile de sınırlı kalmaz. Bu kavram, hem halkın geçmişi (Bulgar devleti, Altın Orda, Kazan Hanlığı) hem şairin yaşadığı bugünü (Sovyetler Birliği, Tataristan ÖSSC) hem genel olarak yaşadığımız gezegeni de kapsar. Kazan Ardı bölgesi ve Arça ilçesi anılan şiirlerinde başlayan gurur duygusu, Tatarların kaybettikleri İdil Bulgar, Altın Orda ve Kazan Hanlığı devletlerini anarken hüznle yoğrulur, Sovyetlerin bir parçası olan Tataristan’ı anlatırken de doruğa çıkar. Yaşadığımız gezegeni vatan olarak algıladığı şiirlerinde ise kocaman bir dünyanın bir parçası olma yani aitlik duygusu ön plandadır. En ilgi çeken nokta, Sibgat Hekim’in şiirlerinde vatan kavramı yıllar geçtikçe her ne kadar genişlese de hayatının sonuna doğru yine daralır ve doğup büyüdüğü köyünden başkası değildir.

1941-1945 Büyük Vatan Savaşı’nda ilk günden son güne kadar vatanını savunan Sibgat Hekim’in vatan konulu şiirlerinde tutku, özlem, mutluluk ve değer görme gibi duyguların yanında savaşırsız bir dünyadaki yaşamın verdiği huzur da büyük önem kazanır. Belki de bu yüzden şairin sanatı, bugün de en çok barışa ve huzura susayan dünyada güncel kalmaktadır.

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COMPUTATIONAL INVESTIGATION ON  $\eta^2$ -TYPE INTERACTIONS  
IN  $\text{Cu}^{2+}$ -CORANNULENE COMPLEXES

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**Özet**

Bu çalışma, gaz fazında  $\text{Cu}^{2+}$  ile koranulen (COR) arasında oluşan komplekslerin yapıları ve etkileşim enerjileri üzerine yapılan ilk araştırmayı temsil etmektedir. Hesaplamalar, çiftli kümeler (coupled-cluster) tekli, ikili ve pertürbatif üçlü yöntemini, alan tabanlı yerel çift doğal orbital yaklaşımı [DLPNO-CCSD(T)] ile birleştirerek yüksek seviyede ab initio yöntemlerle gerçekleştirilmiştir. COR- $\text{Cu}^{2+}$  komplekslerinin etkileşim enerjileri, DLPNO-CCSD(T)/aug-cc-pVTZ seviyesinde, hem relativistik düzeltmeler uygulanarak hem de uygulanmadan hesaplanmıştır. Relativistik etkiler, bağlanma enerjileri üzerindeki etkilerini ayrıntılı bir şekilde analiz etmeyi mümkün kılan Douglas-Kroll-Hess yaklaşımı kullanılarak sisteme dahil edilmiştir. Sonuçlar, periferik aromatik halka ile etkileşim sonucu oluşan COR- $\text{Cu}^{2+}$  komplekslerinde,  $\text{Cu}^{2+}$  kationunun ağırlıklı olarak  $\eta^2$  tipi bağlanma konfigürasyonları oluşturduğunu ortaya koymuştur. Bu bulgular,  $\text{Cu}^{2+}$  iyonlarının poliaromatik hidrokarbon (PAH) sistemlerindeki davranışına dair yeni içgörüler sunmakta ve gaz fazı kimyasında metal-iyon etkileşimlerinin daha geniş kapsamlı bir şekilde anlaşılmasına katkı sağlamaktadır.

**Anahtar Kelimeler:** Koranulen, Polisiklik aromatik hidrokarbonlar, Geçiş metal kompleksleri

COMPUTATIONAL INVESTIGATION ON  $\eta^2$ -TYPE INTERACTIONS  
IN  $\text{Cu}^{2+}$ -CORANNULENE COMPLEXES

**Abstract**

This study represents the first investigation into the structures and interaction energies of complexes formed between  $\text{Cu}^{2+}$  and corannulene (COR) in the gas phase. High-level ab initio calculations were conducted using the coupled-cluster singles, doubles, and perturbative triples method with the domain-based local pair natural orbital approach [DLPNO-CCSD(T)]. The interaction energies of COR- $\text{Cu}^{2+}$  complexes were computed at the DLPNO-CCSD(T)/aug-cc-pVTZ level, both with and without relativistic corrections. Relativistic effects were incorporated through the Douglas-Kroll-Hess approximation, allowing for a detailed analysis of their impact on the binding energies of these complexes. Results revealed that in COR- $\text{Cu}^{2+}$  complexes formed via interactions with the peripheral aromatic ring, the  $\text{Cu}^{2+}$  cation predominantly formed  $\eta^2$ -type binding configurations. These findings provide new insights into the behavior of  $\text{Cu}^{2+}$  ions in polycyclic aromatic hydrocarbon (PAH) systems and contribute to the broader understanding of metal-ion interactions in gas-phase chemistry.

**Keywords:** Corannulene, Polycyclic aromatic hydrocarbons, Transition metal complexes

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## Introduction

Buckybowls, characterized as bowl-shaped polycyclic aromatic hydrocarbons with unique carbon networks, have emerged as a promising area of study in recent years (Duan et al., 2023; Maji et al., 2024; Song & Shao, 2024; Wang & Shao, 2021). These compounds exhibit remarkable structural stability and feature both convex and concave  $\pi$ -faces, enabling their coordination with various cations and anions (Filatov & Petrukhina, 2010). Of these, corannulene is the most widely recognized due to its distinct properties (Rice et al., 2017; Song & Shao, 2024; Stuparu, 2023). Its open-ended structure and strained  $\pi$ -conjugation have drawn significant attention, making it a particularly intriguing subject of research. The synthesis of corannulene, constructed around a central five-membered ring, was first reported in 1966 by Barth and Lawton (Barth & Lawton, 1966; Lawton & Barth, 1971).

Research into the ion-binding properties of buckybowls has captivated both experimental and theoretical scientists due to its fundamental insights and potential applications (Campo-Cacharrón et al., 2014; Carrazana-García et al., 2011; Frash et al., 2001; Green & Dunbar, 2011; Tsipis, 2012; Vijay et al., 2012). The interaction of convex and concave surfaces with ions has been a major area of investigation. Studies focusing on cation coordination reveal varying preferences and stabilities. For example, Dunbar and Carrazana-García demonstrated that sodium ion ( $\text{Na}^+$ ) complexes exhibit greater stability when located outside the bowl structure (Carrazana-García et al., 2011; Green & Dunbar, 2011). Their findings also highlight the critical role of distance in determining interaction energy, with stability varying as the ion's proximity to the bowl changes. Furthermore, Sastry's research elucidated the binding preferences of metal ions (Vijay et al., 2012). Smaller ions such as lithium ( $\text{Li}^+$ ) and copper ( $\text{Cu}^+$ ) tend to favor the rim of the buckybowl, while larger ions, including  $\text{Na}^+$  and potassium ( $\text{K}^+$ ), preferentially bind to the inner hub surface (Vijay et al., 2012). These studies underscore the nuanced interaction dynamics within buckybowls, offering valuable insights into their chemical behavior and broadening their potential applications in fields such as catalysis, material science, and molecular recognition.

The interaction between corannulene and  $\text{Cu}^{2+}$  ions remains an unexplored topic in the scientific literature, with no prior studies addressing their structures or interaction energetics. This study provides the first detailed analysis of COR- $\text{Cu}^{2+}$  complexes, focusing on their structural configurations and binding energies. To investigate these interactions, a range of computational techniques, including density functional theory (DFT), and coupled-cluster singles and doubles with perturbative triples [CCSD(T)], were employed. The research aims to determine the preferred binding orientation and reactive sites of the  $\text{Cu}^{2+}$  ion on the corannulene framework, shedding light on the underlying interaction mechanisms and expanding the understanding of metal-ligand interactions in curved  $\pi$ -systems.

## Materials and Methods

Geometry optimizations and harmonic vibrational frequency calculations were performed in the gas phase employing density functional theory (DFT) with the  $\omega$ B97XD functional (Chai & Head-Gordon, 2008). For these computations, the 6-311++G(d,p) basis set (Hariharan & Pople, 1973; Krishnan et al., 1980; McLean & Chandler, 1980), a Pople-type polarized and diffuse triple- $\zeta$  split-valence basis set, was utilized. To refine energy calculations, single-point energies were determined using the coupled-cluster singles and doubles method, as well as the coupled-cluster singles and doubles with perturbative triples [DLPNO-CCSD(T)] method (Guo et al., 2018; Riplinger et al., 2013), both implemented with the domain-based local pair natural

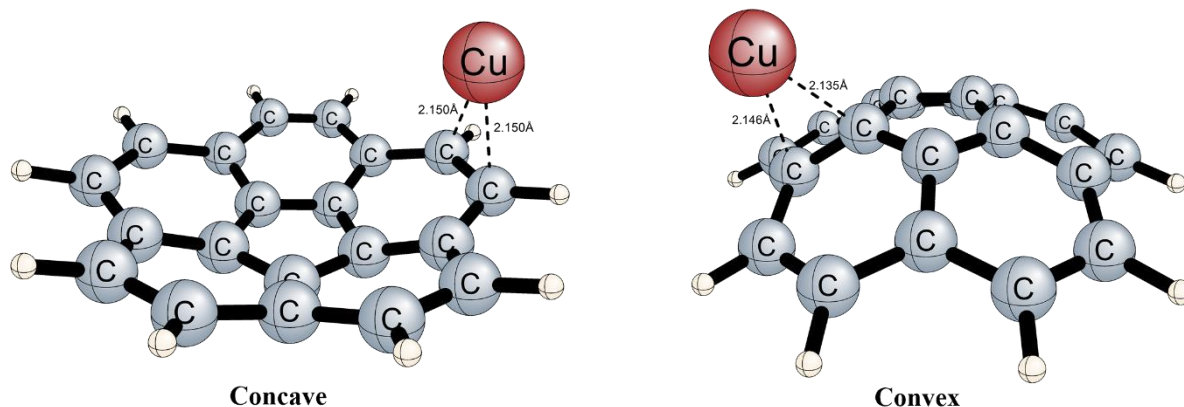
orbital approach. These calculations utilized the aug-cc-pVTZ basis set (Dunning, 1989; Woon & Dunning, 1995) alongside the corresponding aug-cc-pVTZ/C auxiliary basis set. The DFT calculations were conducted using the Gaussian 09 program (Frisch et al., 2009), while the DLPNO computations were carried out with the ORCA software package (Neese, 2012, 2018). For the COR–Cu<sup>2+</sup> complexes, relative energies were computed, incorporating zero-point vibrational energy corrections. Interaction energies ( $E_{\text{int}}$ ) were calculated using the equation:

$$E_{\text{int}} = E_{\text{COR-Cu}^{2+}} - E_{\text{COR}} - E_{\text{Cu}^{2+}}$$

All  $E_{\text{int}}$  values were corrected for basis set superposition errors (BSSE) using the counterpoise correction method (Boys & Bernardi, 1970). To account for scalar relativistic effects, the Douglas-Kroll-Hess (DKH) approximation (Douglas & Kroll, 1974; Hess, 1986; Jansen & Hess, 1989) was applied. Relativistic energy corrections were performed at the  $\omega$ B97XD/6-311++G(d,p) level of theory, ensuring accurate representation of the interaction mechanisms in the COR–Cu<sup>2+</sup> system.

### Findings and Discussion

To initiate the discussion, our relaxation calculations indicate that the  $\eta^2$  site represents the most energetically favorable position for Cu<sup>2+</sup> adsorption on both concave and convex surfaces, as depicted in **Figure 1**. The optimized geometries of the  $\eta^2$ -type COR–Cu<sup>2+</sup> complexes, calculated at the  $\omega$ B97XD/6-311++G(d,p) level of theory, are illustrated in **Figure 1**. In the case of COR–Cu<sup>2+</sup> complexes, the relative energies derived from the DLPNO-CCSD(T) methods using the aug-cc-pVTZ basis set are summarized in **Table 1**. Among the studied complexes, the concave  $\eta^2$ -type COR–Cu<sup>2+</sup> complex demonstrates greater stability compared to its convex  $\eta^2$ -type COR–Cu<sup>2+</sup> counterpart. The energy differences between these two complexes were calculated as 4.1 kcal/mol at the DLPNO-CCSD(T)/aug-cc-pVTZ level, underscoring the enhanced stability of the COR–Cu<sup>2+</sup> complex.



*Figure 1. The optimized geometries of the concave (left) and convex (right)  $\eta^2$ -type COR–Cu<sup>2+</sup> complexes, calculated at the  $\omega$ B97XD/6-311++G(d,p) level*

In the concave  $\eta^2$ -type COR–Cu<sup>2+</sup> complex, the Cu<sup>2+</sup>–C bond lengths are observed to be approximately 2.150 Å. In contrast, the convex  $\eta^2$ -type COR–Cu<sup>2+</sup> complex exhibits slightly varied Cu<sup>2+</sup>–C distances of 2.135 Å and 2.146 Å, as shown in **Figure 1**. The optimized geometry of the concave complex reveals nearly symmetrical Cu<sup>2+</sup>–C interatomic separations, whereas the convex complex is characterized by significantly anisotropic bond lengths.



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**Table 1.** The Computed Relative Energy, Interaction Energies (in kcal/mol) with and without Relativistic Corrections using the DLPNO-CCSD(T) Methods with aug-cc-pVTZ Basis Set for the COR–Cu<sup>2+</sup> Complexes Considered.

	Relative Energy	Nonrelativistic IE	IE including relativistic correction
Convex	4.1	–263.9	–264.4
Concave	0.0	–264.7	–264.8

The calculated nonrelativistic interaction energies for the COR–Cu<sup>2+</sup> complexes, determined using the DLPNO-CCSD(T) method with the aug-cc-pVTZ basis set, are summarized in **Table 1**. The concave  $\eta^2$ -type COR–Cu<sup>2+</sup> complex has an interaction energy of –264.7 kcal/mol, while the convex complex displays a slightly less negative value of –263.9 kcal/mol. Additionally, **Table 1** includes interaction energy values that incorporate relativistic corrections. For the concave complex, the relativistic correction to the interaction energy is –0.10 kcal/mol, and for the convex complex, it is –0.43 kcal/mol, as calculated at the  $\omega$ B97XD/6-311++G(d,p) level. These minor relativistic corrections indicate that relativistic effects have a negligible influence on the interaction energies of these complexes.

When the relativistic corrections are included, the corrected interaction energy of the concave COR–Cu<sup>2+</sup> complex becomes –264.8 kcal/mol, while that of the convex complex is –264.4 kcal/mol, as computed using the DLPNO-CCSD(T)/aug-cc-pVTZ method. From these energy values, it is evident that the concave site in the COR provides a more favorable environment for Cu<sup>2+</sup> binding, forming the most stable conformer. This conclusion aligns well with the stronger interaction energy calculated for the concave COR–Cu<sup>2+</sup> complex.

## Conclusion and Recommendations

This study provides the first detailed computational investigation of the  $\eta^2$ -type interactions in COR–Cu<sup>2+</sup> complexes, highlighting the critical role of geometry and binding configurations in determining stability and interaction energies. The findings demonstrate that the concave  $\eta^2$ -type COR–Cu<sup>2+</sup> complex exhibits slightly stronger binding interactions compared to its convex counterpart, as evidenced by the computed interaction energies and relative stability. Relativistic corrections were found to have minimal influence on the interaction energies, underscoring the dominance of nonrelativistic factors in these systems.

These results contribute to the growing understanding of metal-ion interactions in curved  $\pi$ -systems, offering insights into the behavior of Cu<sup>2+</sup> ions in polycyclic aromatic hydrocarbons. The preference for the concave binding site in corannulene highlights the potential of buckybowls in designing and tailoring materials for applications such as catalysis, molecular recognition, and sensor technologies.

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INVESTIGATION OF ANTIOXIDANT ACTIVITY, TOTAL PHENOLIC AND  
FLAVONOID SUBSTANCE AMOUNTS OF *Sanguisorba minor* (L.)

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**ÖZET**

Ülkemizin her bölgesinde kolaylıkla yetişebilen, soğuğa oldukça dayanıklı, boyu 120 cm'ye kadar uzayabilen, vejetatif üreme yeteneğine sahip, 2000 bin yıldır tüm bitki kısımları tıbbi amaçlı kullanılan önemli bir bitkidir. Batı Asya, Kuzey Amerika ve Avrupa'da yaygın olarak yetişir. Çin tıbbında bitkinin kök kısmı da antik çağlardan beri kanamayı durdurmak için yaygın olarak kullanılmıştır. *Sanguisorba minor*, tatlılarda, meyve sularında ve içeceklerde tatlandırma amaçlı kullanılan tıbbi bir bitkidir. Bitkilerin toprak üstü kısımları 2022 yılında Van Yüzüncü Yıl Üniversitesi Tıbbi ve Aromatik Bitkiler bahçesinden toplanmıştır. Bu çalışmada; antioksidan aktivite, toplam fenolik, toplam flavonoid madde, NBI (Azot Dengesi İndeksi), klorofil, flavonol ve antosiyanin miktarları incelenmiştir. Çalışma sonucunda; Antioksidan madde miktarı 165.65  $\mu\text{mol TE g}^{-1}$ , toplam fenolik madde (188.90 mg GAE  $\text{g}^{-1}$ ), toplam flavonoid madde miktarı 23.14 mg QE 100  $\text{g}^{-1}$  olarak belirlenmiştir. Azot Balans İndeksi (NBI), klorofil içeriği, flavonol ve antosiyanin içeriği gibi Dualex değerleri (dx) açısından elde edilen veriler sırasıyla; 15.20 mg/g, 24.16 mg/cm<sup>2</sup>, 1.62 dx ve 0.13 dx olarak belirlenmiştir.

**Anahtar Sözcükler:** *Sanguisorba minor* Scop., tıbbi bitki, antioksidan, fenolik, flavonoid

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FLAVONOID SUBSTANCE AMOUNTS OF *Sanguisorba minor* (L.)**

**Abstract**

It is an important plant that can grow easily in every region of our country, is quite resistant to cold, can grow up to 120 cm in length, has the ability to reproduce vegetatively, and has been used for medicinal purposes for all plant parts for 2000 thousand years. It grows widely in Western Asia, North America and Europe. In Chinese medicine, the root part of the plant has also been widely used to stop bleeding since ancient times. *Sanguisorba minor* is a medicinal plant used in seasoning desserts, juices, and beverages. The aboveground parts of the plants were collected from Van Yuzuncu Yil University, Medicinal and Aromatic Plants garden in 2022. In this study; antioxidant activity, total phenolic, total flavonoid substance, NBI (Nitrogen Balance Index), chlorophyll, flavonol and anthocyanin amounts were examined. In the result of working; The amount of antioxidant substance was determined as 165.65  $\mu\text{mol TE g}^{-1}$ , the total phenolic substance (188.90 mg GAE  $\text{g}^{-1}$ ), the total flavonoid substance amount was determined as 23.14 mg QE 100  $\text{g}^{-1}$ . The data obtained in terms of Dualex values (dx) such as Nitrogen Balance Index (NBI), chlorophyll content, flavonol and anthocyanin content are respectively; It was determined as 15.20 mg/g, 24.16 mg/cm<sup>2</sup>, 1.62 dx and 0.13 dx.

**Key Words:** *Sanguisorba minor* Scop., medicinal plant, antioxidant, phenolic, flavonoid

## 1. INTRODUCTION

*S. minor* Scop., which belongs to the family of *Rosaceae*, is a perennial plant that commonly grows in most parts of Europe, North Africa, Asia, and America (1,2). It is especially common in China and its roots are used in traditional Chinese medicine. The plant is known to be used to prevent bleeding and internal hemorrhaging. Species of *S. minor* Scop. (Figure 1) have been used in folk medicine for their diuretic, digestive, appetite-stimulating, and fever-relieving properties in infusions and tinctures, *S. minor* Scop. grows at moist, cool altitudes and in subtropical to temperate climates. As it prefers slightly dry calcareous soil with limestone rock on top or well-drained soil, *S. minor* Scop. can thrive in soils that are low in nutrients (3,4,5,6). It has cold properties, tastes bitter and sour, and is non-toxic and fragrance-free. *Sanguisorba minor* Scop. (Figure 2) has been used as a food ingredient because young leaves are edible and available all year round. *S. minor* Scop. exhibits antioxidant, antiulcerogenic, antitumor, antimicrobial, neuroprotective, and anti-inflammatory activities (1,2,7,8,9). Plants with anti-inflammatory effects have long been used as folk remedies for inflammatory conditions such as pain, fever, and arthritis. As the inflammatory causes of some diseases become clearer, anti-inflammatory plants and natural products are gaining more attention (10). It is known that inflammation plays a central role in the pathogenesis of many diseases such as cancer, diabetes, obesity, cardiovascular diseases, and rheumatoid arthritis. Therefore, this plant is used to relieve inflammation and inflammation-based disorders. There are 27 species in the World Meadow button (*Sanguisorba minor* Scop.) is a cold-resistant (-25 °C) plant that can grow easily in every region of our country, can grow 70-100 cm in height under normal conditions, has the ability to reproduce vegetatively, and has been used for medicinal purposes for 2000 thousand years. It is a valuable plant used for various purposes. It has a protective effect against stomach ulcers and fungi, as well as having a lowering effect on high blood sugar. Its roots and leaves are also used as a hemostatic agent. Among these therapeutic properties, it is an extremely important plant due to its ability to relieve inflammation. The genus consists of three species in Turkey, one of which is endemic. In particular, *S. officinalis* is used in folk medicine due to its high variety of biological activities and is a well-known plant for its applications. It is recommended to use as a food supplement for gastrointestinal disorders. For adults, 20-30 drops in half a glass is therapeutic when taken with water. On the other hand, *S. minor* subsp. *muricata* extract has been shown to have anti-ulcerogenic activity, but there is no record of anti-inflammatory activity of this subspecies (11). It is also used as a hemostatic agent, in the treatment of insect bites and diarrhea. The plant is beneficial for human health as well as environmental health. Very complex and prevents erosion in the lands where it is planted with its developed root system. In addition, the button grass is a very important and valuable plant with its bioremediation properties. When the button grass is planted, the plant collects all the harmful chemicals in the soil with its developed root system and is destroyed by mowing, opens it up for agricultural use again. In this study, it was aimed to determine the antioxidant activity, total phenolic and flavonoid content, NBI, chlorophyll, flavonol and anthocyanin content of *Sanguisorba minor* Scop. species, which is widely used for medicinal and aromatic purposes in the world and in our country.



Figure 1. Sanguisorba minor plant

## 2. MATERIALS AND METHODS

The plants were collected from Van Yuzuncu Yil University, Medicinal and Aromatic Plants Garden in 2020. With the Dualex Scientific+ (FORCE-A, France) device, which can measure chlorophyll ( $\mu\text{g}/\text{cm}^2$ ), nitrogen balance index (NBI) ( $\text{mg}/\text{g}$ ), flavonol and anthocyanin content (dx) on the leaf just before the plants are collected, in real time and non-destructively, thanks to the leaf clip on the sensor was measured and recorded. Then, harvesting was done with the help of sterile scissors from the connection part where the soil and the stem part meet. For the analyzes to be performed on dry samples, plant samples were dried in an oven at  $40\text{ }^{\circ}\text{C}$  and stored under appropriate conditions. In this study; Total antioxidant, total phenolic and flavonoid substance contents were examined in 4 replicates. In the study, the amount of total antioxidant activity, FRAP (ferrous ion reducing antioxidant power), Lutz et al. (2011); total phenolic substance amount, Obanda and Owuor (1997); The total amount of flavonoid substances was determined by Quettier et al. It was determined according to the method developed by (2000).

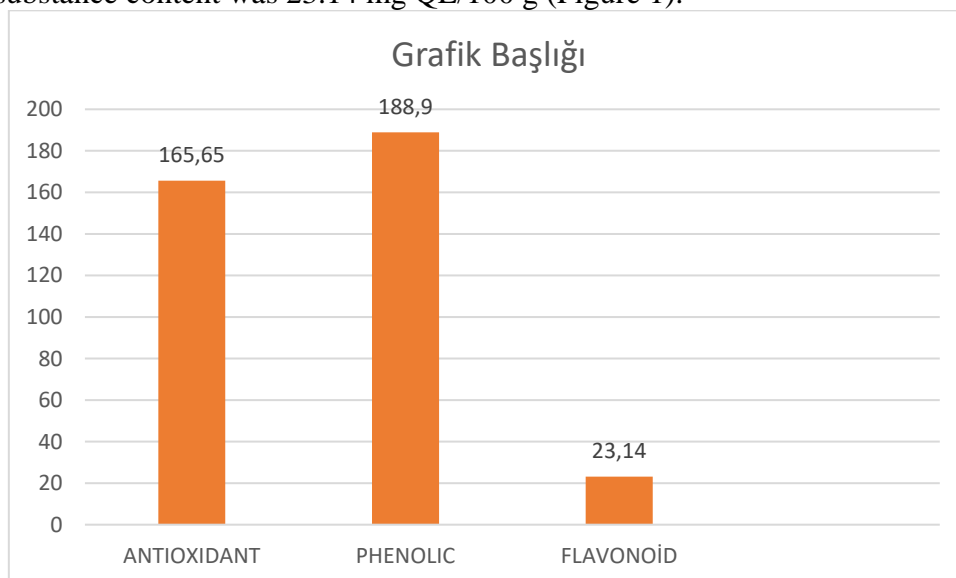


Figure 2. An image from the *Sanguisorba minor* plant



### 3. RESULTS AND DISCUSSION

In this study, the total antioxidant content of the *Sanguisorba minor* Scop. plant was determined as 165.65  $\mu\text{mol TE/g}$ , the total phenolic substance was 188.90 mg GAE/g, and the flavonoid substance content was 23.14 mg QE/100 g (Figure 1).



**Figure 3.** Total antioxidant activity, total phenolic and flavonoid substance contents of *Sanguisorba minor* Scop.

Previous studies (15) highlighted that *S. minor* Scop. is a valuable source of bioactive compounds. It has been determined that the roots and leaves of the plant contain the highest concentrations of these compounds, and the leaves and flowers of the plant contain flavonols and flavonols, especially the dominant compound in the leaves is quercetin-glucuronidine. These compounds are known for their strong antioxidant properties. Antioxidants neutralize the harmful effects of oxidative damage caused by free radicals, and thus prevents or reduces the damage caused by reactive oxygen and reactive nitrogen species (9). According to Zhao et al., 2017, more than 120 compounds belonging to various chemical classes (flavonoids, phenols and triterpenoids) have been detected in the above-ground parts and roots of *S. minor* and *S. officinalis*. Tocai et al. (2021) determined that *Sanguisorba* spp. has the potential to be used as a medicinal plant with antioxidant properties. In a different study, the phenolic content of *Sanguisorba minor* Scop species was determined as 121.36 mg GAE/g dw in the root, 160.96 mg GAE/g dw in the leaf and 131.56 mg GAE/g dw in the flower (15). However, In a study; It was aimed to determine the amount of antioxidant capacity in different plant organs of the *Sanguisorba minor* species. As a result of the study; The amount of antioxidant capacity in the root, leaf and flower parts was determined as 8.31, 8.88 and 8.65 micromole TE/mL, respectively (9). In the study conducted by Tocai et al., (2021), two different species belonging to the genus *Sanguisorba*; The total phenols content was higher in *S. officinalis* root (8.56 mg GAE/g dry weight (DW)), followed by *S. officinalis* leaves (2.80 mg GAE/g DW), *S. officinalis* stem (0.59 mg GAE/g DW), *S. officinalis* flowers (0.41 mg GAE/g DW) compared to *S. minor* root (3.89 mg GAE/g DW), followed by *S. minor* leaves (1.19 mg GAE/g DW), *S. minor* stem (0.19 mg GAE/g DW). The highest DPPH-scavenging capacity was recorded for root extracts, i.e. 94.61 % for *S. officinalis* and 92.93 % and *S. minor* roots respectively. These results

indicate that the roots of *Sanguisorba* species have high antioxidant capacity. *Sanguisorba* species are rich sources of secondary metabolites with significant bioactive properties.

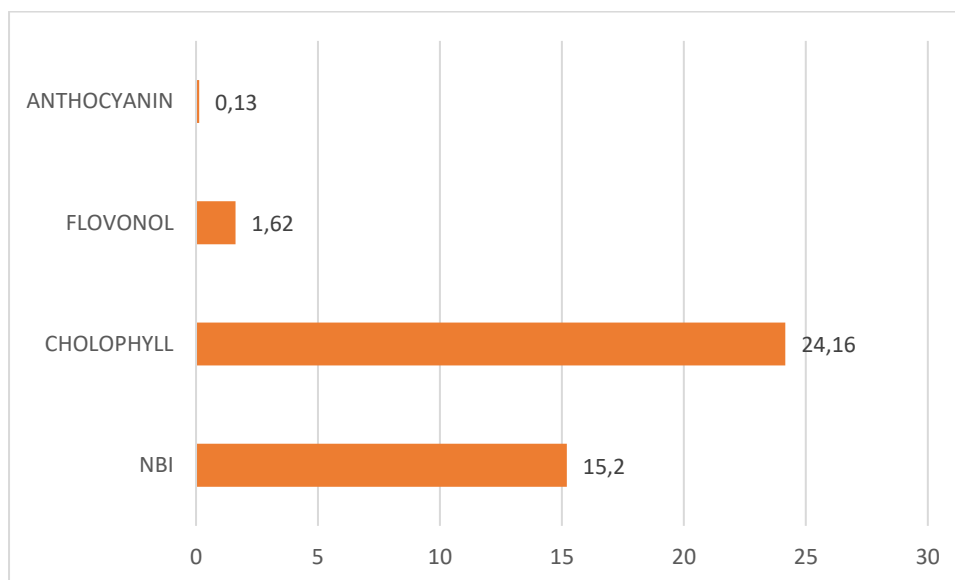


Figure 4. Dualex values of *Sanguisorba minor* Scop.

In this study; NBI (chlorophyll/phenolic) content was determined as 15.20 mg/g, chlorophyll content as 24.16 microgram/cm<sup>2</sup>, flavonol content as 1.62 (dx) and anthocyanin content as 0.13 (dx). The Dualex™ device, created by Goulas et al. (2004) in partnership with FORCE-A, was designed to non-destructively measure the phenolic content in leaves and investigate its correlation with the nitrogen status of plants. Cerovic et al. (2005) reported that phenolic levels rise when plants experience nitrogen deficiency. Meanwhile, chlorophyll levels showed an opposite response. Cartelat et al. (2005) highlighted that the chlorophyll-to-phenolic ratio, represented as the Nitrogen Balance Index (NBI), is a more reliable indicator of leaf nitrogen concentration than either parameter considered separately (21). Phenolics, particularly flavonoids, are among the most significant secondary metabolites and bioactive compounds in plants (22). Their production is closely linked to light, as they function as UV-protective pigments (23). Under high light conditions, a sharp increase in flavonoid biosynthesis is commonly observed, emphasizing their critical role in photoprotection (24,25). Early findings by Barthod et al. (2007) indicated that UV absorbance in the leaf epidermis, as measured by the Dualex™, rose significantly with increased light exposure. This suggests the instrument is a reliable tool for estimating phenolic content in leaves (21).

#### 4. CONCLUSION

Medicinal plants are widely known for their important contribution to supporting the body's defense system. Their use in the treatment of liver and gallbladder disorders is effective in preventing the development of many diseases and disorders, in addition to their antioxidant properties. It is known that the species *Sanguisorba minor* Scop., which is naturally found in our country's flora and can be cultivated, has a high level of adaptation to cool seasons. Due to the chemical composition and antimicrobial effect, the *Sanguisorba* species can be used as food supplements with beneficial effects on human health. In addition, these species are alternatives due to their strong antioxidant effects. It promises great promise for use in medicine or as a

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food supplement. As a matter of fact, as a result of the research, it has been determined that it is also rich in biochemical content that has important and positive effects on human health. It is a valuable plant with benefits from the cosmetics sector to soil improvement. In addition, it has a long-term use in vegetation. It is also a plant that is consumed with pleasure by animals that survive.

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DETERMINATION OF MINERAL AND CHEMICAL PROPERTIES OF COMFREY  
(*Symphytum officinale* L.)

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**Özet**

Genellikle tıbbi Karakafes otu olarak bilinen bu bitki, Boraginaceae familyasına ait bir bitkidir. Yunanca "birlikte büyüme" anlamına gelen "Symphuo" kelimesinden türetilen *S.officinale*, 2000 yıldan uzun süredir kemik kırıkları, artrit, yaralar, hematomlar ve tromboflebit gibi çeşitli hastalıklar için geleneksel olarak kullanılmaktadır. Orta Avrupa, Balkanlar'ın kuzeyi ve Kuzey Anadolu'da yetişir. Ülkemizde kök ve yapraklarının kabızlıkta ve dahili olarak hemoroitlere karşı kullanıldığı bilinmektedir. Bitkilerin toprak üstü kısımları 2022 yılında Van Yüzüncü Yıl Üniversitesi Tıbbi ve Aromatik Bitkiler Bahçesi'nden toplanmıştır. Bu çalışmada; toplam kül ve kuru madde oranı, makro-mikro ve ağır metal içerikleri incelenmiştir. Çalışma sonucunda; toplam kül içeriği %24,08, kuru madde içeriği ise %91.21 olarak belirlenmiştir. Makro ve mikro mineral içeriklerinden bazıları potasyum (K), 43.68 g kg<sup>-1</sup>, kalsiyum (Ca), 26.98 g kg<sup>-1</sup>, magnezyum (Mg), 3.01 g kg<sup>-1</sup>, demir (Fe), 676.15 mg kg<sup>-1</sup>, çinko (Zn), 47.74 mg kg<sup>-1</sup> ve bakır (Cu) içeriği 8.62 mg kg<sup>-1</sup> olarak belirlendi. Ağır metal içeriği açısından kadmiyum (Cd) 0.02 mg kg<sup>-1</sup>, arsenik (As) 0.81 mg kg<sup>-1</sup>, kurşun (Pb) 2.77 mg kg<sup>-1</sup>, krom (Cr) 3.86 mg kg<sup>-1</sup> ve kobalt (Co) içeriği 0.34 mg kg<sup>-1</sup> olarak belirlendi.

**Anahtar kelimeler:** *Symphodium officinale* L., tıbbi bitki, kimyasal içerik, mineral elementler

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**DETERMINATION OF MINERAL AND CHEMICAL PROPERTIES OF COMFREY  
(*Symphytum officinale* L.)**

**ABSTRACT**

Commonly known as medicinal comfrey, this plant is a plant belonging to the Boraginaceae family. *S.officinale*, which derives from the Greek word "Symphuo" meaning "to grow together", has been traditionally used for various diseases such as bone fractures, arthritis, wounds, hematomas and thrombophlebitis for over 2000 years. It grows in Central Europe, the North of the Balkans and Northern Anatolia. In our country, it is known that the root and leaves are used in constipation and internally against hemorrhoids. The above-ground parts of the plants were collected from Van Yuzuncu Yil University, Medicinal and Aromatic Plants Garden in 2022. In this study; total ash and dry matter ratio, macro-micro and heavy metal contents were examined. As a result of the study; total ash content was determined as 24.08% and dry matter content as 91.21%. Some of the macro and micro mineral contents were determined as potassium (K), 43.68 g kg<sup>-1</sup>, calcium (Ca), 26.98 g kg<sup>-1</sup>, magnesium (Mg), 3.01 g kg<sup>-1</sup>, iron (Fe), 676.15 mg kg<sup>-1</sup>, zinc (Zn), 47.74 mg kg<sup>-1</sup> and copper (Cu) content was determined as 8.62 mg kg<sup>-1</sup>. In terms of heavy metal content, cadmium (Cd) was determined as 0.02 mg kg<sup>-1</sup>, arsenic (As) as 0.81 mg kg<sup>-1</sup>, lead (Pb) as 2.77 mg kg<sup>-1</sup>, chromium (Cr) as 3.86 mg kg<sup>-1</sup> and cobalt (Co) content was determined as 0.34 mg kg<sup>-1</sup>.

**Keywords:** *Symphytum officinale* L., medicinal plant, chemical content, mineral elements

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## INTRODUCTION

Thousands of years ago, people recognized the healing power of plants and used them to live healthily. With the increasing desire to benefit from plants, the use of medicinal and aromatic plants among the public for therapeutic purposes, food, tea, spices, dyes, insecticides, treatment of animal diseases, resin, glue, volatile and fixed oils, and in the pharmaceutical, beverage and cosmetic industry has become a part of our traditional cultural wealth that has been going on for many years (1, 2). One of these species, the most common name in the world is “Comfrey”, *Symphytum officinale* L., which is also known as “Black Wort” and “Boneset” in different countries (3). “Symphis” means the growth and strengthening of bones, and “phyton” means plants believed to help heal wounds, referring to their use in ancient times (4). The chemical components of the root parts of the plant include high amounts of polysaccharides, phenolic acids, phytosterols, triterpene saponins, glycosides and pyrocatechol type tannins and pyrrolizidine alkaloids (lycopsamine, intermedin, symphytin), as well as allantoin, caffeic acid, carotene, chlorogenic acid, choline, lithospermic acid, rosmarinic acid, vitamins A, C and E, calcium, potassium, phosphorus and selenium (5). The plant has many pharmacological activities thanks to these active components. For example, it has been reported that it has antifungal, antibacterial, anti-inflammatory, analgesic, antioxidant, antinociceptive, antiexudative, vasoprotective, hepatoprotective, astringent, cicatrizant effects, as well as being effective on skeletal muscle diseases. The genus *Symphytum* L. (Comfrey) is a medicinal plant that is quite common in Europe and grows in some regions of Asia and South America (7,8). In Turkey, it grows in the mountainous areas of the Mediterranean Region, the Black Sea coasts and mountainous areas, and in the Marmara Region, generally under forests, in humid and generally shaded areas. This plant genus, which includes approximately 40 species in the world, is represented by 18 species in Turkey, 7 of which are endemic. Turkey is also the country with the highest number of *Symphytum* species in the world, ranking first with a 39% endemism rate. Plants belonging to the *Symphytum* genus have been traditionally used since ancient times, primarily for their anti-inflammatory and analgesic properties. However, the agricultural and phytopharmaceutical use of the genus is mainly limited to a few species; *S. officinale* is an important example of these species (9). In addition to its medicinal use, it has been used in food and grown as fodder to feed farm animals, and was also used as food during the potato famine in Ireland in the 1840s (10). In Germany, *S. officinale* has been used against musculoskeletal disorders since 1920 (11,12). Some sources recommend *S. officinale* for the reinforcement of bone fractures and the acceleration of bone mineralization (13). It is also beneficial for various skin complications such as chronic wounds, burns, eczema and wrinkles. There is also information that the roots of this plant are traditionally used among the public for colds, asthma, bronchitis, tuberculosis, hemorrhoids, kidney diseases, cancer and anemia (14). It has been stated that the ointment made from the root of the *S. officinale* plant, which grows naturally in the northwest of our country, is used as a pain reliever. In addition to ensuring that wounds and burns scab over quickly, it has also been stated that it is good for varicose veins, fractures and osteoarthritis, and that the root of the plant is used among the public for bronchitis and rheumatism (15,16). There are various uses of the *S. officinale* plant in the world. For example, in the Northern Navara Region of Spain, it is used externally for bone fractures, sprains and rheumatism; in Brazil, it is used as a tea for liver problems, gastritis and ulcers; It is known to be used internally for rheumatism in Mexico, as a poultice for skin problems in America; in Lithuania as a tea or ointment for bone and joint pains and bruises; and in Jamaica as a tonic for the juice obtained from the roots of the plant (17). It is thought that rosmarinic



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acid and allantoin, in particular, play a major role in the analgesic and anti-inflammatory effects of *Symphytum* roots (18,19,20). While ointments or compresses are applied externally, the leaves or roots are promising in the treatment of skeletal muscle disorders, wounds, gout, hematoma and thrombophlebitis (8,21). The internal use of *S. officinale* is currently controversial. Long-term use is not recommended due to the presence of pyrrolizidine alkaloids (PA) in its content. Comfrey products (including those for topical use) may lead to serious clinical safety issues because PAs can cause strong mutagenicity, carcinogenicity, and hepatotoxicity (22,23,24).

Although P, K, Ca, Mg and Na are essential minerals for human and animal health, some elements (Cu, Zn, Mn, Mo etc.) are required in lesser amounts for living things. In their absence, both growth and reproduction stop. Some heavy metals in high concentrations can negatively affect plants and humans and animals that feed on plants. Cadmium and lead create serious health problems in humans and animals as environmental pollutants; chromium is an essential microelement and is a toxic element for mammals and other animals at high concentrations, while nickel is a possible carcinogenic element for the same group of living things. However, nickel has been accepted as an essential nutrient element for higher plants (25). It is stated that the most severely toxic heavy metals are Cd, Pb and Hg (26). This study aimed to determine some nutrient elements and heavy metal contents and ash and dry matter ratio of *Symphytum officinale*, a medicinal and aromatic plant that has not been previously examined in terms of these parameters.



Figure 1. *Symphytum officinale* Plant

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## MATERIAL AND METHODS

Above-ground parts of plants were collected from Van Yuzuncu Yil University, Medicinal and Aromatic Plants Garden in 2022. In this study; total ash and dry matter ratio, macro and micro mineral element concentrations and heavy metal contents were examined. Ash and dry matter amount of plant samples were determined according to Kaçar and Inal (2008). 2 grams of pre-ground samples were weighed, placed in porcelain crucibles and placed in a muffle furnace. In the muffle furnace, dry burning process was applied to the samples at 500-550 0C for 4 hours.

The amount of ash and dry matter formed as a result of the burning process was calculated with the following formula:

$$\text{Ash, \%} = [(K-D)/(B-D)] * 100$$

D: Tare weight of the ash container

B: Weight of the plant sample with the ash container

K: Weight of the ash container with the ash

The determination of the dry matter and water content of the plant samples was made according to Kaçar and İnal (2008). 3-5 grams of plant samples were weighed and dried in an oven at 105 0C for 3-5 hours.

The dry matter and water amounts of the samples were calculated with the following formula:

$$\text{Dry matter, \%} = [(K-D)/(B-D)] * 100$$

D: Tare weight of the drying container

B: Weight of the air-dried plant sample with the drying container

K: Weight of the plant sample dried at 105 0C with the drying container

Atomic Absorption Spectrometer (AAS) device was used to determine the mineral contents of the plant materials (Hanlon, 1992). All analyzes carried out in the study were performed in triplicate and standard deviations were determined.

## RESULTS AND DISCUSSION

In this study, the total ash content of the *Sympodium officinale* plant was determined as 24.08% and the dry matter content as 91.21% (Table 1). One of the most important chemical analyses performed on foods is the total ash analysis used to calculate the inorganic matter in its content. The ash of a food is the inorganic residue remaining after the combustion of organic substances. Most minerals are found in foods bound to organic substances (protein, fat, carbohydrate, etc.). When foods are heated at 500-6000C, water and volatile compounds evaporate and organic compounds burn. Mineral compounds remain in the residue as oxides, sulfates, phosphates, silicates or chlorides depending on the burning conditions and the composition of the burned food. Dry matter in plants is the part of the plant other than water and plays a critical role in many functions such as growth, metabolism, storage of nutrients and industrial use. Plants produce organic compounds by combining water and carbon dioxide using sunlight through the process of photosynthesis. These organic compounds are the basic building blocks that make up the dry matter of plants. Dry matter is necessary for the growth and development of plants. The dry matter content of plants generally varies depending on the age of the plant, its species, environmental conditions and cultivation methods. In other previous studies, the dry matter content of some plants was reported to be between 7.50%-90.6 % (28,45). Total ash content was determined as 6.30% in *Cephalaria schrader ex Roemer & schultes G.C. setosa* Boiss & hohen plant, 6.21% in *Cichorium intybus L.* plant and 5.93%

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in *Centaurea karduchorum* Boiss. plant (29,30,31).

**Table 1.** Total ash and dry matter content (%) of *Symphidium officinale* plant

PARAMETERS	CONTENTS
Total ash content (%)	24.08 ±0.522
Dry matter ratio (%)	91.21 ±0.482

In this study, macro element (K, Ca and Mg) contents were determined as 43.68, 26.98 and 3.01 g/kg, respectively, while micro elements; iron (Fe) content was determined as 676.15, manganese (Mn) as 60.69, zinc (Zn) as 47.74, copper (Cu) as 8.62 mg/kg (Table 2). Turan, (2014), in his study on approximately 50 different plant species; determined the highest Zn (31.63 mg kg<sup>-1</sup>), Fe (848.74 mg kg<sup>-1</sup>) and Na (3150.31 mg kg<sup>-1</sup>) contents in comfrey, while K, Ca and Mg contents were determined as 4044.77, 11691.50 and 1182.04 mg kg<sup>-1</sup>, respectively. Maiti et al., (2016) reported that the concentrations of Fe, Cu and Zn in the micronutrient analysis results of 44 traditionally used medicinal plant species were between 98.28 and 3973.55 mg/kg, 4.17 and 33.88 mg/kg and 9.49 and 216.31 mg/kg, respectively. The researcher's findings are in line with our study. While elements such as calcium (Ca), magnesium (Mg) and sodium (Na) are extremely essential for human and animal health, elements such as copper (Cu), zinc (Zn), manganese (Mn) and molybdenum (Mo) are necessary for organisms in smaller amounts. In their absence, both growth and reproduction stop. The deficiency of these elements can cause abnormalities that may lead to infection of diseases (33). In addition, Kabata-Pendias & Pendias, (2001), in mature leaf tissues of a large number of plant species; It is reported that the tolerance limits of Cu content are between 20-100 mg/kg, Zn between 100-400 mg/kg, Mn between 400-1000 mg/kg and Mo between 10-50 mg/kg and that toxicity occurs when these limits are exceeded. The nutrient contents of plants are affected by many factors such as plant genetic structure, growing conditions, soil properties, water availability, and growing seasons. Therefore, large variability is expected in the mineral compositions and different organs of plants (28). The nutrient element concentration values of some medicinal plants obtained from previous studies are as follows: Magnesium (Mg) was reported as 1.17-86.43 g/kg and potassium (K) as 4.34 to 557.91 g/kg, calcium (Ca) concentrations were reported in a wide range, between 0.03 and 777.52 g/kg (35,36,37). In the study; Nickel was determined as 0.88 mg/kg, aluminum as 13072 mg/kg, arsenic as 0.81 mg/kg, cobalt as 0.344 mg/kg, chromium (3.86), lead as 2.77 and cadmium as 0.027 mg/kg. In the study where Kabata-Pendias and Pendias (2001) investigated trace elements and heavy metal concentrations in different plant species, it was reported that the toxic limit of aluminum (Al) was 30.983-368.877 mg/kg, arsenic (As) which is one of the most toxic trace elements, 5-20 mg/kg, cadmium (Cd) as 5-30 mg/kg, cobalt (Co) as 15-50 mg/kg, chromium (Cr) as 5-30 mg/kg and the tolerance range of lead (Pb) was between 30-300 mg/kg. Some metals, such as lead (Pb), cadmium (Cd), cobalt (Co), mercury (Hg), and nickel (Ni), called heavy metals in plants, have toxic effects when they reach certain levels (38,39). Elements such as Fe, Cu, Zn, Mn, Mo, and Ni can be micronutrients for plants and animals and are not toxic as long as they do not exceed permissible limits (40).

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**Table 2.** Macro-micro and heavy metal contents of *Symphytum officinale* plant

<b>MINERALS</b>	<b>CONTENTS</b>		
Mg(g/kg)	3.019285	±	0.040435
K(g/kg)	43.68122	±	2.251315
Ca(g/kg)	26.98378	±	1.010715
Fe (mg/kg)	676.155	±	117.715
Mn (mg/kg)	60.696	±	2.171
Zn (mg/kg)	47.749	±	1.843
Cu (mg/kg)	8.62985	±	0.27625
Ni (mg/kg)	0.8852	±	0.4567
Al (mg/kg)	13072.89	±	1863.607
As (mg/kg)	0.8152	±	0.2142
Cd (mg/kg)	0.02745	±	0.00075
Co (mg/kg)	0.3447	±	0.051
Cr (mg/kg)	3.86605	±	0.52175
Pb (mg/kg)	2.7789	±	0.1938

In addition, if chromium, nickel and lead are found between 10-100 mg/kg in soils and cadmium is below 1 mg/kg, these amounts are considered normal levels. Extractable heavy metal concentrations in soils: Toxic effects may occur when they are above 1 mg/kg for Cd, 10 mg/kg for cobalt, 0.1 mg/kg for copper, 10 mg/kg for selenium, 0.5-1 mg/kg for vanadium and 100 mg/kg for nickel (25). Similar results were obtained with our research findings; Cr, Cd and Co contents of medicinal plants and wild vegetables were determined to be between 0.10-425.0 mg/kg (41,42), 0.007-0.47 mg/kg (42) and 0.05-1.35 mg/kg (43), respectively. Turan (2014) determined the amounts of Cu, Mn, Pb, Cd, Cr and Ni as 5.44, 55.32, 0.15, 0.26, 2.17 and 1.95 mg kg<sup>-1</sup> in his study on approximately 50 different plant species, respectively.

## **CONCLUSION**

The minerals found in foods should be within the tolerance limits determined by the World Health Organization. In this study, while the contents of essential elements, especially Mn, Cu and Zn, were determined to be well below toxic tolerance levels, the values obtained were determined to be within normal limits. Otherwise, negative and undesirable effects on human health may occur. Heavy metals, on the other hand, show toxic effects when they exceed concentration limits. As a result of the research; It was determined that *Symphodium officinale* is within the tolerance limits in terms of heavy metals, and especially As, Cd, Co, Cr and Pb concentrations are well below the toxicity limits. It is important to consume plants consciously, considering that elements that accumulate in high concentrations in all living things, and especially heavy metals, can be harmful to health.

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**SMART AGRICULTURE TECHNIQUES IN PLANT NUTRITION**

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**Abstract**

Fertilizers play a key role in promoting healthy plant growth and increasing crop yields. However, excessive use of fertilizers often leads to several negative environmental impacts, including soil pollution, nutrient runoff into water bodies and reduction of long-term soil fertility. An abrupt ban on the use of fertilizers would be infeasible hence, sustainable practices play a huge role towards the management of crop health and productivity. Automation in agriculture nowadays is the main focus and area of development for various countries. The population rate of the world is increasing rapidly and will be double in upcoming decades and the need of food is also increasing accordingly. To meet this rapid growth in demand, agriculture automation is the best solution. Traditional strategies employed by farmers are not efficient enough to fulfill the rising demand. Improper use of nutrients, water, fertilizers and pesticides disturbs the agricultural growth and the land remains barren with no fertility.. In this research paper, plant nutrition approaches in smart agriculture are examined and their working rationale is analysed.

**Keywords:** Remote Sensing, Fertilization, Precision Agriculture, Nutrient Use Efficiency, Precision Farming.



### **1. An Introduction to Precision Agriculture**

In order to reduce chemical input and increase plant yield, precision agriculture (PA), also known as "smart agriculture," is necessary. It is described as "a management strategy that gathers, processes, and analyzes temporal, spatial, and individual data and combines it with other information to support management decisions according to estimated variability for improved resource use efficiency, productivity, quality, profitability, and sustainability of agricultural production" (ISPA., 2023). Stated differently, PA is the application of technologies that can control the spatial and temporal variability of the field to maximize crop yield and environmental well-being (Pierce & Novak., 1990). The implementation of PA approaches through soil and plant condition monitoring will increase the efficiency of fertilizer use, optimize agricultural revenue, and lower the risk of contamination. Although precision agriculture offers creative ways to increase crop yield, it necessitates trustworthy instruments that can give accurate, up-to-date data on soil nutrient availability and plant nutritional status, as well as the ability to create a site-specific database of plant-soil relationships (Yin et al., 2022). Because of the expansion of the cultivated area and the significance of agri-food supply chains, the agricultural industry is vital to the economies of Italy and Europe. Therefore, it is essential to strategically support the sector using methods and practices that can satisfy the new Common Agricultural Policy (CAP) objectives. Examples of CAP goals include providing farmers with a sufficient income, boosting business competitiveness, mitigating and adapting to climate change, protecting landscapes, conserving biodiversity, developing rural areas, promoting innovation, transferring knowledge, and managing production factors efficiently. Agricultural businesses must therefore rely on management techniques founded a thorough understanding of the agroecosystem and the potential interactions among its elements. Although the initial applications of PA methods were created for dairy and arable farming, same technologies can also be used in other industries, such as the production of fruits and vegetables, which have significant economic value even on a small scale. Utilizing PA in small-scale farming may also be a useful tactic to lower expenses (reduced resource consumption) and lessen environmental harm. This is helpful in creating more environmentally friendly and economically profitable agronomic management techniques. Innovative equipment and instruments that are currently on the market are the result of scientific and technological advancements over past several decades. techniques can be used in productive processes to boost sustainability and efficiency, they must be used in conjunction with the respectful management of agroecosystems and the elements that make them up (soil, plants, and atmosphere). Thanks to the utilization of multi-source data on soil fertility and plant nutritional status, PA in this case is an efficient approach to achieving these objectives.

### **2. Observation in the Field**

The measuring of particular parameters influencing the soil-plant-atmosphere system as a function of crop development during the biological cycle is known as field monitoring. Using the right instruments to quickly identify and quantify the primary characteristics of soil that are associated with crop development is crucial from a strategic standpoint. OM, soil texture, water availability, temperature, electrical conductivity, and nutrient concentration are a few examples. With regard to plants, proximate or remote-sensing methods (such as satellite or drone imagery) can be used to track vegetative vigor and nutritional status. Lastly, to maintain control over the most significant agrometeorological variables and provide long-term forecasts using climate modeling, atmospheric monitoring using suitable weather stations is required. At

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the moment, methods for identifying these factors rely on the usage of sensors that fall into two different categories: proximate sensing and remote sensing. Drones and satellites are the most widely used remote sensing systems in Pennsylvania. Proximal sensing, on the other hand, uses a variety of sensors that fall into two groups: static and dynamic. Agrometeorological stations and soil sensors are examples of static sensors. Agrometeorological parameters that are helpful for agronomic operations planning can be determined thanks to the former's ability to record climatic trend data over time. The evolution of soil physical variables, such as moisture, temperature, and electrical conductivity, is represented by soil sensors. Dynamic sensors are used to describe crops or soil and their respective properties throughout time (during the season) and space (various places in plots).

## 2.1. Sensing remotely

The measurement of an object's reflected or emitted electromagnetic radiation at a specific distance is the foundation of remote sensing (Lillesand & Kiefer., 1994). Sensors can operate in the optical domain (0.4–2.5  $\mu\text{m}$ ), the thermal infrared (4–10  $\mu\text{m}$ ), or the microwave (3–10 mm), depending on the wavelength of radiation detected. Most sensors, however, assess the average reflectance over a range of wavelengths, known as a band, and are unable to distinguish the full spectrum and all of its nuances. The number of bands and their distribution determine the capacity to distinguish between various things, such as soil and leaves with varying chlorophyll concentrations. The sensors found on the majority of satellites are referred to as multispectral since they have a restricted number of bands (three to ten). Hyperspectral sensors, on the other hand, have many more bands—up to a few hundred—and are able to fully describe an object's spectral fingerprints.

The foundation of remote sensing, regardless of the purpose of the sensor, is the correlation between the sensors' recorded reflectance and agronomic factors including crop canopy development, vegetative vigor, and chlorophyll content. The calculation of vegetation indices (VI), which are mathematical functions that combine two or more spectral bands, is one of the most reliable methods for this purpose. In order to assess the impact of various agronomic management techniques, the most significant vegetation indices are utilized to measure bio-physical characteristics (yield, stress conditions, disease presence, etc.) for crop monitoring (Wiegand et al., 1991). The Leaf Area Index (LAI), which calculates the total leaf surface per unit area, and the chlorophyll content of leaves are two of the most helpful bio-physical parameters for PA applications. Both variables provide information on the vegetative status of the crop (i.e., the existence of sub-optimal plant development). The Normalized Difference Vegetation Index (NDVI) (Tilling et al., 2007) and the Modified Soil-Adjusted Vegetation Index (MSAVI) (Qi et al., 1994) are two vegetation indices that are frequently used to examine crop development and phenological stage. IT systems make it simple to see these as maps. Platforms should be chosen based on their resolution and assessed in relation to the crops and measurement goals. For example, compared to horticultural crops, a lesser resolution is required to define the fertilizing plan for vast crops. Since high spatial and spectral precision is crucial, Unmanned Aerial Vehicles (UAV) can monitor weeds or pathogens with centimeter spatial resolution.

## 2.2. Satellites

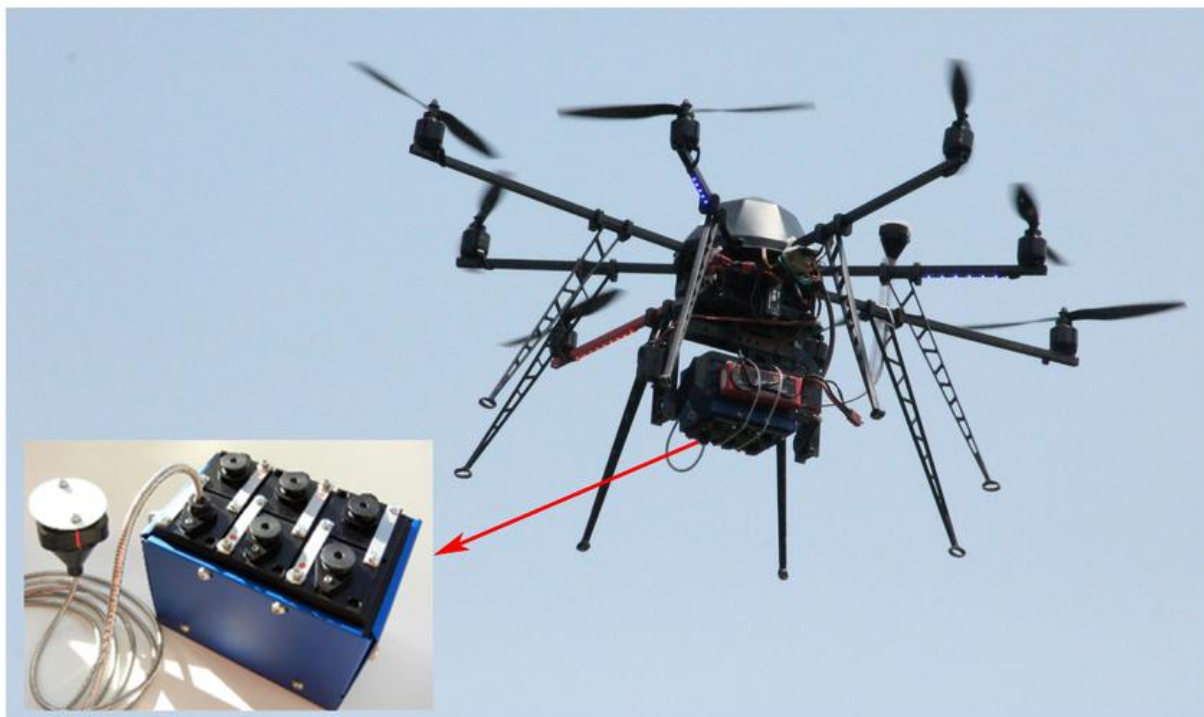
Precision agriculture requires systems with elevated spatial resolution and frequent acquisition rates to assess crop status at various stages of biological cycles. These needs are fulfilled by various satellite systems deployed in orbit by government agencies and private enterprises over the past several decades. These entities frequently operate missions composed of multiple

satellites of the same category, referred to as constellations. Each satellite typically possesses one or more onboard sensors, whose broadcast data are collected by stations and processed to rectify primary distortions (atmospheric effects, geometric distortions, etc.). Subsequently, the photos produced by the system are delivered to consumers via web solutions, rendering data accessible online. Such data can be systematically analyzed using specialized algorithms to derive vegetative vigor indices or to estimate crop biophysical characteristics. Satellite imagery provides accurate data regarding in-field variability; specifically, its capacity to differentiate between various wavelengths (green at 520–600 nm, red at 630 nm, and NIR bands at 760–900 nm) yields critical insights into water and nitrogen deficiencies (Muñoz-Huerta et al., 2013).

### **2.3. Unmanned Aerial Vehicles**

Unmanned Aerial Vehicles, generally referred to as drones, are remotely operated flying platforms controlled by an operator using remote control devices and navigation systems (Figure 1). In Pennsylvania, UAVs are employed for many purposes, including capturing photographs and detecting images. From a technical perspective, UAVs can incorporate many technology components such as flight sensors, cameras, robotic arms, and radio receivers. From an operational perspective, the primary advantages of utilizing UAVs include their superior spatial resolution, access to a diverse array of cameras and sensors (such as multispectral and hyperspectral sensors, laser scanners, thermal, and RGB cameras), and the ability to determine the timing of picture acquisition. Conversely, there are several disadvantages associated with the utilization of drones. For example, photos require correction due to the influence of daylight brightness and atmospheric water vapor content on crop reflectance. Moreover, flights must be conducted by certified specialists who are specifically trained for this task.

For some crops, data collected from weather stations can feed forecasting phenological models able to estimate the evolution of plant phenological stages. In the most advanced weather stations, sensors measuring solar radiation and wind speed are also implemented. These sensors can calculate reference evapotranspiration, allowing the implementation of crop water balance for planning irrigation.



**Figure 1.** Hexacopter UAV equipped with multispectral camera composed of an array of nine sensors to acquire images in the VIS-NIR spectrum

#### **2.4. Soil Moisture Sensors**

Soil moisture sensors are widely used in precision irrigation. Soil water availability can be expressed as water content and is generated from the ratio between the water volume and total volume of soil, or as soil matric potential, that is, the adhesion and cohesion forces that hold water within the soil. Soil moisture sensors are equipped with one or more probes for detecting water content at different soil depths and can be positioned in relation to root depth. The most widespread sensors used for measuring matric potential are the tensiometers, which consists of a porous ceramic cup filled with distilled water and which are buried in the soil. Once in the soil, the water inside the porous cup equilibrates with the soil moisture through the pores in the ceramic cup; the loss of water causes a drop in its hydrostatic pressure that will be indicated by the pressure gauge (Susha Lekhmi et al., 2014).

#### **2.5. Sensors for Soil Nutrient Detection**

In soils with adequate aeration and moderate temperatures, the predominant form of nitrogen is nitrate ( $\text{NO}_3^-$ ), which remains dissolved in soil-water solutions, is not adsorbed by colloids, and is perpetually susceptible to leaching when soil moisture above field capacity. Soil nitrate content exhibits significant variability due to the intricate interplay of microbiological, chemical, and physical processes, and it fluctuates during the growing season as a result of mineralization, immobilization, absorption, and other turnover mechanisms. Efforts to establish a modeling technique aimed at mitigating issues stemming from soil heterogeneity and enhancing precision in fertilization control have frequently been unsuccessful. A comparable tendency is evident in sulfur (S), predominantly found in soil as  $\text{SO}_4^{2-}$  (sulfate anion), but this nutrient has received somewhat less scrutiny. The behaviors of nitrogen and sulfur are consistent across all soils, while the mobility of other nutrients is contingent upon soil conditions. Soils exhibiting a neutral to sub-alkaline pH, with clay, clay-loam, silt, or silt-

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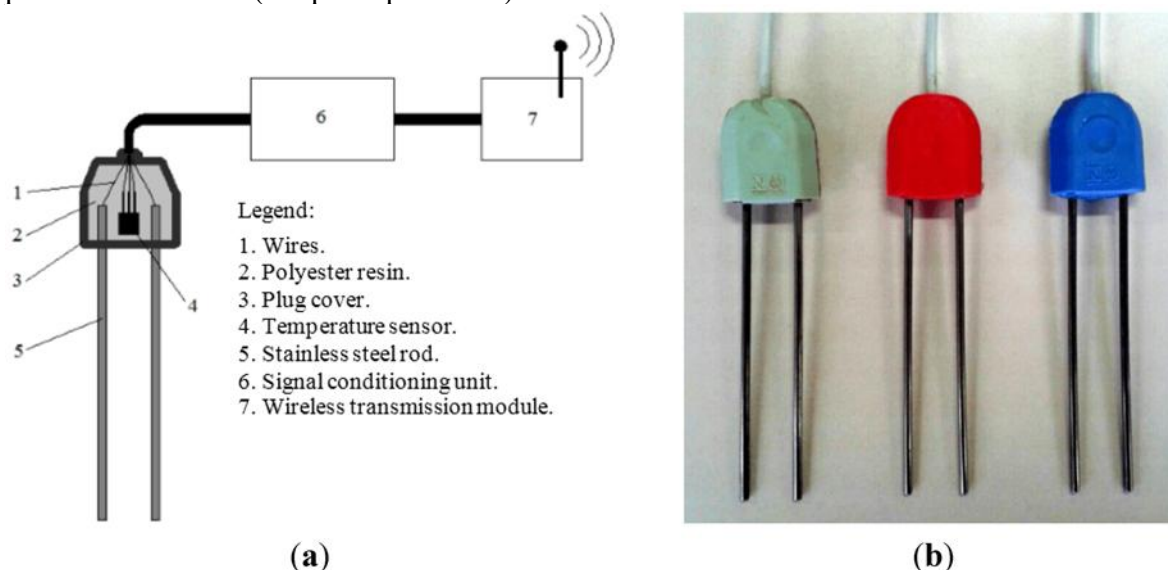
loam textures and elevated organic matter content, are distinguished by a high cation exchange capacity (CEC), which reduces the concentration of cations in a solution and inhibits their leaching. In soils characterized by low pH, sandy texture, and minimal organic matter, the reduced cation exchange capacity heightens the susceptibility to cation leaching in aqueous solutions. Regardless of soil conditions, phosphorus typically exhibits low mobility due to its aggregation in hydroxylic compounds such as  $\text{Ca}(\text{OH})_2$ ,  $\text{Al}(\text{OH})_3$ , and  $\text{Fe}(\text{OH})_3$  in sub-alkaline, neutral, and sub-acid soils, respectively. In this context, prior to deciding on fertilization, it is essential to meticulously assess the nutrient concentrations in the soil solution and the soil moisture; ideally, nutrients should be administered solely to regions with sufficient soil humidity (Tilling et al., 2007).

Soil nitrogen mostly exists in organic form, rendering it unavailable for root absorption until it undergoes mineralization by soil microbes, converting it to ammonium ( $\text{NH}_4^+$ ), followed by oxidation to nitrite ( $\text{NO}_2^-$ ) and nitrate ( $\text{NO}_3^-$ ). Traditionally, mineral nitrogen can be quantified through soil sampling and either offsite laboratory analysis or onsite observations. Laboratory analyses are precise, economical, and straightforward to conduct; yet, they are time-intensive and yield results days after sampling. Conversely, on-site measurements can deliver real-time data regarding nitrogen trends at the root level and can swiftly determine the optimal conditions for the application of smart and precise fertilizer inputs. The existing technologies for on-site nutritional determination can be categorized based on the sensors utilized: optical/radiometric, electrical/electromagnetic, electrochemical, and mechanical.

### 2.6. Electrical and Electromagnetic Sensors

For decades, electrical and electromagnetic sensors have been employed for continuous, non-invasive measurements of nutrient concentration in soil solutions. Their foundation lies in the assessment of apparent electric conductivity (ECa) of a soil solution (Molin et al., 2019), quantifying the soil's ability to store or transmit an electrical charge (Figure 2). The predominant sensors assess electromagnetic induction or electrical resistivity. The previous sensors consist of a transmitter and a receiver that do not directly contact the soil, generating a changeable magnetic field to generate an electrical current in the soil, which is linearly correlated with soil conductivity. Conversely, the probes utilized for measuring electrical resistivity are in direct contact with the soil and have two electrodes: one generates current, while the other measures the resultant potential difference, which indicates the soil's resistivity, the inverse of conductivity (Molin et al., 2019). Electrical conductivity primarily correlates with soil texture and moisture; therefore, these two attributes must be taken into account when utilizing ECa to assess soil nutrient availability. Positioning probes adjacent to water emitters, where soil moisture is maintained consistently, would avert erroneous interpretations of the results concerning soil humidity. A robust correlation between ECa and  $\text{K}^+$  and  $\text{Ca}^{2+}$  was established in the acidic soils of Brazil. Additionally, a significant relationship between soil extract, ECa, and nitrate was noted, with a coefficient of determination ( $R^2$ ) of 0.98 (Patriquin et al., 1993), indicating that data derived from ECa measurements is comparable to that obtained from nitrate analysis (Miyamoto et al., 2015). A decent correlation between ECa and  $\text{NO}_3^-$  was observed solely in clay soils of calcareous Italian regions, yielding an  $R^2$  of 0.64, but no significant link was identified in loam soils (Baldi et al., 2020). The varying responses can be attributed to the influence of soil texture on cation exchange capacity (CEC), primarily associated with the prevalence of clay. As ECa quantifies the presence of soluble and easily dissolvable salts, encompassing cations (e.g.,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Mg}^{2+}$ ,  $\text{Ca}^{2+}$ ) and anionic species ( $\text{Cl}^-$ ,  $\text{HCO}_3^-$ ,  $\text{NO}_3^-$ , and  $\text{SO}_4^{2-}$ ) as well as nonionic solutes, the diminished activity of cations in

a soil solution (adsorbed by the negative electrical charges of the clay) can enhance the precision of  $\text{NO}_3^-$  (the principal anion) measurement.



**Figure 2.** (a) Probe for measuring water content and apparent electrical conductivity of soil; (b) Probes for measuring temperature, electrical conductivity and relative dielectric constant.

### 3. Conclusions

Precision agriculture employs techniques and technologies to gather extensive data from many proximal and remote sources. Technological advancements have rendered state-of-the-art instruments available in the market, characterized by excellent accuracy and reliability. While this is a beneficial component, the gathered data must be integrated into scientifically robust criteria and rationales to develop agronomic models, hence establishing decision support systems. Concerning crop nutrition, these models must replicate nutrient dynamics by accounting for the interactions among the primary components of the agroecosystem, including soil, crop genetics, climatic patterns, and agronomic practices. Currently, two primary disadvantages are present: Reliability and accuracy. Despite the establishment of certain agronomic models grounded in scientific literature, they require validation across diverse contexts and regions, as well as replication over several years to confirm their robustness and replicability. This workflow is currently in the preparatory phase concerning the principal crops. Input data for agronomic models must be easily accessible and useful to provide decision support system outputs, ensuring adequate time for planning field operations. In certain instances, this is feasible due to the employed tools. Notwithstanding the aforementioned difficulties, it is anticipated that scientific advancement and technological innovation will soon render instruments, methods, and gadgets that alleviate such issues available commercially.

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**VARIATION OF SOIL CARBON SEQUESTRATION IN SOIL PROFILES OF SEMI-  
ARID REGIONS**

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**Abstract**

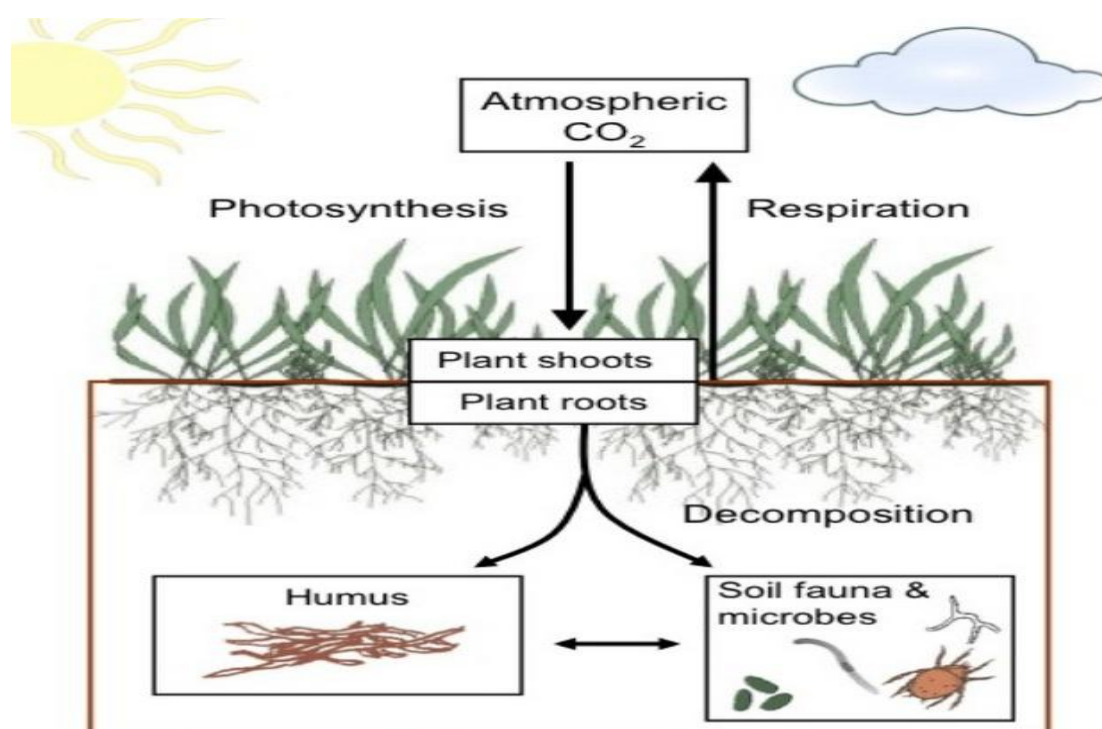
Soil carbon sequestration in semi-arid regions is an essential process for mitigating climate change and enhancing soil fertility. Understanding the dynamics of soil carbon in different soil profiles particularly in semi-arid climates is crucial for managing these ecosystems in the face of increasing anthropogenic pressures and climate variability. This study explores the variations in soil carbon sequestration in semi-arid regions, emphasizing how different soil profiles interact with climatic factors such as temperature, precipitation, and vegetation cover. Additionally, the implications of these findings on sustainable land management and carbon reduction strategies in semiarid ecosystems were also investigated. Through literature review, we evaluated the influence of various factors on soil organic carbon (SOC) at different depths in semiarid regions, focusing on the impacts of land management and climate change on soil organic carbon (SOC).

**Keywords:** Semi-arid regions, soil carbon sequestration, soil organic carbon, soil profile



### Introduction

Soil carbon sequestration refers to the process through which atmospheric carbon dioxide is captured by plants, transformed into organic matter, and stored in soil (Figure 1). This process is of critical importance in semi-arid regions, which cover approximately 30-40% of the Earth's terrestrial surface. These regions are highly susceptible to desertification, erosion, and loss of soil fertility due to limited water availability and fluctuating climatic conditions (Fantappiè et al., 2011). Understanding how soil carbon varies with depth in these environments is vital for devising effective soil management strategies that enhance carbon sequestration and contribute to global climate change mitigation efforts.



**Figure 1.** Carbon balance within the soil) is controlled by carbon inputs from photosynthesis and carbon losses by respiration (Ontl.& Schulte, 2012).

Soil profiles, which are vertical layers that show the distribution of soil horizons from the surface to deeper layers, serve as a useful tool to examine the variation of soil carbon storage at different depths. In semi-arid regions, the ability of soils to sequester carbon is influenced by several factors, including soil texture, microbial activity, organic matter inputs, and the climate. Different soil profiles, ranging from shallow soils with limited water retention to deeper soils with better moisture-holding capacity, demonstrate distinct patterns of carbon accumulation and turnover. The general situation regarding carbon sequestration is given in Figure 2.

This article emphasizes the role of soil profiles in soil carbon sequestration and the specific challenges posed by semi-arid climates, highlighting how soil depth, texture, and land management influence SOC storage and its stability in these regions.

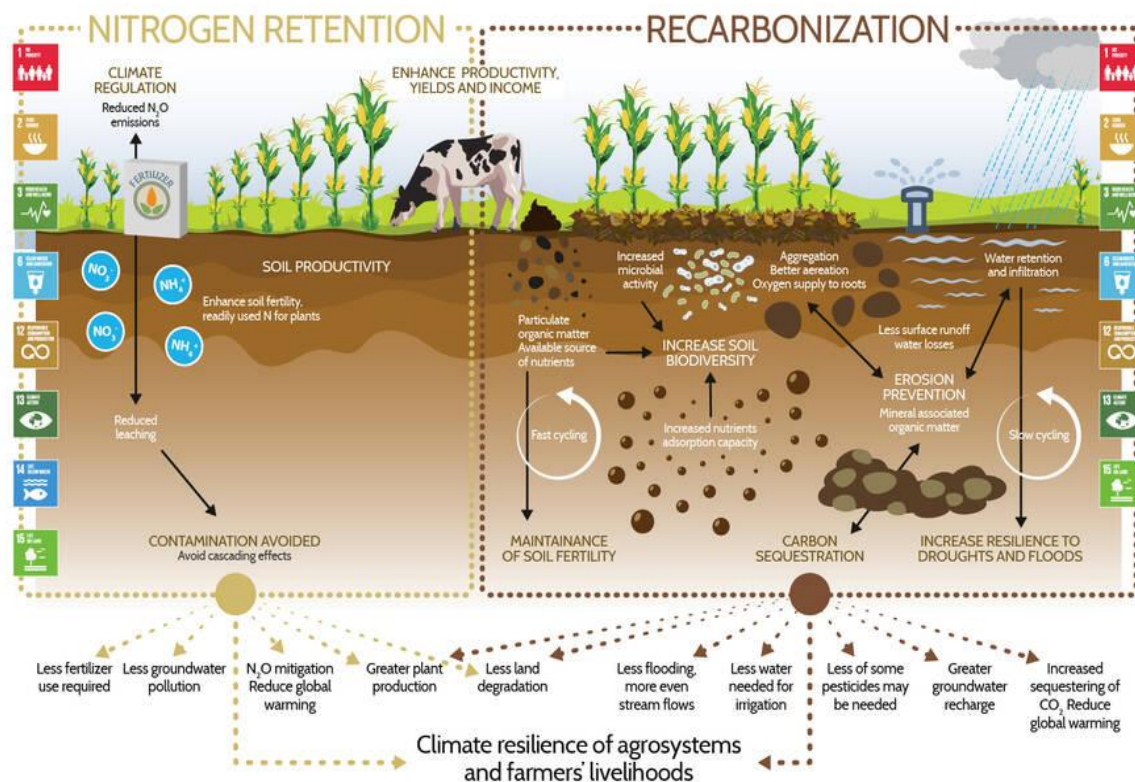


Figure 2. Carbon sequestration in soil (FAO,2024)

### Semi-Arid Climates and Soil Carbon Dynamics

Semi-arid climates are characterized by irregular and generally low rainfall (between 250 mm and 500 mm annually), high evaporation rates, and limited vegetation cover. These conditions pose challenges for soil carbon sequestration, particularly because plant growth—which drives organic matter input to the soil relies on rainfall, which is often erratic and insufficient to support continuous vegetation cover. Additionally, high temperatures and intense solar radiation accelerate the decomposition of soil organic matter, reducing the potential for long-term carbon storage.

In semi-arid regions, precipitation is the primary climatic factor influencing soil carbon dynamics. While rainfall supports plant growth and carbon input into the soil, it also drives microbial activity, which can either enhance or reduce soil carbon stocks. During periods of drought, soil microbes enter a dormant state, reducing decomposition rates and resulting in the accumulation of organic carbon. Conversely, during wet periods, enhanced microbial activity leads to increased decomposition and mineralization of organic carbon into carbon dioxide, which is released into the atmosphere (Cheng et al., 2015). This variability in microbial activity and organic matter turnover creates significant fluctuations in SOC levels across seasons and years.

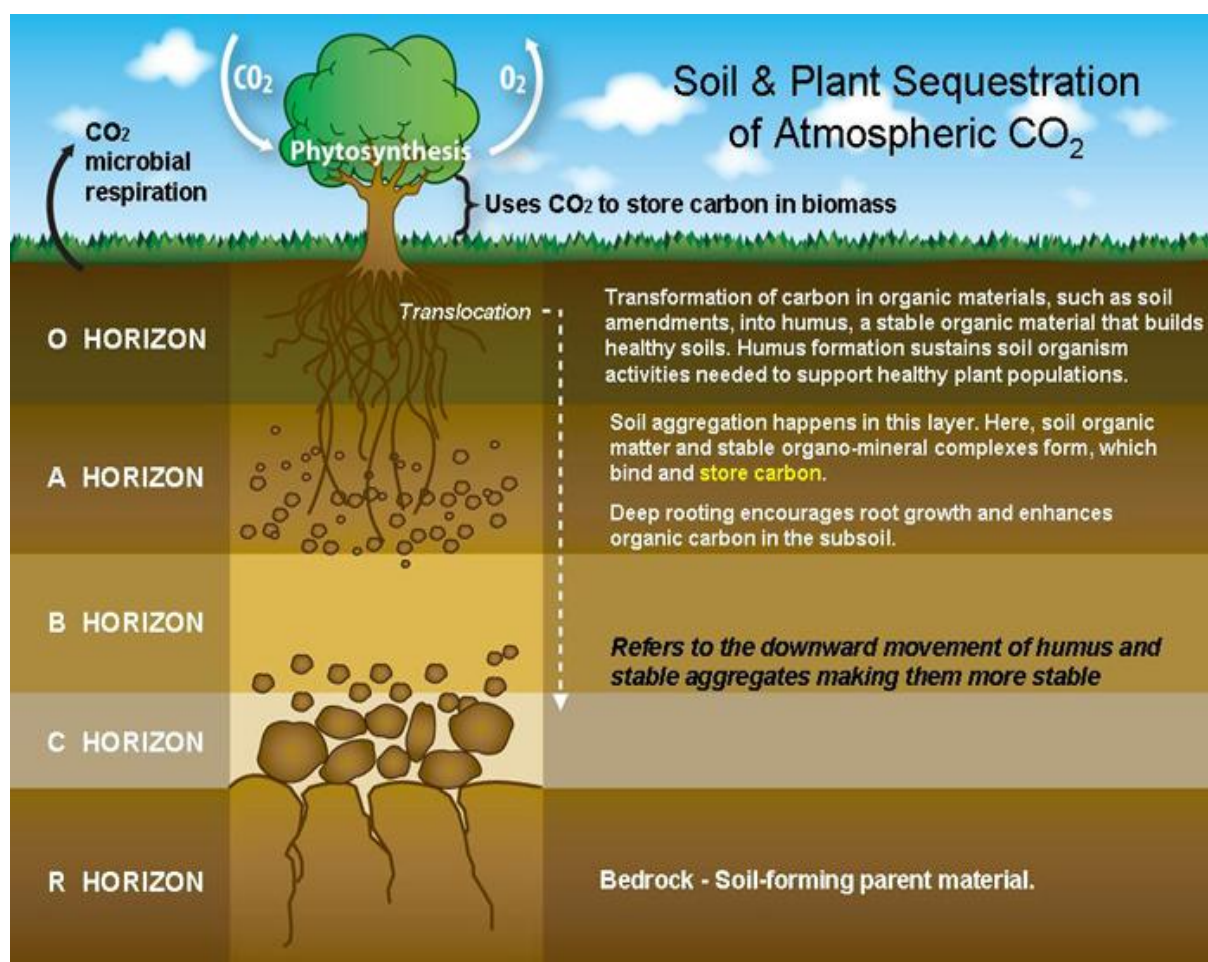
Soil profile depth plays an important role in determining the carbon storage potential in these environments. The uppermost horizons typically accumulate higher quantities of organic carbon due to the continuous input of plant residues and root biomass. However, deeper horizons if they are protected from microbial degradation—can store carbon for much longer periods, as they are less affected by surface soil processes and disturbances (Gu et al., 2018).

### The Role of Soil Profiles in Carbon Sequestration

Soil profiles consist of multiple layers, or horizons, each with distinct physical, chemical, and biological properties that influence carbon sequestration. The primary soil horizons are:

1. **O-horizon (Organic layer):** Rich in plant material and decomposed organic matter, this layer contains the highest concentrations of SOC in most ecosystems.
2. **A-horizon (Topsoil):** The uppermost mineral layer, often rich in organic matter and microbial activity, where the highest rates of carbon turnover occur.
3. **B-horizon (Subsoil):** A deeper, more mineral-rich layer where organic matter is less abundant but can store stable carbon.
4. **C-horizon (Parent material):** Composed mainly of unweathered rocks or unconsolidated materials, this layer typically has little to no organic carbon but can contribute to carbon sequestration when altered by soil processes.

Soil carbon persists throughout the soil profile, typically in higher concentration at the surface and lower concentration in deeper horizons of mineral soils. Soil horizons and soil carbon in profiles given Figure 3.



**Figure3.** Soil horizons and soil carbon in profiles (<https://international-soil-radiocarbon-database.github.io/SOC-Hub/global-context/2017/05/04/Dynamic-role/>)

### Soil Depth and Carbon Storage

In semi-arid regions, the distribution of SOC across these horizons varies greatly. In the

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shallow soils typical of arid or semi-arid environments, carbon is primarily concentrated in the O- and A-horizons, which are directly influenced by plant root systems and surface processes. However, the organic carbon content in these upper layers is highly susceptible to changes in land use and climatic conditions, such as drought or intense heat, which can accelerate decomposition and reduce carbon stocks.

In deeper soil profiles, particularly those that are less disturbed by tillage or human activity, carbon sequestration may be more stable. The B-horizon can accumulate and store SOC for extended periods due to its reduced exposure to microbial activity and slower turnover rates. The deeper horizons act as a reservoir of long-term carbon storage, provided they are protected from erosion or other forms of disturbance. Studies have shown that semi-arid regions with deep soils can store significant amounts of carbon, even under low precipitation conditions, provided that soil structure is preserved (Álvaro-Fuentes & Paustian 2011).

## **Soil Texture and Carbon Storage**

Soil texture defined by the proportions of sand, silt, and clay in a soil sample—also plays a critical role in determining SOC levels. Clay-rich soils have greater carbon storage potential than sandy soils, as the fine particles in clay can adsorb and protect organic matter from microbial decomposition. In semi-arid regions, where soil erosion is a frequent concern, clay soils may offer a greater capacity for long-term carbon sequestration, especially in deeper layers where microbial activity is lower (Schlesinger, 2005). Sandy soils, on the other hand, are more prone to rapid decomposition and carbon loss due to their lower moisture retention capacity and larger particle size, which provides fewer sites for carbon protection.

## **Microbial Activity and Carbon Decomposition**

Microbial activity is a major driver of organic carbon turnover in soil, and its intensity is directly linked to temperature and moisture availability in semi-arid climates. Under dry conditions, microbial populations often decrease, resulting in slower decomposition rates and higher organic carbon retention. However, during wet periods, the rapid increase in microbial activity can lead to the breakdown of organic matter and the release of carbon as CO<sub>2</sub> (Schlesinger & Andrews, 2000). This dynamic microbial activity can cause significant fluctuations in the soil carbon content of semi-arid regions, making it difficult to predict long-term sequestration rates.

## **The Impact of Land Management on Soil Carbon in Semi-Arid Regions**

Land management practices are crucial in determining the capacity of semi-arid soils to sequester carbon. Sustainable land management practices, such as conservation tillage, agroforestry, and the use of organic amendments, can enhance carbon sequestration by reducing soil erosion, improving soil structure, and increasing organic matter inputs. For instance, no-till farming, which minimizes soil disturbance, has been shown to improve SOC stocks by maintaining the integrity of soil profiles and reducing the exposure of carbon to microbial decomposition (Baïamonte et al., 2022). In contrast, intensive land use practices such as overgrazing, monoculture cropping, and conventional tillage can lead to soil degradation, erosion, and a reduction in the soil's carbon storage capacity. These practices typically disrupt soil profiles, causing the loss of organic carbon from the upper horizons and reducing the ability of the soil to sequester carbon at deeper levels (Yu et al., 2020).

## **Vegetation and Carbon Inputs**

The type and density of vegetation cover in semi-arid regions are essential factors in determining the amount of organic carbon entering the soil. Deep-rooted plants, such as

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perennial grasses and shrubs, are particularly effective in contributing carbon to deeper soil layers, where organic matter can be more stable. These plants help stabilize the soil profile by enhancing soil structure and increasing the soil's water-holding capacity, which in turn facilitates greater microbial activity and carbon sequestration (Thapa et al., 2023).

## **Implications for Climate Change Mitigation**

Given the variability in soil carbon sequestration across different soil profiles in semi-arid regions, it is essential that land management practices be tailored to local conditions. Effective soil carbon management strategies in these regions should consider factors such as soil texture, profile depth, vegetation cover, and land use practices to maximize carbon storage. Moreover, understanding the vertical distribution of SOC in these profiles can provide valuable insights into long-term carbon sequestration potential and help inform climate change mitigation strategies.

Sustainable land practices, such as reforestation, agroecological farming systems, and the adoption of conservation tillage, can enhance carbon sequestration by improving organic matter inputs, protecting soil from erosion, and maintaining the stability of deeper soil profiles (Lal, 2004). These strategies not only contribute to mitigating climate change but also help improve soil fertility, water retention, and overall ecosystem resilience in semi-arid regions.

## **Conclusion**

The variation of soil carbon sequestration in semi-arid regions is deeply influenced by the characteristics of soil profiles, including depth, texture, and microbial activity. By understanding the interactions between these factors and the semi-arid climate, land managers can design more effective strategies for enhancing carbon storage in these vulnerable ecosystems. Future research should focus on refining methods to assess and predict the long-term carbon sequestration potential of different soil profiles and evaluating the effectiveness of various land management practices in semi-arid regions. This approach will be crucial in mitigating climate change while maintaining the sustainability of semi-arid agricultural systems.

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**ORGANİK TARIM ÇALIŞMALARININ BİBLİYOMETRİK ANALİZİ: WEB OF  
SCIENCE UYGULAMASI**

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Van-Türkiye

**Özet**

Bu çalışmada, Web of Science (WoS) veri tabanında organik tarım konusundaki akademik çalışmaların bibliyometrik analizini gerçekleştirmiştir. 14606 çalışmanın incelendiği bu analizde, yayınlar yıl, yazar, dergi, organizasyon ve ülke temelinde değerlendirilmiştir. Elde edilen bulgular, organik tarım çalışmalarının özellikle çevre dostu ve sürdürülebilir tarım uygulamaları açısından yoğunlaştığını göstermektedir. En fazla atıf alan yazarlar, en popüler dergiler ve en çok yayın yapan ülkeler tanımlanmıştır. Ayrıca, VOSviewer yazılımı kullanılarak yazarlar ve kurumlar arasındaki bağlantılar görselleştirilmiştir. Çalışma sonuçlarının, organik tarım alanındaki mevcut eğilimlerin belirlenmesine ve literatüre katkı sağlayacağı ümit edilmektedir.

**Anahtar Kelimeler:** Çevre dostu üretim, Çevresel sürdürülebilirlik, Bilimsel literatür analizi,

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**BIBLIOMETRIC ANALYSIS OF STUDIES ON ORGANIC AGRICULTURE: WEB  
OF SCIENCE APPLICATION**

**Abstract**

This study was conducted a bibliometric analysis of academic studies on organic farming in the Web of Science (WoS) database. A total of 14606 studies were examined, evaluating publications based on year, author, journal, organization, and country. The findings indicate that organic farming research is particularly focused on environmentally friendly and sustainable agricultural practices. The most cited authors, popular journals, and countries with the highest publication rates were identified. Additionally, using VOSviewer software, connections between keywords, authors, and institutions were visualized. It is expected that the study results will contribute to the literature and determine current trends in organic agriculture.

**Keywords:** Environmentally friendly production, Environmental sustainability, Bibliometric analysis, VOSviewer



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## Giriş

Organik tarım, ekolojik sistemde hatalı uygulamalar nedeniyle bozulan doğal dengeyi yeniden kurmayı hedefleyen, çevreye ve insana dost bir üretim sistemi olup, sentetik kimyasal ilaçlar ve gübrelerin kullanımı yerine, organik ve yeşil gübreleme, ekim nöbeti, toprağın korunması, bitki direncinin artırılması ve parazit ile predatörlerden yararlanma gibi yöntemleri teşvik eden ve üretimde miktar artışını değil ürünün kalitesinin yükselmesini hedefleyen bir üretim şeklidir (Rehber ve Turhan, 2001). Organik tarım çevresel sürdürülebilirliği teşvik eden, doğal kaynakların korunmasını esas alan ve insan sağlığını ön planda tutan bir üretim sistemi olarak günümüzde giderek önem kazanmaktadır (Pânzaru vd., 2023).

Artan çevresel sorunlar, iklim değişikliği ve tarımsal üretimdeki kimyasal yoğunluk gibi faktörler, organik tarımı daha sürdürülebilir bir alternatif olarak öne çıkarmaktadır (Ondrasek vd., 2023; Sahu ve Pradhan, 2023). Bu durum, organik tarım konusundaki bilimsel çalışmaların da hızla artmasına neden olmuştur. Ancak, bu alandaki araştırma eğilimlerinin, yazar ağlarının ve temel çalışma alanlarının daha iyi anlaşılması, gelecekteki bilimsel ve uygulamalı çalışmalar için yol gösterici olacaktır (Brumă vd., 2023).

Bibliyometrik analiz, belirli bir disiplin veya konu üzerindeki bilimsel literatürün niceliksel bir incelemesini sunarak, araştırma eğilimlerini, önemli bilimsel katkıları ve akademik işbirliklerini anlamaya olanak tanır (Keçeli Erciyas, 2022). Bu analiz yöntemi, özellikle hızlı büyüyen ve genişleyen araştırma alanlarında, mevcut bilgilerin sistematik bir şekilde özetlenmesi ve değerlendirilmesi için güçlü bir araçtır. Organik tarım alanında yapılan çalışmalara yönelik bir bibliyometrik analiz, bu disiplinin mevcut durumunu, gelişim süreçlerini ve gelecekteki yönelimlerini belirlemek açısından kritik öneme sahiptir. Ayrıca, organik tarımın farklı alt başlıklarında yapılan araştırmaların derinlemesine anlaşılması, politikacılara, çiftçilere ve araştırmacılara değerli bilgiler sağlayabilir.

Bu çalışmada, Web of Science (WoS) veri tabanında yer alan organik tarım ile ilgili akademik çalışmaların bibliyometrik analizi yapılmıştır. Çalışma, organik tarım alanındaki mevcut eğilimleri ortaya koymayı, literatüre katkı sağlamayı ve araştırmacılara bu alanda yol gösterici bir çerçeve sunmayı amaçlamaktadır.

## Materyal ve Yöntem

Çalışmada, “Organic agriculture”, “Organic farming”, “Ecological agriculture” ve “Ecological farming” anahtar kelimesi ile WoS veri tabanında yer alan çalışmalara erişim sağlanarak, bu çalışmaların bibliyometrik analizi yapılmıştır. Tarama sonucunda, 14606 çalışmaya erişim sağlanmış ve bu çalışmalar analize dahil edilmiştir. Dahil edilen çalışmalar; yayın yılı, dergi, başlık, yazar, kuruluş, anahtar kelime, belge türü, özet ve alıntı sayısı bilgileri ile ‘txt’ uzantılı dosyaya kaydedilmiştir. Daha sonra çalışmalar; yayın, kaynak, yazar, organizasyon ve ülke bazında analiz edilmiştir.

Analiz için VOSviewer (sürüm 1.6.20) programı kullanılmıştır. VOSviewer programında, analiz sonucu oluşan şekillerdeki düğümlerin boyutları, oluşum sıklıklarını göstermektedir. Düğümler arasındaki eğri çizgiler, aynı yayında kelimelerin birlikte bulunduğunu gösterirken, iki düğüm arasındaki uzaklığın küçük olması, iki anahtar kelimenin bir arada bulunma sayısının yüksek olduğunu ifade etmektedir (van Eck ve Waltman, 2022).

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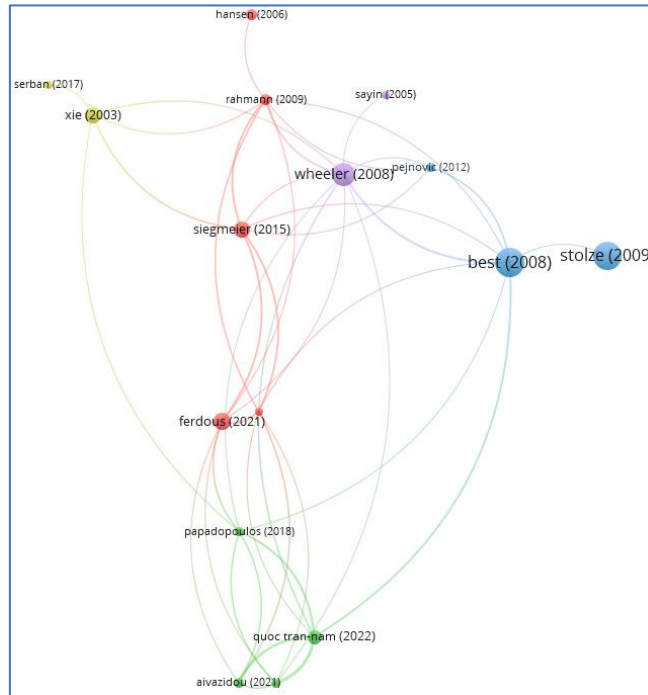
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## Bulgular

**Yayın için sonuçlar:** Yayın için sonuçlar (ilk 20 sonuç), Çizelge 1’ de ve ağ haritası Şekil 1’ de verilmiştir. Çizelge 1 ve Şekil 1’de görüldüğü üzere; Best (2008)’in çalışması, 107 atıf alarak, atıf sıralamasında ilk sırada yer alırken, Stolze (2009), 103 atıf alarak ikinci sıraya yerleşmiştir. Bir ögenin ağ içindeki merkezietini ve diğer öğelerle olan etkileşim yoğunluğunu yani ilgili ögenin çalışma alanında ne kadar merkezi ve etkili olduğunu gösteren toplam bağlantı gücü bakımından ise en yüksek değer 24 ile Quoc Tran-Nam (2022) isimli yazara ait olmuştur.

Çizelge 1. Yayın için sonuçlar

Document	Citations	Total link strength
best (2008)	107	13
stolze (2009)	103	1
wheeler (2008)	67	15
ferdous (2021)	37	12
siegmeier (2015)	32	14
xie (2003)	32	7
quoc tran-nam (2022)	26	24
kalinova (2010)	17	2
rahmann (2009)	16	12
hansen (2006)	16	1
aivazidou (2021)	14	13
pejinovic (2012)	12	5
zhllima (2021)	11	15
papadopoulos (2018)	11	13
narwal (2000)	10	2
serban (2017)	10	1
sayin (2005)	10	1
cakirli akyuz (2021)	8	13
tapaloaga (2018)	8	0
rozman (2012)	7	0



Şekil 1. Yayın için ağ haritası

**Dergi veya kaynak için sonuçlar:** Dergi veya kaynak için sonuçlar ve ağ haritası, sırası ile Çizelge 2 ve Şekil 2’de verilmiştir. Çizelge 2 ve Şekil 2’de görüldüğü üzere; toplam 107 atıfla

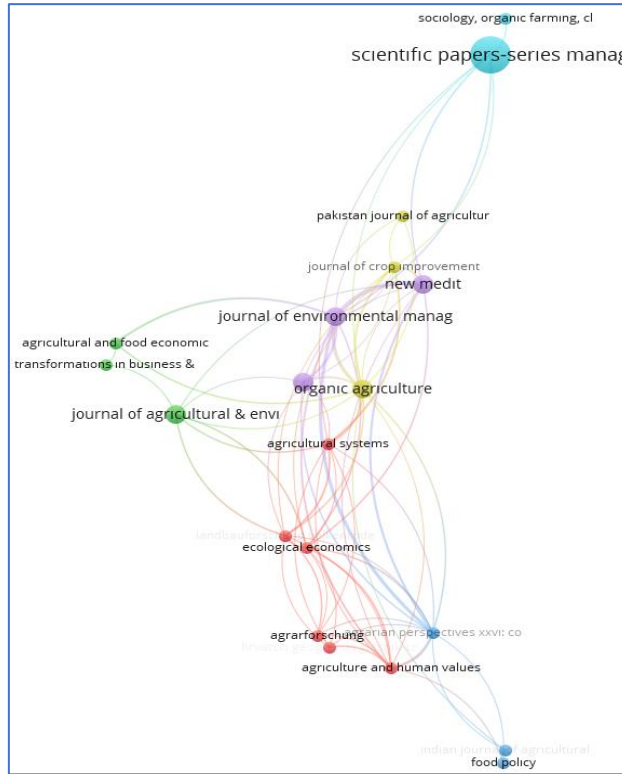
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“Agriculture and Human Values” dergisi birinci sırada yer alırken, bunu 103 atıf ile “Food Policy” dergisi izlemiştir. “Journal of Environmental Management” dergisi ise 53 toplam bağlantı gücü ile ilk sırada yer alan dergi olmuştur.

Çizelge 2. Dergi veya kaynak için sonuçlar

Source	Documents	Citations	Total link strength
agriculture and human values	1	107	21
food policy	1	103	3
ecological economics	1	67	17
journal of agricultural & environmenta...	2	48	10
journal of environmental management	2	40	53
journal of crop improvement	1	37	16
agricultural systems	1	32	19
new medit	2	22	31
sociology, organic farming, climate ch...	1	17	1
landbauforschung volkenrode	1	16	16
scientific papers-series management e...	6	12	8
hrvatski geografski glasnik-croatian ge...	1	12	7
transformations in business & econo...	1	10	2
organic agriculture	2	9	32
pakistan journal of agricultural sciences	1	5	3
agricultural and food economics	1	3	7
agrarian perspectives xxvi: competitive...	1	1	31
sustainability	2	0	16
agrarforschung	1	0	8
indian journal of agricultural sciences	1	0	3



Şekil 2. Dergi veya kaynak için ağ haritası

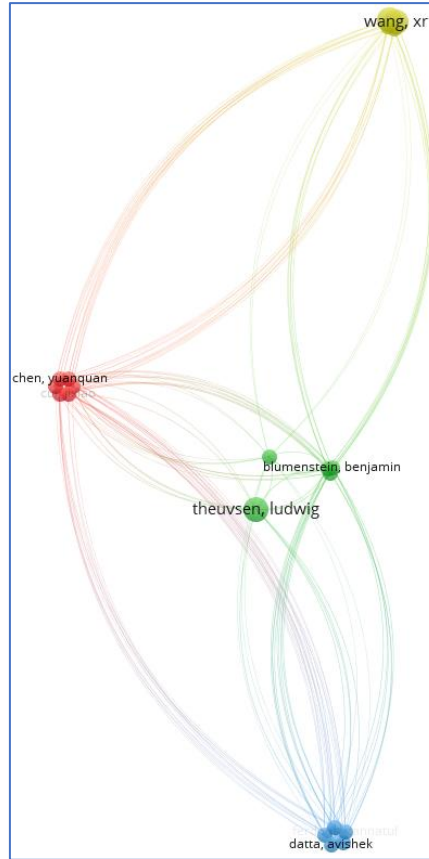
**Yazar için sonuçlar:** Yazar için sonuçlar ve ağ haritası, sırası ile Çizelge 3 ve Şekil 3’te verilmiştir. Çizelge 3 ve Şekil 3’te görüldüğü üzere; “Datta, Avishek”, “Ferdous, Zannatul”, “Hasan, Ahmed Khairul”, “Sarker, Asaduzzaman” ve “Zulfiqar, Farhad” 37 atıf ve 451 bağlantı toplam bağlantı gücü ile birinciliği paylaşan yazarlar olmuştur.

Çizelge 3. Yazar için sonuçlar

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Author	Documents	Citations	Total link strength
datta, avishek	1	37	451
ferdous, zannatul	1	37	451
hasan, ahmed khairul	1	37	451
sarker, asaduzzaman	1	37	451
zulfiqar, farhad	1	37	451
wang, xr	2	34	253
xie, b	2	34	253
blumenstein, benjamin	1	32	262
moeller, detlev	1	32	262
siegmeier, torsten	1	32	262
ding, zh	1	32	250
yang, yp	1	32	250
weissmann, friedrich	1	16	27
theuvsen, ludwig	2	9	42
chen, yuanguan	1	0	305
cui, jixiao	1	0	305
gao, wangsheng	1	0	305
li, hao	1	0	305
yan, juping	1	0	305
wang, shuqi	1	0	305



Şekil 3. Yazar için ağ haritası

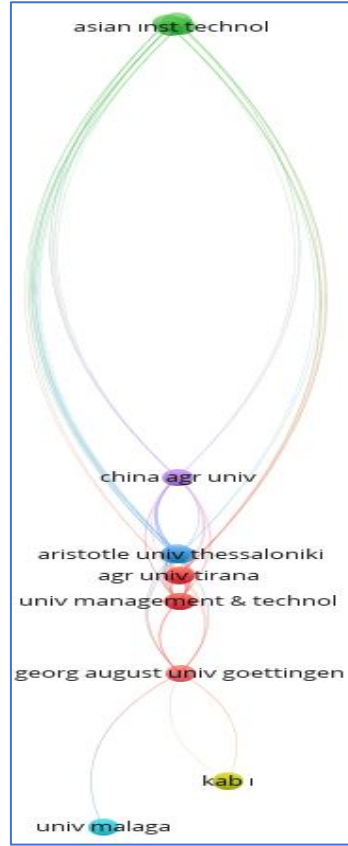
**Kurum veya organizasyon için sonuçlar:** Kurum veya organizasyon için sonuçlar Çizelge 4’te ağ haritası ise Şekil 4’te verilmiştir. 37 atıf ve 331 toplam bağlantı gücü ile Tayland’ta bulunan “The Asian Institute of Technology (AIT)”, “Bangladesh Agricultural Research Institute (BARI)”, “Bangladesh Agricultural University (BAU)” ve Pakistan’da bulunan “The COMSATS University Islamabad (CUI)” ilk sırayı paylaşmıştır (Çizelge 4 ve Şekil 4).

Çizelge 4. Kurum veya organizasyon için sonuçlar

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Organization	Documents	Citations	Total link strength
asian inst technol	1	37	331
bangladesh agr res inst	1	37	331
bangladesh agr univ	1	37	331
comsats univ islamabad	1	37	331
univ management & technol	1	26	133
univ strasbourg	1	26	133
aristotle univ thessaloniki	1	14	232
ctr res & technol hellas certh	1	14	232
univ cambridge	1	14	232
agr univ tirana	1	11	78
tech univ cartagena	1	11	78
georg august univ goettingen	1	1	33
univ malaga	1	0	92
univ pablo olavide	1	0	92
china agr univ	1	0	80
chinese acad agr sci	1	0	80
kab i	1	0	39
ıcar agr technol applicat res inst	1	0	39
int crops res inst semi arid trop	1	0	39
univ oradea	1	0	0



Şekil 4. Kurum veya organizasyon için ağ haritası

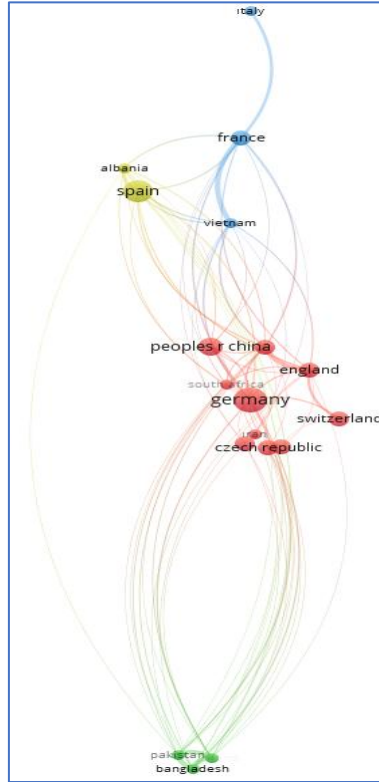
**Yayın yapan ülkeler için sonuçlar:** Yayın yapan ülkeler için sonuçlar Çizelge 5'te, ağ haritası ise Şekil 5'te verilmiştir. En çok yayın yapan ülkelere bakıldığında Almanya 5 adet yayınına 164 atıf alarak öne çıkarken, onu 2 adet yayınına 117 adet atıf alan İngiltere takip etmiştir. Yaptıkları yayımlarla en yüksek toplam bağlantı gücüne (233) sahip ülkeler ise Bangladeş, Pakistan ve Tayland olmuştur. Türkiye ise 1 adet yayın, 10 adet atıf ve 37 toplam bağlantı gücü ile 14 üncü sırada yer almıştır.

Çizelge 5. Yayın yapan ülkeler için sonuçlar

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Country	Documents	Citations	Total link strength
germany	5	164	84
england	2	117	171
switzerland	2	103	37
bangladesh	1	37	233
pakistan	1	37	233
thailand	1	37	233
peoples r china	3	34	27
france	2	29	168
vietnam	1	26	137
greece	2	25	164
czech republic	2	22	9
spain	4	14	89
albania	1	11	77
turkey	1	10	37
usa	1	10	37
india	2	10	6
italy	1	3	31
moldova	2	2	9
iran	1	2	5
south africa	1	1	21



Şekil 5. Yayın yapan ülkeler için ağ haritası

## Sonuç ve Öneriler

Çevre dostu ve sürdürülebilir tarım yöntemleriyle öne çıkan organik tarım, gıda güvenliği, ekolojik denge ve halk sağlığı gibi temel konulara çözüm sunma potansiyeli nedeniyle yıllar içinde artan bir ilgi görmüştür. Organik tarımla ilgili araştırmaların kapsamını anlamak, akademisyenler, politikacılar, üreticiler ve tüketiciler için büyük bir öneme sahiptir. Bibliyometrik analiz, organik tarım konusundaki araştırmaların mevcut durumunu anlamak ve gelecekteki çalışmalara rehberlik etmek için etkili bir yöntemdir. Özellikle Almanya, İngiltere, Tayland, Bangladeş ve Pakistan gibi ülkelerin bu alandaki bilimsel katkılarının yüksek olduğu dikkat çekmektedir. Ülkemizin de organik tarım ile ilgili çalışmalarda ön sıralarda yer alması sevindiricidir. Gelecek çalışmalar için;

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1. Literatürdeki boşlukları doldurmak adına, daha spesifik ve uygulamalı organik tarım arařtırmalarına odaklanılması önerilmektedir.
2. Çevre dostu teknolojilerin organik tarıma entegrasyonu üzerine çalışmalar artırılmalıdır.
3. Bibliyometrik analiz sonuçları stratejik planlama süreçlerinde dikkate alınmalıdır.

Bu sonuçların, organik tarımın bilimsel altyapısını güçlendirmek ve uygulamalı arařtırmalara yön vermek açısından önemli katkılar sağlayacağı düşünülmektedir.

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**KAYNAKLAR**

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**İYİ TARIM UYGULAMALARI (İTU)'NA YÖNELİK ÇALIŞMALARIN WEB OF  
SCIENCE VERİ TABANINA DAYALI BİBLİYOMETRİK ANALİZİ**

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Van-Türkiye

**Özet**

Bu çalışmada, Web of Science (WoS) veri tabanında "İyi Tarım Uygulamaları; (İTU)" anahtar kelimesiyle indekslenen 1.017 makalenin bibliyometrik analizi yapılmıştır. Analiz edilen veriler; yayın yılı, dergi, başlık, yazar, kuruluş, anahtar kelime, belge türü, özet ve atıf sayısı gibi bilgileri içermektedir. VOSviewer programı kullanılarak gerçekleştirilen analizlerde, düğüm boyutları terimlerin oluşum sıklığını, düğümler arasındaki eğri çizgiler ise terimlerin aynı yayında birlikte bulunma durumunu göstermektedir. Çalışma sonuçları, İTU konusundaki araştırmaların küresel dağılımı ve etkisi hakkında önemli bilgiler sunmaktadır.

**Anahtar Kelimeler:** Sürdürülebilir tarım, Tarım ve çevre yönetimi, Araştırma eğilimleri, veri analizi

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**BIBLIOMETRIC ANALYSIS OF PUBLICATIONS ON GOOD AGRICULTURAL  
PRACTICES (GAPS) BASED ON THE WEB OF SCIENCE DATABASE**

**Abstract**

In this study, a bibliometric analysis of 1.017 articles indexed in the Web of Science (WoS) database was performed under the keyword "Good Agricultural Practices; (GAPs) ". The analyzed data includes information such as publication year, journal, title, author, organization, keywords, document type, abstract, and citation count. In the analyses conducted using the VOSviewer program, node sizes represent the frequency of term occurrences, while the curved lines between nodes indicate co-occurrence of terms in the same publication. Results of this study provide significant insights into the global distribution and impact of research on GAPs.

**Keywords:** Sustainable agriculture, Agricultural and environmental management, Research trends, data analysis

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## Giriş

Son yıllarda, sürdürülebilir tarım uygulamaları ve çevre dostu üretim yöntemlerine duyulan ihtiyaç giderek artmaktadır (Thompson vd., 2022). Bu bağlamda, "İyi Tarım Uygulamaları" (İTU) kavramı, yalnızca tarımsal verimliliği artırmakla kalmayıp, çevresel ve toplumsal sorumlulukları da göz önünde bulunduran bir yaklaşım olarak ön plana çıkmaktadır (Eliseu vd., 2024). İTU, tarımsal üretimin çevre, insan ve hayvan sağlığına zarar vermeyecek şekilde kontrol altına alınması ve üretim sonucunda oluşan ürünlerin sertifikalandırılarak tarımda izlenebilirlik ve sürdürülebilirlik ile gıda güvenliğini sağlayan üretim modelidir (Aydın vd., 2016). Bir ülkenin teknolojik ilerlemesi, uluslararası pazardaki konumu ve tanınırlığı, iyi tarım uygulamalarının gelişimini önemli ölçüde etkiler. Örneğin, ABD, Almanya, Hollanda, Fransa, İspanya ve İtalya gibi ekonomik ve teknolojik açıdan ileri ülkelerde, bu sistem başarıyla uygulanarak, üretilen ürünler dünya pazarlarına kolaylıkla sunulmaktadır. İyi tarım uygulamalarının temel çıkış noktası, artan nüfusun gıda ihtiyacını karşılarken doğayı koruma, insan sağlığını gözetme ve sürdürülebilir tarım ilkelerini hayata geçirme fikrine dayanır (Balci Akova, ve Tapan, 2022). İTU, doğal kaynakların verimli kullanılması, gıda güvenliğinin sağlanması ve çiftçilerin yaşam kalitesinin iyileştirilmesi hedeflerini taşıırken, aynı zamanda sürdürülebilir ekonomik kalkınma için de büyük bir potansiyel sunmaktadır (Rahman vd., 2024).

Bilimsel çalışmalar, İTU'nun etkinliğini ve uygulanabilirliğini çeşitli boyutlarıyla ele almakta, bu alandaki yenilikçi yaklaşımlar ve metodolojiler giderek daha fazla ilgi görmektedir. Ancak, bu çalışmaların etkili bir şekilde izlenmesi ve analiz edilmesi, İTU'nun gelecekteki gelişim yol haritasının oluşturulmasında kritik bir rol oynamaktadır. Bu durumda, bibliyometrik analiz devreye girmektedir. Bibliyometrik analiz, bilimsel literatürün nicel bir şekilde incelenmesini sağlayarak, araştırma eğilimlerini, alanın gelişim yönlerini ve en etkili katkıları ortaya koymaktadır. Ayrıca, bu analizler, İTU'ya dair yapılan çalışmaların kapsamını, etkisini ve sürdürülebilirliğini değerlendirme açısından büyük bir öneme sahiptir.

Web of Science gibi prestijli veri tabanları üzerinden gerçekleştirilen bibliyometrik analizler, İTU konusunda dünya genelinde yapılan araştırmaların izlenmesi ile birlikte, araştırmacıların ve uygulayıcıların ihtiyaç duyduğu bilgilerin sunulmasını sağlar. Bu analizler, ilgili alandaki bilgi birikimini daha etkin bir şekilde yönlendirebilir ve karar alıcıların doğru stratejiler geliştirmesinde yardımcı olabilir.

Bu çalışmanın amacı;

- İTU alanına katkıda bulunan en etkili yazarları, kurumları, dergileri ve ülkeleri tespit etmek,
- İTU literatüründeki tematik odak alanlarını ve temel araştırma kümelerini analiz etmek,
- İTU araştırmalarının evrimini değerlendirmek,
- İTU'nun küresel olarak uygulanmasını güçlendirmek için gelecekteki araştırma yönlerine ilişkin öngörüler ve öneriler sunmaktır.

## Materyal ve Yöntem

Çalışmada, WoS veri tabanındaki dergilerde yayımlanan ve "Good Agricultural Practices" anahtar kelimesi ile belirlenen makalelerin bibliyometrik analizi yapılmıştır. WoS'ta yapılan tarama sonucunda, 1017 makale çalışmaya dahil edilmiştir. Analiz için dahil etme kriterlerini sağlayan çalışmalar; yayın yılı, dergi, başlık, yazar, kuruluş, anahtar kelime, belge türü, özet ve alıntı sayısı bilgileri ile 'txt' uzantılı dosya formatında kaydedilmiştir. Daha sonra; yayın, kaynak, yazar, organizasyon ve ülke bazında analiz edilmiştir. VOSviewer programında, analiz

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sonucu oluşan şekillerdeki düğümlerin boyutları oluşum sıklıklarını göstermektedir. Düğümler arasındaki eğri çizgiler, aynı yayında kelimelerin birlikte bulunduğunu gösterirken, iki düğüm arasındaki uzaklığın küçük olması, iki anahtar kelimenin bir arada bulunma sayısının yüksek olduğunu ifade etmektedir (Eck ve Waltman, 2022). Analiz için VOSviewer (sürüm 1.6.20) programı kullanılmıştır.

## Bulgular

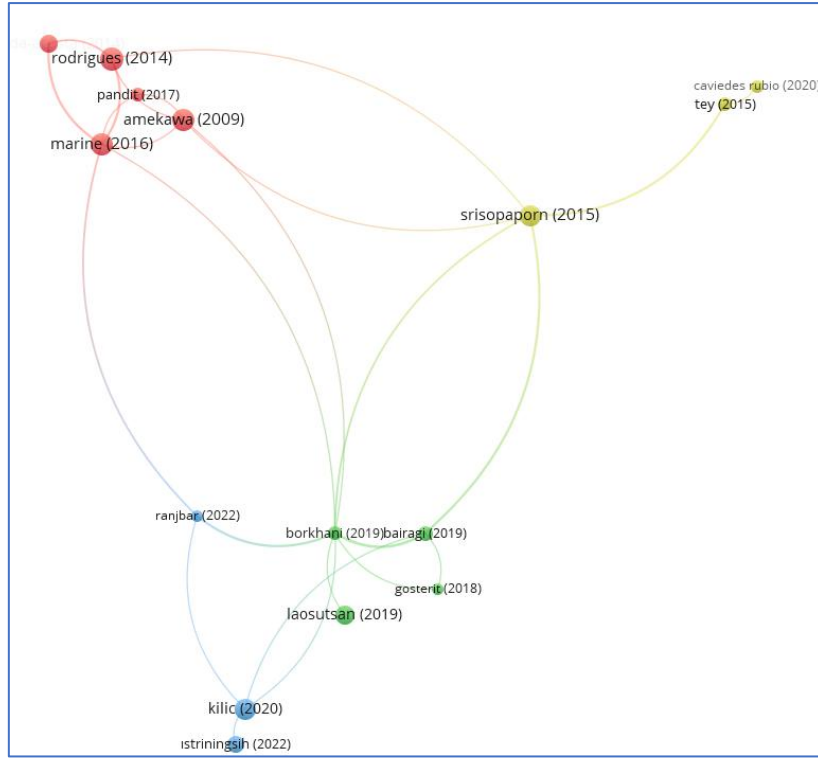
**Yayın için sonuçlar:** Yayın için sonuçlar (ilk 20 sonuç) ve ağ haritası Çizelge 1' ve Şekil 1'de verilmiştir. Buna göre; Rodrigues (2014)'in çalışması, 60 atıf alarak, atıf sıralamasında ilk sırada yer alırken, toplam bağlantı gücü 7 olmuştur. Toplam bağlantı gücü bakımından ise Borkhani (2019), 14 toplam bağlantı gücü ile ilk sırada yer almıştır.

Çizelge 1. Yayın için sonuçlar

Document	Citations ▼	Total link strength
rodrigues (2014)	60	7
marine (2016)	47	11
amekawa (2009)	47	5
srisopaporn (2015)	43	10
kiliic (2020)	40	4
aydin (2018)	34	0
laosutsan (2019)	29	1
estrada-acosta (2014)	23	5
istriningsih (2022)	17	1
ganpat (2014)	15	0
bairagi (2019)	11	9
kokkinakis (2007)	11	0
pandit (2017)	10	2
ersoy (2018)	10	0
parimi (2018)	10	0
borkhani (2019)	8	14
tey (2015)	8	4
caviedes rubio (2020)	6	1
ranjbar (2022)	5	6
gosterit (2018)	5	2

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Şekil 1. Yayın için ağ haritası

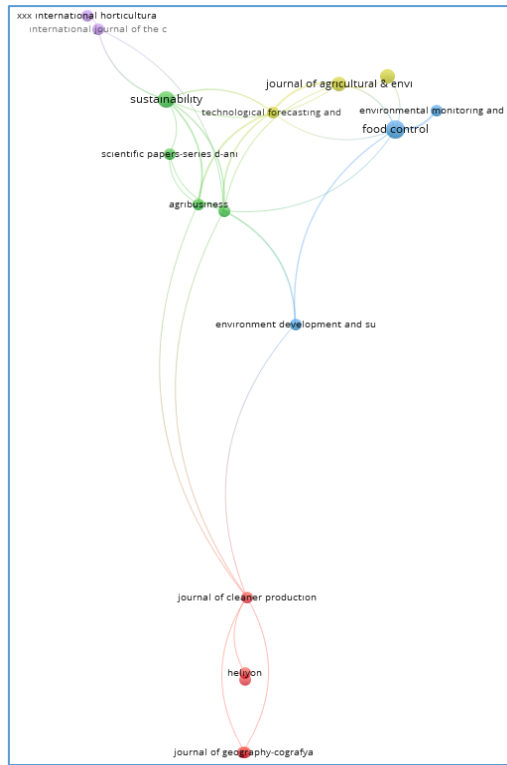
**Dergi veya kaynak için sonuçlar:** Dergi veya kaynak için sonuçlar ve ağ haritası, sırası ile Çizelge 2 ve Şekil 2’de verilmiştir. Çizelge 2 ve Şekil 2’de görüldüğü üzere; toplam 139 atıf ve 12 toplam bağlantı gücü ile “Food Control” dergisi açık ara birinci sırada yer almıştır.

Çizelge 2. Dergi veya kaynak için sonuçlar

Source	Documents	Citations	Total link strength
food control	4	139	12
journal of agricultural & environmenta...	2	55	9
technological forecasting and social c...	1	43	12
journal of cleaner production	1	40	6
energy	1	34	2
international journal of the commons	1	29	4
environmental monitoring and assess...	1	23	5
heliyon	1	17	2
indian journal of agricultural sciences	2	13	2
agribusiness	1	11	12
environmental science and pollution r...	1	8	16
environment development and sustain...	1	5	6
scientific papers-series d-animal science	1	5	3
ksu tarım ve doğa dergisi-ksu journal ...	1	4	6
sustainability	3	3	11
fresenius environmental bulletin	2	1	2
xxx international horticultural congres...	1	1	1
strategies and tools for a sustainable r...	1	1	0
journal of geography-cografya dergisi	1	0	6
international journal of pest managem...	1	0	1

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Şekil 2. Dergi veya kaynak için ağ haritası

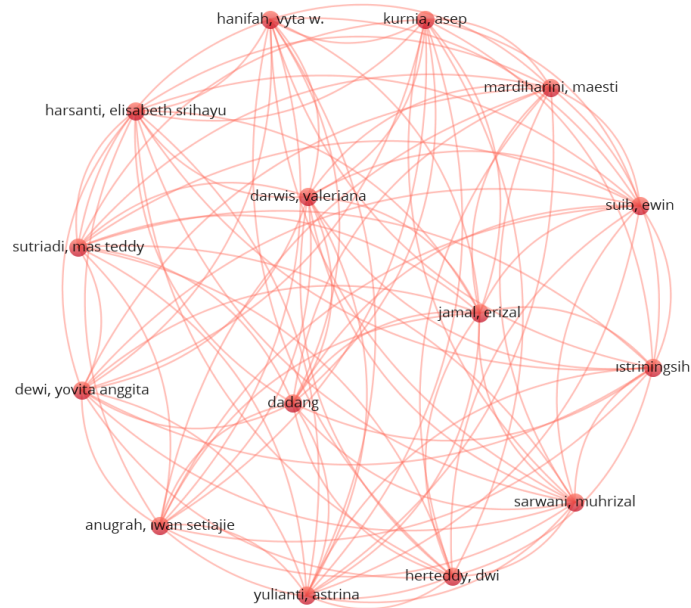
**Yazar için sonuçlar:** Yazar için sonuçlar ve ağ haritası sırası ile Çizelge 3 ve Şekil 3'te verilmiştir. Çizelge 3 ve Şekil 3'te görüldüğü üzere; “Jacxsens, Liesbeth” , “Loiko, Marcia Regina” ve “Rodrigues, Rochele de Quadros”, “Tondo, Eduardo Cesar” ve “Uyttendaele, Mieke” 60 adet atıf ile atıf sıralamasında ilk sırada yer alan yazarlar olmuştur. Bu 5 yazarın da toplam bağlantı gücü 292’dir.

Çizelge 3. Yazar için sonuçlar

Author	Documents	Citations	Total link strength
jacxsens, liesbeth	1	60	292
loiko, marcia regina	1	60	292
rodrigues, rochele de quadros	1	60	292
tondo, eduardo cesar	1	60	292
uyttendaele, mieke	1	60	292
anugrah, iwan setiajie	1	17	1162
dadang	1	17	1162
darwis, valeriana	1	17	1162
dewi, yovita anggita	1	17	1162
hanifah, vyta w.	1	17	1162
harsanti, elisabeth srihayu	1	17	1162
herteddy, dwi	1	17	1162
jamal, erizal	1	17	1162
kurnia, asep	1	17	1162
mardiharini, maesti	1	17	1162
sarwani, muhrizal	1	17	1162
suib, ewin	1	17	1162
sutriadi, mas teddy	1	17	1162
yulianti, astrina	1	17	1162
istriningsih	1	17	1162

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Şekil 3. Yazar için ağ haritası

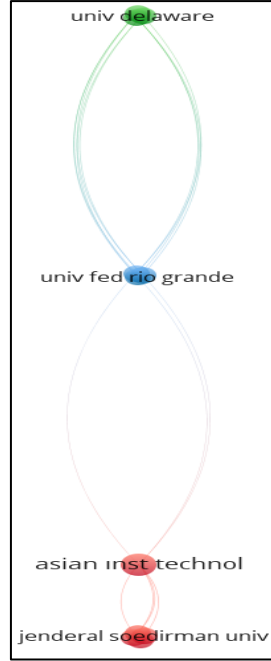
**Kurum veya organizasyon için sonuçlar:** Kurum veya organizasyon için sonuçlar Çizelge 4’te ağ haritası ise Şekil 4’te verilmiştir. Çizelge 4 ve Şekil 4’te görüldüğü üzere; 2 yayın, 72 atıf ve 15 toplam bağlantı gücü ile Tayland’ta bulunan “The Asian Institute of Technology (AIT)” birinci sırada yer almıştır.

Çizelge 4. Kurum veya organizasyon için sonuçlar

Organization	Documents	Citations	Total link strength
asian inst technol	2	72	15
univ fed rio grande	1	60	156
univ fed rio grande icta ufrgs	1	60	156
univ ghent	1	60	156
univ delaware	1	47	151
univ maryland	1	47	151
univ maryland extens	1	47	151
jenderal soedirman univ	1	8	165
rhb investment bank	1	8	165
univ adelaide	1	8	165
univ putra malaysia	1	8	165
ataturk univ	2	1	79
middle black sea transit zone agr res inst	2	1	79
africa rice ctr africanice	1	0	177
csir coll sci & technol	1	0	177
csir soil res inst	1	0	177
int ctr agr res dry areas icarda	1	0	177
c mast ctr mech & aerosp sci & technol	1	0	172
univ beira interior	1	0	172
univ namibe	1	0	172

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Şekil 4. Kurum veya organizasyon için ağ haritası

**Yayın yapan ülkeler için sonuçlar:** Yayın yapan ülkeler için sonuçlar Çizelge 5'te ağ haritası ise Şekil 5'te verilmiştir. Çizelge 5 ve Şekil 5'te görüldüğü üzere; en çok yayın yapan ülkeler sıralamasında 4 yayın ve 109 atıf ve 84 toplam bağlantı gücü ile Amerika Birleşik Devletleri birinci sırada yer alırken; onu 11 yayın ve 99 atıf ve 10 toplam bağlantı gücü ile Türkiye izlemiştir.

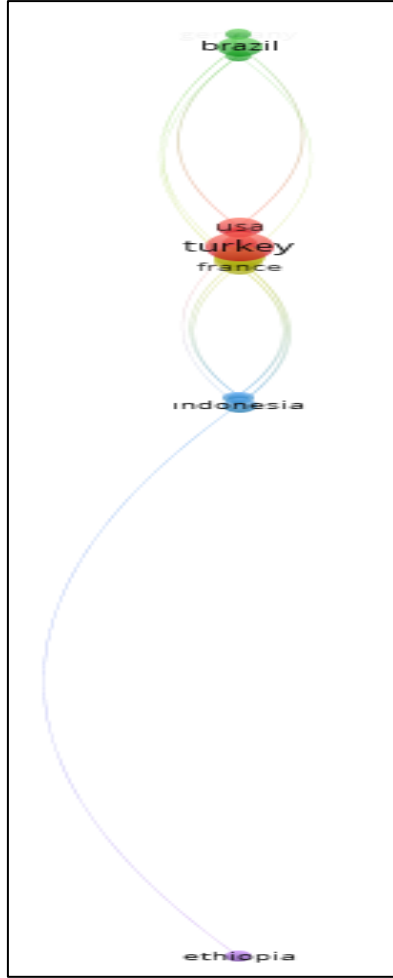
Çizelge 5. Yayın yapan ülkeler için sonuçlar

Country	Documents	Citations	Total link strength
usa	4	109	84
turkey	11	99	10
brazil	4	83	107
thailand	5	76	122
belgium	1	60	79
india	6	52	40
france	2	43	71
indonesia	2	25	118
iran	2	13	23
philippines	1	11	68
australia	1	8	115
malaysia	1	8	115
germany	1	1	28
cote ivoire	1	0	118
ghana	1	0	118
morocco	1	0	118
angola	1	0	86
portugal	1	0	86
ethiopia	1	0	45
taiwan	1	0	45



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Şekil 5. Yayın yapan ülkeler için ağ haritası

### Sonuç ve Öneriler

Bu çalışmada, iyi tarım uygulamaları (İTU)'na dair yapılmış olan çalışmaların bibliyometrik incelemeleri ele alınmış ve bu alandaki bilgi boşlukları ortaya konarak, sürdürülebilir tarım uygulamaları konusundaki stratejilerin şekillendirilmesine katkı sağlamak amaçlanmıştır. Çalışma sonucunda yayın bakımından Rodrigues'in 2014 yılında yaptığı yayın ve kaynak bakımından "Food Control" dergisi öne çıkmıştır. "Jacxsens, Liesbeth", "Loiko, Marcia Regina", "Rodrigues, Rochele de Quadros", "Tondo, Eduardo Cesar" ve "Uyttendaele, Mieke" en çok atıf alan yazarlar olmuştur. Tayland'daki "The Asian Institute of Technology (AIT)" en etkili kurum olarak dikkati çekmiştir. ABD, en çok yayın yapan ülke olarak ilk sıraya yerleşirken Türkiye, ikinci sırada yer almıştır. Ülkemizin bu alandaki bilimsel çalışmalara yön vermesi sevindiricidir. Çalışma sonuçları, özellikle sürdürülebilir tarımın çevresel ve ekonomik kaygılar nedeniyle önceliklendirildiği alanlarda GAP'a artan bir akademik odaklanma olduğunu göstermektedir. Sonuç olarak, bibliyometrik analizler İTU çalışma alanını anlamak için önemlidir ve gelecekteki araştırmaları küresel sürdürülebilir tarımsal ilerleme için en önemli konulara yönlendirebilir.

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**Özet**

YOLO (You Only Look Once) derin öğrenme modellerinin tarımda uygulanması, gelişmiş nesne tespit teknikleri aracılığıyla mahsul ve hayvan yönetimini dönüştüren bir yaklaşım sunmaktadır. Küresel gıda talebinin artması ve çevresel sürdürülebilirliğin önemi, tarım sektöründe mahsullerin izlenmesi, zararlıların ve hastalıkların tespit edilmesi ile hayvan sağlığının değerlendirilmesine yönelik ihtiyaçları artırmıştır. YOLO modelleri, gerçek zamanlı işleme yetenekleri sayesinde hassas tarımda etkili bir şekilde kullanılmakta, çiftçilerin bilinçli kararlar almasına ve kaynak kullanımını optimize etmesine olanak tanımaktadır. Tarımda YOLO'nun başlıca uygulamaları arasında mahsul tespiti, zararlı ve hastalık yönetimi, yabancı ot kontrolü ve hayvan izleme yer almaktadır. YOLOv4 ve YOLOv5 gibi modeller, yüksek doğruluk oranları ile mahsul hastalıkları ve zararlıları tanımlamakta ve otomatik yabancı ot tespit sistemleri aracılığıyla herbisit kullanımını azaltmaktadır. Ancak, veri gizliliği, donanım sınırlamaları ve kapsamlı veri setlerine duyulan ihtiyaç gibi zorluklar, bu teknolojilerin yaygın benimsenmesini engellemektedir. Son gelişmeler, YOLO mimarisinin yeni modelleri olan YOLOv8, YOLOv9, YOLOv10, YOLOv11 ve AgriPest-YOLO'nun tanıtılmasıyla, karmaşık tarımsal ortamlarda model performansını artırmaya yönelik yenilikleri vurgulamaktadır. Bu modeller, küçük veya kamufle olmuş zararlıları tespit etme ve çeşitli koşullarda farklı mahsulleri yönetme gibi zorlukları ele almak için tasarlanmıştır. Eğitim veri setlerinin özgüllüğü ve çevresel değişkenlik, bu modellerin farklı tarımsal bağlamlarda genelleştirilebilirliğini etkileyen önemli faktörlerdir. YOLO derin öğrenme modellerinin tarıma entegrasyonu, operasyonel verimliliği artırmakla kalmayıp, küresel gıda güvenliğine de olumlu katkılarda bulunmaktadır. Araştırma ve teknoloji geliştikçe, YOLO uygulamalarının tarımsal zorlukları ele alma potansiyeli önemini korumakta ve alanda sürekli yenilik ile işbirliği ihtiyacını vurgulamaktadır.

**Anahtar Kelimeler:** YOLO, derin öğrenme, tarım teknolojileri, nesne tespiti

**AGRICULTURAL APPLICATION EXAMPLES OF YOLO DEEP LEARNING**

**Abstract**

The application of YOLO (You Only Look Once) deep learning models in agriculture offers an approach that transforms the management of crops and animals through advanced object recognition techniques. The increasing global demand for food and the importance of environmental sustainability have increased the need for crop monitoring, pest and disease detection and animal health assessment in the agricultural sector. YOLO models are effectively used in precision agriculture thanks to their real-time processing capabilities, enabling farmers to make informed decisions and optimise the use of resources. Key applications of YOLO in agriculture include crop detection, pest and disease management, weed control and animal monitoring. Models such as YOLOv4 and YOLOv5 detect plant diseases and pests with high accuracy and reduce the use of herbicides through automatic weed detection systems. However, challenges such as data confidentiality, hardware limitations and the need for large data sets hinder the widespread application of these technologies. Recent developments highlight innovations to improve model performance in complex agricultural environments with the introduction of new YOLO architecture models, YOLOv8, YOLOv9, YOLOv10, YOLOv11 and AgriPest-YOLO. These models were developed to address challenges such as the detection of small or camouflaged pests and the management of different crops under different conditions. The specificity of the training datasets and the variability of environmental conditions are important factors influencing the generalizability of these models in different agricultural contexts. The integration of YOLO deep learning models in agriculture not only improves operational efficiency, but also contributes positively to global food security. As research and technology evolve, the potential of YOLO applications to address agricultural challenges remains important and underscores the need for continued innovation and collaboration in this field.

**Keywords:** YOLO, deep learning, agricultural technologies, object recognition

## **1.GİRİŞ**

Tarımsal üretim, dünya genelinde artan nüfus ile birlikte sürekli bir dönüşüm ve yenilik ihtiyacı içindedir. Bu bağlamda, derin öğrenme (DL) gibi gelişmiş yapay zeka tekniklerinin tarım sektörüne entegrasyonu, sürdürülebilir tarım uygulamalarını destekleyen önemli bir fırsat sunmaktadır. Günümüzde, derin öğrenme uygulamaları özellikle toprak analizi, zararlı tespiti ve ürün sınıflandırma sistemleri üzerinde yoğunlaşmaktadır. Son yıllarda, derin öğrenme, büyük veri analizi ve görüntü işleme alanlarındaki gelişmeler sayesinde tarım sektöründe devrim niteliğinde değişikliklere yol açmıştır. Tarımsal üretkenliğin artırılması, kaynakların verimli kullanımı ve sürdürülebilir tarım uygulamalarının desteklenmesi amacıyla derin öğrenme teknikleri, uzaktan algılama ve makine öğrenimi ile birleştirilerek kullanılmaktadır. Bu alanlar, tarımda verimliliği artırırken aynı zamanda çevresel sürdürülebilirliği sağlamak için çeşitli stratejiler geliştirmektedir. Güçlü hesaplama yetenekleri ve büyük veri kümesine erişim, derin öğrenme algoritmalarının tarım sektöründeki uygulama alanını genişletmiştir. Derin öğrenme yöntemlerinin tarımsal uygulamalara entegrasyonu, gelecekteki tarım pratiklerini şekillendirecek ve çevresel sürdürülebilirliği destekleyecek önemli bir aşama olarak değerlendirilmektedir. Derin öğrenme teknikleri, tarım sektöründe veri analizi ve karar verme süreçlerini optimize etme konusunda önemli bir potansiyele sahiptir (Kumar ve ark., 2022). Bu teknikler arasında, nesne tespiti alanında öncü bir yöntem olarak bilinen YOLO (You Only Look Once) algoritması, tarımsal uygulamalarda dikkate değer bir rol oynamaktadır. YOLO, gerçek zamanlı nesne tespiti için tasarlanmış bir derin öğrenme modelidir ve tarımda zararlı böceklerin tespiti, bitki hastalıklarının belirlenmesi ve ürün sınıflandırması gibi çeşitli alanlarda etkin bir şekilde kullanılmaktadır (Redmon ve ark., 2016). Bu algoritmanın sunduğu hızlı ve doğru tespit yetenekleri, çiftçilere anlık bilgi sağlayarak tarımsal yönetim süreçlerini geliştirmekte ve kaynakların daha verimli bir şekilde kullanılmasına olanak tanımaktadır (Zhang ve ark., 2023). Ayrıca, uzaktan algılama ve görüntü işleme teknikleri ile entegre edildiğinde, YOLO algoritması tarımsal üretkenliği artırmak ve çevresel sürdürülebilirliği sağlamak için etkili bir araç haline gelmektedir (Patel & Patel, 2022). Tarımsal verimliliği artırmak ve uygulamaları geliştirmek amacıyla hyperspectral ve multispectral bilgi işleme sistemleri ile teknolojileri kullanılmaktadır. Bu sistemler, çiftçilere ve tarım yöneticilerine bitki sağlığı ve büyümesini etkileyen unsurlar hakkında değerli bilgiler sunarak tarım uygulamalarında önemli bir rol oynamaktadır. Hyperspectral ve multispectral verilerin tarımda entegrasyonu, büyük veri, makine öğrenimi ve derin öğrenme potansiyeli ile birleştiğinde oldukça umut verici sonuçlar ortaya çıkarmaktadır (Ang, 2021).

Derin öğrenme teknikleri, tarımsal zararlıların kontrolü ve üretim tahminleri gibi alanlarda da etkin bir şekilde kullanılmaktadır (Durgabai, 2018). Bu yöntemler, tarımsal verilerin analizi, hastalık tespiti, ürün tahmini, su yönetimi, toprak yönetimi ve zararlı yönetimi gibi birçok alanda fayda sağlamaktadır (Jhajharia ve ark., 2022). Ayrıca, derin öğrenme uygulamaları, tarımsal üretimde verimliliği artırmak ve sürdürülebilir tarım uygulamalarını desteklemek için önemli bir araç olarak öne çıkmaktadır (Umar ve ark., 2022). Bu yöntemler tahıl (buğday) verim tahmini gibi tarımsal tahminlerde ve zorlu koşullarda risk analizi yapmak için kullanılmaktadır (Aubakirova ve ark., 2023). Hasat süreçlerinde derin öğrenme yöntemlerinin uygulanmasına dair bir diğer çalışma, Arserim ve Usta tarafından gerçekleştirilmiştir. Bu çalışmada, insansız hava araçlarıyla elde edilen videolar kullanılarak derin öğrenme teknikleri ile nesne tespiti yapılmıştır (Arserim ve ark., 2023). Bu bulgular, derin öğrenme yöntemlerinin hasat uygulamalarında nesne tespiti gibi görevlerde etkili bir şekilde kullanılabileceğini göstermektedir. He ve ark. (2016), "Deep Residual Learning for Image Recognition" başlıklı

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çalışmalarında, derin sinir ağlarının temelini oluşturan derin rezidüel ağları tanıtmış ve bu ağların ImageNet tespiti, ImageNet lokalizasyonu, COCO tespiti ve COCO segmentasyonu gibi görevlerde elde ettiği başarıları vurgulamıştır.

Bu çalışmada, YOLO derin öğrenme algoritmasının tarımsal uygulama örnekleri incelenmiş ve bu uygulamaların tarımsal verimlilik üzerindeki etkileri değerlendirilmiştir. Özellikle, tarımda karşılaşılan zorlukların üstesinden gelmek için YOLO'nun sunduğu avantajlar üzerinde durulacaktır.

## 2.YOLO DERİN ÖĞRENMENİN TARİHSEL GELİŞİMİ VE MODELLERİ

YOLO (You Only Look Once), nesne tespiti alanında önemli bir yenilik olarak kabul edilen bir derin öğrenme modelidir. İlk kez 2016 yılında Joseph Redmon ve ekibi tarafından tanıtılmıştır. YOLO, görüntüleri tek bir geçişte analiz ederek nesnelere hızlı ve etkili bir şekilde tespit etme yeteneği ile öne çıkmaktadır. Bu model, geleneksel nesne tespiti yöntemlerine kıyasla daha hızlı ve verimli sonuçlar sunarak, gerçek zamanlı uygulamalarda yaygın bir şekilde kullanılmaya başlanmıştır.

### 2.1.Tarihsel Gelişim

**YOLO V1 (2015):** İlk versiyonu, görüntüyü 7x7 ızgaraya bölerek her bir hücredeki nesnelere tahmin etmektedir. Bu model, nesne tespitini hızlandırmak amacıyla görüntüyü tek bir ağdan geçirerek çalışır; ancak sınırlı sayıda nesne tespit edebilme kapasitesine sahiptir.

**YOLO V2 (2016):** Bu versiyon, daha iyi doğruluk ve hız sağlamak için çeşitli iyileştirmeler içermektedir. "Batch Normalization" ve "Anchor Boxes" gibi tekniklerin eklenmesiyle modelin performansı artırılmıştır. Ayrıca, daha fazla nesne tespit edebilme kapasitesine sahip olmuştur.

**YOLO V3 (2018):** Bu versiyon, çoklu ölçeklerde nesne tespiti yapabilme yeteneği ile geliştirilmiştir. Farklı boyutlardaki nesnelere daha iyi tespit edebilmek için modelin mimarisine daha fazla katman eklenmiştir. Ayrıca, "Darknet-53" adlı yeni bir arka plan ağı kullanılarak daha derin ve karmaşık özelliklerin öğrenilmesi sağlanmıştır.

**YOLO V4 (2020):** Bu versiyon, daha fazla optimizasyon ve hız artışı sağlamak amacıyla çeşitli teknikler içermektedir. "Mosaic Data Augmentation" ve "Self-adversarial Training" gibi yenilikçi yöntemler kullanılarak modelin genel performansı artırılmıştır. YOLO V4, daha fazla nesne tespit edebilme ve daha yüksek doğruluk oranları sunmaktadır.

**YOLO V5 (2020):** YOLO V5, Redmon'un ekibi tarafından değil, başka bir grup tarafından geliştirilmiştir. Bu versiyon, daha hafif ve hızlı bir model sunarak mobil ve gömülü sistemlerde kullanım için optimize edilmiştir. YOLO V5, kullanıcı dostu bir arayüze sahip olup daha geniş bir uygulama yelpazesine hitap etmektedir.

**YOLO V6 ve V7 (2022-2023):** Bu son versiyonlar, daha fazla hız ve doğruluk sağlamak için çeşitli yenilikler içermektedir. Özellikle, daha iyi genel performans ve daha az hesaplama gücü gereksinimi ile dikkat çekmektedir.

**YOLOv8 (2023):** 2023 yılı itibarıyla piyasaya sürülen YOLOv8, önceki sürümlere göre daha iyi performans sunmayı hedeflemektedir. Bu versiyon, mobil cihazlar ve düşük güçlü donanımlarda çalışmak üzere optimize edilmiştir. Ayrıca, daha iyi nesne tespiti için yeni bir mimari kullanılmıştır ve eğitim ile uygulama süreçlerini kolaylaştıran kullanıcı dostu bir arayüz sunmaktadır.

**YOLO-NAS:** Mayıs 2023'te piyasaya sürülen YOLO-NAS, gerçek zamanlı nesne algılama teknolojisinde önemli bir sıçramayı temsil etmektedir. Deci tarafından geliştirilen bu teknoloji, ağ mimarisini otomatik olarak optimize etmek için Nöral Mimari Arama (NAS) özelliğini

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entegre ederek hız ve doğruluk arasında optimum bir denge sağlamaktadır (Terven ve ark., 2023). YOLO-NAS'ın kuantizasyona duyarlı modüller ve hibrit kuantizasyon yöntemi gibi benzersiz özellikleri, hesaplama kaynaklarının sınırlı olabileceği ancak ürün sağlığını izleme ve zararlıları tespit etme gibi görevler için yüksek performansın gerekli olduğu tarımda uç cihaz uygulamaları için uygunluğunu artırmaktadır (Qin ve ark., 2021).

**YOLOv9:** Bu sürüm, önceki modellere kıyasla daha yüksek doğruluk ve hız sağlamayı hedeflemektedir. Model mimarisinde gerçekleştirilen optimizasyonlar sayesinde, nesne algılama görevlerinde daha iyi sonuçlar elde edilmiştir.

**YOLOv10:** Ultralytics tarafından geliştirilen YOLOv10, maksimum olmayan bastırma (NMS) ihtiyacını ortadan kaldırarak verimliliği artıran yenilikçi bir mimariye sahiptir. Bu model, düşük hesaplama maliyeti ile yüksek doğruluk sunarak gerçek zamanlı nesne algılamada yeni bir standart belirlemiştir (Anonim1, 2023).

**YOLOv11:** En son sürüm olan YOLOv11, özellikle ortalama F1 skoru ve hassasiyet açısından YOLOv10'a göre hafif bir performans artışı sunmaktadır. Bu model, özellikle duman ve yangın tespiti gibi özel uygulamalarda üstün performans sergilemiştir (Alkhamash, 2025).

## 3. UYGULAMA ÖRNEKLERİ

### 3.1. Bitki Hastalığı Tespiti

Derin öğrenme, bitki hastalıklarının tespitinde önemli bir rol oynamaktadır. Bu alandaki gelişmeler, görüntü işleme ve makine öğrenimi tekniklerinin entegrasyonu ile sağlanmaktadır. Özellikle, derin öğrenme algoritmaları, bitki yapraklarının hastalıklarını yüksek doğruluk oranlarıyla tanımlamak için kullanılmaktadır. Bitki hastalıklarının tespiti için kapsamlı bir veri setine ihtiyaç duyulmaktadır. Bu veri seti, hem sağlıklı hem de hastalıklı bitkilerin görüntülerini içermelidir. Veri toplama yöntemleri arasında, dronlar veya kameralar kullanarak tarım alanlarından görüntü almak ve açık veri setlerinden yararlanmak yer almaktadır. Toplanan görüntülerin ön işlenmesi, modelin doğruluğunu artırmak için kritik bir aşamadır. Bu aşama, görüntü boyutlandırma, normalizasyon ve veri artırma tekniklerini içermektedir. Militante ve ark.(2019), derin öğrenme kullanarak bitki yaprağı tespiti ve hastalık tanıma sistemleri geliştirmiştir. Bu sistemler, görüntü işleme teknikleriyle birleştirildiğinde, hastalıkların erken aşamalarda tespit edilmesine olanak tanır, bu da tarımsal verimliliği artırır (Mohan ,2023). Bitki hastalıklarının tespitinde kullanılan yöntemler arasında destek vektör makineleri (SVM) gibi makine öğrenimi algoritmaları da bulunmaktadır. Üzüm bitkisi hastalıklarını tespit etmek için SVM, Rastgele Orman ve AdaBoost gibi algoritmalar kullanmış ve bu yöntemlerin yüksek doğruluk oranları sağladığını göstermiştir (Alagumariappan ve ark., 2020). Ayrıca, Kamal ve ark.(2018), SVM kullanarak yaprak hastalıklarının sınıflandırılmasında %97 doğruluk oranı elde ettiklerini bildirmiştir. Bu tür çalışmalar, bitki hastalıklarının otomatik olarak tanımlanmasına yönelik sistemlerin geliştirilmesine katkıda bulunmaktadır. Görüntü işleme teknikleri, bitki hastalıklarının tespitinde kritik bir rol oynamaktadır. Bitki hastalıklarının sınıflandırılması için görüntü işleme adımlarını içeren bir algoritma geliştirmiştir (Dandawate & Kokare, 2015). Bu algoritma, görüntülerin işlenmesi, yaprakların arka plandan ayrılması ve istatistiksel analiz ile sınıflandırma aşamalarını içermektedir. Ayrıca yer fıstığı bitkisi hastalıklarını tanımlamak için benzer bir görüntü işleme sistemi geliştirmiştir (Mulatu & Mohammed, 2022). Bu tür sistemler, tarımsal üretimde karşılaşılan zorlukların üstesinden gelmek için önemli bir araç haline gelmektedir. Stanford Üniversitesi'nde gerçekleştirilen bir çalışmada, derin öğrenme kullanılarak bitki hastalıkları otomatik olarak tespit edilmiştir. Araştırmada, konvolüsyonel sinir ağları (CNN) kullanılarak

%95 doğruluk oranı elde edilmiştir (Hughes ve ark., 2015).

### 3.2.Sulama Yönetimi

Derin öğrenme, sulama yöntemlerinin optimizasyonunda önemli bir rol oynamaktadır. Akıllı sulama sistemleri, bitkilerin su ihtiyaçlarını belirlemek için çeşitli sensörler ve algoritmalar kullanarak su tasarrufu sağlamak ve tarımsal verimliliği artırmaktadır. Tarım sektörü, dünya nüfusunun artışıyla birlikte su kaynaklarının verimli kullanımını sağlamak zorundadır. Sulama, bitkilerin büyümesi için hayati bir öneme sahiptir; ancak yanlış sulama uygulamaları, su israfına ve bitki sağlığının bozulmasına yol açabilmektedir. Derin öğrenme, büyük veri analizi ve makine öğrenimi teknikleri, sulama yönetiminde devrim yaratma potansiyeline sahiptir. Sulama yönetiminde kullanılan derin öğrenme yöntemleri arasında Konvolüsyonel Sinir Ağları (CNN), Tekrarlayan Sinir Ağları (RNN) ve Uzun Kısa Süreli Bellek (LSTM) gibi modeller bulunmaktadır. Bu modeller, toprak nemi, hava durumu ve bitki büyüme verilerini analiz ederek sulama ihtiyaçlarını tahmin etmek için kullanılmaktadır.

Sulama yönetimi için gerekli veriler, çeşitli kaynaklardan toplanmaktadır. Bu veriler arasında toprak nemi, hava durumu, bitki türleri ve sulama geçmişi yer almaktadır. Veri toplama yöntemleri arasında sensörler, dronlar ve uydu görüntüleri kullanılmaktadır. Toplanan verilerin ön işlenmesi, modelin doğruluğunu artırmak için kritik bir aşamadır. Bu aşama, veri normalizasyonu, eksik verilerin tamamlanması ve veri artırma tekniklerini içermektedir. Akıllı sulama sistemlerinin, tarımda su kullanımını optimize etmek için derin öğrenme ve IoT teknolojilerinin entegrasyonunu vurgulamaktadır (Gurmessa, 2023). Bu sistemler, toprak nemi, hava durumu ve bitki su tüketimi gibi verileri analiz ederek sulama zamanlamasını otomatik olarak ayarlayabilmektedir (Karmakar ve Sarkar, 2021). Akıllı sulama sistemlerinin etkinliği, geleneksel sulama yöntemleriyle karşılaştırıldığında belirgin avantajlar sunmaktadır. Akıllı sulama sistemlerinin su tasarrufunu %90'a kadar artırabileceğini ve bu sistemlerin enerji verimliliği sağladığını belirtmektedir (Baskar M, 2023). Ayrıca, bu sistemler, bitki sağlığını iyileştirerek tarımsal üretkenliği artırmakta ve su israfını azaltmaktadır (Gupta, 2023). Bu bağlamda, akıllı sulama sistemlerinin, tarımda sürdürülebilir uygulamaların yaygınlaşmasına katkıda bulunması beklenmektedir (Bwambale ve ark., 2023). Derin öğrenme algoritmaları, sulama sistemlerinin daha akıllı hale gelmesine yardımcı olmaktadır. Akdere (2023), derin öğrenme yöntemlerinin fotovoltaik sistemlerde maksimum güç noktasını tahmin etmek için kullanıldığını ve bu tür uygulamaların sulama sistemlerinin enerji verimliliğini artırabileceğini göstermektedir. Bu tür uygulamalar, sulama sistemlerinin enerji tüketimini optimize ederek, çevresel sürdürülebilirliği desteklemektedir. Hollanda'daki Wageningen Üniversitesi, derin öğrenme tabanlı bir model geliştirerek sulama yönetimini optimize etmiştir. Geliştirilen model, toprak nem seviyelerini tahmin ederek sulama ihtiyacını %20 oranında azaltmıştır (Jansen ve ark., 2020).

### 3.3.Tarımsal Verim Analizi

Dünya nüfusunun artışıyla birlikte gıda talebi de önemli ölçüde artmaktadır. Bu durum, tarımsal verimliliğin artırılmasını zorunlu kılmaktadır. Tarımsal verim analizi, bitki sağlığını izlemek, hastalıkları tespit etmek ve sulama gibi kaynakları optimize etmek için gereklidir. Derin öğrenme, bu süreçte büyük veri setlerini analiz ederek daha doğru tahminler yapma imkanı sunmaktadır. Tarımsal verim analizinde kullanılan derin öğrenme yöntemleri arasında Konvolüsyonel Sinir Ağları (CNN), Tekrarlayan Sinir Ağları (RNN) ve Uzun Kısa Süreli Bellek (LSTM) gibi modeller bulunmaktadır. Bu modeller, hava durumu, toprak özellikleri ve bitki büyüme verilerini analiz ederek verim tahminleri yapmak için kullanılmaktadır.

Derin öğrenme, tarımsal veri analizi alanında önemli bir dönüşüm sağlamaktadır. Bu teknoloji,



büyük veri kümelerinin işlenmesi ve analiz edilmesi konusunda güçlü yetenekler sunarak, tarım uygulamalarında daha verimli ve sürdürülebilir yöntemlerin geliştirilmesine olanak tanımaktadır. Derin öğrenme algoritmaları, tarımsal verilerin toplanması, işlenmesi ve yorumlanmasında kullanılmakta, bu sayede çiftçilere ve araştırmacılara daha iyi karar verme süreçleri sunulmaktadır (Li, 2024). Özellikle, tarımsal veri analizi için kullanılan derin öğrenme teknikleri, bitki sağlığı, hastalık tespiti ve verim tahmini gibi konularda önemli başarılar elde etmektedir. Derin öğrenme destekli dronlar kullanarak tarımda zararlı ve hastalık tespiti gerçekleştirmiştir. Bu çalışma, görüntü işleme ve nesne tanıma yetenekleri sayesinde, bitki hastalıklarının hızlı ve doğru bir şekilde tespit edilmesine olanak tanımaktadır (Li, 2024). Ayrıca, bu tür sistemler, çiftçilere anlık geri bildirim sağlayarak, tarımsal uygulamalarını optimize etmelerine yardımcı olmaktadır (Bhagat ve ark., 2022). Tarımsal veri analizi, yalnızca bitki sağlığı ile sınırlı kalmayıp, aynı zamanda toprak analizi ve iklim verileri gibi diğer önemli faktörleri de içermektedir. Derin öğrenme algoritmaları, iklim değişikliği ve toprak nemi gibi çevresel faktörlerin tarımsal verim üzerindeki etkilerini analiz etmekte kullanılmaktadır. Ancak, Kantar ve Kilimci'nin çalışması, sosyal medya verilerini finansal duygu analizi amacıyla kullanmakta olup, tarımsal karar verme süreçlerine doğrudan bir entegrasyon sağlamamaktadır (Kantar ve Kilimci, 2022). Bu nedenle, bu tür verilerin analizi, çiftçilerin pazar trendlerini anlamalarına yardımcı olabilir, ancak bu çalışma ile doğrudan bağlantılı değildir. Ayrıca, derin öğrenme yöntemleri, tarımsal üretim süreçlerinin izlenmesi ve yönetilmesi için de kullanılmaktadır. Saralioglu ve Gungo (2022), uzaktan algılama teknikleri ile yüksek çözünürlüklü uydu görüntülerinden tarımsal alanların analizi yapılmakta ve bu veriler, bitki sağlığı ve verim tahmini için kullanılmaktadır. Bu tür uygulamalar, tarımsal üretimde verimliliği artırmakta ve kaynakların daha etkin kullanılmasını sağlamaktadır. Hindistan'da bir araştırma grubu, derin öğrenme yöntemlerini kullanarak ürün verim tahminlerini artırmıştır. CNN ve tekrarlayan sinir ağları (RNN) ile desteklenen bir model, tahıl veriminde %30 artış sağlamıştır (Ghosh ve ark., 2019).

### 3.4. Zararlı Böcek Tespiti

Tarım sektörü, dünya nüfusunun artışıyla birlikte gıda üretimini artırmak zorundadır. Ancak, zararlı böcekler bitkilerin sağlığını tehdit ederek verim kaybına neden olmaktadır. Geleneksel yöntemlerle zararlı böceklerin tespiti genellikle gözlemlere ve deneyimlere dayanmaktadır; bu da hatalı teşhis riskini artırmaktadır. Derin öğrenme, bu sorunu çözmek için etkili bir araç olarak öne çıkmaktadır. Zararlı böcek tespitinde en yaygın kullanılan derin öğrenme yöntemleri arasında Konvolüsyonel Sinir Ağları (CNN) ve YOLO (You Only Look Once) gibi nesne tespiti algoritmaları bulunmaktadır. CNN'ler, görüntü verilerini işlemek için etkili bir mimari sunarken, YOLO gerçek zamanlı nesne tespiti için optimize edilmiştir.

Derin öğrenme, tarımsal zararlı böcek tespitinde önemli bir araç olarak ortaya çıkmaktadır. Bu teknoloji, görüntü işleme ve makine öğrenimi tekniklerini birleştirerek, tarımda zararlı böceklerin hızlı ve doğru bir şekilde tanımlanmasına olanak tanımaktadır. Gupta ve ark.(2022), derin öğrenme yöntemlerinin zararlı ve yabancı ot tespitinde nasıl kullanıldığını açıklamaktadırlar. Bu çalışma, görüntü analizi ve makine öğrenimi uygulamalarının tarımda önemli bir rol oynadığını vurgulamaktadır. Zararlı böceklerin tespitinde derin öğrenme algoritmalarının kullanımı, geleneksel yöntemlere göre birçok avantaj sunmaktadır. Bilgisayarla görme ve yapay zekanın, tahıl ürünlerinde zararlı böceklerin tespitinde nasıl etkili olduğunu incelemiştirler. Bu araştırma, derin öğrenme yöntemlerinin otomatik zararlı tespiti ve mikroorganizma sınıflandırmasında sağladığı başarıları ortaya koymaktadır (Patrício & Rieder, 2018). Ayrıca, Salamut ve ark.(2022), derin öğrenme tabanlı nesne tespiti

yöntemlerinin, yapışkan tuzaklarda kiraz meyve sineği tespitinde nasıl kullanıldığını göstermiştir. Bu tür uygulamalar, zararlı böceklerin izlenmesi ve kontrolü için önemli bir adım teşkil etmektedir. Ayrıca, otomatik zararlı böcek tespiti için derin öğrenme tabanlı yaklaşımlar, daha önce manuel olarak yapılan işlemleri büyük ölçüde kolaylaştırmaktadır. Dewi (2023), ResNet kullanarak zararlı böceklerin otomatik tanımlanması üzerine bir çalışma gerçekleştirmiştir. Bu çalışma, derin transfer öğrenme yöntemlerinin etkili bir şekilde zararlı böceklerin tespitinde kullanılabilirliğini göstermektedir. Bunun yanı sıra, Wang (2022), derin öğrenme tabanlı yöntemlerin, tarımda zararlı böceklerin tanımlanmasında nasıl etkili olduğunu incelemiş ve bu yöntemlerin geleneksel sınıflandırma tekniklerine göre daha iyi sonuçlar verdiğini belirtmiştir. Avustralya'daki bir çalışma, derin öğrenme teknikleri ile bitki zararlılarının tespitinde kullanılmak üzere CNN tabanlı bir sistem geliştirmiştir. Bu sistem, %90 doğrulukla zararlı böcekleri tanımlayabilmiştir (Li ve ark., 2021).

### 3.5. Tarımsal Üretkenlik Tahmini

Dünya nüfusunun artışıyla birlikte gıda talebi de önemli ölçüde artmaktadır. Bu durum, tarımsal üretkenliğin artırılmasını zorunlu kılmaktadır. Tarımsal üretkenlik tahmini, bitki sağlığını izlemek, hastalıkları tespit etmek ve sulama gibi kaynakları optimize etmek için gereklidir. Derin öğrenme, bu süreçte büyük veri setlerini analiz ederek daha doğru tahminler yapma imkanı sunmaktadır. Tarımsal üretkenlik tahmininde kullanılan derin öğrenme yöntemleri arasında Konvolüsyonel Sinir Ağları (CNN), Tekrarlayan Sinir Ağları (RNN) ve Uzun Kısa Süreli Bellek (LSTM) gibi modeller bulunmaktadır. Bu modeller, hava durumu, toprak özellikleri ve bitki büyüme verilerini analiz ederek üretkenlik tahminleri yapmak için kullanılmaktadır.

Derin öğrenme, tarımsal üretkenlik tahmininde önemli bir rol oynamaktadır. Bu teknoloji, büyük veri setlerini analiz etme yeteneği sayesinde, tarımsal verimliliği artırmak ve daha doğru tahminler yapmak için kullanılmaktadır. Tarımsal üretkenlik tahmininde derin öğrenme yöntemlerinin uygulanması, çiftçilere ve tarım yöneticilerine daha iyi karar verme süreçleri sunarak, kaynakların daha verimli kullanılmasına katkı sağlamaktadır Bhagat ve ark. (2022). Özellikle, uzaktan algılama verileri ve iklimsel faktörlerin analizi, derin öğrenme algoritmaları ile birleştirildiğinde, tarımsal verim tahmininde yüksek doğruluk oranları elde edilmektedir. Derin öğrenme tabanlı bir model kullanarak, bölgesel soya fasulyesi verim tahminleri yapmışlardır. Bu çalışma, uzaktan algılama verilerinin kullanımı ile tarımsal üretkenliğin tahmininde önemli ilerlemeler sağladığını göstermektedir (Sun ve ark., 2019). Ayrıca, Joshi ve ark. (2023), uzaktan algılama verileri ile derin öğrenme tekniklerinin tarımsal haritalama ve verim tahmini üzerindeki etkilerini incelemişlerdir. Bu araştırma, tarımsal üretkenliğin tahmin edilmesinde derin öğrenmenin sağladığı avantajları vurgulamaktadır. Derin öğrenme yöntemleri, tarımsal üretkenlik tahmininde çeşitli veri kaynaklarını bir araya getirerek daha kapsamlı analizler yapmayı mümkün kılmaktadır. Kahya ve ark. (2024), YOLOv5 modelini kullanarak tarımsal üretkenliği artırmaya yönelik bir çalışma gerçekleştirmiştir. Bu çalışma, derin öğrenme yöntemlerinin tarımsal verimlilik yönetiminde nasıl etkili olabileceğini göstermektedir. Ayrıca, Wang, derin öğrenme tabanlı yöntemlerin, tarımsal ürünlerin hızlı ve doğru bir şekilde sınıflandırılmasını sağladığını belirtmiştir (Wang, 2024). Bunun yanı sıra, derin öğrenme ile tarımsal üretkenlik tahmini, iklim değişikliği gibi çevresel faktörlerin etkilerini de göz önünde bulundurarak daha doğru tahminler yapma imkanı sunmaktadır. Ibañez (2023), büyük ölçekli tarımsal üretim tahminleri için zaman serisi verilerini kullanarak derin öğrenme yöntemlerinin etkinliğini göstermiştir. Bu çalışma, tarımsal üretkenliğin tahmininde derin öğrenmenin sağladığı avantajları ortaya koymaktadır. Çin'de yapılan bir

araştırma, tarım arazisinin verimliliğini tahmin etmek için derin öğrenme tekniklerini kullanmıştır. Araştırmada, görsel veri ile entegre edilen bir derin öğrenme modeli, üretkenlikte %25 iyileşme sağlamıştır (Zhang ve ark., 2022).

### 3.6.Hasat Sistemleri

Derin öğrenme tekniklerinin entegrasyonu, tarımsal uygulamalardan biri olan hasat sistemi teknolojilerinde önemli ilerlemeler sağlamaktadır. Mahsul tespiti, verim tahmini, meyve hasat robotları ve hassas tarım gibi birçok uygulama günümüzde mevcuttur. Ayrıca, çalışmalar, tanıma ve yerleştirme yöntemleri için derin öğrenmeden yararlanarak görme tabanlı meyve toplama robotlarının geliştirilmesine odaklanmaktadır (Tang ve ark., 2020). Lin ve ark. (2022), derin öğrenme destekli bir muz hasat robotu için ters kinematik çözümü geliştirmişlerdir. Darwin ve ark. (2021), akıllı tarım uygulamaları için mahsul görüntülerinde çiçeklenme ve verimi tanımaya yönelik derin öğrenme modellerini incelemiş ve sonucunda ürünün hasat olgunluğunu doğru tanımlamak adına yüksek doğruluk elde etmişlerdir. Jun ve ark. (2021), derin öğrenme kullanarak hasat robotları geliştirmişlerdir. Son efektör manipülasyonu için 3B algılama ve derin öğrenmeyi kullanan bir domates hasat robotunu tasarlamışlardır. Ni ve ark. (2020), yaban mersini meyvelerinin görüntü segmentasyonu ve özellik çıkarımı için derin öğrenmeyi kullanmışlardır. Hu ve ark. (2019), domates hasat süreçlerinin otomatikleştirilmesinde derin öğrenmenin potansiyelini ortaya koyan Faster R-CNN ve sezgisel bulanık kümeyi birleştirerek bitkilerdeki tek olgun domateslerin otomatik olarak tespitini gerçekleştirmişlerdir. Ko ve ark. (2021), tarımsal ayıklama sistemlerinde domates olgunluğunun tespiti için evrişimli sinir ağlarının stokastik bir karar füzyonunu geliştirerek hasat edilen domateslerin verimli bir şekilde sınıflandırılması ve derecelendirilmesi potansiyelini ortaya koymuşlardır. Magalhães ve ark. (2021), bir seradaki domateslerin tespiti için Tek Atışlı Çoklu Kutu Dedektörü ve YOLO derin öğrenme modellerini değerlendirerek sera tabanlı domates hasadı uygulamalarında derin öğrenmenin potansiyelini vurgulamışlardır. Luna ve ark. (2019), eşikleme, makine öğrenimi ve derin öğrenme tekniklerini kullanarak domates meyvesinin boyut sınıflandırmasını araştırmışlardır. Derin öğrenmenin domates meyvesini boyut ve olgunluğa göre doğru bir şekilde sınıflandırma potansiyelini tespit etmişlerdir. Domates hasadında derin öğrenme yöntemlerinin kullanımı son araştırmalarda önemli bir ilgi görmüştür. Makine öğreniminin bir alt kümesi olan derin öğrenme, büyük miktarda heterojen veriyi özümleme ve karmaşık ve belirsiz olgular için güvenilir tahminler sağlama konusundaki çok yönlülüğünü kanıtlamıştır (Singh ve ark., 2018). Meyve tanıma ve lokalizasyonu alanında, derin öğrenme tabanlı algoritmalar, domates hasadı ve meyve tespiti bağlamında uygulanabilirliklerini gösteren ana yöntemlerden biri olarak incelenmiştir (Tang vd., 2020). Domateslerin olgunluk tespiti için derin öğrenme kullanılmış ve hasat için en uygun zamanın belirlenmesinde çok önemli bir faktör olan domates olgunluğunun değerlendirilmesini otomatikleştirme potansiyelini vurgulamışlardır (Mutha ve ark., 2021). Ayrıca, domates meyvelerinin tespiti için YOLOv5 derin öğrenme modellerinin değerlendirilmesi, hasat robotu geliştirme için gerekli olan gerçek zamanlı görsel domates tespitinde derin öğrenmenin rolünü vurgulayarak mahsul verimi tahmini için önerilmiştir (Bini ve ark., 2022). Valdez (2020), hasat sonrası daha iyi işleme için derin öğrenme tabanlı nesne algılama kullanarak elma kusurlarının tespitine odaklanmış ve derin öğrenmenin hasat sonrası süreçleri ve kalite kontrolünü iyileştirme potansiyelini göstermiştir. Wu ve ark. (2012), meyve ve sebze hasat robotlarında sinir ağlarının uygulama araştırmasını yapmış ve robotik hasat için kamera kalibrasyonu, görüntü segmentasyonu, sınıflandırma ve engellerden kaçınmada derin öğrenmenin kullanımını göstermişlerdir. Yapılan çalışmalar, derin öğrenmenin tarımsal hasat

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uygulamalarında devrim yaratmadaki önemli etkisini ortaya koymaktadır. İleride tarım uygulamalarındaki gelişmelere katkıda bulunarak tarım teknolojisi alanında daha fazla yeniliğin önünü açacağı görülmektedir.

## 4.SONUÇLAR

Bu çalışmada derin öğrenme tekniklerinin tarım sektöründeki çeşitli uygulamaları ele alınmıştır. Bitki hastalığı tespitinden sulama yönetimine, tarımsal verim analizinden zararlı böcek tespitine kadar geniş bir yelpazede derin öğrenmenin sağladığı avantajları vurgulanmıştır. Özellikle Konvolüsyonel Sinir Ağları (CNN) ve Tekrarlayan Sinir Ağları (RNN) gibi derin öğrenme algoritmaları, büyük veri setlerini analiz etme yetenekleri sayesinde tarımsal verimliliği artırmakta ve kaynakların daha etkin kullanılmasını sağlamaktadır. Bitki hastalıklarının tespitinde, derin öğrenme yöntemleri yüksek doğruluk oranları ile hastalıkların erken aşamalarda tanımlanmasına olanak tanımaktadır. Mobil uygulamalar ve web tabanlı sistemler aracılığıyla çiftçilere anlık geri bildirim sağlanması, tarımsal üretkenliği artırmakta ve su israfını azaltmaktadır. Sulama yönetiminde ise, akıllı sulama sistemleri, toprak nemi ve hava durumu verilerini analiz ederek su tasarrufu sağlamakta ve bitki sağlığını iyileştirmektedir. Tarımsal verim analizi, iklim değişikliği ve çevresel faktörlerin etkilerini göz önünde bulundurarak daha doğru tahminler yapma imkanı sunmaktadır. Ayrıca, zararlı böcek tespitinde derin öğrenme yöntemleri, geleneksel yöntemlere göre daha hızlı ve doğru sonuçlar elde edilmesini sağlamaktadır. Hasat sistemlerinde, derin öğrenme tabanlı robotlar, mahsul tespiti ve verim tahmini gibi uygulamalarla tarımsal süreçleri otomatikleştirmekte ve verimliliği artırmaktadır. Genel olarak derin öğrenme tekniklerinin tarımda entegrasyonu, sürdürülebilir tarım uygulamalarının yaygınlaşmasına ve gıda üretiminin artırılmasına önemli katkılar sağlamaktadır. YOLO derin öğrenme algoritması, tarımsal uygulamalarda yüksek doğruluk, hız ve verimlilik sunarak önemli bir araç haline gelmiştir. Tarımsal zararlılar ve hastalıkların tespitinde sağladığı avantajlar, tarım sektöründe verimliliği artırma ve sürdürülebilir tarım uygulamalarını destekleme potansiyelini ortaya koymaktadır. Bu özelliğinden dolayı YOLO'nun sürekli gelişimi ve yeni versiyonlarının ortaya çıkması, tarımsal uygulamalarda daha fazla yenilik ve iyileştirme sağlayacaktır. Gelecekte, bu teknolojilerin daha fazla yenilik ve gelişmeye yol açması beklenmektedir. Tarım sektöründeki bu dönüşüm, hem çevresel sürdürülebilirliği destekleyecek hem de gıda güvenliğini artıracaktır.

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## LANDSCAPE ARCHITECTURE PRACTISES AGAINST THE URBAN HEAT ISLAND EFFECT

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### **Abstarct**

One of the most important global problems of today is climate change. Although there are temperature increases and decreases at certain periods within the ecological balance of nature, especially in the last century, this ecological balance has been disrupted by human influence, causing temperature increases on a global scale. Many situations such as climate change and irregular rainfall regime have extremely negative effects on living things. This effect brings with it undesirable negative effects on plant and animal life. But humankind is both the cause of global climate change and the one affected by it. The need for shelter that emerged with the increase in population has also brought about unplanned urbanization. Rapid and unplanned urbanization has led to the emergence of random and unsystematic cities that no longer conform to urban geometry. As a result, one of the biggest effects of climate change on cities is the heat island effect.

The urban heat island effect is a phenomenon that occurs as a result of dense urban development and the reduction of natural areas. Due to the urban heat island effect, cities are several degrees warmer than their surrounding rural areas. In cities where energy consumption is very high, air quality decreases, temperature increases noticeably, and this negatively affects all living things, especially human health. Landscape architecture is one of the professional disciplines that strives to reduce the urban heat island effect and create comfortable spaces for people.

Landscape architects develop various strategies to ensure environmental sustainability in cities and minimize the effects of climate change by considering the ecological balance. Studies are carried out on the protection of open and green areas, especially in city centers, the creation of new open and green areas, and the reduction of the urban heat island effect, especially on building roofs or exterior facades. Applications such as green roof systems, vertical gardens, and terrace gardens, which are included in green infrastructure applications, are among the working subjects of landscape architects. While such designs add value to cities from an aesthetic perspective and increase the quality of life, they are also very important from an ecological perspective. Landscape architects are one of the most important professional disciplines in creating healthier, more sustainable and livable cities.

**Keywords:** City, urban heat island, landscape architecture

**KENTSEL ISI ADASI ETKİSİNE KARŞI PEYZAJ MİMARLIĞI UYGULAMALARI**

**Özet**

Günümüzün en önemli küresel sorunlarından bir tanesi iklim değişikliğidir. Doğanın ekolojik dengesi içerisinde, belirli periyotlarla sıcaklık artış ve azalmaları olmasına karşın, özellikle son yüzyılda insan etkisiyle bu ekolojik denge bozularak küresel ölçekte sıcaklık artışlarına sebep olmuştur. İklimlerin değişmesi, yağış rejiminin düzensizleşmesi gibi birçok durum, canlı yaşamını son derece olumsuz etkilenmektedir. Bu etki bitki ve hayvan yaşamında istenmeyen olumsuzlukları da beraberinde getirmektedir. Fakat insanoğlu, hem küresel iklim değişikliğine sebep olan ve hem de bu sebepten etkilenen durumdadır. Nüfusun artmasıyla birlikte ortaya çıkan barınma ihtiyacı çarpık kentleşmeyi de beraberinde getirmiştir. Hızlı ve çarpık kentleşme ise bugün artık kent geometrisine uymayan, rastgele ve sistemsiz kentlerin ortaya çıkmasına sebep olmuştur. Bunun sonucunda da iklim değişikliğinin kentlerdeki en büyük etkilerinden biri ısı adası etkisi ortaya çıkmaktadır.

Kentsel ısı adası etkisi, şehirlerde yoğun yapılaşma ve doğal alanların azalmasının sonucunda meydana gelen bir olgudur. Kentsel ısı adası etkisiyle kentler, yakın çevrelerindeki kırsal alanlara göre birkaç derece daha sıcaktır. Enerji tüketiminin çok fazla olduğu kentlerde hava kalitesi düşmekte, sıcaklık hissedilir decede artmakta ve bu durum başta insan sağlığı olmak üzere tüm canlı yaşamını olumsuz etkilemektedir. Peyzaj mimarlığı, kentsel ısı adası etkisinin azaltılması ve insanlar için konforlu mekanlar yaratılması konusunda uğraş veren meslek disiplinlerinden biridir.

Peyzaj mimarları ekolojik dengeyi gözeterek kentlerde çevresel sürdürülebilirliği sağlamak ve iklim değişikliğinin etkilerini en az düzeye indirmek için çeşitli stratejiler geliştirmektedir. Özellikle kent merkezlerinde yer alan açık ve yeşil alanların korunması, yeni açık ve yeşil alanların oluşturulması, özellikle bina çatılarında ya da dış cephelerde kentsel ısı adası etkisinin azaltılması konularında çalışmalar gerçekleştirilmektedir. Yeşil altyapı uygulamaları içinde yer alan yeşil çatı sistemleri ve dikey bahçeler, teras bahçeleri gibi uygulamalar, peyzaj mimarlarının çalışma konuları içinde yer almaktadır. Bu tür tasarımlar estetik açıdan kentlere değer katarak yaşam kalitesini artırırken, aynı zamanda ekolojik açıdan da oldukça önemlidir. Peyzaj mimarları daha sağlıklı, sürdürülebilir ve yaşanabilir kentler oluşturma konusunda en önemli meslek disiplinlerinden biridir.

**Anahtar Kelimeler:** Kent, kentsel ısı adası, peyzaj mimarlığı

## 1. INTRODUCTION

There has been a significant increase in the number of people living in cities around the world. This population growth in today's cities brings with it economic, social and environmental problems. The increase in human activities in the city, the change in the morphological structure of the urban fabric, the decrease in vegetal surfaces and the increase in hard surfaces pave the way for the formation of adverse microclimatic conditions. The urban heat island effect is one of the most common microclimatic problems seen in large cities (Canan, 2017).

Urban heat island is defined as a temperature within a city that is higher than the surrounding rural area. The reason for this temperature difference is the change in land cover in the urban area. These changes are related to dense construction, intensive use of surfaces such as concrete and asphalt, high-rise buildings, insufficient green areas, energy consumption and urban planning (Yüksel and Yılmaz, 2008; Üstündağ et al., 2023).

The geometric structure of the city affects the formation of the urban heat island effect (Rzepa, 2009; Guo, et al. 2016; Cheung et al., 2016). According to Oke (1981), this formation occurs mostly at night. While it may be positive in winter months, it causes undesirable temperature increases in summer periods (White, 2015; Canan, 2017).

The urban heat island effect is a phenomenon that occurs as a result of dense urban development and the reduction of natural areas. Due to the urban heat island effect, cities are several degrees warmer than their surrounding rural areas. In cities where energy consumption is very high, air quality decreases, temperature increases noticeably, and this negatively affects all living things, especially human health. Landscape architecture is one of the professional disciplines that strives to reduce the urban heat island effect and create comfortable spaces for people.

## 2. URBAN HEAT ISLAND AND ITS EFFECTS

This climatic difference between urban and rural areas was first defined as the 'urban heat island' by Luke Howard for the city of London in 1820 and entered the literature and has been researched in major cities of the world to this day (Yüksel and Yılmaz, 2008; Üstündağ et al., 2023). Many factors that cause the urban heat island effect, which emerges as a characteristic feature of the urban climate, are included in the academic literature. Just as the characteristics of urban climate vary according to time and space, similarly, the location-specific characteristics of cities (environmental, social, economic, morphological, etc.) also cause differences in the heat island effect (Baş and Partigöç, 2023).

According to Baş and Partigöç (2023), the factors that cause the urban heat island effect are grouped into three classes: (a) Natural environment - built environment elements, (b) urban geometry and (c) anthropogenic heat radiation.

- a. **Natural environment – built environment elements:** Decreased shadow formation due to the scarcity and/or inadequacy of vegetation and natural structural elements (open and green areas, water availability, etc.) in urban areas, disruption of the moisture balance in the natural cycle, use of surface coating materials (concrete, asphalt, roofing materials, etc.) with low albedo value (tendency to reflect less sunlight) in urban areas (Baş and Partigöç, 2023).
- b. **Urban geometry:** It is important to examine the urban geometry in terms of the typologies of existing buildings, building heights, street widths and wind circulation. It has been shown that urban heat island formation is higher in areas where urban density and the ratio of building heights to street width are high. The high ratio of building

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height to street width represents a process that limits heat dissipation from urban areas to the atmosphere and slows down night cooling (Dursun and Yavaş, 2017; Baş and Partigöç, 2023).

- c. **Anthropogenic heat radiation:** With the increasing population in urban areas, needs have also increased. Accordingly, greenhouse gases released into the atmosphere as a result of the destruction of the natural structure and the intensive use of fossil fuels have caused global warming and changes in the climate structure. Anthropogenic heat radiation occurs due to the use of fossil fuels in domestic heating, industrial production processes, transportation, and energy use for heating and cooling. It has been determined that anthropogenic heat can create a heat effect of 2-3°C during the day and night in the center of a large city (Tozam, 2016; Baş and Partigöç, 2023).

The environmental and human health effects of urban heat islands are given in Table 1.

**Table 1.** Environmental and Human Health Effects of Urban Heat Islands (Kahraman and Şenol, 2018; Üstündağ et al., 2023)

Environmental and Human Health Effects of Urban Heat Islands	
ECOSYSTEM	As natural land covers in urban areas are replaced by impermeable surfaces such as asphalt and concrete, the ecological balance is disrupted and the temperature of the city increases as these surfaces retain heat on their surfaces.
URBAN SETTLEMENT	The formation of urban destruction and climate problems can change the settlement areas. This situation causes the increase of floods, inundation areas and the increase of heat intensity in the region.
WATER RESOURCES	Since rainfall in cities is prevented from reaching the soil compared to rural areas, it becomes difficult for the soil to be saturated with water, causing drought.
AIR QUALITY	The use of fossil fuels in cities, the energy spent on cooling in the summer months, the use of greenhouse gases and other air pollutants increase the urban heat island.
NATURAL LAND DESTRUCTION	Since green areas are not sufficient in built environments and the area of buildings, concrete and asphalt surfaces is excessive, it causes the formation of an urban heat island.
ECONOMY	When the balance of natural life is disrupted, disasters that may occur cause great economic losses.
HUMAN HEALTH	Skin diseases due to temperature increases, respiratory diseases due to air pollution, irregular rainfall regimes due to the disruption of the ecological balance, factors such as floods and droughts and the lack of green areas create both physical and psychological negativities.

### 3. LANDSCAPE ARCHITECTURE APPLICATIONS IN REDUCING URBAN HEAT ISLAND EFFECTS

Today, practices known as 'green systems' emphasize the importance of open and green spaces and water resources in reducing the urban heat island effect. These applications include green-blue infrastructure systems, green buildings, green walls and green roofs. Considering that the amount of green space per person in cities does not provide the necessary and sufficient conditions, it is clear that strategies that can be developed at the building scale with a change between scales can serve the ecological planning approach. By implementing green systems on building walls and roofs, it is possible to increase the albedo value and restore humidity-

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evapotranspiration cycles in urban areas. In addition, these systems will provide significant benefits in reducing air pollution and the integration of ecological approach models into urban planning processes will be possible (Baş and Partigöç, 2023).

Green infrastructure is a functional system including vegetation, shading, water use, green roofs and walls. The systems create living environments by controlling rainwater flow, protecting air quality and biodiversity (Elmqvist et al., 2015; Perini and Sabbion, 2017; Artar, 2023). With these systems, urban heat island can be prevented or reduced by proper planning and design (Üstündağ et al., 2023).

Today, green infrastructure applications are preferred in cities around the world in terms of reducing energy costs, reducing damage caused by floods, and protecting public health and environmental health. Today, green infrastructure applications are preferred in cities around the world in terms of reducing energy costs, reducing damage caused by floods, and protecting public health and environmental health (Yaralıoğlu and Asilsoy, 2021).

In addition to its focus on connectivity, the green infrastructure plan contributes to the preservation of regional image, landscape character, urban identity and local differences, as well as making spaces more aesthetically appealing and original. Green infrastructure is an indispensable spatial planning layer in creating a more distinct “sense of place” and social interaction. In other words, green infrastructure, like roads, sewage systems, hospitals and other built gray infrastructure components, meets important needs of society. Green infrastructure can be complementary and integrative to the health of communities and also to their lives (Li et al., 2005; Yaralıoğlu and Asilsoy, 2021).

The issue of green infrastructure is now an important issue that is being researched and implemented globally. Green infrastructure consists of different components and is implemented with different principles and objectives (Table 2). Landscape architecture is one of the leading professional disciplines working in this field both academically and practically. Landscape architects strive to reduce the urban heat island effect and increase the quality of urban life by using green infrastructure components with different application examples in urban areas (Figure 1).

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Table 2. Green Infrastructure Principles and Targets (Aslan and Yazıcı, 20216; Yaralıoğlu and Asilsoy, 2021)

<b>GREEN INFRASTRUCTURE PRINCIPLES</b>	<b>GREEN INFRASTRUCTURE GOALS</b>
<b>Multifunctionality</b>	<ul style="list-style-type: none"> <li>• It should cover many ecosystems.</li> <li>• Cultural harmony should be ensured.</li> <li>• Different functional uses should be considered together.</li> <li>• Targets should be determined with detailed analysis and participation of stakeholders and a systematic hierarchy should be established between functions.</li> <li>• Society should be informed about green infrastructure functions.</li> </ul>
<b>Connectedness</b>	<ul style="list-style-type: none"> <li>• It is necessary to establish physical and functional connections between green areas with different scales and perspectives, such as rainwater management, recreation, etc.</li> <li>• Urban, green area resources and functions should be shaped according to the analyses to be made.</li> </ul>
<b>Integration</b>	<ul style="list-style-type: none"> <li>• Urban green infrastructure needs to be addressed with a holistic approach, functionally and physically, with other infrastructures.</li> <li>• Administrative units, different professional groups and stakeholders need to communicate and work together.</li> </ul>
<b>Communication / Social Content Process</b>	<ul style="list-style-type: none"> <li>• Cooperation between all stakeholders, both private and public, and experts from different professions should be ensured, and joint decisions should be made by taking the opinions of all stakeholders into account during the decision-making process.</li> </ul>
<b>Long Term Strategy</b>	<ul style="list-style-type: none"> <li>• Long-term interests, not short-term ones, should be considered.</li> <li>• It should be considered within the framework of sustainable development.</li> </ul>

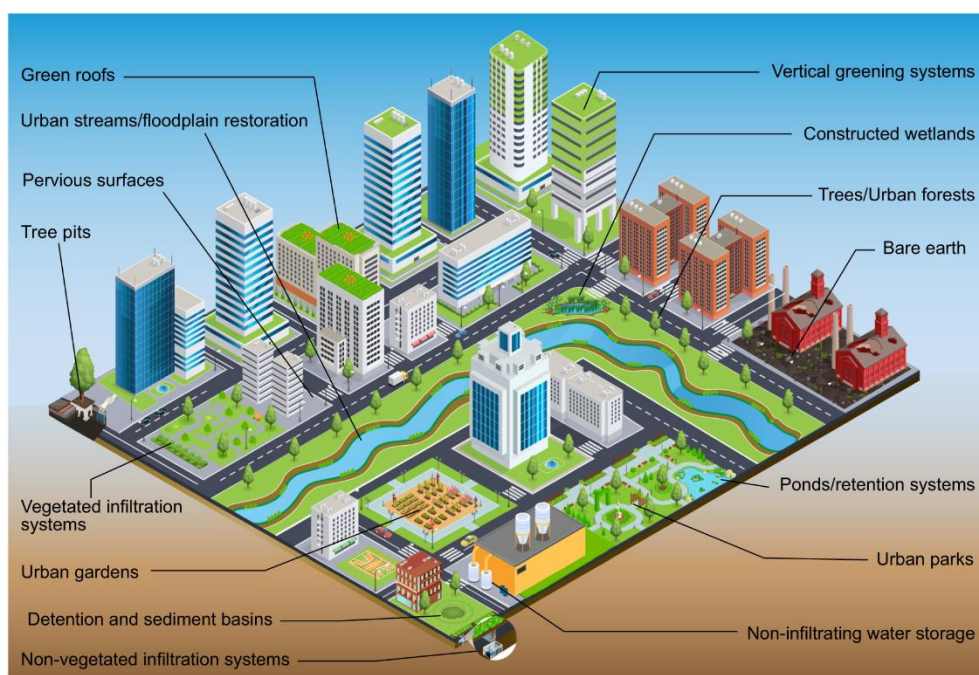


Figure 1. Green infrastructure and its elements (Cook et al. 2024)

#### 4. CONCLUSION

Climate change and cities interact with each other. While cities have a significant impact on the natural environment and climate change, factors that may occur due to climate change also negatively affect the urban system (Çobanyılmaz and Yüksel, 2013; Özgül et al., 2021).

Especially after the industrial revolution, with the acceleration of human-oriented activities such as natural resource use, industrial production and urbanization, the climate has entered a rapid change with negative effects. Climate change does not only involve one region but also requires international work. In order for these studies to be successful, cities where human activities are most intense need to be addressed. Because human activities are the source of greenhouse gas emissions in cities (IPCC Glossary, 2016; Özgül et al., 2021).

With the rapid growth of cities, the pressure on the natural environment increases and this causes the balance of nature to be disrupted. The population of cities is increasing rapidly. This increasing urban population causes an increase in energy consumption and greenhouse gas emissions (Tuğaç 2018; Özgül et al., 2021).

The discipline of landscape architecture has the potential to produce solutions to ameliorate the impacts of climate change through climate-appropriate landscaping, urban planning and design. It is clear that the orientation of buildings, the composition of surface materials, their color and vegetation, their types and locations have major impacts on urban heat islands and microclimates. These interventions can improve outdoor climate conditions and facilitate longer periods of time outdoors. They can also contribute to a better indoor climate and thus less use of air conditioners for heating or cooling (Lenzholzer and Brown 2013; Acar and Yavuz, 2023).



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## PUBLIC PARTICIPATION AND ITS IMPORTANCE IN LANDSCAPE MANAGEMENT APPROACHES

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### **Abstarct**

Landscape is a very broad definition that includes the ecological, visual, physical etc. characteristics of an area. The concept of landscape, which is the environment formed by the combination of natural and cultural elements, where people live, are affected and affected, is defined in the European Landscape Convention (2000) as areas whose characteristics are formed by the interaction of human and/or natural factors, as perceived by people. The protection, design, planning, management and sustainability of landscapes are very important for the continuity of life. The whole of the methods applied to protect, develop and ensure sustainability of natural and cultural resources is called landscape management. According to the European Landscape Convention (2000), landscape management is a set of activities for sustainable development. Thanks to landscape management, changes in the landscape resulting from social, economic and environmental processes are managed with appropriate methods. Landscape management is a concept that prioritizes increasing ecosystem services, ensuring the sustainability of landscapes, ensuring the continuity of life and protecting biodiversity by considering the needs of local people. Today, effective and sustainable landscape management strategies are needed to produce solutions to global environmental problems such as climate change and global warming, environmental pollution, and intensive and unplanned urbanization.

One of the keywords in landscape management approaches is undoubtedly public participation. Public participation aims to increase social ownership and awareness, especially on environmental issues where social benefit is at the forefront. By involving local people in decision-making processes, projects become more transparent and accountable. Public participation is carried out through surveys, interviews, workshops, oral and written interviews and similar practices, depending on the subject of the project, its purpose, target audience, activities to be carried out, etc. Through to public participation, local people are given a say in the environment in which they live. In addition, people can have more in-depth information about the characteristics of the environment in which they live. When people have more information about the area they live in, their spatial attachment increases and their sense of belonging strengthens. People's expectations from the environment they live in, their ability to solve problems in their environment, and the level of meeting their needs are also improving. In this way, it will be possible to use landscapes both appropriately and correctly and to ensure their sustainability.

**Keywords:** Public participation, landscape, landscape management

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## HALKIN KATILIMI VE PEYZAJ YÖNETİM YAKLAŞIMLARINDAKİ ÖNEMİ

### Özet

Peyzaj bir alanın ekolojik, görsel, fiziksel vb özelliklerini kapsayan çok geniş bir tanımdır. Doğal ve kültürel unsurların bir araya gelmesiyle oluşan, insanların yaşadığı, etkilendiği ve etkilediği çevreyi ifade eden peyzaj kavramı Avrupa Peyzaj Sözleşmesi'nde (2000), insanlar tarafından algılandığı şekliyle, özellikleri insan ve/veya doğal faktörlerin etkileşimi ile oluşmuş alanları ifade etmektedir. Peyzajların korunması, tasarlanması, planlanması, yönetimi ve sürdürülebilirliği yaşamın devamlılığı açısından çok önemlidir. Doğal ve kültürel kaynakların korunması, geliştirilmesi ve sürdürülebilirliğinin sağlanması amacıyla uygulanan yöntemler bütününe kısaca peyzaj yönetimi denilmektedir. Avrupa Peyzaj Sözleşmesi (2000)'ne göre peyzaj yönetimi, sürdürülebilir kalkınma açısından faaliyetler bütünüdür. Peyzaj yönetimi sayesinde sosyal, ekonomik ve çevresel süreçler sonucunda peyzajda ortaya çıkan değişiklikler uygun yöntemlerle yönetilmektedir. Peyzaj yönetimi, yöre halkının ihtiyaçlarının gözetilerek, ekosistem hizmetlerinin artırılmasını, peyzajların sürdürülebilirliğinin sağlanmasını, yaşamın devamlılığının güvence altına alınmasını ve biyoçeşitliliğin korunmasını öncelikleyen bir kavramdır. Günümüzde özellikle küresel çevresel sorunlar olan iklim değişikliği ve küresel ısınma, çevre kirliliği, yoğun ve plansız kentleşme gibi tehditlere karşı çözüm üretmek için etkili ve sürdürülebilir peyzaj yönetimi stratejilerine ihtiyaç duyulmaktadır.

Peyzaj yönetimi yaklaşımlarında anahtar kelimelerden biri hiç kuşkusuz halkın katılımıdır. Halkın katılımı, özellikle toplumsal faydanın öne çıktığı çevresel konularda toplumsal sahiplenmeyi ve bilinç düzeyini arttırmayı amaçlamaktadır. Yerel halkın karar alma süreçlerine dahil edilmesiyle, projelerin daha şeffaf ve hesap verebilir olması sağlanmaktadır. Halkın katılımı, projenin konusuna, amacına, hedef kitleye, yapılacak faaliyete vb etkinliklere göre anketler, mülakatlar, atölye çalışmaları, sözlü ve yazılı görüşmeler ve bunun gibi uygulamalarla yapılmaktadır. Halkın katılımı sayesinde, yöre halkının yaşadıkları çevre hakkında söz sahibi olması sağlanmaktadır. Bunun yanı sıra halk, yaşadıkları çevrenin özellikleri konusunda daha derin bilgilere sahip olabilmektedir. İnsanlar, yaşadıkları bölge hakkında daha fazla bilgiye sahip olduklarında, mekânsal bağlılıkları artarak aidiyet duyguları güçlenmektedir. Halkın yaşadıkları çevreden beklentileri, çevrelerinde yaşanan sorunları çözümlene yetenekleri ve ihtiyaçlarını karşılama düzeyleri de gelişmektedir. Bu sayede peyzajların hem amacına uygun ve doğru bir şekilde kullanılması ve hem de sürdürülebilirliklerinin sağlanması mümkün olabilecektir.

**Anahtar Kelimeler:** Halkın katılımı, peyzaj, peyzaj yönetimi

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## 1. INTRODUCTION

Landscape as a scientific term was first defined nearly 200 years ago by German geographer Alexander Von Humboldt as "all the defining features of a piece of land". In 1850, Rosenkranz defined landscape as all local systems that exist in nature and are organized hierarchically (Bastian, 2001). Neef (1967) defined landscape as "a piece of land with a uniform structure and functional texture (pattern)"; he included appearance, components (relief, soil, climate, water, flora, fauna, humans and human structures) and their spatial locations in this definition. However, landscape is not just the individual combination of these geographical factors but the whole formed by their interaction. Forman and Godron (1986) emphasized this deficiency and defined landscape as "a heterogeneous piece of land formed by the coming together of interacting ecosystems and repeating itself in similar forms". Leser (1997) defined landscape as "a spatial texture in which living, non-living and anthropogenic components form a functional whole". Today, the definition of "all structural and textural (pattern) characteristics of a specific geographical area with its biological composition, physical environment and anthropogenic and social structure" (IUCN, 2003) is widely accepted. Many different definitions emerge in the interpretation of the word landscape. However, the common expression that does not change in all of these is "a piece of land containing the mosaic formed by the coming together of landscape elements" (Deniz et al., 2006). In its latest form, the word landscape, as perceived by people, is used in the European Landscape Convention (2000) to refer to areas whose characteristics have been formed by the interaction of human and/or natural factors.

Participation is defined as individuals' influencing the decisions made in the physical environments, programs and institutions that affect and concern them, and taking part in the formation of these decisions (Sarıkocce, 2002). Participation, as defined by Yalçındağ (1996), is the activity carried out by members of the public community by influencing, supervising or directly meeting the needs of the society (Özkiroz and Zeren, 2009).

According to Geray (1995), although the areas and types of participation vary according to the social, political, cultural and economic conditions of each country, the following list can be made (Özkiroz and Zeren, 2009):

- Urban planning
- Environmental protection
- Referendum
- Recall of elected officials
- Complaints of fellow citizens
- Urban, social movements

The protection, design, planning, management and sustainability of landscapes are very important for the continuity of life. The whole of the methods applied to protect, develop and ensure sustainability of natural and cultural resources is called landscape management. According to the European Landscape Convention (2000), landscape management is a set of activities in terms of sustainable development. Thanks to landscape management, changes in the landscape resulting from social, economic and environmental processes are managed with appropriate methods.

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## 2. LANDSCAPE MANAGEMENT AND MANAGEMENT PLANS

Although the concept of landscape management was addressed in previous years, it took its true form with the European Landscape Convention (ELC). In ELC, landscape management is defined as “action to ensure the regular maintenance of a landscape in a way that directs and harmonizes changes caused by social, economic and environmental processes from a sustainable development perspective” (APS, 2003; Kaya Özdemir, 2016).

Anko (1999) defines landscape management as managing the changes caused by ecological, social and economic processes in the landscape in a sustainable manner and guiding these processes (Kaya Özdemir, 2016).

Giorgis (1995) mentioned four principles regarding landscape management (Kaya Özdemir, 2016):

- Protection of landscape diversity,
- Protection of biological diversity,
- Increased solidarity,
- Respect for regional identity and the right to enjoy aesthetics

According to Serdaroğlu (2005), the basic qualities of landscape management (Kaya Özdemir, 2016):

- Landscape management can be applied at different scales,
- Landscape management is holistic,
- Landscape management is ecosystem-based,
- Landscape management is aimed at the sustainable use of ecosystem resources,
- Landscape management has a multidimensional and open-to-dialogue approach,
- The human element is very important in landscape management,
- Spatial and temporal change is taken into account in landscape management,
- Indicators are used in landscape management,
- Landscape management has multi-actor and multi-faceted goals,
- Landscape management is implemented in the light of up-to-date/reliable data and a common understanding,
- Landscape management is within a system perspective.

While creating the actions to be put forward in line with the goals and objectives for the management plan, the decisions taken must have three important principles: sustainability, partnership-participation and scientificness (Özbay, 2008; Güneş, 2011).

## 3. THE IMPORTANCE OF PUBLIC PARTICIPATION IN LANDSCAPE MANAGEMENT

Participation, with its theoretical and practical value, is a wide area of activity that extends from simple curiosity to intense action in order to always take ownership of and shape life, rather than leaving life to the will of others. Participation occurs through the stages of informing, examining, negotiating and raising awareness, and the integrity of these stages (Önder, 2013; Turgut Gültekin and Uysal, 2018).

Nowadays, with the increasing awareness of participation and the increasing awareness on this issue, various methods that include all stakeholders in the planning processes have begun to be used (Açıksöz et al., 2019).

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The right of local people to participate in decisions affecting their living spaces and their effective participation and cooperation in this process will directly contribute to the socio-cultural, economic and administrative-institutional development and/or local democracy that will be achieved through heritage values. Thus, by ensuring ownership with broader participation, the continuity of these values will be guaranteed and their promotion will be facilitated (Turgut Gültekin and Uysal, 2018).

Public participation aims to increase social ownership and awareness, especially on environmental issues where social benefit is at the forefront. By involving local people in decision-making processes, projects become more transparent and accountable. Public participation is carried out through surveys, interviews, workshops, oral and written interviews and similar practices, depending on the subject of the project, its purpose, target audience, activities to be carried out, etc. Thanks to public participation, local people are given a say in the environment in which they live. In addition, people can have more in-depth information about the characteristics of the environment in which they live. When people have more information about the area they live in, their spatial attachment increases and their sense of belonging strengthens. People's expectations from the environment they live in, their ability to solve problems in their environment, and the level of meeting their needs are also improving.

## 4. CONCLUSION

Considering participation as an important part of the local decision-making process, without being independent of the localization dynamics, and encouraging the public in this direction will make participation widespread. While the sensitivity of the local people accelerates voluntary participation activities, the organized structure of civil society organizations that focus on volunteering strengthens participation and makes it effective. The World Heritage Convention's vision of "providing multi-stakeholder consultation" in the conservation process, which is the first and/or primitive signal of awareness, consciousness and participation in the protection of cultural heritage in the international context, has played an important role in the development of this issue in the world (Turgut Gültekin and Uysal, 2018).

Participatory approaches can be used in every sector and at every project stage. In landscape architecture and related professional fields, it is generally used to determine the attitudes, opinions and expectations of individuals living in the area of study and to determine the natural-cultural potential of the study area and its surroundings. When considered from the perspective of related fields, the most distinctive feature of participatory approaches is that they are based on locality and local knowledge. This process approach, which operates from the bottom up, ensures that ecological and sociological incompatibilities that are frequently encountered in planning and design can be prevented (Açıksöz et al., 2019).

Preparation of the management plan with the participation of all stakeholders, including the local community, is a fundamental condition of the process in terms of supporting the negotiations of the planning team, eliminating errors and reaching consensus. Meanwhile, the planning team should also use direct public contact opportunities using various communication tools (Geray and Küçükkaya, 2011; Güneş, 2011).

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**BİYOKÖMÜR KATKILI TOHUM EKİM ORTAMININ HİDROPONİK KUZU  
MARULU YETİŞTİRİCİLİĞİNDE BİTKİ GELİŞİMİ, VERİM VE KALİTEYE  
ETKİLERİ**

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**Özet**

Toprak düzenleyicisi olarak kullanılan biyokömür, ham maddelerin oksijensiz veya az oksijenli ortamda yüksek ısıya maruz bırakılarak oluşturulan, karbon oranı yüksek katı bir maddedir. Biyokömürün toprak verimliliği ve bitki gelişimi üzerine olumlu etkilerinin bilinmesinden yola çıkarak planlanan bu çalışmada, fide yetiştirme ortamına uygulanan biyokömürün hidroponik kuzu marulu yetiştiriciliğinde etkilerinin belirlenmesi amaçlanmıştır. Biyokömür (BK) hacimsel olarak torf (T) ile karıştırılmış ve %0 (%0BK+%100T, kontrol), %5 (%5BK+%95T), %10 (%10BK+%90T) ve 20% (%20BK+%80T) karışım oranları denenmiştir. Hazırlanan karışım nemlendirilerek 45'lik viyollerde file saksılara doldurulmuş ve her bir saksıya 1 adet tohum elle ekilmiştir. Viyoller 3 gün boyunca (18±2°C, %85 RH, karanlık) çimlenme odasında tutulduktan sonra adaptasyon serasına alınmıştır. Fideler 1-2 yapraklı aşamada serada NFT sistemine aktarılmıştır ve hasat aşamasına gelene kadar 39 gün boyunca su kültüründe yetiştirilmiştir. Tek seferde yapılan hasat sonrası bitkilerin agromorfolojik gelişimi, verim ve kalite değerleri belirlenmiştir. Biyokömürün bitki gelişimi ve verimini etkilediği ancak kalitede önemli bir değişiklik yaratmadığı belirlenmiştir. Özellikle bitki ve yaprak boyu biyokömür uygulaması ile artmış, kök boyu azalmıştır. Bitki biyokütlesi ve verim değerleri istatistiksel bir farklılık göstermese de biyokömür uygulaması ile artmıştır. Düşük dozlu biyokömür karışım oranlarının daha etkin olduğu, bunlar içerisinde de yüksek bitki gelişimi ve verim değeri ile %5BK+95%T karışımının daha umutvar olduğu görülmüştür. Biyokömürün torfa alternatif bir ortam olmadığı ancak torf ile karışımının torf yataklarının korunması ve atıkların değerlendirilmesi adına çevreci bir yaklaşım olabileceği sonucuna varılmıştır.

**Anahtar Kelimeler:** *Valeriana locusta*, Mısır Salatası, Topraksız Tarım, NFT, Biyoçar

THE EFFECTS OF BIOCHAR-ENRICHED SEEDLING MEDIUM ON PLANT  
GROWTH, YIELD, AND QUALITY IN HYDROPONIC LAMB'S LETTUCE  
CULTIVATION

**Abstract**

Biochar, which is used as a soil conditioner, is a solid material with high carbon content, which is formed by exposing raw materials to high temperatures in an oxygen-free or low-oxygen environment. Based on the known positive effects of biochar on soil fertility and plant growth, this study aimed to determine the effects of biochar applied to seedling growing medium on hydroponic cultivation in lamb's lettuce. Biochar (BC) was mixed with peat (T) at the rates of 0% (0%BC+100%P, control), 5% (5%BC+95%P), 10% (10%BC+90%P), and 20% (20%BC+80%P) by volume and the mixture was moistened and filled into seedling tray with 45 cells and 1 seed was sown by hand in each tray. The trays were kept in the germination room for 3 days ( $18\pm 2^{\circ}\text{C}$ , 85% RH, darkness) and then transferred to the adaptation greenhouse. The seedlings, at the 1-2 leaf stage, were transferred to the NFT system in the greenhouse and cultivated in hydroponics for 39 days until the harvest stage. After a single harvest, the agro-morphological development, yield, and quality values of the plants were determined. It was found that biochar affected plant growth and yield, but did not cause significant changes in quality. Specifically, plant and leaf length increased with biochar application, while root length decreased. Although no statistical difference was observed in plant biomass and yield values, these were enhanced with biochar application. It was observed that lower doses of biochar mixture ratios were more effective, with the mixture of 5% BC + 95% P showing the highest plant growth and yield value, making it the most promising. It was concluded that biochar is not an alternative to peat but could provide an environmentally friendly approach for the conservation of peat beds and the recycling of waste when mixed with peat.

**Keywords:** *Valeriana locusta*, Corn Salad, Hydroponics, NFT, Biochar

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## GİRİŞ

Günümüzde toprakla ilgili sorunlar nedeniyle bitkisel üretimde üretilen ürünün miktar ve kalitesinde azalışlar gözlenmektedir. Bu azalışın önüne geçmek için alternatif uygulamalar arayışına yönelik çok sayıda çalışmalar yürütülmektedir. Alternatif uygulamalardan biri de toprağın fiziksel, kimyasal ve biyolojik yapısının düzenlenmesinde büyük bir potansiyeli olan biyokömürün tarımda kullanımınıdır. Biyokömür, toprak düzenleyici olarak dünya çapında bilinmekte ve kullanılmaktadır. Bu özelliğinin yanı sıra toprakta zengin bir karbon kaynağı oluşturabilmesi de önemini artırmaktadır (Keskinaslan ve ark., 2023).

Biyokömür, organik atıkların (budama artıkları, pirina vb.) oksijensiz ortamda veya düşük oksijenli ortamda 300-700°C'lik ısıya maruz bırakılması sonucu oluşmaktadır ve Güney Amerika'da "Terra Preta" olarak adlandırılan koyu renkli toprakların keşfiyle dikkat çekmiştir (Kammann ve ark., 2017). Biyokömür, aktif karbon ve odun kömüründen farklı bir materyaldir. Aktif karbon üretiminde uygulanan sıcaklıkların biyokömür üretiminden daha yüksek olması (Akgül, 2017), odun kömürü üretiminde ise biyokütlenin oksijenli ortamda yanması (Akkurt ve ark., 2020) arasındaki farklılığın temel nedenidir. Karbon bakımından zengin bir madde olan biyokömür, toprak kalitesi ve verimliliğini artırmasının (Major ve ark., 2010; Güereña ve ark., 2013) yanı sıra toprak kirlenmesinin bir miktar önüne geçerek, karbon depolanmasını sağlamak ve süzülen toprak suyunun filtre edilmesinin artırılması amacıyla da kullanılmaktadır (Lehmann & Joseph, 2009; Tomczyk ve ark., 2020). Ayrışmaya karşı dirençli yapısı, yüksek spesifik yüzey alanı ve negatif yüzey yükü sayesinde toprağın fiziksel, kimyasal ve biyolojik özelliklerini iyileştirerek bitkisel üretim verimliliğini artıran bir katkı maddesi olduğuna inanılmaktadır (Madari ve ark., 2017; Zhang ve ark., 2017). Toprağa uygulanan biyokömür, topraktaki katyonik faaliyetleri artırarak toprakta kalsiyum, magnezyum ve potasyum elementlerinin tutulmasını sağlamaktadır (Akgül, 2017).

Biyokömürün toprak verimliliği ve dolayısıyla bitki gelişimi üzerindeki etkisi, topraktaki besin elementlerinin miktarı ve bulunabilirliği ile toprağın biyokimyasal özellikleri üzerindeki etkileriyle ilişkilidir. Biyokömürün özelliklerine bağlı olarak, su ve besin maddesi tutma veya mikrobiyal aktivite gibi toprak özelliklerini doğrudan etkilediği de ortaya konmuştur (Atkinson ve ark., 2010; Lehmann ve ark., 2011). Yüksek yüzey alanı ve karbon içeriği, gözenekli yapısı ve genellikle alkali doğasıyla biyokömür uygulamasının toprağın organik madde içeriğini artırdığı (Liu ve ark., 2017), pH'ı yükselttiği (Chan ve ark., 2007; Laird ve ark., 2010), toprak mikroorganizmalarının çeşitliliğini ve miktarını değiştirdiği (Gul ve ark., 2015), toprak yüzey alanını artırdığı (Lehmann ve ark., 2011), toprak sıkışmasını azalttığı (Olmo ve ark., 2014; Liu ve ark., 2017), toplam poroziteyi artırdığı (Githinji, 2014), gözenek boyutu dağılımında değişiklikler yarattığı (Sun & Lu, 2014) ve su tutma kapasitesini artırdığı (Akhtar ve ark., 2015) bildirilmektedir. Tüm bu etkiler, bitki üretimi için daha uygun bir yetiştirme ortamı yaratılmasına katkıda bulunarak daha iyi bitki gelişimi ve nihayetinde ürün veriminde önemli bir artış sağlamaktadır. Biyokömürün en önemli özelliklerinden biri atıkların değerlendirilmesindeki etkinliğidir. Biyokömür üretimi, bitkisel üretimden elde edilen organik atıkların ve tarımsal kökenli endüstriyel atıkların tarımsal alanlarda gübre olarak kullanılmasına olanak sağlamaktadır. Bu sayede hem kimyasal gübrelerden tasarruf edilmekte hem de atıkların olumsuz çevresel etkileri azaltılmaktadır (Şahin ve ark., 2016). Biyokömürün bu amaçla toprak düzenleyici olarak kullanımına ilişkin araştırmalar, atık olarak kabul edilen birçok materyalin bitki besin maddesi ve organik madde kaynağı olarak toprağa eklenebileceğini veya belirli oranlarda karıştırılarak yetiştirme ortamı olarak kullanılabilirliğini göstermiştir (Aydeniz & Brohi, 1991; Benito ve ark., 2005).

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Yürütülen çalışmalarda genellikle bitkisel üretime odaklanmış, biyokömürün topraksız tarımda yetiştirme ortamı olarak kullanımını da denenmiştir (Dunlop ve ark., 2015; Graber ve ark., 2010; Nichols ve ark., 2010; Karakaş ve ark., 2017). Ancak biyokömürün su kültüründe tohum ekim veya bitki kök ortamı olarak kullanımı üzerinde durulmamıştır. Bu nedenle yürütülen bu çalışmada, bitki atıklarından elde edilen biyokömürün ticari bir fide yetiştirme ortamına (torf) farklı oranlarda eklenerek elde edilen fidelerin hidroponik ortamda yetiştirilmesi sonucunda bitki gelişimi, verim ve kalitesine etkilerinin belirlenmesi amaçlanmıştır.

Araştırmada ülkemiz için yeni bir tür olan kuzu marulu (*Valerianella locusta L.*) kullanılmıştır. Mısır salatası olarak da bilinen kuzu marulu, yaprakları tüketilen sebze grubunun bir üyesi olan Avrupa kökenli, tek yıllık bir bitkidir. Koyu yeşil yaprakları ile yurtdışında oldukça beğenilen bitki, salatalarda çiğ olarak tek başına ya da diğer yeşilliklerle karıştırılarak tüketilmekte ve hazır salata paketlerinde satılmaktadır. Kuzu marul Türkiye'de üretilip tüketilmese de tadı ve lezzeti ile Türk damak tadına uygun bir türdür. Tek dönemde hasat edilmesi ve kısa süreli yetiştiriciliğe uygun olması, kış ve erken ilkbahar aylarında seralarda ardışık olarak yetiştirilebileceğini göstermektedir (Öztekın & Tural, 2021). Serada veya açıkta üretim için alternatif bir tür olabilecek kuzu marulunun, ülkemizde tanınırlığının artması ve pazarda yerini bulması için çalışmada model bitki olarak seçilmiştir.

## MATERYAL VE METOD

Çalışma Ege Üniversitesi (EÜ) kampüsü içerisinde (Bornova/İzmir) yer alan EÜ Ziraat Fakültesi Bahçe Bitkileri Bölümü Örtüaltı Sebze Yetiştirme Bilim Dalı'na ait eğitim ve araştırma amaçlı kullanılan serada yürütülmüştür. 16.56 x 50 m ölçülerinde, plastik (PE) örtülü, yan ve çatı havalandırmaları böcek neti ile kaplı ısıtmasız bitünel seranın yaklaşık 10 m<sup>2</sup>'lik alanı bu çalışmada kullanılmıştır.

Araştırmada bitkisel materyal olarak kuzu marulunun (*Valerianella locusta L.*) "Volhart-3" çeşidi (Sperli Tohum, Almanya) kullanılmıştır. Üç fazlı zeytinyağı işleme tesisinden çıkan atıkların 550°C'de yavaş pirolizinden elde edilen biyokömür ise Bilen Kömür Enerji Gübre San. ve Tic. Şti. (Mersin, Türkiye)'den temin edilmiştir.

Tohum ekim ortamı olarak ithal torf (Klassman TS1, Almanya) kullanılmış ve Biyokömür (BK) torf (T) ile hacimsel olarak %0 (%0BK+%100T, kontrol), %5 (%5BK+%95T), %10 (%10BK+%90T) ve %20 (%20BK+%80T) oranlarında karıştırılmıştır. Hacim bazında hesaplanan ekim ortamları temiz bir yüzeyde karıştırılmış, nemlendirilmiş ve ardından saksı başına 25 g ortam gelecek şekilde file saksılara doldurulmuştur. Her saksıya bir tohum 22 Eylül 2023 tarihinde elle ekilmiştir. Saksılar özelleştirilmiş 45 hücreli tepsilere yerleştirilmiş ve her uygulama için 5 tepsi hazırlanmıştır (45x5=225 saksı/bitki). Ortamdan nem kaybını önlemek için tepsilere streç film ile sarılmıştır. Tepsilere gecikme olmaksızın tohum çimlenmesi için 3 gün boyunca çimlenme odasına (karanlık, gece/gündüz 18±2°C, %80 nem) yerleştirilmiştir. Bu sürenin sonunda streç film çıkartılmış ve viyoller fidelerin büyümesi için seraya aktarılmıştır. Fideler 3-4 gerçek yaprak geliştirene kadar burada tutulmuştur. Bu süre boyunca ortamların nem durumuna bağlı olarak sadece yaprakların üzerinden püskürtme şeklinde sulama yapılmıştır.

Tohum ekiminden 35 gün sonra fideler serada "besleyici film tekniği (NFT: Nutrition Film Technique)"ne aktarılmıştır. NFT sistemi %4 eğimle yerleştirilmiş 350 cm uzunluğunda, 10 cm genişliğinde ve 4 cm yüksekliğindeki 16 adet PVC yetiştirme kanallarından oluşmuştur. Her bir kanal, üzerinde 10 cm aralıklar ile açılmış 32 adet deliğe sahiptir. Her 4 kanal (128 saksı/fide) bir uygulamayı oluşturmuştur. File saksılardaki fideler, saksısıyla ve kök ortamıyla

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beraber bu deliklere yerleştirilmiştir.

Saksıların kanallara yerleştirilmesinden itibaren besin solüsyonu uygulamasına başlanmıştır. Besin solüsyonu olarak Alberici ve ark. (2007)'nin yeşilliklerin hidroponik üretimi için önerdiği, gerekli makro ve mikro besin elementlerini içeren besin reçetesi modifiye edilerek [N:160, P:80, K:180, Ca:140, Mg:34, S:86, Fe:2.2, Mn:0.50, Zn:0.05, B:0.50, Cu:0.02, Mo:0.01 ppm] kullanılmıştır (pH: 5.5-6.5, EC: 1.8-2.0 dS/m). Besin reçetesi üzerinden hidroponik sisteme uygun suda eriyebilir gübreler ile gübrelerin karışa birlik durumuna göre makro ve mikro elementler için stok solüsyonlar hazırlanmış, bu stok solüsyonlar ile her bir uygulamanın kendisine ait 50 L hacimli besleme tankları, haftada 2 defa eksilen kısmın tamamlanması şeklinde doldurulmuştur. Her 4 kanal/uygulama için NFT kanalları altında 1 besleme tankı yer almış ve her bir uygulama kendi tankından beslenmiştir. Sistem kapalı sistem olduğu için, kanallardan drene olan besin çözeltisi kendi tankına toplanmış ve tank içindeki dalgıç pompa ile (35 W, H-max1.5 m, saatte 2000 L su basma kapasiteli) kanal başlarına tekrar basılmıştır. Besin solüsyonu NFT kanallarından ince bir film şeridi halinde 24 saat boyunca kesintisiz olarak döndürmüştür. Eksilen kısım yükseklik olarak ölçülüp, hacim hesabı üzerinden litreye çevrilerek ve bu litre su için stok solüsyonlar ilave edilip, EC ve pH kontrolü taşınabilir EC metre (Mettler Toledo, MC-126) ve pH metre (Mettler Toledo, Seven Easy) ile yapılmıştır. Haftada 3 defa, her konuya ait besleme tankında bulunan besin solüsyonunun EC ve pH değerleri, taşınabilir EC ve pH metre ile ölçülüp kaydedilmiştir. Üretim dönemi sonuna yaklaşıldığında besleme tanklarının yeni besin solüsyonu ile doldurulması yapılmamış; mevcut besin solüsyonunun sıfır atık mantığı ile bitene kadar kullanılması sağlanmıştır.

Fidelerin NFT sistemine aktarılmasından 39 gün sonra bitkiler hasada gelmiş ve 6-8 adet tam açılmış yapraklı bitkiler kademeli olarak hasat edilmişlerdir. Fidelerin NFT sisteme aktarılmasıyla birlikte sera içi sıcaklık ve oransal nem değerleri iklim kayıt cihazı (HOB0 U12-013, ABD) ile araştırma süresi boyunca her 15 dakikada bir kayıt alacak şekilde kayıt edilmiştir. Alınan bu verilerden ortalama değerler alınarak günlük maksimum, minimum ve ortalama sıcaklık ve nem değerleri hesaplanmıştır. Hasat edilen bitkilerin ortalama bitki ağırlığı (g/bitki) alınmış, m<sup>2</sup>'deki bitki sayısı üzerinden toplam verim (g/m<sup>2</sup>) değeri belirlenmiştir. İlk hasatta her konudan alınan 10 adet bitkide morfolojik gelişim değerleri ölçülmüştür. Kök ortamı yüzeyinden büyüme ucuna kadar olan bitki kısmı şerit metre yardımıyla ölçülerek bitki boyu (cm), köklerinin kök başlangıç noktası ile en uç kısmına kadar olan uzunluğu şerit metre yardımıyla ölçülerek kök boyu (cm), köklerin başlangıç noktasının hemen üzerinden dijital kumpas (Mitutoyo, Japonya) yardımı ile rozet gövde çapı ölçülerek gövde çapı (mm), orta kısımdaki tam açılmış yapraklarda (5.-6. yaprak) mikronmetre (Mitutoyo, Japonya) yardımıyla yaprak kalınlığı (mm), aynı yaprakların cetvel yardımıyla yaprak eni (cm) ve boyu (cm) belirlenmiştir. Kuzu marulu örneklerinin vejetatif aksam ve kök yaş ağırlıkları (g/bitki) hassas terazi ile tartılıp 65 °C etüvde kurutulduktan sonra kuru ağırlıkları (g/bitki) alınmış; elde edilen veriler yaş ve kuru ağırlık (g/bitki) ve günlük kuru madde miktarı (mg/bitki/gün) olarak verilmiştir. Her bir uygulamanın her tekerrüründe 10 adet tamamen açılmış 3. veya 4. gerçek yaprak üzerinde yaprak rengi (L, a\*, b\*) laboratuvarında kolorimetre (CR-300 Chroma Meter, Konica Minolta, Japonya) kullanılarak ölçülmüştür. Yaprakların vitamin C içeriği (mg/100 mL) Pearson (1970)'a göre, Nitrat (mg/kg) içeriği Cataldo ve ark. (1975)'na göre spektrofotometrik yöntemle belirlenmiştir.

Tek faktörlü ve dört tekrarlı tesadüf blokları deneme desenine göre kurulan denemeden elde edilen veriler, bilgisayarda JMP (versiyon 15.0) istatistik yazılımı kullanılarak tek yönlü varyans analizine (ANOVA) tabi tutulmuştur. Ortalamalar arasındaki farklar TUKEY

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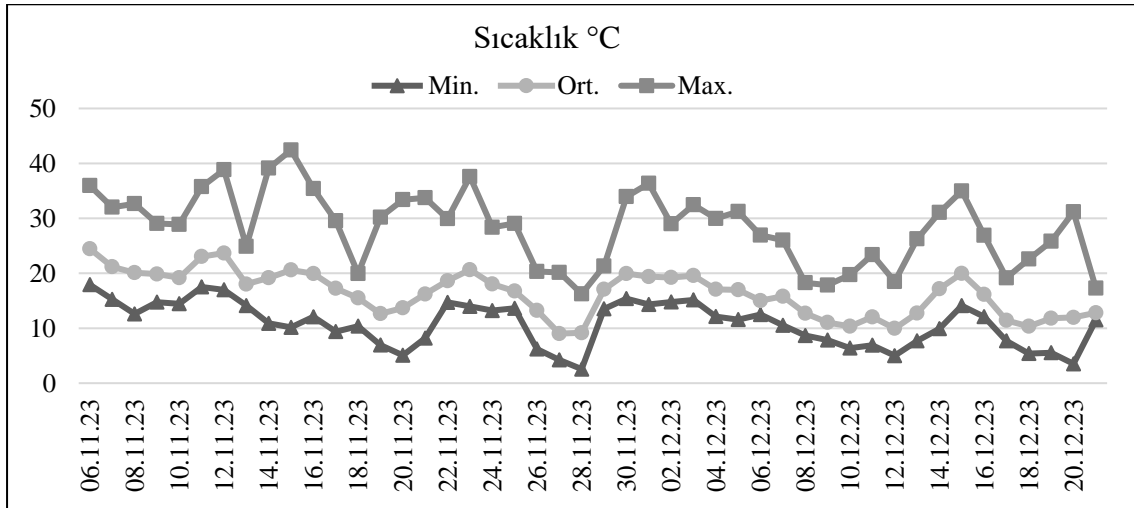
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testlerine göre belirlenmiş ve sonuçlar  $P$  değerlerine göre ( $P \geq 0.05$ : önemli değil,  $P < 0.05$ : önemli) yorumlanmıştır.

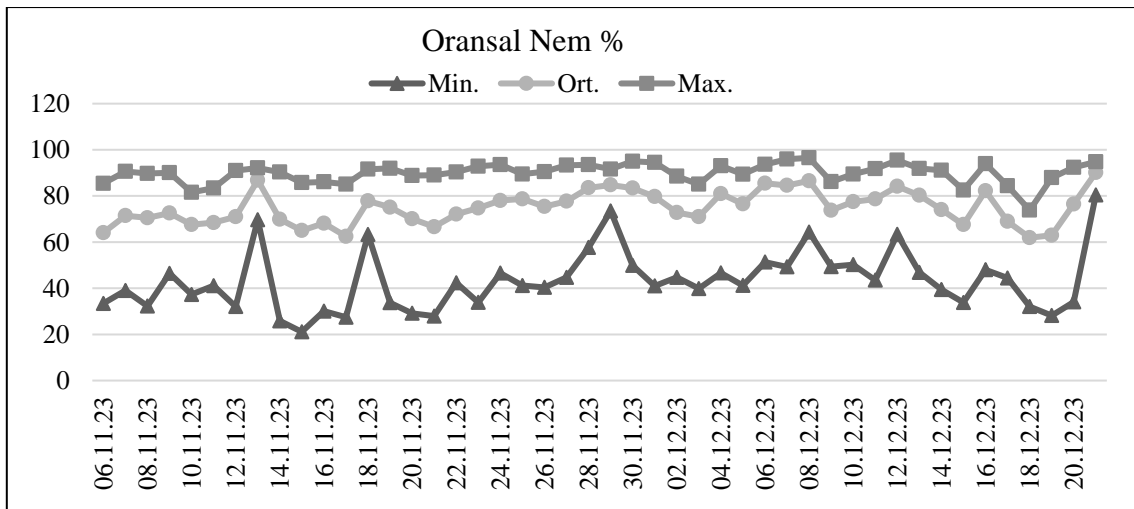
## BULGULAR

### Sera İçi İklim Değerleri

Bitkilerin besleyici film tekniğinde kaldığı süre boyunca elde edilen sıcaklık değerlerine ait veriler Şekil 1'de, oransal nem değerine ait veriler Şekil 2'de verilmiştir. Görülen maksimum sıcaklık 16.25 °C ile 42.42 °C arasında, minimum sıcaklık 2.56 °C ile 17.92 °C arasında ortalama sıcaklık değerleri ise 9.02 °C ile 24.46 °C arasında değişmiş ve ortalama maksimum, minimum ve ortalama sıcaklık değerleri sırasıyla 28.34 °C, 10.81 °C ve 16.32 °C olmuştur. Elde edilen maksimum oransal nem %73.82 ile %96.52 arasında, minimum oransal nem %21.11 ile %80.39 arasında, ortalama oransal nem değerleri ise %61.90 ile %96.52 arasında değişmiş; ortalama maksimum, minimum ve ortalama oransal nem değerleri sırasıyla %89.88, %43.30 ve %75.04 olmuştur.



Şekil 1. Üretim süresi boyunca sera içinde sıcaklık değerleri



Şekil 2. Üretim süresi boyunca sera içinde oransal nem değerleri

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**Bitki Gelişimi**

Uygulamaların bitki boyu, yaprak kalınlığı ile yaprak eni ve boyu üzerine etkisi önemli bulunmuştur. Bitki boyu 8.28 ile 8.99 cm arasında, yaprak eni 3.34 ile 3.67 cm arasında, yaprak boyu 7.47 ile 8.17 cm arasında değişmiştir. Biyokömür uygulaması bitki boyu ve yaprak boyunu arttırmış, BK uygulamaları aynı istatistiksel grupta yer alsalar da en yüksek değerler %20BK+%80T uygulamasından elde edilmiştir. Yaprak kalınlığı biyokömür dozu arttıkça azalmış, en yüksek kalınlık %5BK+%95T uygulamasından elde edilmiştir. Uygulamaların kök boyu, gövde çapı ve büyüme ucu yüksekliği üzerinde etkileri istatistiksel olarak önemli bulunmamış olmasına rağmen biyokömür uygulamalarında kontrol uygulamasına göre daha fazla gelişim gözlemlenmiştir (Tablo 1).

Uygulamaların vejetatif aksam yaş ağırlık, kuru ağırlık, günlük kuru madde miktarı üzerine etkisi ile kök günlük kuru madde üzerine etkisi önemsiz bulunmuş olmasına rağmen kontrole göre biyokömür uygulamalarında artış gözlemlenmiştir. Kök yaş ve kuru ağırlığı uygulamalardan etkilenmiş, düşük dozda biyokömür içeren ortamlar (%5BK+%95T ve %10BK+%90T) kontrol ile aynı istatistiksel grupta yaş ağırlık ve kuru ağırlık değerlerine sahip olmuştur (Tablo 2).

Tablo 1. Uygulamaların bitki morfolojisine etkileri

Uygulama	Büyüme Ucu Yüksekliği (mm)	Bitki Boyu (cm)	Kök Boyu (cm)	Gövde Çapı (mm)	Yaprak Kalınlığı (mm)	Yaprak Eni (cm)	Yaprak Boyu (cm)
%0BK+%100T	18.06	8.28 b	13.40	1.833	0.318 ab	3.67 a	7.47 b
%5BK+%95 T	19.57	8.87 ab	13.94	1.880	0.326 a	3.56 ab	7.90 ab
%10BK+%90 T	19.14	8.85 ab	13.67	2.030	0.303 ab	3.42 b	8.17 a
%20BK+%80 T	18.58	8.99 a	12.11	1.883	0.300 b	3.34 b	8.10 a
P	0.2986	0.0197	0.7080	0.1596	0.0226	0.0063	0.0139

Tablo 2. Uygulamalarının kuzu marulunda bitki biyokütlesine etkileri

Uygulama	Vejetatif Aksam			Kök		
	YA (g/bitki)	KA (g/bitki)	GKM (mg/bitki/gün)	YA (g/bitki)	KA (g/bitki)	GKM (mg/bitki/gün)
%0BK+%100T	4.41	0.368	0.834	1.27 a	0.072 a	0.569
%5BK+%95T	4.91	0.385	0.769	1.39 a	0.080 a	0.574
%10BK+%90T	4.79	0.424	0.883	1.48 a	0.074 a	0.499
%20BK+%80T	4.77	0.441	0.924	0.97 b	0.051 b	0.522
P	0.4204	0.6673	0.5663	0.0002	0.0003	0.0818

YA: yaş ağırlık, KA: kuru ağırlık, GKM: günlük kuru madde

**Verim Değerleri**

Uygulamaların ortalama bitki ağırlığı ve toplam verim değeri üzerine etkileri önemsiz bulunmuştur. Ortalama bitki ağırlığı 7.12 ile 7.58 gram arasında değişmiştir (Şekil 3).

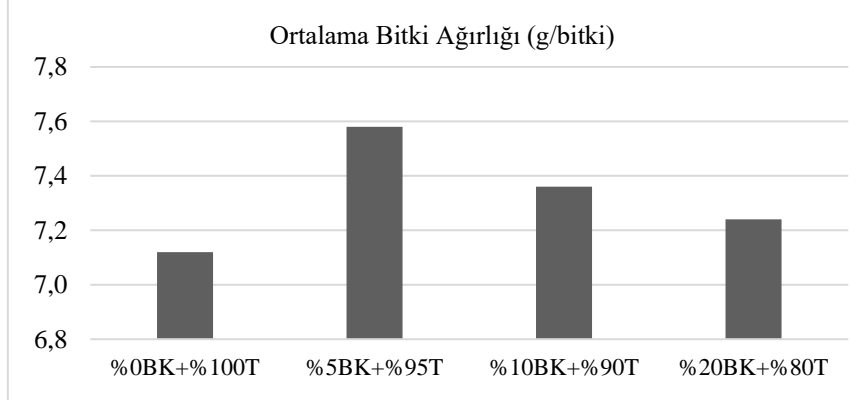
Toplam verim 712.2 ile 758.4 g/m<sup>2</sup> arasında değişmiştir (Şekil 4). Biyokömür uygulaması genel olarak kontrol ortamına göre verim değerlerini arttırmıştır. En fazla artış %5BK+%95T



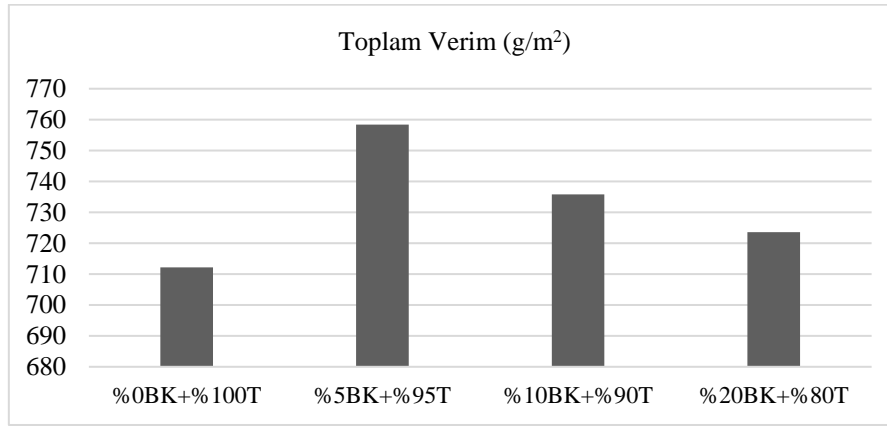
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uygulanmasında olup kontrole göre her iki parametrede de %6.46 oranında artış sağlamıştır.



Şekil 3. Uygulamaların ortalama bitki ağırlığı üzerine etkisi



Şekil 4. Uygulamaların toplam verim üzerine etkisi

#### Kalite Değerleri

Biyokömür uygulamaları yaprak rengi değerleri ( $L^*$ ,  $a^*$ ,  $b^*$ ,  $a^*/b^*$ ,  $h^\circ$  ve  $C^\circ$  değerleri) ile Vitamin C ve nitrat içeriği üzerine etkisi istatistiksel olarak önemsiz bulunmuştur (Tablo 3). Vitamin C ve nitrat içeriği biyokömür dozu arttıkça kısmen artmıştır.

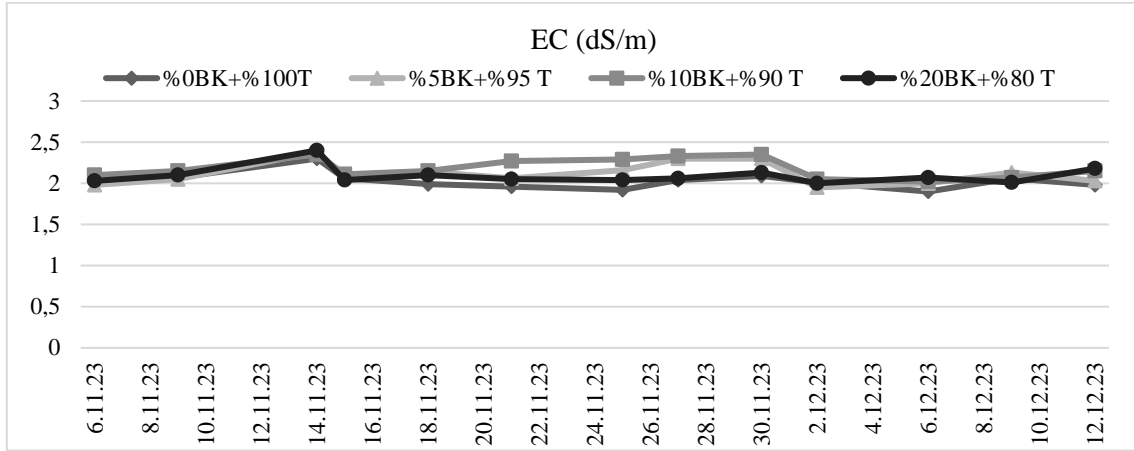
Tablo 3. Uygulamaların yaprak rengi üzerine etkileri

Uygulama	Renk					$C^\circ$	Vitamin C (mg/100 g)	Nitrat (mg/kg)
	$L^*$	$a^*$	$b^*$	$a^*/b^*$	$h^\circ$			
%0BK+%100T	35.63	-13.53	14.59	-0.928	132.84	19.90	14.7	143.9
%5BK+%95T	36.12	-13.85	15.05	-0.921	132.65	20.46	16.5	153.2
%10BK+%90T	35.71	-13.99	15.24	-0.918	132.56	20.68	18.8	155.8
%20BK+%80T	35.51	-14.00	15.38	-0.910	132.31	20.79	18.3	156.9
P	0.7994	0.1203	0.2215	0.5412	0.5469	0.1733	0.3067	0.9541

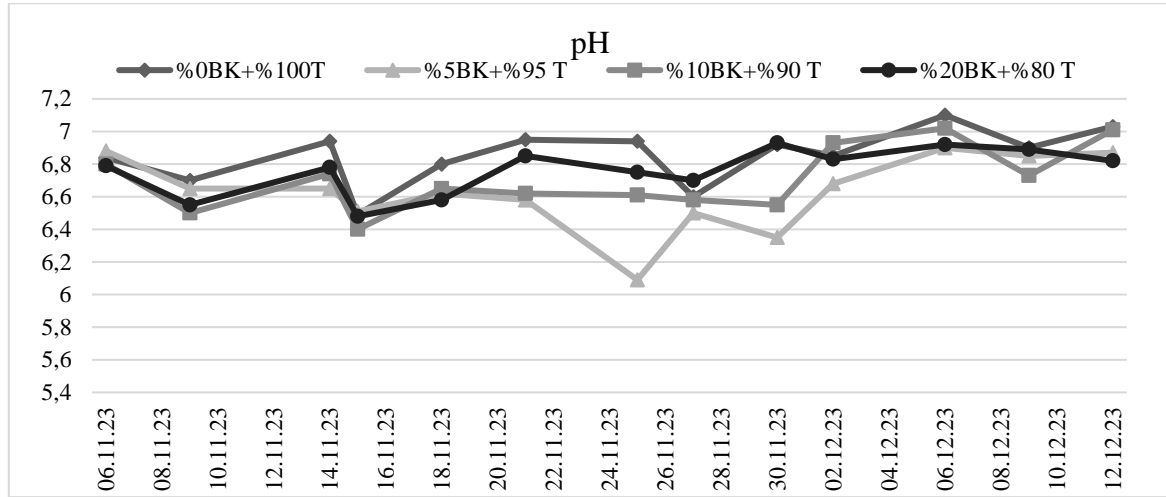
#### Besin Solüsyonu EC ve pH Değerleri

Bitkilerin besleyici film tekniğinde kaldığı 6 hafta boyunca elde edilen EC ve pH değerlerine ait grafikler Şekil 5 ve Şekil 6'da verilmiştir. Kontrol uygulamasının EC değerleri 1.90 ile 2.30 arasında değişirken pH değerleri ise 6.49 ile 7.10 arasında değişmiştir. %5BK+%95T uygulamasının EC değerleri 1.95 ile 2.38 arasında değişirken pH değerleri 6.09 ile 6.90 arasında değişmiş; %10BK+%90T uygulamasına EC değerleri 2.02 ile 2.35 arasında değişirken; pH değerleri 6.40 ile 7.02 arasında değişmiş; %20BK+%80T uygulamasına EC değerleri 2.00 ile

2.40 arasında değişirken pH değerleri 6.48 ile 6.93 arasında değişmiştir.



Şekil 5. Yetiştirme dönemi boyunca uygulamalara göre besin solüsyonu EC değerinin değişimi



Şekil 6. Yetiştirme dönemi boyunca uygulamalara göre besin solüsyonu pH değerinin değişimi

### Tartışma, Sonuç ve Öneriler

File saksılarda torf yetiştirme ortamına farklı oranlarda biyokömür karıştırılarak yapılan su kültüründe kuzu marulu yetiştiriciliğinde uygulamaların bitki gelişimi, verim ve kaliteye etkileri incelenmiştir. Araştırmada kontrol uygulaması olarak torf kullanılmıştır. Torf kök bölgesindeki gözenekli yapısı, uygun hava-su oranı, yüksek katyon değişim kapasitesi, stabilitesi ve temizliği ile fide üretiminde tercih edilen bir materyaldir (Tüzel ve ark., 2020). Nitekim kuzu marulunda fide eldesinde yürütülen çalışmadan elde edilen veriler, torfta yetiştirilen fidelerin ölçülen parametrelerin çoğunda yüksek değerlere sahip olduğunu göstermiştir (Öztekin ve ark., 2024). Bu sonuçlar önceki çalışmalarla da tutarlı bulunmuştur (Yılmaz & Kınay, 2016; Ghanbari & Aboutalebi, 2009).

Torf doğadan elde edilen bir malzeme olduğu için torf yataklarının azalması ve üretimde alternatif uygulamalara geçilmesi gerekliliği ön plana çıkmıştır. Sürdürülebilirlik yaklaşımında

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organik tarımda torf kullanımını kısıtlanmakta (EUR-LEX, 2017) ve Bio Suisse Standartları fide üretiminde torf kullanımının en aza indirilmesini savunmaktadır (BIO-SUISSE, 2017). AB Organik Tarım Teknik Danışma Grubu (EGTOP) da yetiştirme ortamında torf kullanımının en fazla %80 ile sınırlandırılmasını önermektedir (EGTOP, 2013). Bu bağlamda yapılan önceki çalışmalarda kök ortamına torfa biyokömür ilavesi, torf kullanımını azaltarak doğal kaynakların korunmasına katkıda bulunacak şekilde fide üretiminde kullanılmaya uygun bulunmuştur (Mulcahy ve ark., 2013; Zhu ve ark., 2018; Bu ve ark., 2020; Ali ve ark., 2021; Öztekin ve ark., 2024). Yürütülen çalışmada da kök ortamına biyokömür ilavesi ile torf kullanımının azaltılmasına hizmet edilmiştir.

Çalışmanın sonuçları istatistiksel olarak değerlendirildiğinde uygulamalar arasında bir çok parametrede anlamlı bir farklılık görülmemiştir. Biyokömür uygulamaları özellikle bitki ve yaprak boyunu etkilemiş; her iki değer de torfda yetişen bitkilere göre daha uzun olmuştur. Biyokömür ve kontrol uygulamaları arasında istatistiksel olarak bir fark görülememesine rağmen biyokömür uygulamaları verim ve bitki gelişimini kısmen artırmıştır. Toplam yaş ağırlık kontrol grubuna kıyasla %5BK+%95T ve %10BK+%90T uygulamaları ile sırasıyla %10.9 ve %10.4 oranında artış; toplam kuru ağırlık ise aynı uygulamalarda sırasıyla %5.7 ve %13.2 oranında artış sağlamıştır. En yüksek ortalama bitki ağırlığı ve verimin alındığı %5BK+%95T uygulaması kontrol grubuna göre %6.1 oranında artış sağlamıştır. Önceki çalışmalar da biyokömürün bitki gelişimini artırdığını göstermiştir (Graber ve ark., 2010; Bioderman & Harpole, 2013; Schmidt ve ark., 2014). Bu iyileşmenin nedeni, fotosentezde kilit bir ürün olan ve bitki büyümesini ve gelişimini kontrol eden makro moleküllerin yapı taşları olarak hizmet eden çözünür şeker içeriğindeki artışa bağlanmıştır (Gibson, 2000). Çözünebilir şeker, hücresel düzeyde ozmotik basıncın kontrolünde tetikleyici bir rol oynamakta ve besin alımının artmasına katkıda bulunarak bitki büyümesini teşvik etmektedir (Altland & Locke, 2012; Cha-um ve ark., 2009; Zhu ve ark., 2018).

Kuzu marulu yetiştiriciliğinde verim değerleri çevresel koşullar, çeşit ve yetiştirme sistemi yanında birim alandaki bitki sayısına ve hasat zamanına (bitki biyokütlesine) göre değişmektedir. Kuzu marulu serin iklimde yetiştirilen bir bitkidir. Nitekim, Osvald & Kogoj-Osvald (2023) kuzu marulu için optimum yetiştirme sıcaklığını 15-18°C olarak belirtmiş; yüksek sıcaklık ve yüksek ışık yoğunluğunun ürün kalitesinde düşümlere neden olacağını vurgulamıştır. Yürütülen çalışmada ortalama sıcaklık değeri 16.32 °C olmuş ve üretim kuzu marulu için elverişli dönemde yapılmıştır. Buna bağlı olarak da optimum verim elde edilmiştir. Farklı su kültürlerinde yürütülen çalışmalarda Öztekin ve Tural (2021) verim değerleri 0.40 ile 0.61 kg/m<sup>2</sup> arasında; Gottardi ve ark. (2012) verim değerlerini 1.3 ile 2.1 kg/m<sup>2</sup> arasında bulmuştur. Yürütülen çalışmada m<sup>2</sup>'de 100 bitki kullanılmış ve verim değerleri 0.64-0.78 kg/m<sup>2</sup> arasında değişmiş ve bu sonuçlar önceki çalışmalardan elde edilen verim değerleri aralığında bulunmuştur.

Araştırmada bitki gelişimini ve dolayısıyla verimdeki artış özellikle düşük doz biyokömürün kullanıldığı uygulamalarda dikkat çekmiştir. %5BK ve %10BK ilavesi genelde %20 BK uygulamasına göre daha iyi sonuçlar vermiştir. Yin ve ark. (2024) yaptıkları çalışmalarında ortamdaki biyokömür oranı artıkça besin emilimini ve translokasyonunun azalabileceğini, topraksız sistemde pirinç, buğday ve mısır bitkilerini, özellikle de pirinç bitkisinin gelişimini engelleyebileceğini ortaya konmuştur. Bu durum yürütülen çalışmada elde edilen hidroponik ortamda biyokömür oranının artmasıyla bitki gelişimi ve verimin düşmesinin sebebi olarak görülebilmektedir. Bununla birlikte yetiştirme süresi uzadıkça, yavaş salınımlı biyokömürün etkisinin daha da belirgin olacağı düşünülmektedir.

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Biyokömür uygulaması bitki kök gelişimini de etkilemiştir. %20BK uygulamasında en düşük kök ağırlığı ve boyu elde edilmiştir. Bu durum Liu ve ark. (2021) tarafından yapılan çalışma ile desteklenmiş, düşük dozda uygulanan biyokömürün kök gelişimini arttırdığı ortaya konmuştur. Ortamdaki biyokömür oranı artıkça köklerde nano boyutta biyokömür parçalarının biriktiği, bunun da gelişimi olumsuz etkilediği bildirilmiştir (Yin ve ark., 2024).

Yetiştirme ortamına biyokömür katkısı kuzu marulunda renk, vitamin C ve nitrat içeriğinde önemli bir değişiklik yaratmamıştır. Yaprakları tüketilen sebzelerin çoğunun iyi bir vitamin C kaynağı olduğu bilinmektedir. Kuzu marulu vitamin C içeriği 38.2 mg/100 g olarak belirtilmiştir (Self Nutrition Data, 2019). Yürütülen çalışmada vitamin C içeriği tekerrür bazında 10.29 ile 24.0 mg/100 g arasında değişmiş ve belirtilen değerden düşük çıkmıştır. Bunun nedeninin bitkilerin vitamin C içeriğinin üretim zamanı ve yetiştirme koşullarına göre değişmesi ile ilgili olduğu düşünülmektedir. Sonuçlarımızı destekler şekilde Öztekin ve Tural (2021) kuzu marulu vitamin C içeriğini 21.4 ile 28.6 mg/100 g arasında bulmuştur. Fazla tüketildiğinde insan sağlığını olumsuz etkilemesi nedeni ile yaprakları yenilen sebzeler için önemli bir kalite kriteri olan nitrat için eşik değeri, Avrupa Birliği 1258/2011 sayılı yönetmelikle salatalar için soğuk mevsimde ve örtü altı yetiştiriciliğinde 5000 ppm, sıcak mevsimde ve açık alanda üretimde 3000 ppm olarak belirlemiştir (Tomasi et al., 2015). Hidroponik yetiştiricilikte kuzu marulunun nitrat içeriğini Manzocco ve ark. (2011) 3878-4695 mg/kg arasında; Gottardi ve ark. (2012) ise çeşitlere göre değişmekle birlikte 3180 ile 4170 mg/kg arasında, Öztekin ve Tural (2021) ise 371.1 ile 465.1 mg/kg arasında bulmuştur. Yürütülen çalışmada nitrat içeriği 102.7 ile 226.8 mg/kg arasında değişmiş ve Avrupa mevzuatı tarafından izin verilen maksimum seviyelerden ve önceki çalışmalardan düşük bulunmuştur. Topraksız yetiştiricilikte optimum verim için besin solüsyonu EC ve pH değerleri önem taşımaktadır. Yeşillikler için bu değerlerin EC:1.8-2.0 dS/m, pH:5.5-6.5 arasında olması istenmektedir. Böylece bitkilerin besin elementlerinden maksimum düzeyde faydalanmaları sağlamış olur. Yürütülen bu çalışmada uygulamalara göre değişmekle beraber EC değerleri 1.90 ile 2.40 dS/m arasında, pH değerleri 6.09 ile 7.10 arasında değişim göstermiş ve optimum değerler önerilen değerlere uyumlu/yakın bulunmuştur. Uygulamalar arasında besin solüsyonu EC ve pH değeri açısından önemli bir farklılık görülmemiş, biyokömür katkısı besin solüsyonu EC ve pH değerini etkilememiştir.

Biyokömür uygulamalarının bitki gelişimi üzerine etkilerinin olduğu açıktır. Çalışmadan elde edilen veriler kısmen daha yüksek verim ve biyokütle değeri ile öne çıkan düşük dozdaki uygulamalar içerisinde, daha olumlu sonuçlara sahip olan ve işin ekonomik boyutu hesaba katıldığında %5BK+%95T uygulamasının daha etkin olduğunu ortaya koymuştur. Besin çözeltisi içerisindeki biyokömürün çözünmesi ve köklere tutunmasının olumsuz etki yapabileceği de düşünüldüğünde konu ile ilgili detaylı araştırmalara ihtiyaç duyulmaktadır.

Biyokömür fide yetiştirmede henüz torfa alternatif bir uygulama olarak görülmemektedir. Ancak torfa ile karıştırılarak fide üretiminde kullanılması uygun görülmektedir. Ayrıca torf yataklarının korunmasına çevreci bir çözüm de sunulmuş olmaktadır. Fakat biyokömürün bitkisel atıklardan elde edildiği düşünüldüğünde, her biyokömürün ham maddesinin ve özelliklerinin aynı olmayacağı kesindir. Sonuçların biyokömürün özelliklerine ve çevresel koşullarla (pH gibi) etkileşiminin yanı sıra kullanılan malzemelerin karışımına bağlı olarak değişebileceği unutulmamalıdır. Bu nedenle sonuçların farklı kaynaklı ve farklı oranlarda biyokömürler ile yapılacak yeni çalışmalarla güçlendirilmesi tavsiye edilmektedir.

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**TEŐEKKÖR**

Lisans bitirme tezi olarak yürütölen bu alıŐmaya vermiŐ oldukları maddi destek iin TÖBİTAK 2209/A “Öniversite Öđrencileri AraŐtırma Projeleri Destek Programı”na teŐekkÖrlerimizi sunarız.

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**İKİNCİ ÜRÜN ŞEKER MISIR BITKİSİNDE VERİM VE DİĞER PARAMETRELER  
ARASINDAKİ KORELASYONUN IRDELENMESİ**

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**ÖZET**

Bu çalışmanın amacı İkinci ürün şeker mısır bitkisinde verim ve diğer parametreler arasındaki korelasyonun irdelenmesi amacıyla ikinci ürün şeker mısırın yetiştirme sezonu boyunca yürütülmüştür. Araştırmada bitki materyali olarak erkenci kompozit şeker mısır hibriti kullanılmıştır. Çalışma 2024 yılında Siirt Üniversitesi Ziraat Fakültesi deneme arazisinde yürütülmüştür. Sulama programı bir tam sulama (I100) ve bir farklı seviyede stres içeren sulama konusundan (I50) oluşmuştur. Sonuç olarak bu çalışmanın sonucunda elde edilen verilerin ışığında Şeker mısırının bitki su stres indeksi (CWSI) ile yaş verim (kuru verim), su kullanım randımanı ve klorofil içeriği arasındaki ilişkilere ait korelasyon katsayılarına bakıldığında tüm bu özellikler arasında istatistik olarak önemli ilişkiler ( $p \leq 0.01$  ve  $p \leq 0.05$ ) olduğu tespit edilmiştir. Ayrıca yüksek yaş (fresh) ve kuru verim için çiçeklenme döneminden 10 gün önce kısıntılı sulama veya su atlaması yapılmaması ve çiçeklenme periyodu boyunca tam sulama (I100) yapılması önerilmektedir. Bu çalışmadan elde edilen verilerin mısır bitkisinin yarı kurak iklim koşullarında sulama programının hazırlanmasında kullanılabileceği söylenebilir.

**Anahtar Kelimeler:** Şeker mısır, Korelasyon, Verim

*\*Teşekkür*

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**INVESTIGATION OF THE CORRELATION BETWEEN YIELD  
D AND OTHER PARAMETERS IN SECOND CROP SWEET CORN PLANT**

**ABSTRACT**

The aim of this study was to investigate the correlation between yield and other parameters in second crop sweet corn plants during the growing season of second crop sweet corn. Early composite sweet corn hybrid was used as plant material in the study. The study was carried out in the experimental field of Siirt University Faculty of Agriculture in 2024. The irrigation program consisted of one full irrigation (I100) and one irrigation with different levels of stress (I50). As a result, in the light of the data obtained as a result of this study, when the correlation coefficients of the relationships between the plant water stress index (CWSI) of sugar corn and fresh yield (dry yield), water use efficiency and chlorophyll content were examined, it was determined that there were statistically significant relationships ( $p \leq 0.01$  and  $p \leq 0.05$ ) between all these characteristics. In addition, for high fresh and dry yield, it is recommended not to apply deficit irrigation or skip water 10 days before the flowering period and to apply full irrigation (I100) during the flowering period. It can be said that the data obtained from this study can be used in the preparation of irrigation programs for corn plants in semi-arid climate conditions.

**Keywords:** Sweet corn, Correlation, Yield

*\*Thanks*

*\* A part of this study was sent to be published in a journal abroad in 2024.*

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## Giriş

Dünyada mısır; hububat içerisinde ilk sırada, ekim alanı bakımında ise ikinci sırada yer almaktadır. Mısır bitkisi silaj ve dane yemi olarak değerlendirilmesinden dolayı hayvan beslenmesinde önemi büyüktür. Mısırdan yağ, tatlandırıcı ve biyoyakıt üretilmesi, ambalaj malzemesi olarak kullanılması önemini bir kat daha arttırmıştır. 1980 yılında 1.2 milyon ton olan mısır üretimimiz, 2020 yılında yaklaşık 3.5 kat artarak 5.3 milyon tona ulaşmıştır (TÜİK, 2020). Dünya’da ve Türkiye’de farklı gıda kollarının geliştirilmesiyle farklı sebze türlerinin değişik şekillerde işlenerek tüketiciye sunulması hedeflenmektedir. Özellikle dengeli ve sağlıklı beslenmenin öneminin gittikçe artması besin maddesi içeriği bakımından daha üstün özelliklere sahip sebze türlerinin tüketimini arttırmaktadır. Sebze türü kapsamında değerlendirilen şeker(tatlı) mısır bünyesinde yüksek miktarda besin maddeleri bulundurması ve bu anlamda tercih nedeni olması sebebiyle yetiştiriciliği de önem kazanmıştır.

Tatlı mısırın orijini hakkında kesin bir bilgi bulunmamakla birlikte muhtemelen Perulu’ların “Chuspillo” yada “Chullpi” dedikleri bir mısır varyetesinden mutasyon sonucu oluştuğu belirtilmektedir. Standart tatlı mısır bir mutant ve diğer mısır tiplerinden kromozomlarında bulunan ‘Su’ geni ile ayrılmaktadır. Taze tüketiminin söz konusu olduğu dönemde, süt olum döneminde, ‘Su’ geni endosperm içeriğini iki kat daha tatlılaştırır ve 8-10 kat daha fazla suda çözünebilen polisakarit ile doldurmaktadır.. ‘Su’ dokusunda meydana gelen mutasyon muhtemelen farklı zamanlarda ve farklı mısır ırklarında oluşmuştur (Creech, 1968). Eski kültürlerde bu mısırın şekerli formları var olmasına rağmen taze tatlı mısırın saklanması çeşitli zorlukların bulunması, o dönemde çok fazla popüler olmasının önüne geçmiştir (Dickerson, 1996).

Tatlı mısırın olgun daneleri saydam ve buruşuktur. Süt olum döneminde hasat edilen “tatlı mısırın daneleri” oldukça tatlıdır. Olgun danelerinde şeker oranı daha düşük olmakla beraber yine de tatlı lezzetini devam ettirmektedir. Embriyosu iri olduğundan yağ ve protein oranı da diğer mısır varyete gruplarına göre daha yüksektir. Bu bilgilerden besin değeri oldukça yüksek olduğu anlaşılacak olan tatlı mısır, dünyada daha çok süt olum döneminde hasat edilerek dondurulmuş ürün veya konserve olarak taze tüketim amacıyla üretilmekte ve tüketilmektedir (Sade, 2002). Mısır çeşitleri arasında büyük öneme sahip olan tatlı mısır ülkemize 1930’lu yıllarda girmiş olmasına rağmen son yıllara kadar üretim ve tüketim miktarlarında büyük artış sağlanamamıştır (Eşiyok ve ark., 2004). Ülkemizde mısır yetiştiriciliğinin yapıldığı yerlerde üretimi yapılabilen tatlı mısırın daha iyi tanıtılması ve yaygınlaştırılmasıyla üretim ve tüketim miktarları artacaktır. Dünya literatüründe; at dişi mısır, sert mısır, cin mısır, şeker mısırı (tatlı mısır), kavuzlu mısır, unlu mısır ve mumlu olmak üzere mısırlar 7 grupta ele alınır. Bu grubun dünyada en çok yetiştirileni sert ve at dişi olanlardır. (Elçi ve ark. 1987). Tatlı mısır ve cin mısır da hemen sonrasında ekim alanı olarak listede yer alırlar. Ülkemizde tatlı mısırın gerek destekleme dışı bir ürün olması gerekse de aynı yıl içinde birden fazla kez yetiştiriciliği yapılabildiğinden resmi istatistik verileri bulunamamıştır.

Korelasyon iki ya da daha fazla değişken arasındaki doğrusal ilişkiyi gösterir. İki değişken arasındaki ilişki miktarı, ikili ya da basit korelasyon denen korelasyon teknikleriyle hesaplanır (Anonim, 2025). Bir değişkenin iki ya da daha çok değişken ile olan ilişkisi çoklu korelasyon; bu değişkenlerden birinin sabitlenerek diğer değişkenler ile olan ilişkisi ise kısmi korelasyon teknikleriyle hesaplanır (Köklü ve ark., 2006). Değişkenler arasındaki ilişki, korelasyon katsayısı ile hesaplanmaktadır. Hangi korelasyon katsayısının kullanılacağı; Değişkenlerin hangi ölçek düzeyinde ölçüldüğüne, Değişkenlerin sürekli veya süreksiz olmalarına, Verilerin doğrusal olup olmamasına göre değişmektedir.

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Ayçiçeğinde tane verimine etkide bulunan önemli verim öğeleri arasında karşılıklı ilişkiler değişik araştırmacılar tarafından incelenmiştir. Tyagi (1985), ayçiçeğinde verim öğelerinde, genotipik korelasyon değerlerini fenotipik korelasyona göre daha yüksek bulmuş ve bitki boyunun verim üzerinde doğrudan etkisini negatif olarak tespit ederken, tabla çapının ise, verime yüksek oranda pozitif etkide bulunduğunu gözlemlemiştir. Sivaram (1986), ayçiçeğinde genotip korelasyonun, incelenen tüm verim öğelerinde yüksek düzeyde pozitif yönde önemli olduğunu gözlemlerken, genotipik korelasyonun fenotipik korelasyona nazaran, tüm bu karakterlerde daha yüksek olduğunu tespit etmiştir. Marinkovic ve Skoric (1988) ise, ayçiçeğinde tane veriminin belirlenmesinde, bitki boyu yüksek oranda olumlu etkide bulunurken, çiçeklenme zamanı, kabuk oranı ve tane genişliğinin olumsuz etkide bulunduğunu gözlemlemiştir. Aynı araştırmacılar, tane verimi ile kabuk oranı ve çiçeklenme zamanı arasında negatif, tane verimi ile diğer verim komponentleri arasında ise, pozitif yönde bir korelasyon tespit etmişlerdir.

Kaya ve Atakişi (2003), Yaptıkları korelasyon analizlerinde, tane ve yağ verimiyle diğer tüm verim öğeleri arasında, çiçeklenme ve kabuk oranında negatif, diğerlerinde pozitif yönde ve tümünde önemli bir ilişkinin mevcut olduğunu tespit etmişlerdir.

Bu çalışmanın amacı İkinci ürün şeker mısır bitkisinde verim ve diğer parametreler arasındaki korelasyonun irdelenmesidir. Şekil 1'de şeker mısır hasatı görülmektedir.



*Şekil 1. Tatlı (şeker) mısır.*

## 2. Gereç ve Yöntem

### 2.1. Deneysel Çalışmalar

Damlama sulama yönteminin kullanıldığı deneme parsellerinde su dağıtımı, 4 atm çalışma basıncı ve 16 mm dış çapa sahip yumuşak PE lateral boru hatları kullanılarak sağlanmıştır. Araştırma alanının toprakları ağırdır ve 7 mm h<sup>-1</sup> infiltrasyon oranına sahiptir. Her lateralde, sıralı tip basınç düzenleyicisi ve 1 atm çalışma basıncında 4 L h<sup>-1</sup> akış hızına sahip damlaticılar kullanıldı ve aralarında 0.33 m boşluk kaldı. Bu nedenle, bitki damla sulama yöntemi ile sulama suyu sadece doğru miktarda uygulanmıştır. Herhangi bir sızma veya yüzey akışı meydana

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gelmesine izin verilmemiştir. Sırta ekilecek tohum yatağı hazırlanmıştır. Her parsel, sıra arasında 70 cm boşluk, sıra üzeri 20 cm boşluk, parsellerin boyutları 6 m uzunluğunda ve 2,8 m genişliğinde (parsel yüzeyi = 16,8 m<sup>2</sup>) olmak üzere 4 çizgiye sahip olacak şekilde tasarlanmıştır. Tohumun 4-5 cm derinlikte ekildiğinden emin olmak için 4 hatlı pnömatik tohum makinası kullanılmıştır. Koliler ve tekrarlar arasındaki etkileşimleri önlemek için 2 m tampon bölge oluşturulmuştur. Çalışmada, etkili kök derinliğinin (90 cm) nem içeriği her sulamadan önce gravimetrik yöntem kullanılarak tespit edilmiştir. Her tür için tam sulama (I100) ile kontrol parselinde 90 cm toprak derinliğinde eksik nem getirmek için sulama suyu miktarı, her bir konu için uygulanacak sulama suyu miktarını belirlemek için kullanılmıştır. Bu amaçla, sulama öncesi her sulama derinliği için 90 cm'lik toprak profilinin 0-30, 30-60 ve 60-90 cm'lik tabakalarından alınan toprak numuneleri toplanmış ve kuru toprak ağırlık yüzdesi (%Pw) olarak belirlenmiştir. Her katman için belirlenen nem içeriği, denklem 1 kullanılarak derinlemesine nem içeriğine dönüştürülmüştür.

$$d=(Pw-PwAW)*As*D/100..... (1)$$

Burada; d derinliğinde toprak nem içeriğidir (mm), Pw tarla kapasitesi (%), PwAW; her katmanın nem içeriği (%), As ,Toprak birim ağırlığı (g/cm<sup>3</sup>)  
D katman derinliği (mm) olduğu gibi uygulanacak suyun hacmi aşağıdaki denklem kullanılarak hesaplanmıştır (Eşitlik. (2));

Her tabaka için hesaplanan su içeriği nin eklenmesiyle, etkili kök derinliği için toplam su miktarı (dT) bulunmuştur (Eşitlik. (2)).

$$dT=d(0-30)+ d(30-60) + d(60-90) ..... (2)$$

Her sulama konusunun aylık ve mevsimsel evapotranspirasyon değerleri, büyüme mevsiminde hasadın başlangıcında ve sonunda ölçülen toprağın nem oranı (90 cm) su bütçe yöntemi ve nem içeriği değerleri kullanılarak hesaplanmıştır (Zelege ve Wade 2012).

Bitkinin su tüketiminin hesaplanmasında aşağıdaki su dengesi denklemi kullanılmıştır (Eq. (4)) (Zelege ve Wade 2012).

$$ETa= P + I - Rf - Dp \pm \Delta S .....(Eq. (5)).$$

ETa: Evapotranspirasyon (mm),

P: yağış (mm),

I: sulama suyu miktarı (mm),

Rf: yüzey akışı (mm),

Dp: Derin infiltrasyon (mm) ve

$\Delta S$  (mm) kökündeki toprak nem değişimidir. Çalışmada tercih edilen damla akış hızı toprağın sızma hızından daha düşük olduğundan, yüzey akışı oluşmamıştır. Sulama suyu miktarı mevcut nemi saha kapasitesine getirmek için yeterli olduğu için derin bir sızma meydana gelmediği varsayılmıştır.

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Çizelge 1. Siirt iline ait uzun yıllık meteorolojik veriler (1938-2024).

Parametre	Maksimum Sıcaklık (°C)	Minimum Sıcaklık (°C)	Ortalama Nispi Nem (%)	Toplam Yağış Ortalaması (mm)	Maksimum Yağış (mm)	Ortalama Buharlaşma (mm)	Ortalama Güneşlenme Süresi (Saat)
Rasat Süresi (Yıl)	79	79	78	78	79	79	57
Ocak	19.7	-19.3	71.9	34.6	53.4	12.0	3.6
Şubat	20.6	-16.5	67.1	29.4	53.2		4.4
Mart	28.5	-13.3	62.0	24.1	63.0	33.0	5.4
Nisan	32.9	-4.1	58.0	22.4	71.4	84.0	6.5
Mayıs	36.2	2.0	50.7	21.2	68.1	186	9.0
Haziran	40.2	8.2	34.6	15.5	16.7	284.8	11.7
Temmuz	44.4	13.1	27.4	13.5	22.2	368.0	12.2
Ağustos	14.4	46.0	26.4	13.3	12.2	351.8	11.4
Eylül	39.9	8.5	31.2	14.4	37.5	254.3	9.9
Ekim	36.6	0.3	46.7	49.7	70.8	137.6	7.2
Kasım	25.8	-14.1	62.4	82.5	102.9	53.0	5.2
Aralık	24.3	-14.6	70.6	94.5	71.8	13.1	3.6
Yıllık	46	-19.3	50.8	719.8	102.9	1753.6	7.5

Çalışmadan elde edilen bulgular varyans analizine tabi tutulmuş ve varyans analizi sonuçlarına göre istatistiksel olarak önemli çıkan uygulamalar LSD testi ile karşılaştırılmıştır. Özellikler arasındaki ilişkiyi tespit etmek için korrelasyon analizi yapılmıştır (Der ve Everitt, 2002).

### 3. Bulgular ve Tartışma

#### Korelasyon analizi

Korelasyon katsayılarına bakıldığında tüm bu özellikler arasında istatistik olarak önemli ilişkiler ( $p \leq 0.01$  ve  $p \leq 0.05$ ) olduğu tespit edilmiştir. Yaş verim ile kuru verim arasında  $r = 0.923$  gibi yüksek bir artan (pozitif) ilişki bulunmaktadır. Bir başka deyişle yaş verim arttıkça doğrusal olarak kuru verimde artmaktadır. Yaş verim ile bitki su stres indeksi (CWSI) arasında ise  $r = -0.895$  gibi yüksek bir azalan (negatif) ilişki bulunmaktadır. Bir başka deyişle yaş CWSI'i azaldıkça yaş verim artmaktadır. Yaş verim ile klorofil indeksi (CC) arasında  $r = 0.869$  gibi yüksek bir artan (pozitif) ilişki bulunmaktadır. Bir başka deyişle klorofil indeksi arttıkça yaş verimde artmaktadır. Kuru verim ile bitki su stres indeksi (CWSI) arasında ise  $r = -0.846$  gibi yüksek bir azalan (negatif) ilişki bulunmaktadır. Bir başka deyişle yaş CWSI'i azaldıkça kuru verimde artmaktadır.

### 4. Sonuç

Son zamanlarda küresel ısınmaya bağlı olarak ciddi bir tehdit olarak karşımıza çıkan ani iklimsel değişim, ülkemizdeki kısıtlı olan su kaynaklarının tükenmesine yol açmakta önemli bir oynamaktadır. korelasyon katsayılarına bakıldığında incelenen özellikler arasında istatistik olarak önemli ilişkiler ( $p \leq 0.01$  ve  $p \leq 0.05$ ) olduğu tespit edilmiştir. Kuru

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verim ile bitki su stres indeksi (CWSI) arasında ise  $r = -0.846^{**}$  gibi yüksek bir azalan (negatif) ilişki bulunmaktadır. Bir başka deyişle CWSI'i azaldıkça kuru verimde artmaktadır. Kuru verim ile klorofil indeksi (CC) arasında  $r = 0.755^{**}$  gibi yüksek bir artan (pozitif) ilişki bulunmaktadır. Bir başka deyişle klorofil indeksi arttıkça kuru verimde artmaktadır. Araştırmadan elde edilen sonuçlar diğer araştırmacılar tarafından da test edilebilir.



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**PHYTOCHEMICAL INVESTIGATION OF VALUABLE SPECIES OF *THYMUS*  
GENUS**

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**Abstract:** This study aimed to compare the performance and essential oil compositions of seven ecotypes from three thyme species: *Thymus daenensis* (genotypes 49, 60, 68, and 72), *Thymus transcaucasicus* (genotypes 12 and 24), and *Thymus vulgaris* (used as the control) at the rainfed agricultural research station of Tikmeh Dash, located in East Azerbaijan Province, Iran. The experiment was conducted in a 40×10-meter field using a randomized complete block design (RCBD) with three replications. The seeds of the ecotypes were sown in peat moss beds in a greenhouse in December 2019 and were transplanted to the main field in late June. After plant establishment, irrigation was performed via drip irrigation based on water requirements. The planting distances between rows and plants were set at 50 cm. After the plants were fully established, sampling was conducted to extract essential oils and estimate their percentage and yield. Essential oil extraction was performed using hydrodistillation, and the samples were sent to a research institute for chemical analysis. The chemical composition of the essential oils was analyzed using gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS), allowing the identification of chemical constituents and their respective quantities.

The results showed that in the *T. vulgaris* species (control), 19 compounds were identified, with thymol (54%), gamma-terpinene (11.58%), and p-cymene (10.97%) being the major components. In the *T. transcaucasicus* species (Zanjan population, genotype 12), thymol (44.19%), carvacrol (26.24%), and E-caryophyllene (22.05%) were identified as the dominant components of the essential oil. In the *T. daenensis* species, thymol was the predominant compound in all four genotypes, including Isfahan (genotype 49) with 76.85%, Markazi Province (genotype 60) with 74.98%, Fereydan-Isfahan (genotype 68) with 69.1%, and Markazi Province (genotype 72) with 80.45%. Based on the results of this study, the *T. daenensis* species with genotypes 72 (Markazi Province) and 49 (Isfahan), due to their high thymol content and economic performance, are recommended for cultivation in similar rainfed regions with comparable climatic conditions.

**Keywords:** Thyme, seeds, essential oil, *Thymus daenensis*, *Thymus transcaucasicus*, *Thymus vulgaris*

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## 1. Introduction

Medicinal plants are one of nature's valuable resources, and improving and selecting local cultivars to enhance various traits such as resistance to environmental stresses, increased yield and product quality, and optimal utilization of existing germplasms is essential. In Iran, which boasts a high diversity of medicinal plant species, such improvements can strengthen agricultural systems and enhance economic productivity (El-Shazly et al., 2020). In this regard, genetic research and biotechnology can play a crucial role in developing new cultivars adapted to the specific environmental conditions of each region.

The cultivation of perennial medicinal plants as an alternative to annual grains in low-yield and rainfed areas offers numerous benefits. In addition to preventing soil erosion and providing vegetation cover, these crops can serve as a source of income for farmers in arid and semi-arid regions (Giri, 2011). Given their high economic and medicinal value, expanding the cultivation of medicinal plants particularly in low-yield lands can improve economic conditions and create job opportunities in these areas (Marcelino et al., 2023). Moreover, supplying organic and high-quality products to global markets can generate significant profits for producers.

The improvement of medicinal plants, especially thyme one of the most important and widely used medicinal herbs is considered a key strategy for enhancing the quality and quantity of its production and ensuring high-quality raw materials for the pharmaceutical and healthcare industries. Due to its numerous medicinal properties, drought resistance, and low water requirements, thyme has great potential for cultivation under diverse climatic conditions and in rainfed lands (Babotã et al., 2023). Therefore, breeding and introducing new thyme cultivars capable of producing high concentrations of active compounds and withstanding environmental stresses is a necessary endeavor. The active compounds of medicinal plants, such as essential oils, are influenced by various environmental factors, including climate, altitude, and soil type. Therefore, evaluating and selecting different thyme ecotypes with the highest essential oil yield and the most desirable chemical composition can optimize the utilization of this plant (Kuate, 2020). This study focuses on assessing the morphological and chemical characteristics of various thyme ecotypes to identify the most suitable options for thyme cultivation in different regions.

In this regard, the provision of improved seeds and the introduction of suitable thyme cultivars, along with the establishment of optimal conditions for their commercial propagation, are of particular importance. This approach not only helps preserve thyme's genetic resources but also enables the production of high-quality and more effective medicinal products. Therefore, selecting and introducing the best thyme cultivars is of great significance. In this study, six ecotypes from two thyme species are examined.

## 2. Material and Methods

In this study, seven promising accessions from three *Thymus* species: *Thymus vulgaris*, *T. transcaucasicus*, and *T. daenensis* were selected based on preliminary evaluations. The experiments were conducted in two separate designs: one with replication and one without. Seed cultivation began in greenhouse trays, and after adequate growth, the seedlings were transplanted into the main field. The planting distance was set at 75 cm between rows and 50 cm between plants. Maintenance practices included drip irrigation and mechanical weed control. Herbarium samples were collected at the flowering stage and sent to the Research Institute of Forests and Rangelands for identification.

The main experiment, comparing seven accessions from the three species, was carried out in a randomized complete block design with three replications at the Tikmeh Dash research station.

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Seeds were initially sown in a greenhouse, and once sufficiently developed, seedlings were transferred to the field. Due to continuous rainfall during the growing season, maintenance operations for the seedlings were sustained. After plant establishment in the field, irrigation was provided as needed. At the flowering stage, sampling was conducted for essential oil extraction and yield assessment. Seed collection was avoided due to genetic interference, and for further propagation, seeds were cultivated under isolated conditions.

In the second phase of the experiment, selected seeds from the first phase were sown in trays, and seedlings were planted in separate fields 500 meters apart. This stage aimed to purify and standardize plants for producing mother seeds. Evaluations included shoot yield, essential oil yield, and other traits. Sampling from flowering shoots was conducted at the early flowering stage, and essential oils were extracted using hydrodistillation. The extracted essential oils were sent to the Research Institute of Forests and Rangelands for compound analysis.

For essential oil extraction, dried samples were ground and subjected to hydrodistillation using a Clevenger apparatus for 2.5 hours. The obtained essential oils were weighed, dehydrated with sodium sulfate, and stored in a refrigerator until analysis. The chemical composition of the essential oils was analyzed using gas chromatography (GC) and gas chromatography-mass spectrometry (GC/MS).

Finally, based on the analysis results, the top-performing accessions from each species were selected. Genotype 68 from *T. daenensis* and genotype 12 from *T. transcaucasicus* were identified as the best candidates based on morphological performance, essential oil yield, and chemical composition. The seeds of these accessions were sent to the Research Institute of Forests and Rangelands for propagation and further development.

### 3. Results

#### - Qualitative Analysis of Essential Oil in Three Thyme Species and Their Populations in 2019

The qualitative analysis of essential oil from three thyme species (*Thymus vulgaris*, *Thymus transcaucasicus*, and *Thymus daenensis*) and their respective populations in 2019 at the Tikmeh Dash research station in East Azerbaijan revealed that the main constituents of the essential oil were thymol, carvacrol, para-cymene, gamma-terpinene, and E-caryophyllene. However, the proportion of these compounds varied among species and populations. In *T. vulgaris*, thymol was the dominant component (54%), followed by gamma-terpinene (11.58%) and para-cymene (10.97%). In contrast, the Zanjan population of *T. transcaucasicus* contained 44.19% thymol and 26.24% carvacrol, whereas population 24 of the same species had the highest concentrations of carvacrol (27.46%) and geraniol (27.05%). Significant variations in essential oil composition were also observed among populations of *T. daenensis*. The Isfahan population had the highest thymol content (76.85%), with carvacrol (5.28%) ranking second. In the Markazi province population, thymol remained dominant (74.98%), but carvacrol content (7.59%) was higher than in the Isfahan population. The Fereydan population from Isfahan province contained 69.1% thymol and 10.38% carvacrol, whereas in the Markazi province population (code 72), thymol had the highest share (80.45%), and the proportions of other minor compounds such as borneol and gamma-terpinene were estimated to be below 2%. A comparative analysis of the compositions indicated that thymol and carvacrol were the primary constituents across different thyme species. However, their relative proportions varied depending on genetic and environmental factors. *T. vulgaris* was primarily rich in thymol, whereas *T. transcaucasicus* exhibited a notable balance of thymol and carvacrol. In *T. daenensis*, certain populations, particularly those from Markazi province and Isfahan, displayed high

thymol concentrations. Overall, these findings highlight the significance of genetic and environmental diversity in determining the chemical composition of thyme essential oils. Populations with high thymol and carvacrol content could serve as valuable candidates for the development and improvement of medicinal thyme cultivation.

**- Qualitative Analysis of Essential Oil in Three Thyme Species and Their Populations in 2020**

The qualitative analysis of essential oil from three thyme species (*Thymus vulgaris*, *Thymus transcaucasicus*, and *Thymus daenensis*) and their various populations in 2020 revealed a diverse range of chemical compounds. In the *T. vulgaris* population, the major constituents included thymol (29.62%), linalool (18.36%), and geraniol (15.87%). Other compounds, such as gamma-terpinene, alpha-terpinyl acetate, and para-cymene, were also present, while components like alpha-thujene, camphene, and sabinene were reported at levels below 1%. For *T. transcaucasicus*, the dominant compounds varied across populations. In the Zanjan population, thymol (22.83%) and linalool (21.45%) were the most abundant, whereas another population of this species had higher concentrations of carvacrol (29.04%) and geraniol (21.16%). Significant variations were also observed among populations of *T. daenensis*. In the Isfahan population, geraniol (31.28%) and carvacrol (25.7%) were the most abundant components, whereas in the Markazi province population, thymol (61.68%) had the highest concentration. Secondary compounds such as para-cymene, borneol, and gamma-terpinene were present in all populations, although their percentages were below 2% in certain cases. The Fereydan population was characterized by high levels of thymol (56.24%) and para-cymene (24.11%).

Overall, thymol and carvacrol were identified as the primary constituents across all populations, particularly in *T. daenensis* and *T. vulgaris*, though their proportions varied significantly between species and populations. These variations are likely influenced by genetic factors and environmental conditions. Other minor compounds, such as alpha-pinene, camphene, and sabinene, were reported in concentrations below 1%. These findings highlight the chemical diversity of thyme essential oils across different populations, influenced by genetic and environmental factors. This diversity could be beneficial for the medicinal and industrial applications of thyme, particularly in the selection and breeding of superior varieties.

**-Qualitative Analysis of Essential Oil in Two Selected Accessions of *T. daenensis* (68 – Fereydan, Isfahan) and *T. transcaucasicus* (12 – Zanjan)**

The chemical composition analysis of essential oils from two selected populations of *Thymus daenensis* (Fereydan, Isfahan) and *Thymus transcaucasicus* (Zanjan) in 2021 at the Tikmeh Dash research station revealed significant differences in their essential oil profiles. In *T. daenensis* from the Fereydan population, Plot 1 was characterized by a high concentration of thymol (67.71%), followed by gamma-terpinene (7.32%) and carvacrol (5.88%). Other minor compounds, including para-cymene, myrcene, and E-caryophyllene, were also identified, while components such as alpha-thujene, camphene, and beta-pinene were detected in amounts below 1%. In Plot 2 of the same population, thymol (71.88%) remained the dominant component, with carvacrol (6.72%) and gamma-terpinene (5.44%) following. Minor compounds showed slight variations in concentration compared to Plot 1, but alpha-thujene, alpha-pinene, and camphene were still found at levels below 1%. For *T. transcaucasicus* from the Zanjan population, Plot 1 contained thymol (34.41%) and carvacrol (22.58%) as the major constituents. Gamma-terpinene (8.66%), para-cymene (5.64%), and cineole (3.04%) were also present as secondary components, while other compounds such as geraniol, linalool, alpha-

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pinene, and borneol were detected in lower concentrations. In Plot 2 of the Zanjan population, thymol (31.92%) and carvacrol (28.05%) remained the predominant compounds, followed by gamma-terpinene (6.36%) and linalool (3.04%). Other minor constituents, including geraniol, para-cymene, and cineole, were present in lower amounts. These findings highlight significant variability in the chemical composition of thyme essential oils across different populations, particularly in the dominant compounds thymol and carvacrol. Such differences likely reflect the influence of genetic and environmental factors on essential oil composition, which has important implications for medicinal and industrial applications.

## 4. Discussion

The essential oil analysis of three *Thymus* species—*T. vulgaris*, *T. transcaucasicus*, and *T. daenensis*—and their various populations at the Tikmeh Dash research station in East Azerbaijan in 2019 revealed that thymol, carvacrol, and gamma-terpinene were the dominant compounds in most populations. In the *T. vulgaris* population, thymol (54%) and gamma-terpinene (11.58%) were the most abundant constituents, whereas in *T. transcaucasicus* (Zanjan), thymol (44.19%) and carvacrol (24.26%) were the primary components. In *T. daenensis* (Isfahan), thymol was the predominant compound, accounting for 76.85% of the essential oil composition.

In 2020, the essential oil analysis of different populations of these species indicated that thymol and carvacrol remained dominant in most cases. In *T. vulgaris*, thymol (29.62%) and linalool (18.36%) were the most abundant compounds, while in *T. transcaucasicus* (Zanjan), thymol (22.83%) and linalool (21.45%) were predominant. In *T. daenensis* from Isfahan, thymol (76.85%) remained the major component, while other populations from Markazi province and Fereydan exhibited similar compositions, including thymol and para-cymene.

Comparative analysis of the essential oil compositions in 2019 and 2020 also revealed variations in other compounds, such as geraniol, borneol, and gamma-terpinene, which differed across populations, indicating qualitative diversity in essential oils among these species. Furthermore, environmental conditions were found to significantly influence the production of essential oil compounds. For instance, the findings suggest that to achieve higher thymol yields, populations from Markazi province and Isfahan should be cultivated more extensively under similar climatic conditions.

Previous studies have shown that major compounds such as thymol and carvacrol are consistently present in various *Thymus* species and play a crucial role in essential oil composition. Some research has also examined the impact of environmental stressors, such as drought, on thymol concentration and plant performance, revealing that increased drought stress enhances thymol levels in thyme plants. Consequently, optimizing cultivation and environmental conditions is essential for producing high-thymol essential oils (Chroho et al., 2024).

Overall, findings from this study and similar research indicate that phenolic compounds and monoterpenes, particularly thymol and carvacrol, are critical to the essential oil production of *Thymus* species. However, their concentrations and compositions vary depending on environmental and geographical conditions (Amani Machiani et al., 2024).

## 5. Conclusion

The findings of this study indicate that for achieving and producing key compounds such as thymol, linalool, geraniol, and carvacrol, the cultivation of two selected populations from Zanjan (code 12) and an unidentified source (code 24) from the gene bank of the Research Institute of Forests and Rangelands in Tikmeh Dash Station and other ecologically similar

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regions is feasible. Notably, populations of *T. daenensis* in three different groups predominantly contained thymol as their major compound. Therefore, expanding the cultivation of populations that contribute significantly to thymol production, such as populations 60 and 68 from Markazi and Isfahan provinces, would be beneficial. The analysis of essential oil components in different populations of *T. daenensis* at Tikmeh Dash Station revealed that thymol was remarkably present in two sections of the Fereydan Isfahan population (code 68). Given this, cultivating these populations in similar ecological regions could be a strategic approach for obtaining thymol along with other valuable compounds such as gamma-terpinene, carvacrol, and p-cymene. Additionally, the essential oil composition of the Zanjan population from *T. transcaucasius* demonstrated that its major components were thymol and carvacrol, highlighting its potential for use in pharmaceutical and fragrance industries. Seeds from these populations were sent to the Research Institute of Forests and Rangelands for propagation and further evaluation, ensuring the sustainable utilization of their potential in future studies. Ultimately, assessing and introducing superior *Thymus* populations for cultivation under different climatic conditions across the country is essential. Given that excessive harvesting of wild thyme species can lead to a reduction in genetic diversity and the loss of valuable germplasm, selecting and promoting improved high-yielding cultivars is of particular importance for both conservation and industrial applications.

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**INVESTIGATION OF THE EFFECT OF PLANT DENSITY AND NUTRITION ON  
THE PERFORMANCE OF *Satureja mutica* UNDER RAINFED CONDITIONS**

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**Abstract:** *Satureja mutica* (Fisch. & C.A. Mey.), commonly known as Marzeh-e-Mutika, is a native Iranian species and a significant medicinal plant. It has garnered attention due to its high essential oil content, particularly the phenolic compound thymol. Thymol, as one of the primary constituents of this plant, exhibits strong antibacterial, antifungal, and antioxidant properties, making it valuable in pharmaceutical, food, and hygiene industries. Enhancing the quantitative and qualitative performance of this medicinal plant requires careful consideration of key factors such as optimal planting density and effective soil fertility management. This study examined the effects of nutrient management and planting density on *Satureja mutica* under rainfed conditions. Conducted over three years (2020–2022) at the Tikmeh Dash Research Station in East Azerbaijan Province, Iran, the experiment utilized a split-plot design within a randomized complete block layout with three replications. Nutrient treatments consisted of sheep manure, straw mulch, and a control group (no fertilizer), while planting density was assessed at three spacings: 25 cm, 50 cm, and 75 cm. The results revealed that straw mulch significantly improved dry matter yield, achieving 777 kg per hectare compared to 565 kg per hectare with sheep manure and 442 kg per hectare in the control group. Additionally, essential oil yield in the straw mulch treatment reached 12.5 kg per hectare, outperforming the sheep manure treatment (7.19 kg per hectare) and the control (4.73 kg per hectare). Regarding planting density, the 25 cm spacing resulted in the highest dry matter yield of 780 kg per hectare, followed by 655 kg per hectare at 50 cm and 350 kg per hectare at 75 cm. The findings of this study indicate that using straw mulch and adopting a planting density of 25 cm significantly enhance the dry matter and essential oil yield of *Satureja mutica*. This combination is recommended as an effective strategy for increasing the production efficiency of this medicinal plant under rainfed conditions.

**Keywords:** *Satureja mutica*, rainfed agriculture, planting density, nutrient management.

## 1. Introduction

Under rainfed conditions, one of the major challenges in agriculture is the lack of suitable vegetation cover and soil erosion, which can lead to the degradation of natural resources. In this regard, cultivating perennial medicinal plants as an alternative to annual grains can contribute to soil stabilization and enhance the sustainability of agricultural ecosystems (Kocabaş ve Kaplan, 2009). The development of agricultural goods depends on the plant nutrition management approach. To increase plant yield and productivity, the interaction between various fertilizers and necessary nutrients is crucial. Medicinal plants, by establishing permanent vegetation cover, prevent soil erosion and play a crucial role in conserving natural resources. Savory (*Satureja* spp.) is one of the important medicinal plants that, due to its drought tolerance and adaptability to harsh conditions, can be considered a suitable option for rainfed agriculture in Iran. The amount of organic matter in the soil is quite low in dry and semi-arid areas, like Iran. Thus, soil fertility is extremely important to preserve and enhance agricultural sustainability (Bergottini et al., 2015). Planting management can affect plant growth and development. Plant density is a management cultivation practice that affects plant growth by adjusting soil water and nutrients. Planting pattern creates a special situation for plants by changing microclimate and soil properties. According to environmental, geographical and soil-related factors, plants adopt appropriate plant densities to utilize optimum nutrients and water (Mirjalili et al., 2021).

Savory, a beneficial medicinal herb that can withstand drought, can be used into the agriculture system, particularly in areas with limited precipitation and water resources (Karimi et al., 2022; Yousefi et al., 2024). This plant is not only valued for its medicinal properties but also holds significant economic importance due to its production of essential oils, which are widely used in the food and pharmaceutical industries (Karimi et al., 2016). Research has shown that the application of organic fertilizers, such as animal manure, can improve the performance of medicinal plants, including savory, and lead to the production of higher-quality and more economically viable essential oils (Askary et al., 2018; Hitha et al., 2021). Plant competition frequently leads to power-law relationships between metrics including individual biomass, average size, and plant density (Freidman, 2016). One of the main management parameters influencing plant growth is plant density, which modifies the plant's ability to absorb nutrients, water, and radiation (Perrott et al. 2018). Variations in plant density produce distinct microclimates for plants, which in turn affect soil moisture content, soil microorganisms, canopy temperature, and other factors. The plants adopt their optimal plant density in relation to the edaphic, geographical, and environmental factors (Morla et al. 2018).

The morphological traits of *Satureja* sp. are affected by agronomic practices and growth performance can be increased by appropriate cultural practices (Mohammadpour et al., 2013). While increasing plant density in *Satureja hortensis* increased the yield of dry leaves and essential oil per unit area, it decreased the yield and yield components of the plants (Katar, 2022). In *S. mutica*, the application of chemical fertilizers together with animal manure and worm manure is used to increase the yield of various parts of the plant and the yield of essential oil (Asadollahi et al., 2022). This study was conducted to evaluate the ecological requirements of savory under rainfed conditions and determine the optimal planting density and fertilization strategy at the Tikmeh Dash Research Station in East Azerbaijan Province to maximize yield and essential oil quality.

## **2. Material and Methods**

This study aimed to evaluate the effects of planting density and fertilization on the yield of savory (*Satureja mutica*) under rainfed conditions in East Azerbaijan Province. The research was conducted over three years (2020-2022) at the Tikmeh Dash Research Station, located in southeastern Tabriz. The region has a semi-arid climate, characterized by mild summers, cold winters, and an average annual rainfall of 386 mm. The soil has a loam-clay texture, transitioning to a sandier composition at depths of 30 to 40 cm.

The experiment was designed as a split-plot arrangement based on a randomized complete block design (RCBD) with three replications. The main treatments included three fertilization levels (sheep manure, straw, and a control with no fertilization), while the sub-treatments consisted of three within-row planting distances (25 cm, 50 cm, and 75 cm). The inter-row spacing was fixed at 50 cm for all densities. The plant populations for the 25 cm, 50 cm, and 75 cm spacings were 66,666, 40,000, and 26,666 plants per hectare, respectively. Sheep manure (30 tons per hectare) and straw (10 tons per hectare) were applied in the furrows, with ammonium sulfate (20 g/m<sup>2</sup>) added to the straw treatment. No fertilizers were applied to the control treatment. Seeds were sown in trays on February 10, and the first irrigation was carried out on February 15. Germination was observed by March 10, and seedlings were transplanted to the field on June 10. Weeding was performed six times throughout the growing season. Measured traits included plant height, canopy cover (major and minor diameters), dry matter yield, flowering stages, seed maturity, and the number of branches per plant. To assess single-plant dry weight, wood weight, leaf weight, essential oil content, and oil yield, 10 plants were randomly sampled from each plot. In all three species, samples were collected from flowering shoots at the 50% flowering stage. After shade-drying, essential oils were extracted using hydrodistillation with a Clevenger-type apparatus. Essential oil yield was calculated based on the plant's dry weight. Data analysis was performed using a split-split-plot design and Duncan's multiple range test in SPSS software. Mean squares were estimated through expected mean squares calculations.

## **3. Results**

### **3.1. Plant Height**

The analysis of variance showed that bed fertilization, planting density, and their interaction had a significant effect on plant height at the 1% level. However, no significant differences were observed between the experimental years. The average plant height in the first, second, and third years was 46.19 cm, 45.55 cm, and 45.87 cm, respectively. The highest plant height (48.02 cm) was recorded with manure application, followed by straw treatment and the control. In terms of planting density, the greatest height (48.35 cm) was observed at the 75 cm spacing. The tallest plants (51.7 cm) were obtained in the manure treatment combined with a 75 cm spacing, while the shortest plants (39.44 cm) were recorded in the control treatment with a 25 cm spacing.

### **3.2. Canopy Area**

The results indicated that bed fertilization, planting density, and their interaction had a significant effect on canopy area at the 1% level. However, no significant differences were observed between the experimental years. The largest canopy area was recorded in the first year (3745.261 cm<sup>2</sup>). Regarding fertilization, the highest canopy area (4150.21 cm<sup>2</sup>) was observed in the straw treatment, followed by manure and the control. In terms of planting density, the greatest canopy area (4181.241 cm<sup>2</sup>) was achieved at the 75 cm spacing. The highest overall canopy area (5167.68 cm<sup>2</sup>) was obtained with the combination of straw

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treatment and 75 cm spacing, while the smallest (2470.205 cm<sup>2</sup>) was recorded in the control treatment with a 25 cm spacing.

### 3.3. Dry Matter Yield

The effects of bed fertilization, planting density, and some of their interactions were significant at the 1% and 5% levels. However, no significant differences were observed between the experimental years (Table 1). The highest biomass yield was recorded in the second year (605 kg/ha). Regarding fertilization, the highest dry matter yield (777 kg/ha) was obtained from the straw treatment, followed by manure and the control. In terms of planting density, the highest dry matter yield (780 kg/ha) was observed at the 25 cm spacing. The maximum dry matter yield (1027 kg/ha) resulted from the combination of straw treatment and 25 cm spacing, whereas the lowest yield (281 kg/ha) was recorded in the control treatment with a 75 cm spacing.

### 3.4. Total Dry Weight, Stem Weight, and Leaf Weight per Plant

The effects of planting density and bed fertilization on total dry weight, stem weight, and leaf weight per plant in *Satureja mutica* were evaluated. The results indicated that both factors had a significant impact on these traits (at the 1% probability level). The highest total dry weight (193 g) was observed at the 25 cm spacing, while the lowest (126.3 g) was recorded at the 75 cm spacing. Among fertilization treatments, the control had the highest total dry weight (169.6 g), followed by the straw treatment (150 g) and manure (149.3 g). The combination of straw treatment and 25 cm spacing resulted in the highest total dry weight (201.1 g). The highest stem weight per plant was recorded in the first year (106.3 g). The 75 cm spacing had the highest stem weight (175.6 g). Among fertilization treatments, the control (144.8 g) ranked first, followed by manure (90 g) and straw (67.8 g). The interaction of manure fertilization and 75 cm spacing yielded the highest stem weight (67.7 g). The highest leaf weight per plant was observed in the first year (181.5 g). The control treatment had the highest leaf weight (199.3 g), followed by manure (118.5 g) and straw (110 g). The highest leaf weight was recorded at the 25 cm spacing (192.2 g), with the maximum leaf weight (135.8 g) observed in the combination of straw fertilization and 25 cm spacing.

### 3.5. Essential Oil Percentage

Analysis of variance (ANOVA) revealed that the effect of substrate nutrition, as well as the interaction effects of substrate nutrition × planting density and year × substrate nutrition, were significant at the 1% level. The highest essential oil percentage was observed in the first year (1.46%). Among the substrate nutrition treatments, straw yielded the highest essential oil percentage (1.63%), followed by manure (1.44%) and the control (1.22%). Additionally, the highest essential oil percentage (1.49%) was recorded at a planting density of 75 cm.

### 3.6. Essential Oil Yield

The effects of substrate nutrition, planting density, and their interactions were significant at the 1% level. The highest essential oil yield was recorded in the second year (8.32 kg/ha). Among the substrate treatments, straw showed the best performance, yielding 12.5 kg/ha. The highest essential oil yield (11.23 kg/ha) was observed at a planting density of 25 cm.

### 3.7. Number of Branches per Plant

The effects of substrate nutrition and planting density on the number of branches were not significant. The highest number of branches per plant was observed in the second year (14.3 branches). Among the substrate treatments, straw had the greatest effect, resulting in 15.11 branches. Regarding planting density, the 75 cm spacing produced the highest number of branches (15.56).

### 3.8. Days to Flowering and Seed Maturity

No significant differences were observed in the effects of substrate nutrition and planting density. The longest delay in flowering was recorded in the straw × 25 cm planting density treatment (158.2 days). For seed maturity, the manure × 25 cm planting density treatment showed the greatest delay (189.5 days).

### 3.9. Plant Establishment Percentage

The effects of substrate nutrition and planting density were significant at the 5% level, while the effect of year was significant at the 1% level. The highest plant establishment percentage was observed in the first year (55.44%). Among the treatments, the straw substrate (55.19%) and the 25 cm planting density (52.15%) resulted in the highest establishment percentages.

## 4. Discussion

One of the primary objectives in the cultivation of medicinal plants is to enhance both quantitative and qualitative yield while ensuring environmental sustainability. Organic fertilizers not only improve plant nutrition and increase production but also prevent pollution caused by chemical fertilizers. In this study, the effects of a straw substrate combined with ammonium sulfate and manure on the quantitative and biochemical characteristics of *Satureja mutica* were evaluated. The results demonstrated that the application of a straw substrate had more positive effects on plant growth than manure and the control treatment, leading to improvements in traits such as plant height, canopy area, dry yield, stem and leaf weight per plant, essential oil percentage, and plant establishment rate. The observed positive impact of the straw substrate can be attributed to its high water retention capacity and ability to enhance nutrient solubility, which ultimately improves plant nutrition and increases both yield and quality. Straw, as an organic amendment, provides a more favorable microenvironment by maintaining soil moisture and promoting better root development. This is particularly beneficial in dryland farming conditions, where water availability is a limiting factor for plant growth and productivity. Additionally, planting density significantly influenced the growth and yield of *Satureja mutica*. Although plant height and canopy area decreased at the 25 cm spacing compared to the 50 cm and 75 cm treatments, dry yield, plant weight, leaf weight, essential oil yield, and plant establishment rate increased significantly. This can be attributed to better access to environmental resources such as light, water, and nutrients in lower-density plantings, which reduces competition and provides optimal growth conditions. However, an increase in planting density led to a reduction in essential oil percentage, likely due to decreased light intensity and altered microclimatic conditions around the plants. Nonetheless, the higher essential oil yield per unit area at the 25 cm spacing compensated for the lower essential oil concentration per plant. Several studies have supported these findings. For instance, Esmailpour et al. (2018) reported that the application of organic fertilizers in *Satureja hortensis* L. significantly affected the essential oil percentage and compound composition of thyme. Ghanbari et al. (2015) reported that manure application in intercropping systems of barley and fenugreek enhanced forage yield. Similarly, Olorunnismo & Ayodelet (2009) found that manure application in maize and amaranth cultivation improved dry matter production. Research by Yolcu et al. (2010) also indicated that cattle manure application in barley and vetch intercropping increased forage yield. Application of cattle manure and high plant density can increase yield (Hosseini et al., 2022). Furthermore, studies on oregano (*Origanum* sp.) have demonstrated that municipal waste compost application improves vegetative growth and fresh weight, primarily due to improved nutrient supply and soil physical conditions.

### **5. Conclusion**

Overall, this study demonstrated that preparing the cultivation bed for *Satureja mutica* using a straw substrate combined with ammonium sulfate had the most significant positive impact on plant performance and essential oil quality, showing a considerable advantage over manure and the control treatment. Furthermore, selecting an appropriate planting density is crucial for optimizing the productivity of medicinal plants. The 25 cm spacing provided a balance between resource distribution and reduced plant competition, leading to increased dry yield and essential oil production. Therefore, for the sustainable cultivation of *Satureja mutica* under dryland conditions, a combination of a straw substrate with ammonium sulfate and a planting density of 25 cm is recommended.

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**Özet**

Yabancı otların insan faaliyetleri yönünden hem faydalı hem de zararları yönleri vardır. Yabancı otların olumlu yönleri incelendiğinde ilaç ve gıda olarak kullanılma, toprak sağlığını iyileştirme, erozyonu önleme, yaban hayatı için besin ve barınak sağlama, biyoçeşitliliği artırma, rekreasyon ve biyoremediasyon gibi faydaları vardır. Ancak bu çalışma yabancı otların zararlı yönlerine odaklanmaktadır. Bu bağlamda yabancı otlar kısaca "istenmeyen bitkiler" olarak adlandırılmaktadır. Yabancı otlar genellikle çok sayıda tohum üretir. Bu, yayılmalarını ve kalıcılıklarını artırır. Hızlı büyüyerek ekilen bitkilerle rekabet etmede avantaj sağlarlar. Farklı toprak tiplerine, iklimlere ve yetiştirme koşullarına uyum sağlama yetenekleri yüksektir. Birçok yabancı ot tohumu, toprakta uzun yıllar canlı kalabilir ve uygun koşullar oluştuğunda çimlenir. Rüzgar, su, hayvanlar ve insanlar aracılığıyla kolayca yayılabilirler. Kök sürgünleri veya rizomlar gibi vejetatif üreme yöntemleriyle de yayılabilirler. Su, besin, ışık ve alan için diğer bitkilerle (özellikle ekilen ürünlerle) rekabet etme yetenekleri yüksektir. Herbisitlere karşı direnç geliştirebilirler, bu da kontrol edilmelerini zorlaştırır. Yaşam sürelerine göre tek yıllık, iki yıllık ve çok yıllıktırlar. Yaprak yapılarına göre; geniş yapraklı ve dar yapraklıdırlar. Ekolojik habitatlarına göre; tarla yabancı otları, sucul yabancı otlar, vb. gruplandırılabilirler. Yabancı otlara karşı kültürel, mekanik, kimyasal, biyolojik kontrol taktikleri uygulanabilir. Kültürel kontrol olarak ekim nöbeti, ekim normu vs. önemlidir. Mekanik kontrol amaçlı elle yolma, çapalama ve biçme yapılabilir. Kimyasal kontrolde herbisitler kullanılır. Biyolojik kontrolde yabancı otları yiyen böcekler, mantarlar veya diğer organizmalar kullanılır. Farklı kontrol yöntemlerinin bir arada kullanılması ile entegre yönetim sağlanabilir.

**Anahtar Kelimeler:** Kontrol, Ortak özellik, Rekabet, Sınıflandırma, Yabancı ot

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**CHARACTERISTICS OF WEEDS**

**Abstract**

Weeds have both beneficial and harmful aspects in terms of human activities. When the positive aspects of weeds are examined, they have benefits such as being used as medicine and food, improving soil health, preventing erosion, providing food and shelter for wildlife, increasing biodiversity, recreation and bioremediation. However, this study focuses on the harmful aspects of weeds. In this context, weeds are simply called "unwanted plants". Weeds usually produce a large number of seeds. This increases their spread and persistence. They provide an advantage in competing with planted plants by growing quickly. They have a high ability to adapt to different soil types, climates and growing conditions. Many weed seeds can survive in the soil for many years and germinate when suitable conditions occur. They can easily spread by wind, water, animals and people. They can also spread by vegetative reproduction methods such as root suckers or rhizomes. They have a high ability to compete with other plants (especially planted crops) for water, nutrients, light and space. They can develop resistance to herbicides, which makes them difficult to control. According to their life span, they are annual, biennial and perennial. According to their leaf structure; they are broad-leaved and narrow-leaved. According to their ecological habitat; they can be grouped as field weeds, aquatic weeds, etc. Cultural, mechanical, chemical and biological control tactics can be applied against weeds. Crop rotation, planting norm etc. are important as cultural control. Manual plucking, hoeing and mowing can be done for mechanical control. Herbicides are used in chemical control. Insects, fungi or other organisms that eat weeds are used in biological control. Integrated management can be achieved by using different control methods together.

**Key Words:** Control, Common feature, Competition, Classification, Weed

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## 1. GİRİŞ

Yabancı ot, genellikle istenmeyen yerlerde büyüyen, tarımsal faaliyetleri, insanları veya çevreyi olumsuz etkileyen bitkiler olarak tanımlanır (Fracchiolla et al., 2022).. Tanımlar, bitkilerin sadece biyolojik özelliklerini değil, aynı zamanda insan faaliyetleri üzerindeki etkilerini de içerir (Zimdahl & Basinger, 2024). Yabancı otlar genellikle hızlı büyüme, çevresel dayanıklılık ve yüksek üreme kapasitesi gibi özelliklere sahiptir (Buchholtz, 1967). Yabancı otlar tarımsal verim kaybı, rekabet, hayvan sağlığına zarar ve estetik bozulmalar yaratabilir (Humburg & Colby, 1989). Diğer yandan yabancı otlar hem bir zorluk hem de doğal ve tarımsal manzaranın bir bileşenidir. Tarım ve bahçecilikte sorun teşkil ederken, aynı zamanda biyolojik çeşitliliğe ve ekosistem işlevlerine de katkıda bulunurlar (Blanco, 2016). Biyolojilerini, ekolojilerini ve yönetimlerini anlamak, etkili kontrol ve sürdürülebilirlik için çok önemlidir.

## 2. YABANCI OTLARIN ÖZELLİKLERİ

Yabancı otların özellikleri, onları ekosistemlerde ve tarımsal alanlarda nasıl başarılı kıldığını açıklayan biyolojik, ekolojik ve genetik faktörlerden oluşur (Parker, 2022). Yabancı otların genel özellikleri bu bitkilerin karakteristik özelliklerinin bilinmesini sağlar (Zimdahl & Basinger, 2024).

### 2.1. Yabancı Otların Karakteristik Özellikleri

**Hızlı Fide Büyümesi:** Kısa sürede büyür ve üreme yeteneği kazanır. *Örnek:* Amaranthaceae (Kırmızı köklü tilkikuyruğu - *Amaranthus retroflexus*)

**Çift Üreme Yöntemi:** Hem tohum hem de vejetatif yolla ürer. *Örnek:* Convolvulaceae (Tarla sarmaşığı - *Convolvulus arvensis*)

**Çevresel Esneklik:** Çeşitli iklim ve toprak koşullarına uyum sağlar. *Örnek:* Poaceae (Salkım otu - *Poa annua*)

**Uzun Süreli Tohum Uyuma Durumu:** Tohumlar uzun süre toprakta canlı kalır. *Örnek:* Asteraceae (Kanaryaotu - *Senecio vulgaris*)

**Hızlı Çoğalma ve Dağılım:** Yüksek tohum üretir. *Örnek:* Polygonaceae (Kuzu kulağı - *Rumex acetosella*)

**Derin ve Güçlü Kök Sistemleri:** Çevresel streslere dayanıklıdır. *Örnek:* Apiaceae (Yabani havuç - *Daucus carota*)

**Her Yerde Bulunma Eğilimi:** Tarımsal alanlarda sık görülür. *Örnek:* Poaceae (Yabani yulaf - *Avena fatua*)

**Çevresel Direnç:** Zor çevre koşullarına dayanıklıdır. *Örnek:* Brassicaceae (Yabani hardal - *Sinapis arvensis*)

**Rekabet Yeteneği:** Besin, ışık ve su için agresif rekabet eder. *Örnek:* Fabaceae (Ak üçgül - *Trifolium repens*)

**Tohum ve Bitki Özellikleri:** Tarım ürünleriyle benzer tohum yapısına sahiptir. *Örnek:* Poaceae (Yabani yulaf - *Avena fatua*)

**İstilacılık:** Hızla yayılarak habitatları işgal eder. *Örnek:* Amaranthaceae (Dev horozibiği - *Amaranthus palmeri*)

**Allelopatik Özellikler:** Diğer bitkilerin büyümesini engeller (Sharma et al., 2021). *Örnek:* Asteraceae (Pelin otu - *Artemisia absinthium*)

### 2.2. Yabancı Ot Rekabetinin Etkileri

Yabancı otlar genellikle diğer bitkiler ile besin (mineral madde), su, ışık, alan (yer) için rekabet ederler (da Silva et al., 2022).

**Besin Rekabeti:** Topraktaki besinleri tüketir. *Örnek:* Poaceae (Salkım otu - *Poa annua*)

**Su Rekabeti:** Su kaynaklarını hızla tüketir. *Örnek:* Polygonaceae (Kuzu kulağı - *Rumex*)

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*acetosella*)

**Işık Rekabeti:** Kültür bitkilerini gölgeler. *Örnek:* Amaranthaceae (Horoz ibiği - *Amaranthus spinosus*)

**Alan Rekabeti:** Kökleriyle geniş alan kaplar. *Örnek:* Apiaceae (Yabani havuç - *Daucus carota*)

### 2.3. Yabancı Otların Ekolojik ve Tarımsal Önemi

Yabancı otlar, erozyonu önlemede faydalı olabilir ancak tarımda ciddi verim kayıplarına yol açar. Bu özelliklerin anlaşılması, etkili yabancı ot yönetim stratejileri geliştirilmesi için kritik öneme sahiptir.

### 3. YABANCI OTLARIN ZARARLARI

Yabancı otlar, tarım, hayvancılık, çevre ve insan sağlığı üzerindeki zararlı etkileriyle dikkat çeker. Yabancı otların zararları çeşitli kategorilere ayrılır (Zimdahl & Basinger, 2024). Yabancı otlar, tarım, hayvancılık, çevre ve insan sağlığı üzerinde çeşitli olumsuz etkiler yaratır.

**Bitki Rekabeti:** Ekili bitkilerle su, besin ve ışık için rekabet ederek verim kayıplarına neden olur. Özellikle mısır, pamuk ve soya fasulyesi gibi ürünlerde ciddi zararlar görülür.

**Koruma Maliyetleri:** Hastalık ve zararlı böceklere konakçı olarak ürünlerin zarar görmesine sebep olur. Buğdaygil yabancı otları, buğdayda pas hastalığına yol açar.

**Ürün Kalitesinin Düşmesi:** Yabancı ot tohumları, tahılların kalitesini bozar. Yabani soğan ve sarımsak, un ve süte kötü tat verir.

**Hayvan Kalitesinin Azalması:** Zehirli otlar hayvanlarda zehirlenme, düşük ve ölüm gibi sorunlara yol açar. Mahmuz dikenli ve halogeton gibi türler tehlikelidir.

**Üretim ve İşleme Maliyetlerinin Artması:** Kontrol için yapılan kimyasal, mekanik işlemler maliyetleri artırır. Hasat makinelerinde aşınmaya neden olur (Holt, 2004).

**Su Yönetimi Sorunları:** Sulama kanallarında büyüyen otlar, su kaybına ve akışın azalmasına neden olur. Su yosunları, akışı %40-80 oranında azaltabilir.

**İnsan Sağlığı Üzerindeki Etkiler:** Polenleri alerjiye, zehirli türler cilt tahrişlerine yol açar. Ambrosia poleni saman nezlesi yapabilir.

**Arazi Değeri ve Ürün Seçiminin Azalması:** İstilalar, tarımsal çeşitliliği azaltır ve arazi değerini düşürür. Küsküt, bitkilerin büyümesini tamamen engelleyebilir.

**Estetik ve Rekreatif Zararlar:** Görsel kirlilik, yangın riski ve kazalara yol açar. Su yosunları, rekreasyon alanlarını olumsuz etkiler.

**Çevresel ve Sosyal Etkiler:** Bazı türler toprak stabilizasyonu gibi ekolojik faydalar sağlasa da, kontrol edilmezlerse ekonomik, çevresel ve sosyal kayıplara neden olur.

**Yabancı Otların Maliyeti:** Ürün kayıpları, kontrol giderleri ve çevresel zararlar ciddi maliyetler doğurur (Ionescu et al., 2023). ABD’de 1980’lerde yabancı otların yıllık zararı 18,2 milyar dolar olarak hesaplanmıştır (Zimdahl & Basinger, 2024).

**İnsan Sağlığı ve Rekreasyon Maliyetleri:** Alerji, cilt tahrişi ve yangın gibi risklerin yanı sıra rekreasyon alanlarında bakım maliyetlerini artırır.

Bu zararlar, etkili yabancı ot yönetim stratejileri ve modern kontrol yöntemlerinin uygulanmasını gerektirir.

### SONUÇ

Yabancı otlar, insan faaliyetleri açısından hem faydalı hem de zararlı özelliklere sahiptir. Faydalı yönleri arasında ilaç ve gıda olarak kullanılması, toprak sağlığını iyileştirmesi, erozyonu önlemesi, yaban hayatına besin ve barınak sağlaması, biyoçeşitliliği artırması ve biyoremediasyon gibi ekosistem hizmetleri bulunur.

Ancak yabancı otlar genellikle istenmeyen bitkiler olarak kabul edilir. Çok sayıda tohum

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üretrek hızla yayılır ve uzun süre toprakta canlı kalabilirler. Rüzgar, su, hayvanlar ve insanlar aracılığıyla taşınabilir, ayrıca kök sürgünleri ve rizomlarla vejetatif üreme yapabilirler. Hızlı büyümeleri sayesinde ekili bitkilerle su, besin, ışık ve alan için rekabet ederler. Bazı türler herbisitlere karşı direnç geliştirerek kontrolü zorlaştırır.

Yabancı otlar yaşam sürelerine göre tek yıllık, iki yıllık ve çok yıllık; yaprak yapılarına göre geniş yapraklı ve dar yapraklı; ekolojik habitatlarına göre ise tarla ve sucul yabancı otlar gibi gruplara ayrılır.

Mücadele yöntemleri arasında kültürel (ekim nöbeti, ekim normu), mekanik (elle yolma, çapalama, biçme), kimyasal (herbisit kullanımı) ve biyolojik (yabancı otlarla beslenen organizmaların kullanımı) yöntemleri bulunur. Bu yöntemlerin birlikte uygulanmasıyla entegre yönetim sağlanabilir.

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**KİMYASAL YABANCI OT YÖNETİMİ**

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**Özet**

Kimyasal yabancı ot yönetimi, tarımsal üretimde yabancı otların kontrol altına alınması için kullanılan önemli bir yöntemdir. Bu yöntemde, herbisit adı verilen kimyasal maddelerle yabancı otların büyümesi engellenir. Böylece ürün verimliliği artar, iş gücü tasarrufu sağlanır ve yabancı otların bitkilerle rekabeti önlenir. Ancak çevresel etkiler ve herbisit direnci gibi faktörler nedeniyle dikkatli ve bilimsel uygulama şarttır. Seçici herbisitler, belirli bitki türlerine zarar vermeden sadece hedef yabancı otları etkiler. Örnek: Buğday tarlalarında geniş yapraklı otlara karşı kullanılır. Seçici olmayan herbisitler, tüm bitkileri etkiler, genellikle alan temizliği için tercih edilir. Çıkış öncesi herbisitler, yabancı otlar çimlenmeden önce uygulanarak toprakta uzun süreli kontrol sağlar. Çıkış sonrası herbisitler, yabancı otların büyüme döneminde kullanılır. Kimyasal yönetimin avantajları vardır. Geniş alanlarda hızlı ve etkili kontrol sağlar. Fiziksel yöntemlere kıyasla daha az iş gücü gerektirir. Özellikle büyük ölçekli tarım işletmeleri için ekonomiktir. Kimyasal yönetimin dezavantajları da mevcuttur. Sürekli aynı herbisit kullanımını, yabancı otlarda dayanıklılık gelişimine neden olabilir. Toprak ve su kirliliğine yol açabilir. Yanlış uygulamalar çevredeki doğal bitki örtüsüne zarar verebilir. Kimyasal yabancı ot yönetiminde sürdürülebilir yaklaşımlar önemlidir. Entegre yabancı ot yönetimi; kimyasal, mekanik, biyolojik ve kültürel yöntemlerin birlikte kullanımını içerir. Herbisit rotasyonu; farklı etki mekanizmasına sahip herbisitlerin dönüşümlü kullanılmasıdır. Teknoloji kullanımı; GIS, GPS ve sensör destekli sistemlerle yalnızca ihtiyaç duyulan bölgelere kimyasal uygulanması yapılır. Akıllı tarım; dronlar ve robotlar yardımıyla daha hassas ve verimli kimyasal uygulamalar yapılabilir. Biyoherbisitler; doğal kaynaklardan elde edilen çevre dostu alternatiflerdir. Kimyasal yabancı ot yönetimi, dikkatli ve doğru uygulandığında tarımsal üretimde verimliliği artırmada etkili bir yöntemdir. Sürdürülebilir yaklaşımlar ve entegre yönetim stratejileriyle çevreye zarar vermeden uzun vadeli başarı sağlanabilir.

**Anahtar Kelimeler:** Avantaj, Dezavantaj, Herbisit, Kimyasal, Yabancı ot

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## CHEMICAL WEED MANAGEMENT

### **Abstract**

Chemical weed management is an important method used to control weeds in agricultural production. In this method, weed growth is prevented with chemical substances called herbicides. Thus, product efficiency increases, labor savings are provided and weeds' competition with plants is prevented. However, careful and scientific application is essential due to factors such as environmental effects and herbicide resistance. Selective herbicides affect only target weeds without harming certain plant species. Example: Used against broadleaf weeds in wheat fields. Non-selective herbicides affect all plants and are generally preferred for field cleaning. Pre-emergence herbicides are applied before weeds germinate and provide long-term control in the soil. Post-emergence herbicides are used during the growth period of weeds. Chemical management has advantages. It provides fast and effective control in large areas. It requires less labor compared to physical methods. It is economical especially for large-scale agricultural enterprises. Chemical management also has disadvantages. Continuous use of the same herbicide can cause resistance development in weeds. It can lead to soil and water pollution. Incorrect applications can damage the surrounding natural vegetation. Sustainable approaches are important in chemical weed management. Integrated weed management includes the combined use of chemical, mechanical, biological and cultural methods. Herbicide rotation is the alternate use of herbicides with different mechanisms of action. Use of technology; Chemical application is made only to the areas where needed with GIS, GPS and sensor-supported systems. Smart agriculture; More precise and efficient chemical applications can be made with the help of drones and robots. Bioherbicides are environmentally friendly alternatives obtained from natural resources. Chemical weed management is an effective method for increasing productivity in agricultural production when applied carefully and correctly. Long-term success can be achieved without harming the environment with sustainable approaches and integrated management strategies.

**Keywords:** Advantage, Disadvantage, Herbicide, Chemical, Weed



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## 1. GİRİŞ

Kimyasal yabancı ot yönetimi (herbisitlerle kontrol), tarımsal üretimde bitki koruma stratejilerinin önemli bir unsurudur (Kearney & Kaufman, 2024). Bu yöntem, yabancı otların yetiştirilen bitkilerle rekabetini önleyerek verim artışı sağlar (Mia et al., 2020). Ancak yanlış uygulamalar çevreye zarar verebilir ve hedef dışı organizmaları etkileyebilir.

### 1.1. Kimyasalların Avantajları

Geniş alanlarda hızlı ve etkili sonuçlar sağlar (Wilcut & Askew, 1999). Elle temizliğe kıyasla daha az iş gücü gerektirir. Ürün verimini artırarak su ve besin rekabetini önler.

### 1.2. Kimyasallar

Seçici herbisitler belirli yabancı otları hedef alır. Örnek: Buğday tarlasında geniş yapraklı otlar için kullanılır. Seçici olmayan (total) herbisitler tüm bitkileri yok eder. Genellikle ekim öncesi veya hasat öncesi kullanılır. Sistemik herbisitler bitki bünyesine girerek köklere kadar taşınır. Kontak herbisitler sadece temas ettiği bölgede etkilidir.

### 1.3. Uygulama

Yabancı otların hassas büyüme döneminde uygulanmalıdır. Hedef dışı bitkilere zarar vermemek için dikkatli püskürtme yapılmalıdır (Bradshaw, 2019). Aşırı kimyasal kullanımı çevre kirliliği ve dayanıklılık sorunlarına yol açabilir.

### 1.4. Riskler

Uzun süre aynı herbisit kullanımı, yabancı otların direnç geliştirmesine neden olur (Qasem, 2013). Rotasyonlu kullanım önerilir. Su ve toprak kirliliğini önlemek için dikkatli uygulama gereklidir (Cléments et al., 1994). Kullanım sırasında koruyucu ekipman kullanılmalı ve talimatlara uyulmalıdır.

### 1.5. Entegre Yaklaşımlar

Kimyasal yöntemler, biyolojik, fiziksel ve kültürel yöntemlerle birleştirilmeli ve entegre yönetim stratejileri uygulanmalıdır (Singh, 2018). Böylece çevre dostu ve sürdürülebilir bir tarım pratiği sağlanır (Scavo & Mauromicale, 2020). Tarım uzmanlarından ve yerel kuruluşlardan destek alınması faydalı olacaktır (Bhaskar et al., 2021; Gerhards & Schappert, 2020).

## 2. HERBİSİTLER

Herbisitler, tarımsal üretimde yabancı otların kontrolünde kullanılan kimyasal bileşiklerdir (Vats, 2015). Bu maddeler, bitkilerde belirli biyokimyasal süreçleri hedef alarak yabancı otların büyümesini engeller (Qu et al., 2021). Doğru herbisit seçimi ve kullanımı, etkili kontrol sağlarken çevresel etkileri azaltır (Cobb, 2022; Heap, 2014b).

### 2.1. Herbisit Türleri

#### 2.1.1. Etki Alanına Göre:

Seçici Herbisitler: Belirli yabancı otları hedef alır. *2,4-D*: Geniş yapraklı otlar içindir (örn. Yonca, devedikeni). *Dicamba*: Mısırdaki geniş yapraklı otları kontrol eder.

Seçici Olmayan (Total) Herbisitler: Tüm bitkileri öldürür. *Glifosat*: En yaygın total herbisittir. *Paraquat*: Hızlı etkilidir, çevresel riskleri yüksektir.

#### 2.1.2. Uygulama Zamanına Göre:

Çıkış Öncesi (Pre-Emergence): Tohum çimlenmesini önler. Örn. *Pendimethalin*, *Metolachlor*  
Çıkış Sonrası (Post-Emergence): Büyüyen otları hedefler. Örn. *Glyphosate*, *Quizalofop-P-Ethyl*

#### 2.1.3. Etki Mekanizmasına Göre:

Sistemik Herbisitler: Bitkinin tamamına yayılır. Örn. *Glifosat*, *Triclopyr*

Kontak Herbisitler: Temas ettiği bölgede etkilidir. Örn. *Diquat*: Yüzeysel ve hızlı etki gösterir.

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## 2.2. Yaygın Herbisitler

Yaygın olarak kullanılan herbisitler Tablo 1’de verilmiştir (Heap, 2014b, 2014a).

Aktif Madde	Kullanım Alanı	Hedef Otlar
<i>Glyphosate</i>	Total herbisit	Tüm otlar
<i>2,4-D</i>	Geniş yapraklılar	Yonca, diken
<i>Atrazine</i>	Mısır, sorgum	Dar/geniş otlar
<i>Metolachlor</i>	Çıkış öncesi	Çim, geniş otlar
<i>Pendimethalin</i>	Sebze, tahıl	Dar/geniş otlar
<i>Paraquat</i>	Total, hızlı	Çim, geniş otlar
<i>Clodinafop</i>	Buğday	Dar yapraklılar

Clodinafop ve 2,4-D gibi selektif herbisitler ile glyphosate ve paraquat gibi total herbisitler yaygın olarak kullanılmaktadır.

## 2.3. Etki Mekanizması

Herbisitlerin aktif maddeleri, bitkilerdeki hayati işlevlere müdahale ederek yabancı otların büyümesini engeller (Székács, 2021).

Fotosentez Engelleyiciler: Fotosentezi durdurur (Örn: *Atrazine*)

Amino Asit Sentez Engelleyiciler: Protein oluşumunu önler (Örn: *Glyphosate*)

Hormon Taklit Ediciler: Anormal büyümeye neden olur (Örn: *2,4-D*)

Hücre Zarı Tahrip Ediciler: Hücreleri hızla öldürür (Örn: *Paraquat*)

## 2.4. Çevresel Etkiler

Herbisitlerin yanlış kullanımı su, toprak kirliliği ve direnç gelişimine yol açabilir (Bansal, 2020). Riskleri azaltmak için; önerilen dozlarda kullanılmalı, su kaynaklarına yakın bölgelerde dikkatli olunmalı, aynı herbisit türü sürekli kullanılmamalı (rotasyon uygulanmalı) ve uygulayıcılar koruyucu ekipman kullanmalıdır (Sathish Kumar et al., 2024).

## 2.5. Biyoherbisitler ve Gelecek Yaklaşımlar

Biyoherbisitler, çevreye dost alternatifler olarak ön plana çıkmaktadır (Kremer, 2005).

Phytotoxin: Bitkisel özler içerir.

Mycoherbicide: Mantar bazlı biyoherbisitlerdir.

Biyoherbisitler, düşük çevresel etki ve yüksek etkinlik sağlayarak sürdürülebilir tarımı desteklemektedir.

## 3. KİMYASAL YABANCI OT KONTROLÜNÜN PRENSİPLERİ

Kimyasal yabancı ot kontrolünün prensipleri, herbisitlerin etkili, güvenli ve sürdürülebilir kullanımını hedefler. Bu kurallar, hem etkili yabancı ot yönetimini hem de çevre ve insan sağlığının korunmasını sağlar (Kearney & Kaufman, 2024).

### 1. Doğru Herbisit Seçimi:

Herbisitler, hedeflenen yabancı ot türüne uygun seçilmelidir (Heap, 2014b).

Seçici herbisitler: Belirli ot türlerini hedef alır. (Ör. 2,4-D geniş yapraklı otlar için)

Seçici olmayan (total) herbisitler: Tüm bitkileri yok eder. (Ör. *Glyphosate*)

### 2. Uygun Dozaj ve Zamanlama:

Üretici talimatlarına uyulmalı; fazla doz çevreye zarar, az doz etkisizlik yaratır (Manisankar et al., 2022). Herbisitler, yabancı otların büyüme dönemlerine uygun uygulanmalıdır. Çıkış öncesi (pre-emergence): Çimlenmeyi önler. Çıkış sonrası (post-emergence): Büyüyen otları yok eder. Rüzgâr, aşırı sıcaklık ve yağmur gibi olumsuz koşullarda uygulamadan kaçınılmalıdır.

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### 3. Uygulama Teknikleri ve Ekipman Kullanımı:

Ekipmanlar doğru kalibre edilerek eşit dağılım sağlanmalıdır. Kimyasal, sadece hedeflenen otlara uygulanmalı, komşu bitkiler korunmalıdır.

### 4. Herbisit Direnci Yönetimi:

Aynı etki mekanizmasına sahip herbisitlerin sürekli kullanımı direnç oluşturur. Farklı etki mekanizmalarına sahip herbisitlerin dönüşümlü kullanımı (rotasyon) önerilir. Kimyasal yöntemler, mekanik, biyolojik ve kültürel yöntemlerle desteklenmelidir.

### 5. Çevresel Risklerin Yönetimi:

Su kaynaklarına karışımın önlenmesi için tampon bölgeler oluşturulmalıdır (Bansal, 2020). Arı popülasyonlarının yoğun olduğu alanlarda düşük toksisiteli herbisitler kullanılmalıdır.

### 6. Güvenlik Önlemleri:

Uygulama sırasında kişisel koruyucu ekipmanlar (eldiven, maske, gözlük) kullanılmalıdır. Üretici talimatları dikkatlice okunmalı ve uygulanmalıdır.

### 7. Entegre Yabancı Ot Yönetimi:

Kimyasal kontrol, farklı yöntemlerle birleştirilmelidir (Cardina et al., 2020).

Mekanik yöntemler: Çapa, biçme gibi fiziksel müdahaleler.

Kültürel önlemler: Ekim nöbeti veya sık ekim gibi yöntemlerle otların yayılması engellenir.

Biyolojik kontrol: Böcekler veya mantarlar gibi doğal düşmanların kullanımı.

### 8. Uygulama Sonrası İzleme:

Uygulama sonrası yabancı otların kontrol durumu düzenli olarak izlenmelidir (Harrison & Loux, 2017). Direnç gelişimi izlenmeli ve gerektiğinde farklı müdahale yöntemleri uygulanmalıdır.

### 9. Sürdürülebilirlik ve Çevre Dostu Yaklaşımlar:

Çevreye daha az zarar veren yeni formülasyonlar tercih edilmelidir. Biyoherbisitler (mikroorganizma veya doğal bileşik bazlı) çevreye uyumlu bir alternatif sağlar.

Bu prensipler, kimyasal yabancı ot kontrolünün etkili ve sürdürülebilir bir şekilde uygulanmasına katkı sağlayarak tarımsal üretimde uzun vadeli başarıyı destekler.

## 4. KİMYASAL OT YÖNETİM TAKTİKLERİ

Yabancı ot kontrolünü daha etkili, çevre dostu ve sürdürülebilir bir şekilde gerçekleştirmek için kullanılan yöntemler ve yenilikçi araçları kapsar (Forouzesh et al., 2015). Tarımda verimliliği artırırken çevreye ve insan sağlığına zarar vermemeyi hedefleyen bu yaklaşımın anlaşılması ve yaygınlaştırılması önemlidir.

### 4.1. Kimyasal Yabancı Ot Yönetimi Stratejileri

#### 4.1.1. Herbisit Seçimi

Seçici herbisitler belirli yabancı otları hedef alırken ekinlere zarar vermez (Cobb, 2022). *Örn:* Mısır tarlalarında geniş yapraklı yabancı otlar (*Amaranthus* spp. – Horozibiği, *Chenopodium album* – Sirken) için kullanılır. Seçici olmayan (total) herbisitler tüm bitkileri öldürür, genellikle ekim öncesi uygulanır. *Örn:* Tarla kenarında veya bağ alanlarında çok yıllık yabancı otlar (*Cynodon dactylon* – Ayrık otu, *Convolvulus arvensis* – Tarla sarmaşığı) için tercih edilir.

#### 4.1.2. Zamanlama ve Uygulama

Ekim Öncesi (Pre-Emergence): Çimlenmeden önce uygulanır (Cobb, 2022). *Örn:* dar yapraklı yabancı otlar (*Avena fatua* – Yabancı yulaf, *Lolium rigidum* – Sert tilki kuyruğu) kontrolünde etkilidir.

Ekim Sonrası (Post-Emergence): Çimlenmiş yabancı otlara doğrudan uygulanır (Cobb, 2022). *Örn:* Ayçiçeği tarlalarında geniş yapraklı yabancı otlar (*Xanthium strumarium* – Köygöçüren) için kullanılır.

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## 4.1.3. Herbisit Rotasyonu

Aynı kimyasalın sürekli kullanımı dayanıklılık oluşturabilir. Farklı etki mekanizmaları ile rotasyon yapılmalıdır (Qu et al., 2021). *Örn:* Resistant (Dayanıklı=Dirençli) Türler (*Amaranthus palmeri* – Dev horozibiği, *Echinochloa crus-galli* – Darıcan) için rotasyon önerilir.

## 4.1.4. Entegrasyon

Kimyasal, biyolojik ve mekanik yöntemler birleştirilerek daha sürdürülebilir bir çözüm sağlanır (Cléments et al., 1994). *Örn:* **Biyolojik Mücadele** için Dalapon herbisiti kullanılarak **Cyperaceae familyasına** ait *Cyperus rotundus* (topalak) baskılanabilir.

## 4.2. Kimyasal Ot Yönetiminde Kullanılan Yeni Teknolojiler

### 4.2.1. Hassas Tarım Araçları

GPS Destekli Püskürtme: Sadece hedeflenen alanlara ilaç uygulanır (Dayana et al., 2025).

Drone Teknolojisi: Geniş alanları tarayarak yabancı ot yoğunluğunu belirler (Clay & Dille, 2021). *Örn:* Pirinç tarlalarında *Echinochloa crus-galli* (darıcan) erken tespit edilir.

### 4.2.2. Sensör Tabanlı Sistemler

Optik Sensörler: Yabancı ot ile kültür bitkisini ayırt eder (Clay & Dille, 2021).

Yapay Zeka (AI): Gerçek zamanlı ot tespiti yapar. *Örn:* *Chenopodium album* (sirken) tespit edilerek doğrudan ilaç püskürtülür (Clay & Dille, 2021).

### 4.2.3. Kontrollü Damlacık Uygulaması

Kimyasalın damlacık boyutu kontrol edilerek minimum kayıpla maksimum etki sağlanır (Clay & Dille, 2021).

### 4.2.4. Robotik ve Otomatik Sistemler

Otonom Yabancı Ot Robotları: Mekanik olarak otları söker ve gerektiğinde kimyasal uygular (Vijayakumar et al., 2023).

Akıllı Püskürtücüler: Sadece yabancı otlara ilaç sıkarak (Monteiro & Santos, 2022). *Örn:* *Sinapis arvensis* (yabani hardal) gibi türlere karşı verimli bir yöntemdir.

## 4.3. Sürdürülebilir Uygulamalar

Mikrodozlama: Gereğinden fazla kimyasal kullanımını önler (Ruuskanen et al., 2023; Triolet et al., 2022).

Biyoherbisitler: Doğal mikroorganizmalar veya bitkisel bileşenler içerir (Kremer, 2005). *Örn:* *Phytophthora palmivora* adlı mantar, Moraceae familyasındaki incir otlarına karşı etkilidir.

Koruma Alanları: Su kaynaklarına yakın bölgelerde herbisit kullanımını sınırlandırır (Ruuskanen et al., 2023).

Düşük Toksikite: Hedef dışı canlılara zarar vermeyen formüller tercih edilir.

## 4.4. Herbisit Direnci ile Mücadele Stratejileri

Tank Karışımları: Farklı mekanizmalar içeren herbisitler aynı anda kullanılır (Heap, 2014b). *Örn:* *Echinochloa crus-galli* (Darıcan) gibi dirençli türlerde etkilidir.

Kültürel Önlemler: Ekim nöbetiyle yabancı otların yaşam döngüsü kesilir (Moss, 2017). *Örn:* Nadas sistemi, *Lolium* spp. (Delice türleri) popülasyonunu azaltabilir.

Erken Tespit ve İzleme: Dirençli yabancı otlar tarlada erken belirlenerek müdahale edilir (Heap, 2014b).

## 4.5. Gelecek Eğilimler

Dijital Tarım: Nesnelerin interneti (IoT), bulut sistemleri ve yapay zeka entegre ediliyor (Clay & Dille, 2021; Dayana et al., 2025).

CRISPR Teknolojisi: Gen düzenleme ile herbisitlere dayanıklı bitkiler geliştiriliyor (Kumam et al., 2023; Mia et al., 2020).

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Biyolojik Çözümler: Kimyasal yerine çevre dostu biyoherbisitler tercih ediliyor.

Bu yöntemler, tarımsal üretimde verimliliği artırırken çevresel etkiyi minimize etmeyi amaçlamaktadır.

## 5. SONUÇ

Sürekli aynı aktif maddelerin kullanımı, yabancı otların dayanıklılık geliştirmesine neden olmaktadır. *Örn: Amaranthus spp.* (horozibiği türleri) glifosata direnç kazanmıştır. Bazı herbisitler uzun süre toprakta kalarak mikrobiyota dengesini bozabilir. *Örn: Cyperus rotundus* (topalak) gibi çok yıllık otlar, bu kimyasallara karşı daha dirençli olabilir. Yağış sonrası kimyasallar yer altı ve yüzey sularına karışarak ekosistemlere zarar verebilir. *Örn: Echinochloa crus-galli* (darıcan) gibi pirinç tarlalarındaki sucul yabancı otlar daha fazla etkilebilir. Faydalı organizmalar ve ekinler zarar görebilir. *Örn: Sinapis arvensis* (yabani hardal) kontrolü için kullanılan bazı herbisitler, arılar ve diğer tozlayıcıları olumsuz etkileyebilir. Yanlış veya aşırı kullanım, herbisit kalıntılarının gıdalarda bulunmasına ve insan sağlığını tehdit etmesine neden olabilir. Kullanıcıların maruziyeti toksik etkiler yaratabilir. Yeni nesil herbisitler pahalıdır ve küçük ölçekli çiftçiler için ekonomik bir yük oluşturabilir. Avrupa Birliği gibi bölgelerde bazı herbisitler yasaklanmış veya kısıtlanmıştır.

Mikroorganizmalar veya bitkisel bileşiklerden elde edilen doğal herbisitler, çevre dostu alternatifler sunmaktadır. *Örn: Alternaria cassiae* mantarı, *Cassia obtusifolia* kontrolünde kullanılabilir. Daha az kalıntı bırakan ve doğada hızla parçalanan herbisitler geliştirilmektedir. GPS, dronelar ve sensörler kullanılarak yalnızca ihtiyaç duyulan alanlara uygulama yapılabilir. *Örn: Lolium rigidum* (delice) gibi dirençli otların tespiti için optik sensörler kullanılabilir. CRISPR ve gen düzenleme teknikleri, yabancı otların büyümesini engelleyen çözümler sunabilir. Kimyasal yöntemlerin biyolojik, mekanik ve kültürel yöntemlerle birleştirilmesi yaygınlaşmaktadır. *Örn: Ekim nöbeti, Chenopodium album* (sirken) gibi istilacı otların baskılanmasını sağlayabilir. Sadece belirli yabancı ot türlerine etkili, hedef dışı organizmalara zarar vermeyen kimyasallar geliştirilmektedir. Sürdürülebilir uygulamalar için teşvikler artırılmalıdır.

Kimyasal yabancı ot kontrolü, tarımda verimi artırmak için herbisitlerin kullanıldığı bir yöntemdir. Ancak sürekli aynı kimyasalların kullanımı dirençli yabancı otların oluşmasına yol açabilir (*örn: Amaranthus spp.*). Ayrıca toprak ve su kirliliği, faydalı organizmalara zarar verme ve sağlık riskleri gibi çevresel etkileri bulunmaktadır.

Gelecekte biyoherbisitler, hassas tarım teknolojileri ve genetik çözümler gibi sürdürülebilir alternatifler ön plana çıkmaktadır. Entegre yönetim stratejileri ile kimyasal kullanım azaltılarak çevre dostu tarım teşvik edilmektedir

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**KISINTILI SULAMA VE FARKLI FERTİGASYON UYGULAMALARININ  
DOMATES BİTKİSİNİN KLOROFİL İÇERİĞİNE ETKİLERİ**

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**Özet**

Araştırma Çukurova Bölgesi'nde farklı sulama düzeyleri ve fertigasyon tekniklerinin, damla sulama yöntemi kullanılarak sulanan domates bitkisinin klorofil içeriği üzerine etkileri ile verim arasındaki ilişkilerin belirlenebilmesi amacıyla 2014 yılında Alata Bahçe Kültürleri Araştırma Enstitüsü Müdürlüğü Tarsus Toprak ve Su Kaynakları Lokasyonunda yürütülmüştür. Araştırmada üç farklı sulama düzeyi (I<sub>100</sub>: tam sulama, I<sub>70</sub> ve I<sub>50</sub>: kısıntılı sulama) ve üç farklı fertigasyon ekipmanları (F<sub>1</sub>: enjeksiyon pompası, F<sub>2</sub>: ventüri, F<sub>3</sub>: basınç farkı) konuları test edilmiştir. Araştırmada fertigasyon yöntemleri ile sulama konularının verim üzerine etkisi istatistiksel olarak önemli bulunmuştur (P < 0.01). En yüksek klorofil içeriği enjeksiyon pompası tekniği (F<sub>1</sub>) ile fertigasyonun uygulandığı I<sub>100</sub> tam sulama konusundan elde edilmiş ve sulama suyu miktarı azaldıkça klorofil değerlerinin de azaldığı belirlenmiştir. Klorofil içeriği değerleri ile verim arasında ikinci dereceden önemli ilişkiler (P < 0.05) belirlenmiştir. Klorofil içeriğinin F<sub>1</sub>I<sub>100</sub> konusunda 62.9 değerinde sulanmasıyla en yüksek verim alınmıştır. Klorofil içeriği değerleri, özellikle iklimsel değişikliklerin gelecek yıllarda su kaynakları üzerindeki olumsuz etkileri göz önüne alındığında tarımsal su yönetimi çalışmalarında kullanılabilir olduğu sonucuna varılmıştır.

**Anahtar Kelimeler:** Domates, fertigasyon, klorofil içeriği, kısıntılı sulama



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**EFFECTS OF RESTRICTED IRRIGATION AND DIFFERENT FERTIGATION  
PRACTICES ON THE CHLOROPHYLL CONTENT OF TOMATO PLANTS**

**Abstract**

Research was conducted at Alata Horticultural Research Institute Directorate Tarsus Soil and Water Resources Location in order to determine the effects of different irrigation levels and fertigation techniques on the chlorophyll content (SPAD) of drip irrigated tomato and the relationships between yield in Çukurova Region in 2014. In the study, three different irrigation levels (I<sub>100</sub>: full irrigation, I<sub>70</sub> and I<sub>50</sub>: deficit irrigation) and three different fertigation equipment (F1: injection pump, F2: venturi injector, F3: pressure difference) were tested. The effects of fertigation techniques and irrigation treatments on tomato yield was found to be statistically significant ( $P < 0.01$ ). The highest chlorophyll content was obtained from I<sub>100</sub> full irrigation treatment where injection pump fertigation technique was applied and it was determined that chlorophyll values decreased as the amount of irrigation water decreased. Significant polinimical relationships between chlorophyll content (SPAD) and yield were determined ( $P < 0.05$ ). The highest yield was obtained when irrigation application of the chlorophyll content with value of 62.9 (SPAD) in the tomato plant (F<sub>1</sub>I<sub>100</sub>). It was concluded that chlorophyll content values can be used in agricultural water management studies, especially considering the adverse effects of climatic changes on water resources in the future.

**Key words:** Tomato, fertigation, chlorophyll content, deficit irrigation

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## Giriş

### Dünya’da Domates Üretimi

Domatesin en çok yetiştirilen sebze olmasının sebepleri, hem insanların beslenme alışkanlıklarının çok önemli bir parçası olması hem de sanayide üretilen salça ya da ketçap gibi birçok ürünün hammaddesi olarak kullanılması gösterilmektedir. Domates kolaylıkla taze, konserve, salça ve soslar içerisinde yer almakta olup, farklı formlarda elde edilebilir ve aynı zamanda düşük bütçelere de uygundur (Demircan, 2023).

Dünya domates ekim alanında 2021 yılında %22 ile Çin en büyük paya sahiptir. Çin’den sonra sırasıyla %16.4 ile Hindistan ve Nijerya, %3.3 ile Pakistan ve %3.2 ile Türkiye gelmektedir. Bu beş ülke dünya domates ekim alanının yaklaşık %61.2’sini oluşturmaktadır. 2021’de dünya domates ekim alanının bir önceki yıla göre %3.2 artmasında Çin, Hindistan ve Pakistan’da domates ekim alanlarının bir önceki yıla göre artması etkin rol oynamaktadır. Dünya domates üretiminde önde gelen ülkelerden olan Çin, Hindistan, Türkiye, ABD, İtalya’nın toplam domates üretimleri 2021 yılı itibarıyla domates üretiminin %63’ünü oluşturmaktadır. Bahsi geçen ülkelerdeki üretim artışı dünya domates üretiminin 2021 yılında bir önceki sezona göre yaklaşık %2.9 artarak 189.1 milyon tona ulaşmasında etkili olmuştur (Demircan, 2023).

### Türkiye’de Domates Üretimi ve Durumu

Birleşmiş Milletler Dünya Gıda ve Tarım Örgütü (FAO) verilerine göre, Türkiye 2021 yılı itibarıyla yaklaşık 13.1 milyon ton ile dünya domates üretiminde Çin ve Hindistan’ın ardından 3’üncü sırada gelmektedir. TÜİK verilerine göre, Türkiye’nin 2022 yılı itibarıyla sebze üretimi yaklaşık 31.6 milyon tondur. Türkiye’de en fazla üretimi yapılan sebze olan domates, üretim miktarı açısından 2022 yılı toplam sebze üretiminde %41.2 (13 milyon ton) paya sahiptir. Domatesin üretimi Türkiye’de hem açıkta ve hem de örtü altında yapılmaktadır. Türkiye’de örtü altında üretilen domates üretim miktarı toplam domates üretiminin %31.8’lik kısmını (4.1 milyon ton) oluşturmaktadır. Türkiye domates ekim alanlarına bakıldığında 2022 yılında bir önceki yıla göre ekim alanlarının yaklaşık %3.6 daraldığı görülmektedir. Türkiye’nin 2022 yılı toplam domates üretimi ise bir önceki yıla göre yaklaşık %0.7 azalarak 13 milyon ton olmuştur. Verim 2022’de bir önceki yıla göre %3 artarak 81.8 ton/ha olmuştur. Türkiye 2022 yılı domates üretiminin %61.2’si sofralık, %38.8’i ise salçalık olarak gerçekleşmiştir. Sofralık domates üretimi 2022 yılında bir önceki yıla göre yaklaşık %7.3 azalırken salçalık domatesin üretimi ise yaklaşık %11.7 artmıştır. Domates üretimi 2022 yılında en çok %30.7 ile Akdeniz, %22 ile Ege, %13.2 ile Doğu Marmara, %9 ile Batı Marmara Bölgeleri’nde gerçekleşmektedir (Demircan, 2023).

Artan nüfusa ve insanların ihtiyaçlarına bağlı olarak talepleri göz önüne alındığında, sınırlı üretim kaynaklarını kullanarak bu taleplerin karşılanması her geçen gün önemini artırmakta olup daha fazla üretim yapabilme zorunluluğu ortaya çıkmaktadır. Özellikle son yıllarda etkisini daha fazla görmekte olduğumuz iklim değişikliğinin su kaynakları üzerindeki olumsuz etkileri dikkate alındığında, bitkinin ihtiyaç duyduğu kadar suyun kullanılarak birim alandan en yüksek verimi alabilmek amacı ile planlama ve stratejilerin geliştirilmesi gerekmektedir (Bozkurt Çolak ve ark., 2022).

Bitkiler fizyolojik faaliyetlerde hem toprak hem de çevre koşullarının etkisi altındadır. Su stresi, bitkilerin büyüme mevsimi boyunca farklı aşamalarındaki verim üzerinde olabilecek etkilerin belirlenmesinde kritik bir öneme sahiptir. Bu anlamda, uygun sulama programlaması için bitki su stresinin güvenilir bir şekilde tahmin edilmesi önemlidir. Bu amaçla bitkiye dayalı

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yöntemler kullanılarak sulama zamanı belirlenebilmektedir. Bu yöntemlerden biri olan klorofilmetre (SPAD), kırmızı (yaklaşık 660 nm) ve yakın infrared (yaklaşık 940 nm) gibi iki dalga boyunda yaprağa iletilen ışığa, bu dalga boylarındaki absorbe edilen ışığın farkından klorofil miktarını ölçme yöntemine dayanan bir sistemdir. Fotosentez olayında en aktif görev yapan pigment klorofildir. Yapraktaki klorofil içeriği bir bitkinin fizyolojik durumunun göstergesidir. Yapraklar klorofili, klorofil a ve klorofil b olarak içerirler. Klorofil, ışık enerjisinin kimyasal enerjiye dönüşümünde zorunlu olması gereken pigmentlerdir. Güneşten emilen radyasyonun miktarı da yapraktaki fotosentetik miktarına bağlıdır. Bu nedenle klorofil miktarı içeriği fotosentetik aktivite ve birincil üretimle ilgilidir (Curran ve ark., 1990). Yaprak klorofil düzeyi bitki stresi ve yaşlanma ile direkt ilgilidir (Hendry ve ark., 1987). Fotosentez olayında en aktif görev yapan pigment klorofil olup bitki fizyolojisi açısından da gerekli bir indikatördür. Yapraklarda klorofil miktarının fazla olması ile yapraklarda daha fazla ışık tutulmaktadır. Bu durum ise direk fotosentez miktarını etkilemektedir. Aynı zamanda yaprak klorofil miktarı ile yapraktaki besin durumu da dolaylı olarak tahmin edilebilmektedir (Penuelas ve ark., 1995). Yaprak klorofil içeriğini belirlemede kullanılan geleneksel yöntemler zaman alıcı ve zahmetli olduğu için klorofilmetre (SPAD) cihazı gibi yapraktaki nisbi klorofil içeriğini hızlı ve kolay bir biçimde ölçebilen cihazlar kullanılmaktadır (Li ve ark., 2014). Yapılan bu çalışmayla ülkemiz domates yetiştiriciliğinde fazla sulama suyu kullanımının önüne geçerek su tasarrufu sağlayabilmek ve su kısıntısı uygulamaları ile farklı fertigasyon ekipmanlarının domates bitkisinde klorofil içeriğine etkisi belirlenmiştir.

## Materyal ve Metod

### Çalışma Alanı İklim ve Toprak Özellikleri

Araştırma Alata Bahçe Kùltürleri Araştırma Enstitüsü Müdürlüğü Tarsus Lokasyonu'nda 2014 yılında yapılmıştır. Araştırma yeri, deniz seviyesinden 60 m yükseklikte olup, 36°53' enlem ve 34°57' boylam arasında yer almaktadır. Deneme alanı Akdeniz iklim kuşağında kışlar ılık ve yağışlı, yazlar sıcak ve kurak geçmektedir. Deneme alanı iklim istasyonu verilerine göre, yörenin uzun yıllık yağış ortalaması 616 mm'dir. Bölgede uzun yıllık sıcaklık ortalaması 18.2°C'dir. En sıcak ay ortalaması Ağustos ayında 27.2°C, en soğuk ay ortalaması Ocak ayında 3.9°C'dir. Uzun yıllar ölçümlerine göre oransal nem ortalaması %70.2'dir. Uzun yıllar ortalamalarına göre yıllık buharlaşma ise 1478 mm'dir. En fazla buharlaşma 212.1 mm ile Temmuz ayında olmaktadır.

Deneme alanının fiziksel özellikleri, toprağın pH'sı 7.91 - 8.11; EC içeriği 0.914 - 1.028 dS m<sup>-1</sup>; hacim ağırlığı 1.30 - 1.42 g cm<sup>-3</sup>; tarla kapasitesi 29.64 - 30.70 g g<sup>-1</sup>. solma noktası ise 12.71 - 19.75 g g<sup>-1</sup> arasında belirlenmiştir. Deneme alanı topraklarının profil boyunca 0 - 30 cm kil, diğer katmanların siltli kil olduğu ve 60 cm profil derinliğindeki kullanılabilir su miktarı 201 mm olarak hesaplanmıştır. Tarla kapasitesi ve solma noktası su içerikleri ise derinlik olarak 245 mm ve 157 mm olarak belirlenmiştir. Ayrıca 3 farklı derinlikten (0 - 30, 30 - 60, ve 60 - 90 cm) bozulmamış toprak örnekleri alınarak yapılan hacim ağırlığı değerleri de her bir derinlik için ortalama 1.37 g cm<sup>-3</sup> olarak elde edilmiştir.

### Araştırma Konuları ve Sulama Sistemi

Araştırmada son yıllarda yaygın olarak görülen domates sarı yaprak kıvrıcıklığı virüsü (TYLCV) ve fusarium hastalığına dayanıklı Marmara F1 salçalık domates (*Solanum lycopersicum*) fidesi kullanılmıştır. Yaprakları meyveyi çok iyi örten bir çeşit olup meyve ağırlığı genel olarak 250-280 g arasında değişen ve görünüm olarak hafif basık olan bir çeşittir.

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Çalışma tesadüf blokları bölünmüş parseller deneme desenine göre 3 tekerrürlü yürütülmüştür. Araştırmada üç farklı fertigasyon ekipmanları ana konuları (F<sub>1</sub>: enjeksiyon pompası, F<sub>2</sub>: ventüri, F<sub>3</sub>: basınç farkı) ve üç farklı sulama düzeyi ise alt konuları (I<sub>100</sub>: tam sulama, I<sub>70</sub> ve I<sub>50</sub>: kısıntılı sulama) oluşturacak şekilde düzenlenmiştir. (I<sub>100</sub>: Tam sulama konusu olup bir haftalık sulama aralığında 60 cm'lik toprak profilindeki eksik nemin tarla kapasitesine getirildiği konudur; I<sub>70</sub> ve I<sub>50</sub>: Kısıntılı sulama konuları ise I<sub>100</sub> konusuna uygulanan suyun %70 ve %50'sinin uygulandığı konulardır.)

Domates bitkisinin sulanmasında damla sulama sistemi kullanılmıştır. Toprağın infiltrasyon özellikleri dikkate alınarak damlatıcı arası mesafe 40 cm ve damlatıcı debisi ise 4 L h<sup>-1</sup> olan damlatıcılar, içten geçik ve basınç kontrollü olup her sıraya bir lateral gelecek şekilde düzenlenmiştir. Lateraller Ø16 mm dış çapında olup 1.0 mm et kalınlığında PE malzemeden üretilmiştir.

Uygulanan sulama suyu miktarı eşitliğe göre belirlenmiştir:

$$R = AxPx\Delta s$$

Burada;

R : Sulama suyu miktarı, lt

A : Parsel alanı, m<sup>2</sup>

P : Islatılan alan yüzdesi, %

Δs: 60 cm derinlikteki eksik toprak su içeriği, mm

Islatılan alan yüzdesi sulama aralıklarında örtü yüzdesi olarak izlenmiş ve örtü genişliğinin sıra arası uzaklığa oranlanmasıyla ıslatma yüzdesi hesaplanmıştır. Örtü genişliği değeri 0.70 m değerine ulaştığında sabit olarak kabul edilmiştir.

Klorofil ölçümleri, tüm konularda sulamalardan önce "Minolta SPAD-502" portatif klorofilmetre cihazı ile ölçülmüştür. Bu amaçla gün ortasında (12:00-14:00), her parselde tam gelişmiş, güneşe bakan 10 yaprakta ölçüm yapılmış ve bunların ortalaması alınmıştır.

## **Bulgular**

### **Sulama Suyu Miktarı ve Verim**

Domates bitkisinin araziye dikimden sonra tüm parsellere eşit miktarda 15.0 mm can suyu verilmiştir. Ayrıca belirli tarihlerde can suyu uygulamaları yapılmıştır. Konulu sulamalara domates bitkisinde parsellerde yaklaşık %70 çiçeklenme oluşumunun belirlendiği tarihte, 60 cm toprak profilindeki eksik nem tarla kapasitesine getirilerek başlanmış ve hasattan 10 gün önce son sulama yapılmıştır. Her üç fertigasyon konularında (F<sub>1</sub>, F<sub>2</sub> ve F<sub>3</sub>) üç farklı sulama düzeyinde (I<sub>100</sub>, I<sub>70</sub> ve I<sub>50</sub>) 2014 deneme yılında 5 eşit sulama ve toplamda 12 konulu sulama uygulamaları yapılmıştır. Deneme süresince F<sub>1</sub>, F<sub>2</sub> ve F<sub>3</sub> fertigasyon konularına I<sub>100</sub> tam sulama düzeyinde toplam 397.9 mm sulama suyu uygulanmıştır. Aynı fertigasyon konularında I<sub>70</sub> kısıntılı sulama uygulamasında toplam 303.4 mm ve I<sub>50</sub> konusunda ise toplamda 240.4 mm sulama suyu verilmiştir.

Fertigasyon konuları ve sulama düzeylerine ait ortalama verim değerleri LSD gruplandırması Çizelge 1'de verilmiştir. Domates ortalama toplam verim değerleri 2803 - 4875 kg da<sup>-1</sup> arasında değişmiştir. Enjeksiyon pompası olan fertigasyon yönteminde (F<sub>1</sub>), ortalama toplam verim değerleri 3660 - 4875 kg da<sup>-1</sup> arasında, ventüri olan fertigasyon yönteminde (F<sub>2</sub>), 2803 - 3721 kg da<sup>-1</sup> ve basınç farkı olan fertigasyon yönteminde (F<sub>3</sub>), 3760 - 4514 kg da<sup>-1</sup> olarak belirlenmiştir. LSD gruplandırması sonucuna göre en yüksek verim enjeksiyon pompası ile fertigasyon yönteminin uygulandığı (F<sub>1</sub>) I<sub>100</sub> konusunda 4875 kg da<sup>-1</sup> olarak belirlenmiştir. En

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düşük verim değerleri ise venturi fertigasyon yönteminin uygulandığı (F2) I<sub>50</sub> konusundan 2803 kg da<sup>-1</sup> ve (F2) I<sub>70</sub> konusundan 2840 kg da<sup>-1</sup> olarak elde edilmiştir. Basınç farkı yönteminin uygulandığı fertigasyon yönteminde (F3) en yüksek verim I<sub>100</sub> konusunda 4514 kg da<sup>-1</sup> olduğu sonucuna varılmıştır.

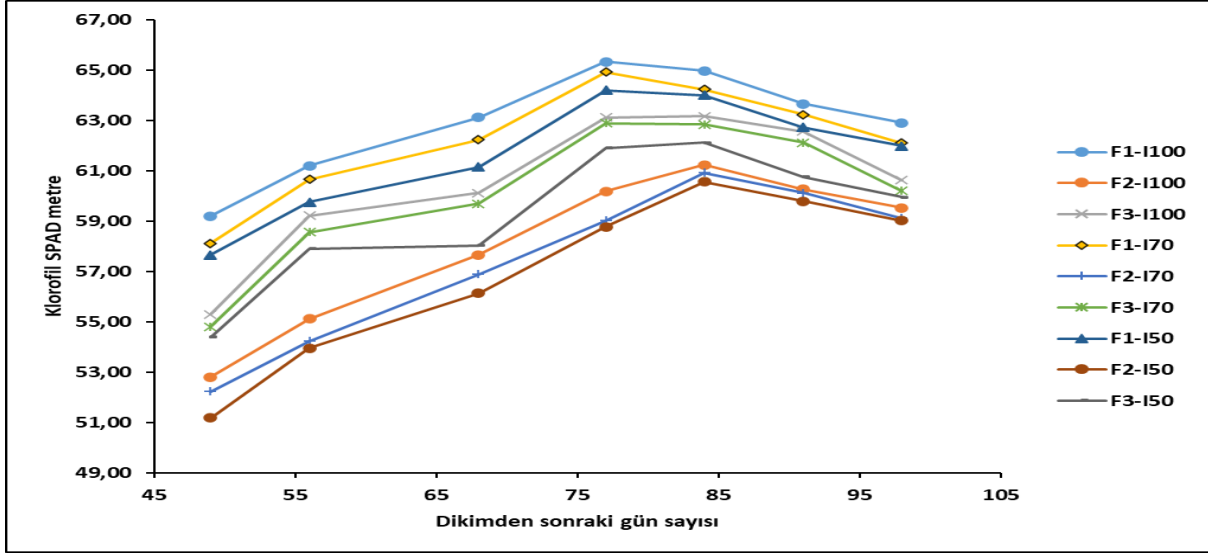
Fertigasyon Yöntemi	Sulama Konuları		
	I <sub>100</sub>	I <sub>70</sub>	I <sub>50</sub>
F1	4875 a	4049 d	3660 e
F2	3721 e	2840 f	2803 f
F3	4514 b	4263 c	3760 e
İstatistiksel Analiz	F*SK: LSD (0.05)=203.3; P=0.01**		

Çizelge 1. Fertigasyon ve sulama konularının verime ilişkin LSD gruplandırması

Gürbüz (2001), farklı sulama yöntemleri ile sulama suyu düzeylerinin domates bitkisi üzerinde ki etkilerini incelediği araştırmada, açık su yüzeyinde meydana gelen yığışımli buharlaşma miktarlarını (k<sub>1</sub>:0.35 – k<sub>2</sub>:0.70 – k<sub>3</sub>:1.05 ve k<sub>4</sub>:1.40) kp esas almışlardır. Çalışma sonucuna göre en yüksek domates verimini damla sulamada kp:1.40 konusunda 3.538 kg da<sup>-1</sup> olarak elde etmişlerdir. Papadopoulos (2000), azot gübresini geleneksel olarak toprağa ve fertigasyon uygulaması ile vererek farklarını inceledikleri araştırmada fertigasyon ile azot gübrelemesinde, geleneksel toprağa verilen gübreleme yöntemine göre %50 daha yüksek verim elde ettiklerini bildirmişlerdir.

### **Bitki Klorofil İçeriği**

Klorofil miktarı, yeşil renk yansıma oranını ölçen SPAD cihazı ile belirlenmiştir. Bitki klorofil değerlerine ilişkin ölçümler, sulama uygulamalarıyla başlayıp hasata kadar sürdürülmüştür. Tüm ölçümler, sulama işlemlerinden önce gerçekleştirilmiştir. Farklı fertigasyon ve sulama konularında SPAD değerlerinin mevsim boyunca değişimi Şekil 1’de verilmiştir. Araştırma sonuçlarına göre domates bitkisinde en yüksek klorofil içeriği değeri (SPAD), enjeksiyon pompası yöntemi ile gübrelemenin yapıldığı (F1) tam sulama (I<sub>100</sub>) konusundan ortalama olarak 62.9 olarak elde edilmiştir. En düşük ortalama SPAD değeri ise ventüri ile fertigasyon yöntemi (F2) ve kısıntılı sulama (I<sub>50</sub>) konusundan 57.1 elde edilmiştir. Mevsim içerisinde sulama öncesi ortalama klorofil (SPAD) değerleri F1 fertigasyon uygulamasında 57.7-65.3 arasında, F2 fertigasyon uygulamasında 51.2-61.2 arasında ve F3 fertigasyon uygulamasında 54.4-63.2 arasında değişmiştir.

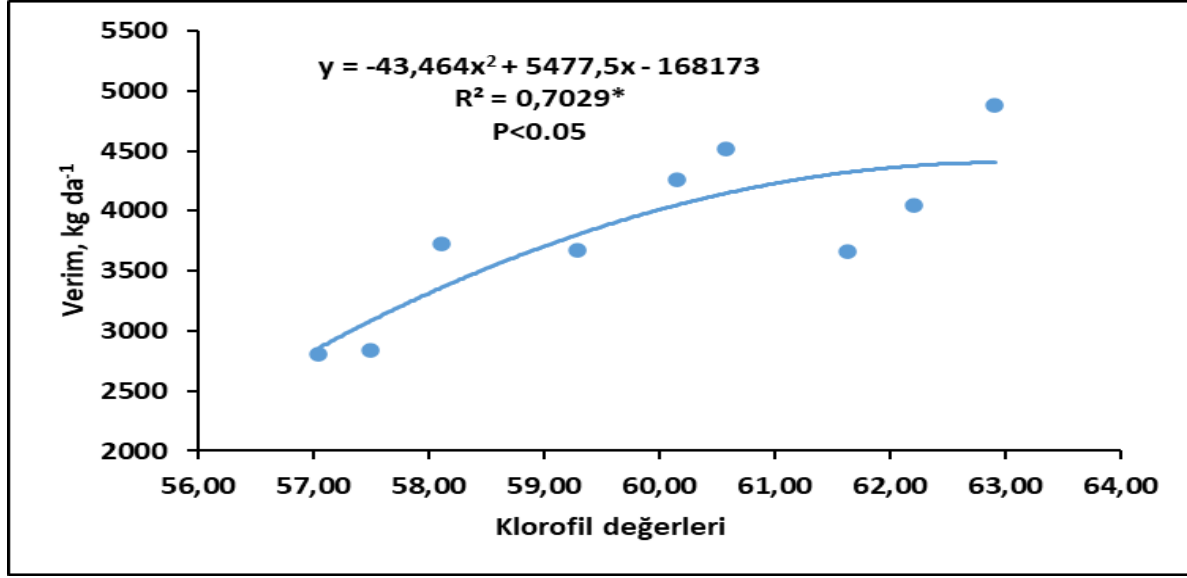


Şekil 1. Farklı fertigasyon ve sulama konularında SPAD değerlerinin mevsim boyunca değişimi

Domates bitkisinde sulama suyu miktarları arttıkça klorofil içeriği değerlerinde de artışlar elde edilirken daha az suyun uygulandığı su kısıntısı koşullarında ise daha düşük değerler elde edilmiştir. Munne-Bosch ve Alegre (2000), yaptıkları araştırmada sulama suyu miktarındaki azalmaların, klorofil içeriğini de azalttığını bildirmişlerdir. Biber bitkisinde toplam klorofil miktarı su kısıntısı koşullarında azalmaktadır (Pıtır, 2015). Çalışmaya göre ventüri yöntemi ile uygulanan fertigasyon yöntemi ve su kısıntısı domates bitkisinde klorofil içeriğinin azalmasına, enjeksiyon pompası yöntemi ile fertigasyon tekniğinde tam sulama koşullarında ise artmasına neden olmuştur.

#### Verim ile Klorofil Değerleri (SPAD) İlişkisi

Çalışmada deneme konularından ele edilen klorofil içeriği değerleri ile verim değerleri arasındaki ilişkiler Şekil 2.'de verilmiştir. Klorofil SPAD metre değerleri ile verim arasında istatistiksel olarak ikinci dereceden önemli ilişkiler bulunmuştur ( $P < 0.05$ ). Duraktekin ve ark. (2019) karpuz verimi ile SPAD değerleri arasında güçlü korelasyon olduğu sonucuna varmışlardır.



Şekil 2. Verim ile klorofil değerleri (SPAD) arasındaki ilişki  
( $P < 0.01$  \*\*) %1 önemli ( $P < 0.05$  \*) % 5 önemli ( $P > 0.05$  ö.d.) önemli değil

### Sonuç

Araştırmada Dünya’da insan beslenmesinde en büyük paya sahip olan domates bitkisinde, damla sulama sistemlerinde kullanılan farklı fertigasyon ekipmanları ile sulama düzeylerinin klorofil içeriğine olası etkileri belirlenmeye çalışılmıştır.

Uygulanan sulama suyu miktarı arttıkça verim değerlerinde artışlar meydana gelmiştir. Klorofil içeriği değerleri sulama suyu miktarı ve fertigasyon yöntemi ekipmanlarına göre farklılıklar göstermiştir. Su kısıntısı koşullarında, bitkinin stres durumu arttıkça SPAD değerlerinde azalmalar tespit edilmiştir. Enjeksiyon pompası fertigasyon yönteminde, diğer yöntemlere göre daha yüksek verim değerleri tespit edilmiş ve bu durum SPAD değerlerinde artışa sebep olmuştur. F1 fertigasyon yönteminde en yüksek klorofil içeriği 62.9 olarak tam sulama konusunda elde edilmiştir. Araştırma sonunda elde edilen veriler ile domates bitkisi için en uygun fertigasyon yöntemi ve sulama düzeyi belirlenerek klorofil değerinin su stresini belirlemede sulama programlanmasında kullanılabileceği söylenebilir. Yapılan araştırmalar ve yayımlanan raporlar gelecek yıllarda iklim değişikliklerinin tarımsal üretimde su kaynakları üzerinde fazlasıyla olumsuz etkiler yaratacağını göstermektedir. Bu anlamda domates bitkisinde sulama programlaması ile su stres koşullarının belirlenmesinde klorofil içeriği kullanılabilir durumdadır.

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**KAYNAKLAR**

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**NOHUT ÜRETİMİNİN GELİŞİMİ VE REKABET GÜCÜ ANALİZİ**

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**Özet**

Bu çalışmanın amacı dünyada ve Türkiye’de nohut üretimi ve dış ticaretine ilişkin göstergeleri ortaya koymak ve küresel rekabet gücünü saptamaktır. Türkiye 2022 verilerine göre 580 bin ton üretim miktarı ile dünya nohut üretiminden %3.21 oranında pay almaktadır. Nohut ihracat değerinde 4. Sırada ihracat miktarı bakımından ise 5. sırada yer almakta olup dünya nohut ticaretinde söz sahibidir. Bu noktada küresel rekabet gücü önem arz etmektedir. Çalışmada küresel rekabet gücünün hesaplanmasında Balassa’nın Açıklanmış Karşılaştırmalı Üstünlük İndeksi (RCA), Vollrath’ın Görelî İhracat Avantajı İndeksi (RXA) ve Laursen’in Açıklanmış Simetrik Karşılaştırmalı Üstünlük İndeksi (RSCA) kullanılmıştır. Buna göre 2004-2022 yılları ortalamasına göre Türkiye için hesaplanmış olan RCA indeks değeri 9.85, RXA indeks değeri 11.17 ve RSCA indeks değeri ise 0.66 saptanmıştır. Elde edilen bu indeks değerlerine göre Türkiye küresel rekabette yüksek derecede açıklanmış karşılaştırmalı üstünlüğe, Vollrath’ın Görelî İhracat Avantajı ve Laursen’in Açıklanmış Simetrik Karşılaştırmalı Üstünlük indeksi değerlendirmesine göre rekabet avantajına sahip olduğu, tespit edilmiştir. Türkiye’nin nohut ihracatındaki performansı, küresel pazarlardaki rekabetçi yapısının güçlendirilmesi için önemli bir potansiyele sahiptir. Sürdürülebilir bir tarımsal ihracat modeli oluşturulması, hem üreticilerin gelirlerini artıracak hem de Türkiye’nin küresel ticaretteki konumunu daha da sağlamlaştıracaktır. Türkiye’nin nohut ihracatında rekabet avantajını daha da artırmak, üretimden pazarlamaya kadar bütüncül bir yaklaşımı gerektirmektedir. Yüksek kaliteli ve işlenmiş nohut ürünlerine yönelerek katma değer artırılabilir. Yeni hedef pazarlara ulaşmak için tanıtım faaliyetleri güçlendirilirken, modern tarım uygulamalarıyla üretim verimliliği artırılmalıdır.

**Anahtar Kelimeler:** Nohut, Rekabet Gücü, Türkiye

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## DEVELOPMENT OF CHICKPEA PRODUCTION AND COMPETITIVENESS ANALYSIS

### **Abstract**

The aim of this study is to reveal the indicators related to chickpea production and foreign trade in the world and Türkiye and to determine global competitiveness power. According to 2022 data, Türkiye has a share of 3.21% in world chickpea production with a production amount of 580 thousand tons. It ranks 4th in chickpea export value and 5th in terms of export amount and has a say in world chickpea trade. At this point, global competitive power is important. In the study, Balassa's Revealed Comparative Advantage Index (RCA), Vollrath's Relative Export Advantage Index (RXA) and Laursen's Revealed Symmetric Comparative Advantage Index (RSCA) were used in calculating global competitive power. Accordingly, the RCA index value calculated for Turkey according to the average of the years 2004-2022 was determined as 9.85, the RXA index value as 11.17 and the RSCA index value as 0.66. According to these index values obtained, it has been determined that Türkiye has a high level of revealed comparative advantage in global competition, a competitive advantage according to Vollrath's Relative Export Advantage and Laursen's Revealed Symmetric Comparative Advantage index evaluation. Türkiye's performance in chickpea exports has an important potential for strengthening its competitive structure in global markets. Creating a sustainable agricultural export model will both increase producers' incomes and further strengthen Türkiye's position in global trade. Increasing Türkiye's competitive advantage in chickpea exports requires a holistic approach from production to marketing. Added value can be increased by focusing on high-quality and processed chickpea products. While promotional activities should be strengthened to reach new target markets, production efficiency should be increased with modern agricultural practices.

**Keywords:** Chickpea, Competitiveness, Türkiye.

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## GİRİŞ

Tarım sektörü, hem ekonomik büyüme hem de toplumsal refah açısından stratejik bir öneme sahiptir. Tarım ürünlerinin uluslararası ticaretteki rolü, ülkelerin tarımsal üretim kapasiteleri, ihracat performansları ve rekabet avantajları üzerinden değerlendirilir. Bu bağlamda, baklagiller grubu, özellikle nohut, dünya genelinde önemli bir ticaret ürünü haline gelmiştir. Nohut, besleyici değeri, geniş tüketim alanıyla dikkat çeken bir üründür (Atalay ve Gökbulut, 2021).

Türkiye, nohut üretimi ve ihracatı açısından küresel piyasada önde gelen ülkeler arasında yer almasına rağmen, sektördeki rekabet avantajlarının derinlemesine incelenmesi gerekmektedir. İhracatın sürdürülebilirliği ve katma değer oluşturma potansiyelinin artırılması için nohut ürününe yönelik karşılaştırmalı üstünlüklerin analiz edilmesi büyük önem taşımaktadır. Bu çalışmada, Türkiye'nin nohut ihracatındaki rekabetçi konumu ve karşılaştırmalı üstünlükleri, Açıklanmış Karşılaştırmalı Üstünlükler İndeksi (RCA), Görelî İhracat Avantajı İndeksi (RXA) ve Açıklanmış Simetrik Karşılaştırmalı Üstünlük İndeksi (RSCA) kullanılarak analiz edilmiştir. Bu indeksler tarım ekonomisi alanında rekabet gücü konusunda daha önce yapılmış olan çalışmalarda sıkça rastlanan yöntemlerdir. Nitekim; Bashimow (2016) çalışmasında Türkiye'nin domates ihracat performansı ve rekabet gücünü Balassa'nın Açıklanmış Karşılaştırmalı Üstünlükler indeksi (AKÜ) ile birlikte Vollrath'ın Görelî İhracat Avantajı (RXA) indeksi ile ölçmüştür. Kadakoğlu vd. (2022) çalışmalarında incir üretiminin gelişimini ve küresel rekabet gücü analizini incelemişlerdir. Rekabet analizinde Balassa'nın Açıklanmış Karşılaştırmalı Üstünlük İndeksi (RCA), Vollrath'ın Görelî İhracat Avantajı İndeksi (RXA) ve Laursen'in Açıklanmış Simetrik Karşılaştırmalı Üstünlük İndeksi (RSCA) kullanmışlardır. Türkiye'de ceviz üretim projeksiyonu ve rekabet gücünü analiz ettikleri çalışmalarında ise Balassa'nın Açıklanmış Karşılaştırmalı Üstünlük İndeksini kullanmışlardır (Kadakoğlu vd., 2022). Binboğa ve Demirbaş (2024) çalışmalarında tavuk eti ticaretinde uluslararası rekabet gücünün analizi etmişlerdir. Rekabet gücü analizinde "açıklanmış karşılaştırmalı üstünlüğü" Balassa ve Vollrath indeksleri ile ölçmüşlerdir. Ayrıca çalışmalarında ithalat sızma oranı, dış rekabete açıklık, ihracat/ithalat oranı, net ihracat oranı ve uzmanlaşma katsayısı gibi göstergeleri kullanmışlardır. Kadakoğlu vd. (2024) vişnede küresel rekabet gücünü ortaya koydukları çalışmalarında Balassa'nın Açıklanmış Karşılaştırmalı Üstünlük İndeksi (RCA), Vollrath'ın Görelî İhracat Avantajı İndeksi (RXA) ve Laursen'in Açıklanmış Simetrik Karşılaştırmalı Üstünlük İndeksi (RSCA) kullanmışlardır. Bu kapsamda, çalışmanın temel amacı dünyada ve Türkiye'de nohut üretimi ve dış ticaretine ilişkin göstergeleri ortaya koymak ve küresel rekabet gücünü saptamaktır. Nitekim Türkiye'nin nohut ihracatında sürdürülebilir bir rekabet avantajı sağlayabilmesi için mevcut durumun analiz edilmesi ve potansiyel stratejiler geliştirilmesi önem arz etmektedir.

## MATERYAL VE YÖNTEM

Bu çalışmanın ana materyalini Birleşmiş Milletler Gıda ve Tarım Örgütü (FAO) ve Dünya Ticaret Örgütü (WTO) istatistik veri tabanlarından elde edilen ikincil veriler oluşturmuştur. Çalışmada kullanılan veriler 2004-2022 dönemini kapsamaktadır. Çalışmada dünyada önemli nohut üreticisi ülkelerin üretim miktarı, verimi, üretim alanı ve dış ticaretine ilişkin verilerin yüzdesel olarak dağılımı ile yıllar içindeki değişimi basit indeks (2004=100) kullanılarak hesaplanmıştır.

Çalışmada küresel rekabet gücünün hesaplanmasında Balassa'nın Açıklanmış Karşılaştırmalı Üstünlük İndeksi (RCA), Vollrath'ın Görelî İhracat Avantajı İndeksi (RXA) ve Laursen'in

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Açıklanmış Simetrik Karşılaştırmalı Üstünlük İndeksi (RSCA) kullanılmıştır. Bu indeksler, ihracat performansını ölçmek ve ürünlerin uluslararası piyasalardaki rekabet gücünü değerlendirmek için yaygın olarak kullanılan yöntemlerdir. İndeks değerlerinin hesaplanmasına ihracat miktarı ve değeri bakımından 2022 yılı verilerine göre önde gelen ülkeler tercih edilmiştir. İlgili ülkelerin ihracat değerlerine ilişkin veriler Dünya Ticaret Örgütü (WTO, 2024), Birleşmiş Milletler Gıda ve Tarım Örgütü (FAO, 2024) veri tabanlarından elde edilmiştir. Balassa'nın Açıklanmış Karşılaştırmalı Üstünlük İndeksi (Revealed Comparative Advantage, RCA), bir ülkenin belirli bir ürün veya sektördeki karşılaştırmalı üstünlüğünü ölçmek için kullanılan bir indekstir (Balassa, 1965; Laursen, 2015). Vollrath'ın Göreli İhracat Avantajı İndeksi (Relative Export Advantage, RXA) ise, bir ülkenin belirli bir üründe dünya piyasalarındaki ihracat payının, diğer tüm ürünlerdeki dünya ihracat payına oranı olarak tanımlanır (Vollrath, 1991; Widodo, 2009). Laursen'in Açıklanmış Simetrik Karşılaştırmalı Üstünlük İndeksi (Revealed Symmetric Comparative Advantage, RSCA), Balassa'nın Açıklanmış Karşılaştırmalı Üstünlük İndeksi (Revealed Comparative Advantage, RCA)'nin geliştirilmiş ve simetrik bir versiyonudur. Bu indeks, RCA'nın asimetrik yapısını gidermek ve daha tutarlı bir analiz sağlamak amacıyla oluşturulmuştur. RSCA değerleri -1 ile +1 arasında değişmektedir (Laursen, 2015; Dalum, vd, 1998).

## ARAŞTIRMA BULGULARI

Dünyada 2022 yılı verilerine göre 14.810.916 hektar alanda nohut üretimi gerçekleştirilmiştir. Dünya nohut ekim alanlarının %72,5'ine Hindistan sahiptir. Hindistan'ı %5,8 ile Pakistan, %4,2 ile Avustralya takip etmektedir. Türkiye dünya nohut ekim alanlarının %3,1'ini oluşturmaktadır olup 4. Sıradadır. Dünya nohut ekim alanları 2004 yılı verileri baz alındığında %41,8 artmıştır. Hindistan'da ise %52,4 artış gerçekleşmiş olup dünya nohut ekim alanında ikinci sırada yer alan Pakistan'da 2004 yılına göre %12,3 azalma gerçekleşmiştir. 2004 yılına göre nohut ekim alanında en fazla artış 5,59 kat ile Avustralya'da saptanmıştır. Türkiye'de ekim alanlarında %24,5 azalma gerçekleşmiştir (Çizelge 1).

Çizelge 1. Dünyada nohut ekim alanında gelişim

Ülkeler	Hektar	Oran (%)	Basit indeks (2004=100)
Hindistan	10.740.100	72,5	152,4
Pakistan	861.688	5,8	87,7
Avustralya	615750	4,2	558,9
Türkiye	456.480	3,1	75,5
Iran	429.670	2,9	75,0
Rusya	344.499	2,3	96,2
Myanmar	340.212	2,3	166,5
Etiyopya	227.040	1,5	125,4
ABD	138.360	0,9	787,7
Meksika	111.672	0,8	151,1
Diğer ülkeler	545.445	3,7	84,2
Dünya toplamı	14.810.916	100,0	141,8

Kaynak: FAO, 2024.

Çizelge 2, dünya nohut üretimindeki gelişimi ve ülkelerin üretim paylarını göstermektedir. 2022 yılı verilerine göre, dünya genelinde toplam 18.095.248 ton nohut üretimi gerçekleştirilmiştir. Hindistan, 13.543.650 ton ile dünya nohut üretiminin %74,8'ini karşılayarak açık ara birinci sırada yer almaktadır. Hindistan'ı, 1.062.250 ton ve %5,9'luk pay ile Avustralya takip etmektedir. Türkiye ise 580.000 ton nohut üretimi ile dünya üretiminin %3,2'sini

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gerçekleştirmiş ve üçüncü sırada yer almıştır.

2004 yılı verileri baz alındığında, nohut üretiminde en fazla artışı Avustralya'nın kaydettiği görülmektedir (%685,6 artış), bu da 2004 yılına göre nohut üretiminde yaklaşık 7,86 kat artış olduğunu göstermektedir. Hindistan'ın basit indeks değeri 236,9 olup, 2004 yılına verilerine göre nohut üretimini önemli ölçüde artırdığı anlaşılmaktadır (2.37 kat). Türkiye'nin indeks değeri ise 93,5 olarak hesaplanmıştır, bu da 2004 yılına göre üretimde %6.5 oranında azalma olduğunu göstermektedir.

Çizelge 2. Dünyada nohut üretiminde gelişim

Ülkeler	Ton	Oran (%)	Basit indeks (2004=100)
Hindistan	13.543.630	74,8	236,9
Avustralya	1.062.250	5,9	785,6
Türkiye	580.000	3,2	93,5
Etiyopya	492.691	2,7	302,5
Rusya	467.934	2,6	146,2
Myanmar	447.500	2,5	190,3
Pakistan	316.176	1,7	51,7
Meksika	189.037	1,0	180,8
Iran	176.080	1,0	61,4
Diğer ülkeler	819.951	4,5	157,3
Dünya toplamı	18.095.248	100,0	215,6

Kaynak: FAO, 2024.

Çizelge 3, dünya nohut ithalatındaki gelişimi ve ülkelerin ithalat paylarını göstermektedir. 2022 yılı verilerine göre, dünya genelinde toplam 1.881.269 ton nohut ithal edilmiştir. Bu ithalatın %20,2'sini (379.547 ton) Pakistan gerçekleştirmiştir. Pakistan'ın nohut ithalat değeri 284.012 dolar olup, dünya nohut ithalat değerinin %16,8'ini oluşturmuş ve birinci sırada yer almıştır. Pakistan'ı, 256.557 ton nohut ithal eden Bangladeş takip etmektedir; bu miktar toplam ithalatın %13,6'sına karşılık gelirken, üçüncü sırada yer alan Birleşik Arap Emirlikleri (BAE), 137.474 ton nohut ithal etmiştir. Türkiye ise 106.247 ton nohut ithal ederek dünya nohut ithalat miktarının %5,6'sını gerçekleştirmiştir. Türkiye'nin nohut ithalat değeri ise 109.082 dolardır. 2004 yılı verilerine göre nohut ithalatı miktarında dünya genelinde %153,9'luk bir artış yaşanmış olup Hindistan hariç diğer ülkelerde artış yaşanmıştır. En fazla artış % 19.359,2 (yaklaşık 194,6 kat) artış ile Türkiye'de gerçekleşmiş, Hindistan'da ise %37,5'lik bir azalma yaşanmıştır. Nohut ithalat değerinde ise dünya genelinde %366,3 oranında artış gerçekleşmiştir. En fazla artış yaklaşık 356,5 kat ile Türkiye'de gerçekleşirken Hindistan'da %2,4'lük bir azalma yaşanmıştır.

Çizelge 3. Dünyada nohut ithalatında gelişim (Kaynak: FAO, 2024)

MİKTAR				DEĞER			
Ülkeler	Ton	Oran (%)	Basit indeks (2004=100)	Ülkeler	Bin Dolar	Oran (%)	Basit indeks (2004=100)
Pakistan	379.547	20,2	547,6	Pakistan	284.012	16,8	1193,9
Bangladesh	256.557	13,6	245,1	Bangladesh	146.250	8,6	467,2
B. Arap Emirlikleri	137.474	7,3	653,5	B. Arap Emirlikleri	113.183	6,7	1175,2
Türkiye	106.247	5,6	19.459,2	Türkiye	109.082	6,4	35.647,7
Hindistan	82.846	4,4	62,5	Cezayir	107.089	6,3	278,1
Cezayir	77.800	4,1	159,7	ABD	71.998	4,2	769,8
ABD	67.834	3,6	493,6	Irak	62.068	3,7	997,4
Iran	60.303	3,2	224,2	Iran	56.402	3,3	673,3
Nepal	46.632	2,5	2.168,9	Hindistan	50.020	3,0	97,6
Irak	46.031	2,4	395,0	Suriye	48.367	2,9	1779,5
Diğer ülkeler	6.199.99	33,0	184,2	Diğer ülkeler	64.6943	38,2	339,6
Dünya toplamı	1.881.269	100,0	253,9	Dünya toplamı	1.695.414	100,0	466,3

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Dünya nohut ihracatındaki gelişim Çizelge 4’te verilmiştir. 2022 verilerine göre dünya genelinde toplam 2.097.418 ton nohut ihracata konu olmuştur. Söz konusu bu ihracat miktarının %28,9’unu (605.933 ton) Avusturya gerçekleştirmiştir. Avusturya’yı 235.084 ton ihracat ile Hindistan takip etmiştir. Üçüncü sırada yer alan Kanada 222.479 ton nohut ihracatı gerçekleştirmiş olup, bu değer dünya nohut ihracat miktarının %10,6’sını oluşturmuştur. Türkiye ise 2022 yılı verilerine göre 183.189 ton nohut ihracatı gerçekleştirmiş ve bu ihracat miktarı ile dünya nohut ihracatından % 8,7 pay ile 5.sırada yer almıştır. Dünya nohut ihracat miktarı dikkate alındığında 2004 yılı verilerine göre dünyada %176 oranında bir artış yaşanmıştır.

**Çizelge 4. Dünyada nohut ihracatında gelişim**

MİKTAR				DEĞER			
Ülkeler	Ton	Oran (%)	Basit indeks (2004=100)	Ülkeler	Bin Dolar	Oran (%)	Basit indeks (2004=100)
Avustralya	605.933	28,9	405,8	Avustralya	357.368	21,2	768,1
Hindistan	235.084	11,2	1920,0	Hindistan	225.000	13,3	2.838,8
Kanada	222.479	10,6	325,9	Kanada	203.300	12,0	628,6
Rusya	185.232	8,8	2007,3	Türkiye	191.128	11,3	276,3
Türkiye	183.189	8,7	137,7	Meksika	137.809	8,2	203,8
Tanzanya	167.547	8,0	675,6	Rusya	130.713	7,7	6618,4
Meksika	100.952	4,8	121,3	B. Arap Emirlikleri	89.429	5,3	3301,2
B. Arap Emirlikleri	95.095	4,5	1.113,5	Tanzanya	83.893	5,0	1134,8
ABD	66.720	3,2	534,9	ABD	66.534	3,9	874,1
Arjantin	64.141	3,1	5.131,3	Arjantin	45.561	2,7	6381,1
Diğer ülkeler	171.045	8,2	66,5	Diğer ülkeler	156.690	9,3	139,1
<b>Dünya toplamı</b>	<b>2.097.418</b>	<b>100,0</b>	<b>276,0</b>	<b>Dünya toplamı</b>	<b>1.687.425</b>	<b>100,0</b>	<b>473,1</b>

Kaynak: FAO, 2024.

Çizelge 5’te 2004-2022 yılları arasındaki dünyada nohut ihracatında önde gelen ülkelerin Açıklanmış Karşılaştırmalı Üstünlük indeks değerleri hesaplanmıştır. Buna göre, dünyada öne çıkan ülkeler arasında Arjantin, Avustralya, Hindistan, Meksika, Tanzanya ve Türkiye’nin yüksek karşılaştırmalı üstünlüğe sahip olduğu belirlenmiştir. Bu ülkelerin yıllık ortalama RCA değerleri 2004-2022 dönemi ortalaması sırası ile; 8.52, 21.37, 9.18, 6.23, 80.78 ve 9.85 olarak hesaplanmıştır. Kanada ve Rusya’nın RCA ortalamaları ise sırasıyla 2.55 ve 2.45 olarak belirlenmiş ve bu ülkelerin orta derecede karşılaştırmalı üstünlüğe sahip olduğu tespit edilmiştir. Birleşik Arap Emirlikleri’nin yıllık ortalama RCA indeks değeri 1.29 olarak hesaplanmış ve zayıf karşılaştırmalı üstünlüğe sahip olduğu saptanmıştır. ABD’nin ise yıllık ortalama RCA değeri 0.52 olarak belirlenmiş, bu nedenle nohut ihracatında karşılaştırmalı üstünlüğe sahip olmadığı ve dezavantajlı konumda olduğu sonucuna varılmıştır. Türkiye’nin yıllar içerisindeki karşılaştırmalı üstünlüğü incelendiğinde ise 2012-2017 dönemi haricinde yüksek karşılaştırmalı üstünlüğe sahip olduğu 2012-2017 dönemlerinde 2012 yılında orta derecede üstünlüğe sahip olduğu 2013-2017 yıllarında ise zayıf karşılaştırmalı üstünlüğe sahip olduğu belirlenmiştir. İlgili dönem (2004-2022) ortalamasında Türkiye, Tanzanya ve Avustralya’nın ardından üçüncü sıradadır.

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Çizelge 5. Açıklanmış Karşılaştırmalı Üstünlükler İndeksi(RCA)

Yıllar	Arjantin	Avusturya	Kanada	Hindistan	Meksika	Rusya	Tanzanya	Türkiye	BAE*	ABD**
2004	0,53	13,89	2,64	2,67	9,30	0,28	129,22	28,31	0,77	0,24
2005	0,45	14,81	2,03	8,17	8,55	0,27	148,32	26,92	0,73	0,38
2006	1,42	22,16	2,98	8,26	10,84	0,24	32,17	16,20	0,28	0,30
2007	1,56	17,12	3,10	21,49	8,62	0,47	92,64	10,02	1,15	0,35
2008	2,46	18,23	2,34	14,01	9,31	0,57	47,83	13,64	2,06	0,30
2009	3,64	26,02	2,83	8,56	9,62	0,94	31,19	12,82	1,91	0,35
2010	3,56	19,52	2,98	15,50	6,42	0,31	59,88	8,94	1,27	0,56
2011	12,56	16,33	2,88	14,10	3,80	2,50	46,39	5,15	0,80	0,57
2012	12,55	27,55	1,26	7,44	8,13	2,31	47,01	2,44	0,47	0,56
2013	10,79	19,56	1,67	18,21	5,78	2,15	43,15	1,99	0,99	0,54
2014	7,05	22,17	1,55	10,06	8,40	3,93	75,57	1,88	0,79	0,48
2015	6,94	42,08	1,91	6,68	3,91	4,67	63,53	1,41	0,97	0,26
2016	14,34	37,91	2,38	4,41	3,27	4,87	39,67	1,69	1,23	0,55
2017	19,72	37,51	2,39	3,13	3,16	2,45	28,35	1,39	1,36	0,71
2018	24,39	14,29	1,93	9,21	4,27	1,88	26,26	7,30	1,97	0,54
2019	11,00	12,79	2,73	4,84	4,14	5,84	139,36	11,02	1,67	0,90
2020	17,22	12,82	2,40	7,31	3,64	5,01	135,22	12,60	1,86	1,07
2021	3,99	18,43	3,42	3,11	3,70	4,65	167,81	12,27	1,67	0,67
2022	7,60	12,77	5,01	7,32	3,52	3,26	181,33	11,09	2,56	0,48
Ortalama	8,52	21,37	2,55	9,18	6,23	2,45	80,78	9,85	1,29	0,52

\*Birleşik Arap Emirlikleri

\*\*Amerika Birleşik Devletleri

Çizelge 6'da Görelî İhracat Avantajı (RXA) indeks değerleri hesaplanmıştır. RXA indeks değeri bakımından önde gelen ülkeler arasında Arjantin, Avusturya, Kanada, Hindistan, Meksika, Rusya, Tanzanya, Türkiye ve Birleşik Arap Emirlikleri yer almaktadır. Bu ülkelerin yıllık ortalama RXA değerleri sırasıyla 8.92, 31.62, 2.68, 10.99, 7.18, 2.62, 83.10, 11.17 ve 1.30 olarak hesaplanmıştır. Bu bulgular doğrultusunda, söz konusu ülkelerin nohut ihracatında görelî bir avantaja sahip olduğu belirlenmiştir. Öte yandan, Amerika Birleşik Devletleri'nin (ABD) yıllık ortalama RXA değeri 0.50 olarak hesaplanmış ve nohut ihracatında avantajlı bir konumda olmadığı tespit edilmiştir. Türkiye'nin ise bu yıllarda RXA değerleri 1'in altına düşmemiş ve nohut ihracatı açısından rekabet avantajı sağladığı görülmektedir.

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Çizelge 6. Görelî İhracat Avantajı İndeksi (RXA)

Yıllar	Arjantin	Avusturya	Kanada	Hindistan	Meksika	Rusya	Tanzanya	Türkiye	BAE	ABD
2004	0,53	15,83	2,80	2,71	11,24	0,27	131,93	34,87	0,77	0,22
2005	0,45	17,23	2,11	8,78	10,14	0,26	151,89	32,92	0,73	0,36
2006	1,42	28,32	3,19	8,92	13,66	0,23	32,33	18,16	0,28	0,28
2007	1,56	20,48	3,32	27,60	10,15	0,46	93,96	10,76	1,15	0,33
2008	2,47	22,83	2,43	16,64	10,98	0,56	48,26	15,23	2,09	0,28
2009	3,69	37,75	2,97	9,52	11,46	0,94	31,42	14,19	1,94	0,33
2010	3,61	26,42	3,14	19,81	7,19	0,30	60,83	9,50	1,27	0,54
2011	13,27	21,23	3,02	18,08	4,01	2,61	46,94	5,31	0,80	0,55
2012	13,21	43,97	1,27	8,32	9,52	2,40	47,61	2,47	0,46	0,54
2013	11,24	26,12	1,69	25,67	6,40	2,22	43,60	2,01	0,99	0,52
2014	7,21	30,40	1,57	11,93	9,98	4,27	76,97	1,90	0,79	0,46
2015	7,09	79,49	1,95	7,37	4,20	5,06	64,71	1,42	0,97	0,25
2016	15,06	68,70	2,47	4,68	3,45	5,23	40,11	1,70	1,24	0,53
2017	21,03	72,41	2,48	3,25	3,33	2,53	28,53	1,40	1,37	0,70
2018	26,35	17,36	1,98	10,69	4,62	1,92	26,40	7,75	2,01	0,52
2019	11,39	15,41	2,85	5,18	4,50	6,56	144,63	12,19	1,69	0,89
2020	18,13	15,46	2,48	8,13	3,89	5,43	141,75	14,20	1,89	1,07
2021	4,04	25,37	3,63	3,23	3,94	5,07	176,24	13,87	1,69	0,66
2022	7,78	15,94	5,56	8,29	3,74	3,45	190,76	12,38	2,65	0,45
Ortalama	8,92	31,62	2,68	10,99	7,18	2,62	83,10	11,17	1,30	0,50

2004-2022 yılları arasında dünya nohut ihracatında önemli ülkelerin Açıklanmış Simetrik Karşılaştırmalı Üstünlük (RSCA) indeksi değerleri Çizelge 7’de irdelenmiştir. Açıklanmış Simetrik Karşılaştırmalı Üstünlük (RSCA) indeks değerleri 2004-2022 ortalamasına göre, öne çıkan ülkeler arasında Arjantin, Avusturya, Hindistan, Meksika, Tanzanya ve Türkiye yer almaktadır. Bu ülkelerin yıllık ortalama RSCA değerleri sırasıyla 0.58, 0.90, 0.75, 0.68, 0.96 ve 0.66 olarak hesaplanmış ve karşılaştırmalı rekabet avantajına sahip oldukları belirlenmiştir. Kanada, Rusya ve Birleşik Arap Emirlikleri’nin (BAE) yıllık ortalama RSCA değerleri ise sırasıyla 0.41, 0.18 ve 0.06 olarak hesaplanmıştır ve bu ülkelerin diğer ülkelere nazaran daha az derecede olsa da rekabet avantajına sahip oldukları tespit edilmiştir. Öte yandan, Amerika Birleşik Devletleri’nin (ABD) yıllık ortalama RSCA değeri -0.34 olarak belirlenmiş ve bu rekabet dezavantajına sahip olduğu saptanmıştır. Türkiye’nin yıllar içindeki karşılaştırmalı üstünlüğü incelendiğinde, RSCA değerinin ilgili dönemde sıfırın altına düşmediği, başka bir ifadeyle ihracat dezavantajlı pozisyonda değerlendirilmediği görülmüştür. Türkiye’nin rekabet avantajı genel olarak yüksek seviyede devam etmiş, ancak 2012-2017 döneminde bu avantaj yüksek olmasa da varlığını sürdürmüştür.



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**Çizelge 7. Açıklanmış Simetrik Karşılaştırmalı Üstünlük İndeksi (RSCA)**

Yıllar	Arjantin	Avusturalya	Kanada	Hindistan	Meksika	Rusya	Tanzanya	Türkiye	BAE	ABD
2004	-0,30	0,87	0,45	0,46	0,81	-0,56	0,98	0,93	-0,13	-0,61
2005	-0,38	0,87	0,34	0,78	0,79	-0,58	0,99	0,93	-0,15	-0,45
2006	0,17	0,91	0,50	0,78	0,83	-0,62	0,94	0,88	-0,56	-0,54
2007	0,22	0,89	0,51	0,91	0,79	-0,36	0,98	0,82	0,07	-0,48
2008	0,42	0,90	0,40	0,87	0,81	-0,28	0,96	0,86	0,35	-0,54
2009	0,57	0,93	0,48	0,79	0,81	-0,03	0,94	0,86	0,31	-0,48
2010	0,56	0,90	0,50	0,88	0,73	-0,53	0,97	0,80	0,12	-0,28
2011	0,85	0,88	0,48	0,87	0,58	0,43	0,96	0,67	-0,11	-0,27
2012	0,85	0,93	0,12	0,76	0,78	0,39	0,96	0,42	-0,36	-0,28
2013	0,83	0,90	0,25	0,90	0,70	0,36	0,95	0,33	0,00	-0,30
2014	0,75	0,91	0,21	0,82	0,79	0,59	0,97	0,31	-0,12	-0,35
2015	0,75	0,95	0,31	0,74	0,59	0,65	0,97	0,17	-0,01	-0,58
2016	0,87	0,95	0,41	0,63	0,53	0,66	0,95	0,26	0,10	-0,29
2017	0,90	0,95	0,41	0,52	0,52	0,42	0,93	0,16	0,15	-0,17
2018	0,92	0,87	0,32	0,80	0,62	0,31	0,93	0,76	0,33	-0,30
2019	0,83	0,85	0,46	0,66	0,61	0,71	0,99	0,83	0,25	-0,05
2020	0,89	0,86	0,41	0,76	0,57	0,67	0,99	0,85	0,30	0,03
2021	0,60	0,90	0,55	0,51	0,57	0,65	0,99	0,85	0,25	-0,19
2022	0,77	0,85	0,67	0,76	0,56	0,53	0,99	0,83	0,44	-0,36
Ortalama	0,58	0,90	0,41	0,75	0,68	0,18	0,96	0,66	0,06	-0,34

### SONUÇ VE ÖNERİLER

Bu çalışmada nohut ürününün küresel rekabet gücünün hesaplanmasında Balassa'nın Açıklanmış Karşılaştırmalı Üstünlük İndeksi, Vollrath'ın Görelî İhracat Avantajı İndeksi ve Laursen'in Açıklanmış Simetrik Karşılaştırmalı Üstünlük İndeksi kullanılmıştır. Hesaplamaya dahil edilen ülkelerin seçilmesinde ihracat miktarı ve değeri bakımından 2022 yılı verilerine göre önde gelen ülkeler tercih edilmiştir. Türkiye'nin, 2004-2022 dönemi ortalamasında bu üç indeks değeri için ayrı ayrı değerlendirildiğinde karşılaştırmalı üstünlüğe sahip olduğu saptanmıştır.

Türkiye her ne kadar nohut ihracatında karşılaştırmalı üstünlüğe sahip olsa da, 2004 yılı verileri baz alındığında ekim alanları ve üretim miktarının da düştüğü saptanmıştır. Bu düşüşle küresel rekabette sürdürülebilirlik risk altındadır. Dolayısıyla Türkiye nohut ihracatında rekabet avantajını daha da artırmak için üretimden pazarlamaya kadar bütüncül bir yaklaşımı sağlamalıdır. Yüksek kaliteli ve işlenmiş nohut ürünlerine yönelerek katma değer artırılabilir. Yeni hedef pazarlara ulaşmak için tanıtım faaliyetleri güçlendirilirken, modern tarım uygulamaları vb. yöntemlerle de üretim verimliliğini artırarak rekabet gücünü kaybetmemelidir.

Ayrıca uluslararası kalite standartlarına tam uyum sağlayarak, Türk nohutunu bir marka olarak küresel pazarda konumlandırıldığında, hem ekonomik getirisini hem de rekabet gücünü arttırabilecektir.

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**ÇİFT CİDARLI BACA SİSTEMLERİNDE ALTERNATİF TASARIMLARLA  
ENERJİ VERİMLİLİĞİ ANALİZİ**

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**Özet**

Binalardaki bacalarda enerji verimliliği, ısı kayıplarını azaltarak enerji tüketimini düşürme ve yakıt maliyetlerini minimize etme açısından büyük önem taşır. Enerji verimli bacalar, ısının maksimum oranda kullanılmasını sağlarken, çevreye zararlı emisyonları azaltır. Özellikle kış aylarında ısıtma sistemleri için kullanılan yakıt miktarını ve karbon ayak izini azaltan verimli baca sistemleri, sürdürülebilir bir enerji yönetimi için kritik rol oynar.

Bir binanın baca sistemi, sıcak gazları dışarıya taşıırken yeterince yalıtılmış değilse önemli miktarda ısı kaybına neden olabilir. Bu durum, kazan gibi ısıtma cihazlarının daha fazla çalışmasına yol açarak enerji tüketimini artırmaktadır. Çift cidarlı ve iyi yalıtılmış baca tasarımları, ısının bacadan dışarıya çıkmadan önce iç ortamda daha fazla kalmasına imkan tanımaktadır. Bu nedenle doğal gazı enerji kaynağı olarak kullanan sistemlerin baca malzemesinin seçiminde de enerji verimliliği açısından yüksek ısı tutma kapasitesine sahip çelik veya benzeri dayanıklı malzemeler tercih edilmektedir.

Bu çalışmada, İstanbul'da bulunan 80.000 kcal/h kapasiteye sahip doğal gaz kazanlı bir yazlık ev için enerji verimliliğini artırmak amacıyla bina içi ve dışı kullanıma uygun bir baca tasarımı gerçekleştirilmiştir. Çift cidarlı baca sistemi tasarımında, ana yapı malzemesi olarak paslanmaz çelik, kaynak yapılmış çelik, oluklu çelik ve flex çelik tercih edilmiştir. Çalışmada, bacanın ısı kaybını minimuma indirmek ve enerji verimliliğini artırmak amacıyla 30 mm, 40 mm ve 50 mm kalınlığında taş yünü yalıtım seçenekleri kullanılmıştır. Enerji yönetimi ve baca tasarım optimizasyonu için KesaAladin yazılımı kullanılmış ve farklı malzemelerle birlikte yalıtım kalınlığının bina içinde ve bina dışında tasarlanan baca performansı üzerindeki etkileri incelenmiştir.

**Anahtar kelimeler:** İstanbul ili, Baca tasarımı, KesaAladin simülasyon programı, Binalarda enerji verimliliği, Enerji performansı

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**ENERGY EFFICIENCY ANALYSIS WITH ALTERNATIVE DESIGNS IN DOUBLE  
WALLED CHIMNEY SYSTEMS**

**Abstract**

Energy efficiency in chimneys in buildings is of great importance in terms of reducing energy consumption and minimizing fuel costs by reducing heat losses. Energy-efficient chimneys ensure maximum use of heat while reducing emissions harmful to the environment. Efficient chimney systems, which reduce the amount of fuel used for heating systems and the carbon footprint, especially in the winter months, play a critical role in sustainable energy management.

If a building's chimney system is not sufficiently insulated while carrying hot gases outside, it can cause significant heat loss. This causes heating devices such as boilers to work more, increasing energy consumption. Double-walled and well-insulated chimney designs allow the heat to remain in the interior environment longer before exiting the chimney. For this reason, steel or similar durable materials with high heat retention capacity are preferred in terms of energy efficiency in the selection of chimney materials of systems that use natural gas as an energy source.

In this study, a chimney design suitable for indoor and outdoor use was carried out for a summer house with a natural gas boiler with a capacity of 80,000 kcal/h in Istanbul in order to increase energy efficiency. In the design of the double-walled chimney system, stainless steel, welded steel, corrugated steel and flex steel were preferred as the main structural material. In the study, 30 mm, 40 mm and 50 mm thick stone wool insulation options were used to minimize the heat loss of the chimney and increase energy efficiency. KesaAladin software was used for energy management and chimney design optimization and the effects of insulation thickness with different materials on the performance of the chimney designed inside and outside the building were examined.

**Keywords:** Istanbul province, Chimney design, KesaAladin simulation program, Energy efficiency in buildings, Energy performance

## 1 Giriş

Baca tasarımında yalıtım kalınlığı, enerji verimliliğini artırmada ve güvenli bir baca sistemi sağlamada kritik bir unsurdur. Bacadaki yalıtım, baca içinden geçen sıcak duman gazlarının çevreye ısı kaybetmesini önleyerek binanın enerji tüketimini azaltır. Yeterli yalıtım kalınlığı, sıcaklık farkını minimumda tutarak ısının sistem içinde kalmasını sağlar; böylece yakıt tüketimi düşer ve ısıtma sisteminin verimliliği artar [1, 2].

Yalıtım kalınlığı aynı zamanda bacanın yüzey sıcaklığını düşürerek çevredeki yapı malzemelerinin zarar görmesini ve yangın riskini azaltır. Özellikle yüksek sıcaklıkta çalışan sistemlerde, ince yalıtım katmanları ısı kaybını tam olarak engelleyemediğinden, baca dış yüzeyine yakın yerlerde aşırı ısınma ve yapısal hasarlar meydana gelebilir. Örneğin, 30 mm ile 50 mm arasındaki yalıtım farkı bile, ısı kaybını artırma ve azaltmada önemli bir etki yaratabilir[3-5]. Doğru yalıtım katmanları, bacanın iç yüzey sıcaklığını sabit tutmaya yardımcı olarak duman gazlarının yoğunlaşmasını ve yoğunlaşmadan kaynaklanan korozyonu önler. Bu nedenlerle, baca tasarımında optimum yalıtım kalınlığı seçimi hem enerji verimliliği hem de güvenlik açısından önemlidir. Uygun kalınlıkta yalıtım malzemesi kullanımı, uzun ömürlü ve çevre dostu bir baca sistemi sağlarken enerji maliyetlerini azaltarak ekonomik fayda sunar [6, 7].

Baca sistemlerinde kullanılan malzemeler arasında **paslanmaz çelik, kaynak yapılmış çelik, oluklu çelik ve flex çelik** baca sisteminin üretimde yüksek oranda kullanımda olan malzemelerdir.

Paslanmaz çelik, korozyona karşı dayanıklı, uzun ömürlü ve estetik bir malzemedir. Çelik alaşımında krom, nikel ve molibden gibi elementler bulunur. En önemli **avantajları arasında** yüksek sıcaklık dayanımı, korozyona karşı dirençli olması sayesinde hem iç hem de dış mekanlarda kullanılabilmesi sayılabilir. Baca malzemesi olarak paslanmaz çelik kullanıldığında pürüzsüz yüzeyi sayesinde kurum ve kir birikimi azaltılabilir bu da baca temizliğini kolaylaştırması açısından önemlidir. Katı, sıvı veya gaz yakıtlı sistemlerde ve modern ve endüstriyel tesislerde sıklıkla kullanılmaktadır.

Kaynakla birleştirilmiş çelik malzemeler, çeşitli kalınlık ve ebatlarda üretilerek dayanıklılık ve sızdırmazlık sağlamak için özel olarak tasarlanmaktadır. Bu malzemelerin ek yerlerinde sızdırmazlık sağlanır. Aşırı sıcaklık ve yüksek basınca dayanıklıdır. Bu malzeme özellikle büyük çaplı baca sistemlerinde tercih edilir. Endüstriyel kazan bacaları ve yüksek sıcaklık ve kimyasal gaz çıkışı olan yerlerde daha yoğun kullanılmaktadır.

Oluklu çelik baca malzemelerinin, iç yüzeyi dalgalı bir yapıya sahiptir. Bu yapı, mekanik dayanımı artırır ve esneklik sağlar. Bu esnek yapısı sayesinde dar alanlarda ve eğimli kurulumlarda kullanılabilir. Daha az malzeme ile daha hafif bir çözüm sunmaktadır. Aynı zamanda maliyeti de diğer bazı çelik türlerine göre daha düşüktür. Düşük ve orta sıcaklıklı sistemlerde ve sık sık yön değiştiren baca sistemlerinde kullanımı daha yaygındır.

Flex (**esnek**) çelik, özellikle esnekliği ile dikkat çeken bir baca malzemesidir. Genellikle ince paslanmaz çelikten üretilir. Zor erişilen alanlarda kurulum kolaylığı sağlamaktadır. Kurulumu için özel bir işleme gerek yoktur. Darbelere ve titreşimlere karşı dayanıklıdır. Özellikle bacaların restorasyonu ve tamiratında kullanılmaktadır. Dar ve zor erişimli baca sistemlerinde tercih edilmektedir.

Araştırmada kullanılan malzemelerin işletim süreci açısından karşılaştırmalı değerlendirmesi Tablo 1'de sunulmuştur.

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**Tablo 1.** Araştırmada kullanılan malzemelerin işletim süreci açısından karşılaştırmalı değerlendirmesi

Özellik	Çelik türü			
	Paslanmaz	Kaynak Yapılmış	Oluklu	Flex
<b>Dayanıklılık</b>	Yüksek	Çok Yüksek	Orta	Orta
<b>Kullanım Ömrü</b>	Uzun	Çok Uzun	Orta	Orta
<b>Kurulum Kolaylığı</b>	Orta	Düşük	Yüksek	Çok Yüksek
<b>Maliyet</b>	Orta-Yüksek	Yüksek	Düşük-Orta	Düşük-Orta
<b>Esneklik</b>	Düşük	Düşük	Yüksek	Çok Yüksek

Her bir malzemenin avantajları ve sınırlamaları, baca sistemlerinde kullanım yerlerini belirlemektedir. Bu çalışmada, bu kıyaslamayı derinleştirerek ve simülasyonla bir bölgede tasarlanan bir baca sistemi için analiz ederek enerji verimliliği açısından performanslarının değerlendirilmesi amaçlanmıştır.

Bu amaçla çalışmada, farklı baca malzemeleri ve yalıtım kalınlıklarının enerji verimliliği üzerindeki etkilerini inceleyerek en etkin baca tasarımı belirlemeyi amaçlanmaktadır. Baca tasarımında enerji kayıplarını azaltmak için ana yapı malzemesi olarak paslanmaz çelik, kaynak yapılmış çelik, oluklu çelik ve esnek çelik kullanılmıştır. Bu malzemeler, 30 mm, 40 mm ve 50 mm kalınlığında taş yünü yalıtım katmanlarıyla birleştirilmiş ve çeşitli kombinasyonlar halinde test edilmiştir.

## 2. Analiz sonuçları ve değerlendirmeler

Bina içi oval formu kesaAladin yazılımı değerlendirmeleri flex çelik boru baca için Tablo 1’de, kaynak yapılmış çelik baca için Tablo 2’de, oluklu çelik baca için Tablo 3’de, paslanmaz çelik baca için Tablo 4’de sunulmuştur. Bina dışı oval formu kesaAladin yazılımı değerlendirmeleri flex çelik boru baca için Tablo 5’de, kaynak yapılmış çelik baca için Tablo 6’de, oluklu çelik baca için Tablo 7’de, paslanmaz çelik baca için Tablo 8’de gösterilmiştir.

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**Tablo 1.** Bina içi oval formlu flex çelik boru baca için kesaAladin yazılımı değerlendirmeleri

Bina İçi- Oval Kesit Flex Çelik Boru	Flex Çelik Boru		
	30 mm yalıtım	40 mm yalıtım	50 mm yalıtım
Ağız Kesiti (mm)	177,6	175,3	173,7
Akım Hızı (m/s)	2,41	2,49	2,56
Atık Gaz Yoğunluğu (kg/m <sup>3</sup> )	1,014	0,993	0,974
Akım Sesi (dBA)	6,6	7,2	7,8
(-15) °C Rüzgar Hızı (m/s)	5,76	5,83	5,88
(+15) °C Rüzgar Hızı (m/s)	6,43	6,51	6,56
Durgun Basınç (Pascal)	88,7	93,3	97,2
Atık Gaz Hızı (m/s)	3,25	3,31	3,36
Azami Negatif Basınç (Pascal)	92,7	97,4	101,4
Atık Gaz Sıcaklık (°C)	160	162	164
İç Cidar Sıcaklık (°C)	143	146	150
Malzeme Sıcaklığı (°C)	143	146	150

**Tablo 2.** Bina içi oval formlu kaynak yapılmış çelik baca için kesaAladin yazılımı değerlendirmeleri

Bina İçi- Oval Kesit Kaynak Yapılmış Çelik	Kaynak Yapılmış Çelik		
	30 mm yalıtım	40 mm yalıtım	50 mm yalıtım
Ağız Kesiti (mm)	149,9	147,9	146,7
Akım Hızı (m/s)	2,91	3,01	3,09
Atık Gaz Yoğunluğu (kg/m <sup>3</sup> )	0,994	0,973	0,955
Akım Sesi (dBA)	10	10,6	11,2
(-15) °C Rüzgar Hızı (m/s)	6,82	6,91	6,96
(+15) °C Rüzgar Hızı (m/s)	7,61	7,71	7,77
Durgun Basınç (Pascal)	93	97,3	100,9
Atık Gaz Hızı (m/s)	3,87	3,94	3,99
Azami Negatif Basınç (Pascal)	98,6	103,1	106,8
Atık Gaz Sıcaklık (°C)	161	163	165
İç Cidar Sıcaklık (°C)	140	144	148
Malzeme Sıcaklığı (°C)	140	144	148

Tablo 1'dan Tablo 8'e kadar tüm tablolar birlikte değerlendirildiğinde akım hızı için en düşük değer bina içi 30 mm yalıtım ile flex çelik boru malzeme kullanıldığında 2,41 m/s olarak belirlenmiştir. Akım sesi açısından en düşük değer yine bina içi oval formlu bacada 30 mm yalıtım ile flex çelik boru malzeme kullanıldığında 6,6 dBA olarak analiz edilmiştir. -15 °C rüzgar hızı için en büyük değer 50 mm yalıtım ile bina dışı oval kesit paslanmaz çelik malzeme kullanıldığında 7 m/s ve +15 °C rüzgar hızı için yine aynı malzeme tasarım tipi kullanıldığında 7,81 m/s olarak belirlenmiştir. Durgun basınç değerinin en yüksek değeri de 50 mm yalıtım ile bina dışı oval kesit paslanmaz çelik malzeme kullanıldığında 102,2 Pa olarak bulunmuştur. Atık gaz hızı için ve azami negatif basınç için en yüksek değerler aynı tasarımla sırasıyla 4.01 m/s ve 108.2 Pa olarak tespit edilmiştir. Atık gaz sıcaklığı için en düşük değer bina içinde ve

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bina dışında her iki tasarım için de oval formlu bacada 30 mm yalıtım ile flex çelik boru malzeme kullanıldığında 160 °C olarak tespit edilmiştir. İç cidar sıcaklığı ve malzeme sıcaklığının en yüksek değeri 50 mm yalıtım ile bina dışı oval kesit için kaynak yapılmış çelik, oluklu çelik ve paslanmaz çelik malzemelerle 149 °C olarak analiz edilmiştir.

**Tablo 3.** Bina içi oval formlu oluklu çelik baca için kesit yazılımı değerlendirmeleri

Bina İçi- Oval Kesit Oluklu Çelik	Oluklu Çelik		
	30 mm yalıtım	40 mm yalıtım	50 mm yalıtım
Ağız Kesiti (mm)	160,2	158,1	156,8
Akım Hızı (m/s)	2,7	2,79	2,87
Atık Gaz Yoğunluğu (kg/m <sup>3</sup> )	1,003	0,982	0,964
Akım Sesi (dBA)	8,6	9,3	9,8
(-15) °C Rüzgar Hızı (m/s)	6,39	6,46	6,52
(+15) °C Rüzgar Hızı (m/s)	7,13	7,21	7,28
Durgun Basınç (Pascal)	91,1	95,5	99,2
Atık Gaz Hızı (m/s)	3,61	3,68	3,72
Azami Negatif Basınç (Pascal)	96	100,5	104,3
Atık Gaz Sıcaklık (°C)	161	163	164
İç Cidar Sıcaklık (°C)	142	146	148
Malzeme Sıcaklığı (°C)	142	146	148

**Tablo 4.** Bina içi oval formlu paslanmaz çelik baca için kesit yazılımı değerlendirmeleri

Bina İçi- Oval Kesit Paslanmaz Çelik	Paslanmaz Çelik		
	30 mm yalıtım	40 mm yalıtım	50 mm yalıtım
Ağız Kesiti (mm)	150	148,3	146,7
Akım Hızı (m/s)	2,89	3	3,09
Atık Gaz Yoğunluğu (kg/m <sup>3</sup> )	0,999	0,973	0,955
Akım Sesi (dBA)	9,8	10,6	11,2
(-15) °C Rüzgar Hızı (m/s)	6,78	6,88	6,96
(+15) °C Rüzgar Hızı (m/s)	7,56	7,68	7,77
Durgun Basınç (Pascal)	93,5	97,3	100,9
Atık Gaz Hızı (m/s)	3,85	3,93	3,99
Azami Negatif Basınç (Pascal)	99,1	103	106,8
Atık Gaz Sıcaklık (°C)	161	163	165
İç Cidar Sıcaklık (°C)	140	144	148
Malzeme Sıcaklığı (°C)	140	144	148



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**Tablo 5.** Bina dışı oval formulu flex çelik boru baca için kesaAladin yazılımı değerlendirmeleri

Bina Dışı- Oval Kesit Flex Çelik Boru	Flex Çelik Boru		
	30 mm yalıtım	40 mm yalıtım	50 mm yalıtım
Ağız Kesiti (mm)	152,2	150,3	148,8
Akım Hızı (m/s)	2,91	3,03	3,12
Atık Gaz Yoğunluğu (kg/m <sup>3</sup> )	0,979	0,953	0,933
Akım Sesi (dBA)	10	10,8	11,4
(-15) °C Rüzgar Hızı (m/s)	6,72	6,81	6,86
(+15) °C Rüzgar Hızı (m/s)	7,5	7,6	7,66
Durgun Basınç (Pascal)	92,4	97,5	101,1
Atık Gaz Hızı (m/s)	3,8	3,87	3,92
Azami Negatif Basınç (Pascal)	97,8	103,1	106,8
Atık Gaz Sıcaklık (°C)	160	162	164
İç Cidar Sıcaklık (°C)	139	144	148
Malzeme Sıcaklığı (°C)	139	143	148

**Tablo 6.** Bina dışı oval formulu kaynak yapılmış çelik baca için kesaAladin yazılımı değerlendirmeleri

Bina Dışı- Oval Kesit Kaynak Yapılmış Çelik	Kaynak Yapılmış Çelik		
	30 mm yalıtım	40 mm yalıtım	50 mm yalıtım
Ağız Kesiti (mm)	149,5	147,8	146,3
Akım Hızı (m/s)	2,96	3,07	3,18
Atık Gaz Yoğunluğu (kg/m <sup>3</sup> )	0,979	0,954	0,932
Akım Sesi (dBA)	10,3	11,1	11,8
(-15) °C Rüzgar Hızı (m/s)	6,83	6,91	6,99
(+15) °C Rüzgar Hızı (m/s)	7,63	7,71	7,8
Durgun Basınç (Pascal)	92,6	97,5	101,5
Atık Gaz Hızı (m/s)	3,88	3,94	4
Azami Negatif Basınç (Pascal)	98,2	103,3	107,4
Atık Gaz Sıcaklık (°C)	161	163	165
İç Cidar Sıcaklık (°C)	140	145	149
Malzeme Sıcaklığı (°C)	140	145	149

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**Tablo 7.** Bina dışı oval formulu oluklu çelik baca için kesaladin yazılımı değerlendirmeleri

Bina Dışı- Oval Kesit Oluklu Çelik	Oluklu Çelik		
	30 mm yalıtım	40 mm yalıtım	50 mm yalıtım
Ağız Kesiti (mm)	159,6	157,3	155,6
Akım Hızı (m/s)	2,75	2,87	2,96
Atık Gaz Yoğunluğu (kg/m <sup>3</sup> )	0,958	0,959	0,939
Akım Sesi (dBA)	9	9,9	10,5
(-15) °C Rüzgar Hızı (m/s)	6,41	6,49	6,55
(+15) °C Rüzgar Hızı (m/s)	7,15	7,24	7,32
Durgun Basınç (Pascal)	90,8	96,5	100,1
Atık Gaz Hızı (m/s)	3,63	3,7	3,75
Azami Negatif Basınç (Pascal)	95,7	101,6	105,3
Atık Gaz Sıcaklık (°C)	161	163	164
İç Cidar Sıcaklık (°C)	141	146	149
Malzeme Sıcaklığı (°C)	141	146	149

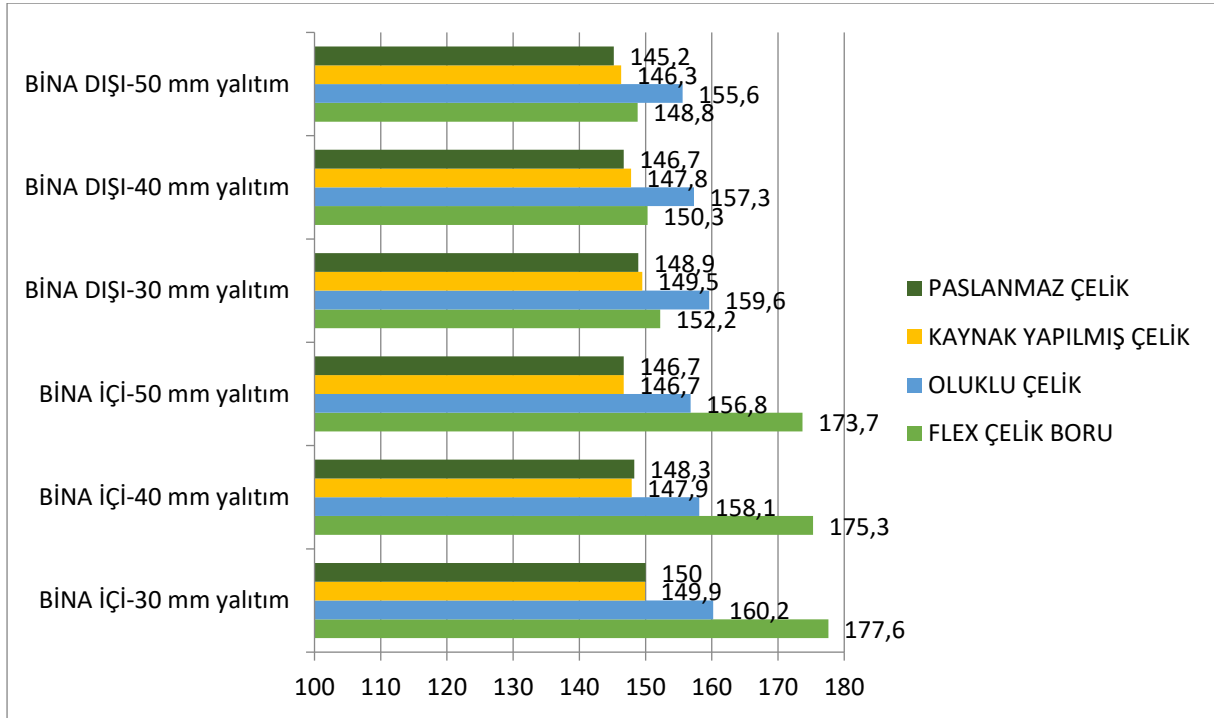
**Tablo 8.** Bina dışı oval formulu paslanmaz çelik baca için kesaladin yazılımı değerlendirmeleri

Bina Dışı- Oval Kesit Çelik	Paslanmaz	Paslanmaz Çelik		
		30 mm yalıtım	40 mm yalıtım	50 mm yalıtım
Ağız Kesiti (mm)		148,9	146,7	145,2
Akım Hızı (m/s)		2,96	3,09	3,19
Atık Gaz Yoğunluğu (kg/m <sup>3</sup> )		0,984	0,957	0,935
Akım Sesi (dBA)		10,3	11,2	11,8
(-15) °C Rüzgar Hızı (m/s)		6,84	6,94	7
(+15) °C Rüzgar Hızı (m/s)		7,63	7,74	7,81
Durgun Basınç (Pascal)		93	98,2	102,2
Atık Gaz Hızı (m/s)		3,87	3,95	4,01
Azami Negatif Basınç (Pascal)		98,6	104	108,2
Atık Gaz Sıcaklık (°C)		161	163	165
İç Cidar Sıcaklık (°C)		140	145	149
Malzeme Sıcaklığı (°C)		140	145	149

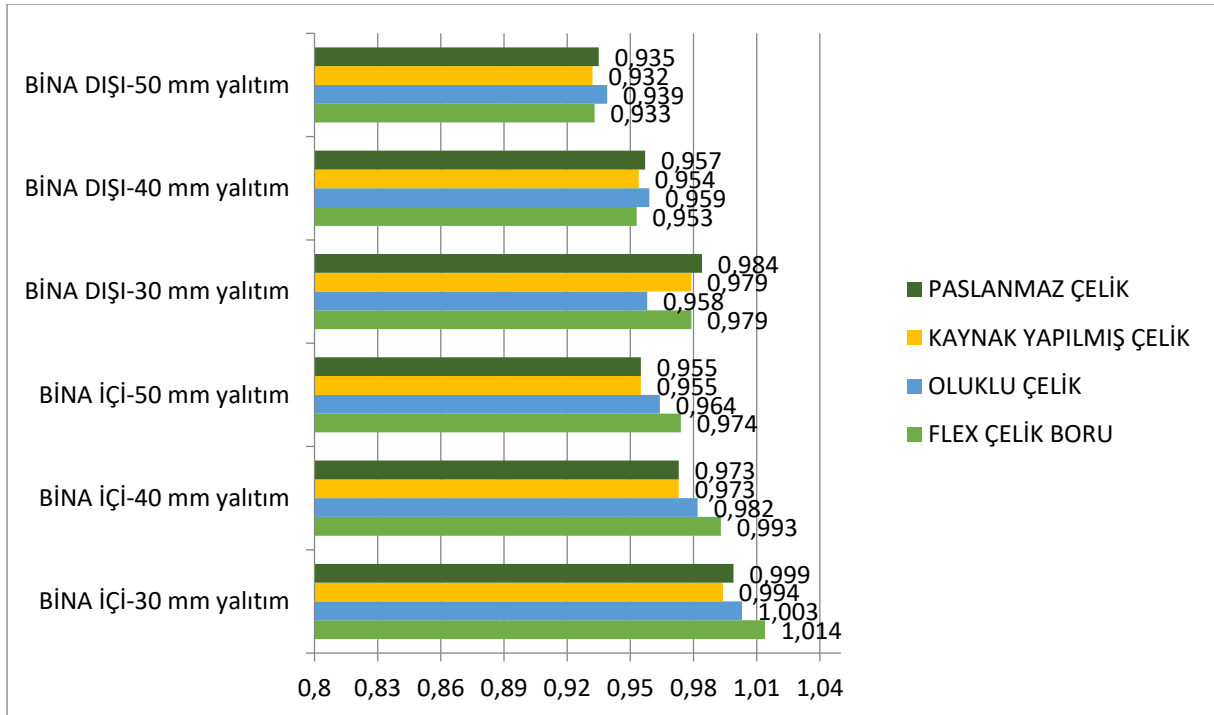
Baca ağız kesiti açısından en yüksek değer bina içi oval formulu bacada 30 mm yalıtım kullanılarak flex çelik boru malzeme ile 177.6 mm olarak elde edilmiştir (Şekil 1). Enerji performansı açısından en önemli değerlendirme parametrelerinden biri atık gaz yoğunluğudur. Bu parametre incelendiğinde bina içi oval formulu bacada 30 mm yalıtım kullanılarak flex çelik boru malzeme ile en yüksek atık gaz yoğunluğu 1,014 kg/m<sup>3</sup> olarak analiz edilmiştir (Şekil 2).

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Őekil 1. Baca ağız kesiti grafiksel görünümü



Őekil 2. Atık gaz yoğunluđu grafiksel görünümü

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**3. Sonuç**

Analiz sonuçlarına göre, taş yünü kalınlığının değişmesiyle ısı kayıplarının ve baca verimliliğinin değişimi ve farklı çelik malzemelerinin baca performansına etkisi bina içi ve bina dışı baca sistemleri için değerlendirilmiştir. İstanbul ili şartlarında tasarlanan sistemde bina içinde, 50 mm kalınlığında taş yünü yalıtımı ile kaynak yapılmış çelik boru malzeme kombinasyonunun, ısı kaybını minimize ettiği ve en yüksek enerji verimliliğini sağladığı tespit edilmiştir.

Enerji analizlerinde, daha kalın yalıtım katmanlarının ısı kaybını azalttığı ve baca performansını artırdığı tespit edilmiştir. Özellikle 50 mm taş yünü yalıtımı, yüksek ısı tutuculuğu ile enerji verimliliğini maksimum seviyeye çıkarmıştır. Ayrıca, çelik gibi dayanıklı malzemelerle yapılan bacaların daha düşük enerji kaybına yol açtığı gözlemlenmiştir.

Sonuçlar, hem malzeme seçiminin hem de yalıtım kalınlığının baca verimliliği üzerindeki etkisini ortaya koymakta olup, enerji verimli baca tasarımları için uygun malzeme ve yalıtım kalınlığı kombinasyonlarının önemini vurgulamaktadır. Bu bulgular, özellikle kış aylarında enerji maliyetlerini azaltmak ve çevresel sürdürülebilirliği desteklemek adına önem taşımaktadır.

**TEŞEKKÜR**

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**KAYNAKLAR**

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**9<sup>TH</sup> INTERNATIONAL CONFERENCE ON GLOBAL PRACTICE OF  
MULTIDISCIPLINARY SCIENTIFIC STUDIES**

**January 21-28, 2025 / Havana, CUBA**

**ÇEVRESEL KİRLİLİĞİNİN YÖNETİMİ İÇİN KÖMÜRLÜ KAZAN KULLANAN  
ENDÜSTRİYEL TESİSLERDE OPTİMAL BACA TASARIMI**

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**Özet**

Binalarda enerji verimli baca kullanımı, hem ekonomik hem de çevresel sürdürülebilirlik açısından hayati bir öneme sahiptir. Enerji verimli baca tasarımı, konfor seviyesini artırır ve uzun vadede bakım maliyetlerini düşürür. Enerji verimli bacalar, daha az enerji tükettiği için ve daha az miktarda enerji kaynağı kullanılarak işletilebildiği için atmosfere daha az emisyon atılmasına sebep olmaktadır. Özellikle kömür gibi katı yakıtlı enerji kaynağı olarak kullanan kazanlara bağlantılı baca sistemleri doğru tasarlanmadığında daha fazla hava kirliliğine neden olabilmektedir. Bu manada, çevre yönetiminde baca tasarımıyla salınan emisyonları azaltmak, çevreyi korumak açısından önemli bir rol oynar. Salınan emisyonlar, özellikle fosil yakıtların kullanıldığı endüstriyel tesislerde, enerji santrallerinde ve ısınma amaçlı büyük binalarda büyük bir çevresel etki yaratır. Bu durum, aynı zamanda işletme maliyetlerini artırır ve çevre üzerinde uzun vadeli olumsuz etkiler bırakır. Doğru tasarlanmış bir baca, kirleticilerin atmosfere daha az salınmasını sağlayarak hava kalitesini iyileştirir ve karbon ayak izini de azaltır. Verimli bir baca sistemi, hem çevre dostu bir yapı sağlarken hem de sürdürülebilir enerji yönetimi hedeflerine katkıda bulunur.

Bu çalışmada, Elazığ ilinde faaliyet gösteren bir un üretim binasının ısı enerjisi ihtiyacını karşılamak için çalıştırılan 200 000 kcal/h kapasiteli bir kömürlü kazanla irtibatlandırılan bir baca sistemi planlanmıştır. Kırmızı tuğla beton, şamot form parçaları, şamot form taşı, ve beton form taşı olmak üzere dört farklı baca malzemesi kullanılarak tasarlanan sistem kare form ve dikdörtgen form olmak üzere iki değişik kesitte modellenmiştir. Planlanan baca sisteminin hem bina içinde hem de bina dışında tasarlanması durumunda çevre kirliliğine olan olumsuz etkileri analiz edilerek, çevre kirliliğinin yönetimine en uygun baca bileşenleriyle elde edilebilecek tasarım araştırılmıştır.

**Anahtar kelimeler:** Baca tasarımı, Elazığ ili, KesaAladin yazılımı, Çevre kirliliği, Çevre yönetimi

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**OPTIMAL CHIMNEY DESIGN IN INDUSTRIAL FACILITIES USING COAL  
BOILERS FOR THE MANAGEMENT OF ENVIRONMENTAL POLLUTION**

**Abstract**

The use of energy-efficient chimneys in buildings is of vital importance in terms of both economic and environmental sustainability. Energy-efficient chimney designs increase comfort levels and reduce maintenance costs in the long term. Energy-efficient chimneys cause fewer emissions to be released into the atmosphere because they consume less energy and can be operated using fewer energy sources. In particular, chimney systems connected to boilers that use solid fuels such as coal as an energy source can cause more air pollution when not designed correctly. In this sense, reducing emissions released with chimney design in environmental management plays an important role in protecting the environment. Emissions released create a major environmental impact, especially in industrial facilities, power plants and large buildings where fossil fuels are used for heating purposes. This also increases operating costs and leaves long-term negative effects on the environment. A correctly designed chimney improves air quality by ensuring that pollutants are released less into the atmosphere and reduces the carbon footprint. An efficient chimney system both provides an environmentally friendly structure and contributes to sustainable energy management goals. In this study, a chimney system connected to a 200,000 kcal/h capacity coal boiler operating to meet the heat energy needs of a flour production building operating in Elaziğ province was planned. The system designed using four different chimney materials, namely crushed brick concrete, chamotte form pieces, chamotte form stone, and concrete form stone, was modeled in two different sections as square form and rectangular form. The negative effects of the planned chimney system on environmental pollution in case of designing both inside and outside the building were analyzed and the design that could be obtained with the most suitable chimney components for environmental pollution management was investigated.

**Keywords:** Chimney design, Elaziğ province, KesaAladin software, Environmental pollution, Environmental management

## 1 Giriş

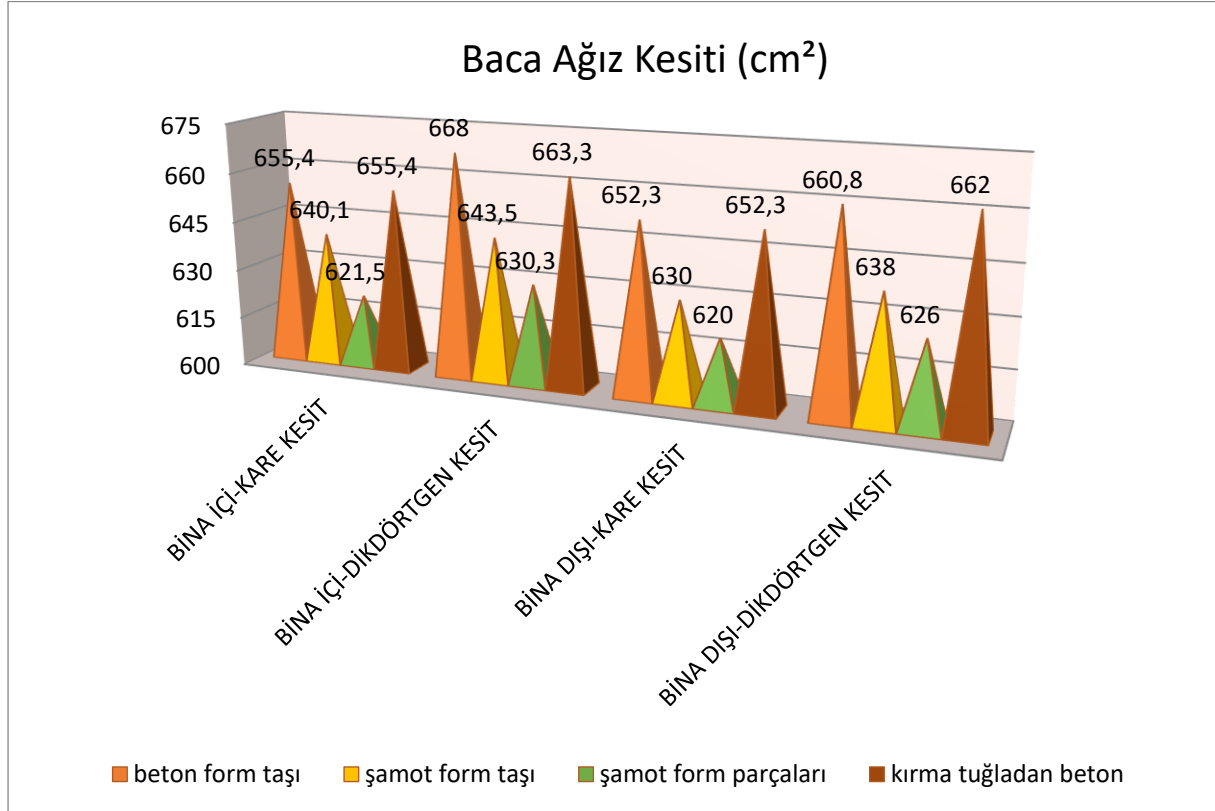
Çevre yönetiminde doğru baca tasarımı, enerji verimliliğini ve hava kalitesini artırmak için temel bir unsurdur. Bu amaçla birçok farklı yöntem başvurulmaktadır [1, 2]. Örneğin, bacaların duman gazı filtrasyonuna yönelik sistemlerle entegre edilmesi çevre yönetimi açısından büyük avantaj sağlar. Filtrasyon sistemleri, duman gazlarındaki partikül maddeleri, kükürt ve azot oksit gibi kirleticileri filtreleyerek dışarıya daha temiz bir gaz çıkışı sağlamaya olanak tanıyabilmektedir. Bu da hava kirliliğini azaltarak insan sağlığına olan olumsuz etkileri minimuma indirebilmektedir. Baca tasarımında kullanılan malzemeler, baca formu ve sistemin verimliliği gibi unsurlar da çevre dostu bir enerji yönetim sistemi oluşturulmasında önemlidir. Enerji verimli bir baca tasarımı, ısı kayıplarını minimize ederek yakıt tüketimini azaltır ve böylece daha az zararlı gazın atmosfere salınmasına yardımcı olur. Yeterince yalıtılmamış veya verimli tasarlanmamış bacalar ise yüksek miktarda ısı kaybına yol açar ve daha fazla yakıt kullanılarak çevreye zarar verir. Bu nedenle baca sistemlerinin optimal düzeyde tasarlanması önemlidir. Optimum baca tasarımı, baca performansını ve sistem verimliliğini artırarak hem enerji tasarrufu sağlar hem de çevresel etkiyi minimuma indirebilir. Optimum baca tasarımında dikkate alınması gereken özelliklerden biri doğru baca boyutu ve baca yüksekliğinin belirlenmesidir. Bacanın çapı ve yüksekliği, yakıt türüne, yanma odası kapasitesine ve hava akışı gereksinimlerine göre belirlenmektedir. Yeterli yüksekliğe sahip bir baca, dumanın güvenli bir şekilde yayılmasını sağlayabilir. Çok kısa bacalar, dumanın hızlı bir şekilde yayılmasını engelleyebilir ve zararlı gazların iç ortama geri dönmesine neden olabilir. Aynı şekilde bacanın çapı, yanma sonucu oluşan gaz miktarına uygun olarak seçilmelidir. Dar veya geniş bir çap, hava akışını etkileyerek verimsiz yanma ve enerji kaybına neden olabilmektedir. Benzer şekilde yüksek kaliteli yalıtım malzemeleri ile yalıtılan bir baca, ısı kaybını minimuma indirir ve baca yüzeylerinde yoğunlaşmayı önler [3-5]. Yalıtım ayrıca, baca içinde sıcaklığın korunmasını sağlar ve baca gazlarının soğumasını önleyerek daha verimli bir hava çekişi sağlayabilir. Baca sisteminde doğru malzeme seçimi de çevresel kirliliğin yönetimini etkileyen önemli bir parametredir. Baca malzemesi, yanma sonucu oluşan gazların sıcaklığına ve kimyasal yapısına dayanıklı olmalıdır. Paslanmaz çelik, seramik veya cam gibi dayanıklı malzemeler, hem ısıya hem de korozyona karşı dirençli olup uzun ömürlü bir kullanım sunar. Yüksek sıcaklık ve kimyasal dayanıklılığa sahip malzemeler seçilerek baca içindeki asitli duman gazlarının neden olabileceği yıpranma önlenir. Bir diğer seçenek ısı geri kazanım sistemleridir. Bu sistemler baca gazlarındaki atık ısıyı tekrar kullanılabilir enerjiye dönüştürerek toplam enerji verimliliğini artırabilen sistemlerdir. Bu sistemler, özellikle sanayi ve büyük kazanlarda yaygındır ve enerji maliyetlerini azaltmak için idealdir. Bacalar için çekiş kontrol sistemleri, bacadaki hava akışını izleyerek duman gazlarının uygun hızda tahliye edilmesini sağlayabilmektedir. Bu kontrol, dumanın güvenli şekilde dışarı atılmasına yardımcı olmakta ve enerji kaybını önleyebilmektedir. Otomatik kontrol sistemleriyle baca çekişi optimize edilerek gereksiz enerji kayıpları önlenmektedir. Yine yoğunlaşmalı kazanlarda kullanılan bacalarda yoğunlaşma nedeniyle asidik su oluşabilir. Bacaya eklenen yoğunlaşma kontrolü ve drenaj sistemi, suyun tahliyesini sağlayarak baca içi korozyon ve tıkanma riskini azaltabilmektedir. Bu sistem, baca ömrünü uzatır ve bakım ihtiyacını azaltır. Ayrıca endüstriyel kazanlarda, baca gazlarında bulunan zararlı gazları ve partikülleri filtreleyen veya arıtan emisyon kontrol sistemleri de kullanılabilir. Partikül filtreleri, kükürt tutucu sistemler ve elektrostatik çöktürücüler gibi filtreler, çevreye salınan kirletici gazlarını azaltabilir. Bacaların tıkanma ve korozyon gibi sorunları önlemek için düzenli bakım ve temizlik yapılmalıdır. Bacanın iç yüzeyinde biriken kurum ve partiküller, çekişi azaltarak dumanın yeterince dışarı



atılmasını engelleyebilir. Düzenli bakım, optimum baca performansını korumaya yardımcı olabilmektedir [6-8].

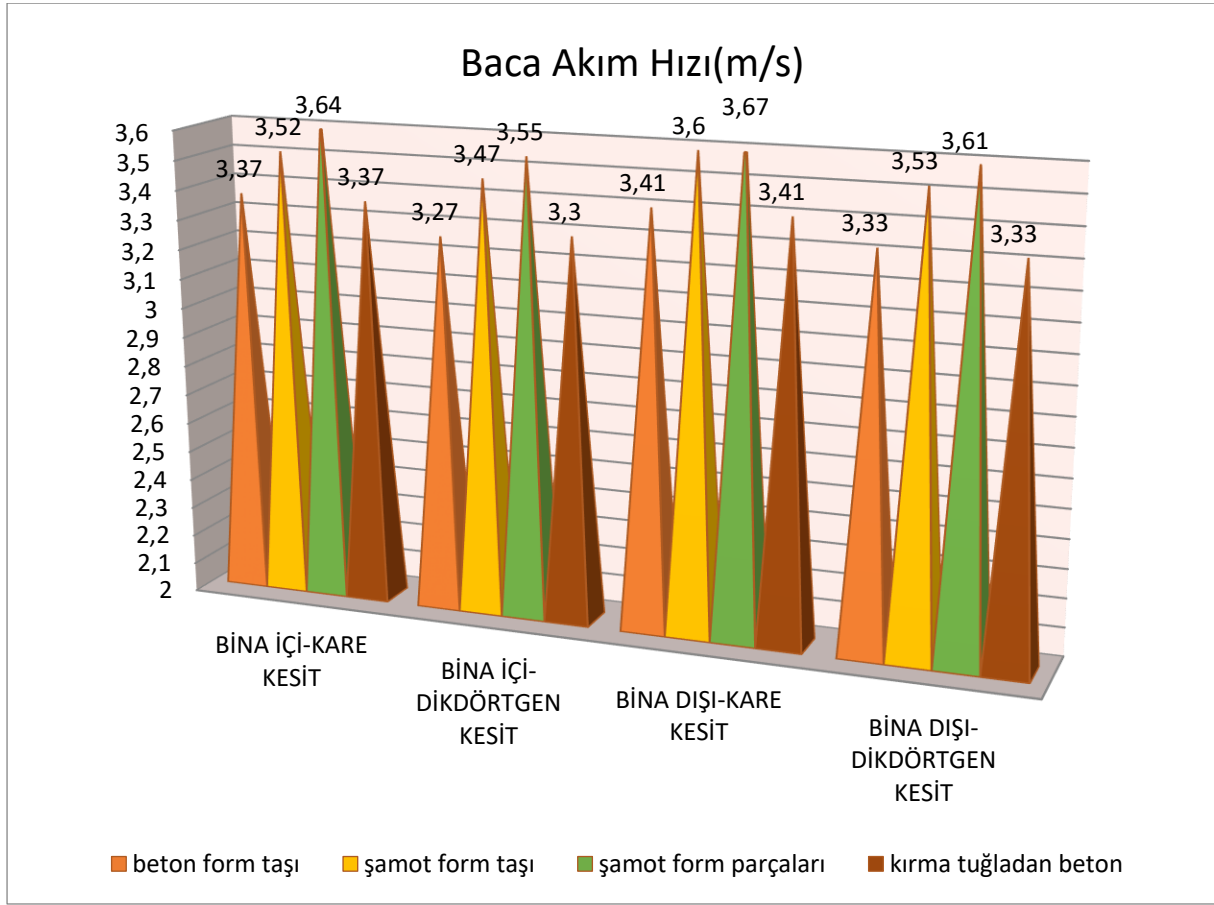
Bu çalışmada, KesaAladin yazılımı kullanılarak 200 000 kcal/h kapasiteli bir kömürlü kazanla irtibatlandırılan bir baca sisteminin uygun bileşenlerle optimal tasarım parametreleri belirlenmeye çalışılmıştır.

## 2. Analiz sonuçları ve değerlendirmeler



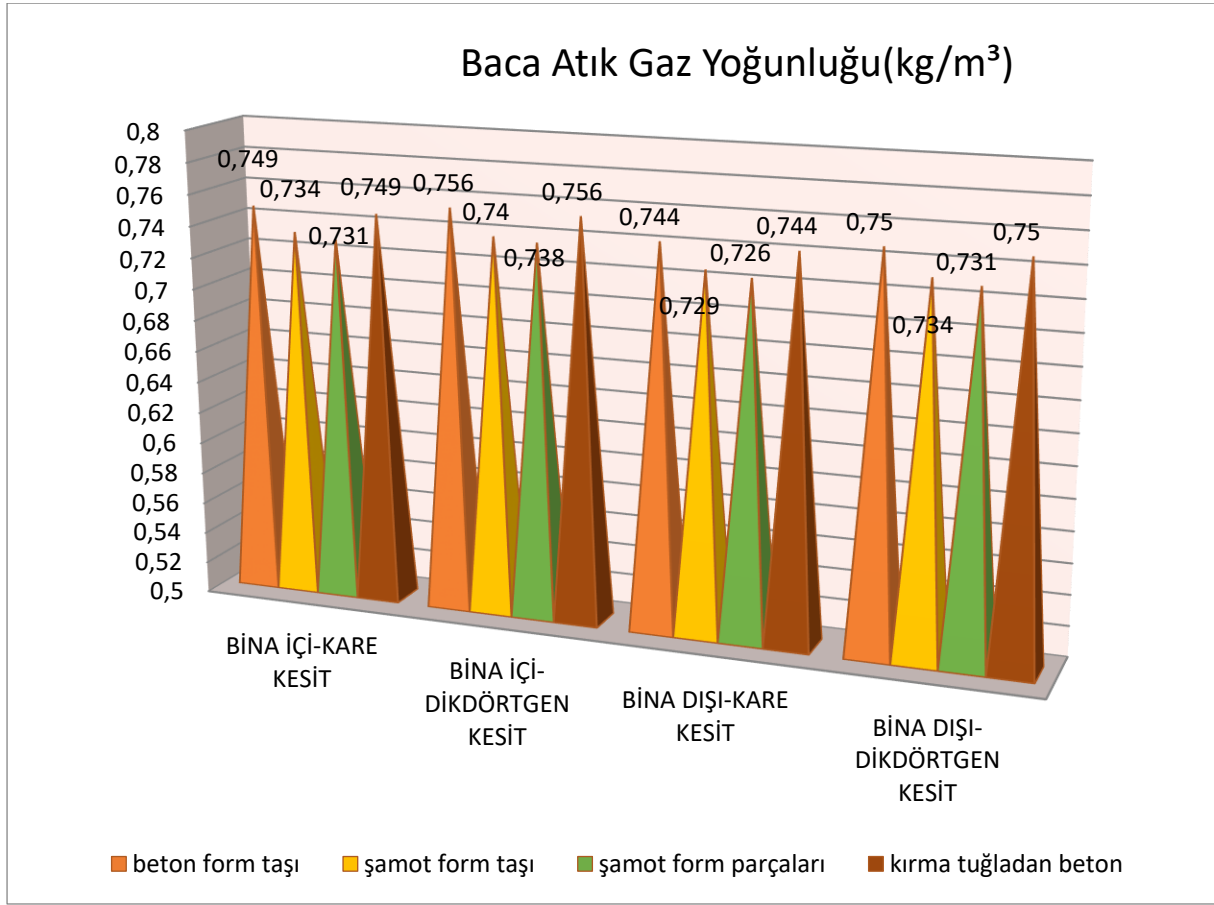
Şekil 1. Baca ağız kesiti

Baca ağız kesiti kıyası Şekil 1’de sunulmuştur. En yüksek baca ağız kesiti bina içi dikdörtgen kesit beton form taşı malzeme ile 668 cm<sup>2</sup> olarak elde edilmiştir. En küçük baca ağız kesiti değeri bina dışı kare formülü bacada şamot form parçaları malzeme ile 620 cm<sup>2</sup> olarak belirlenmiştir.



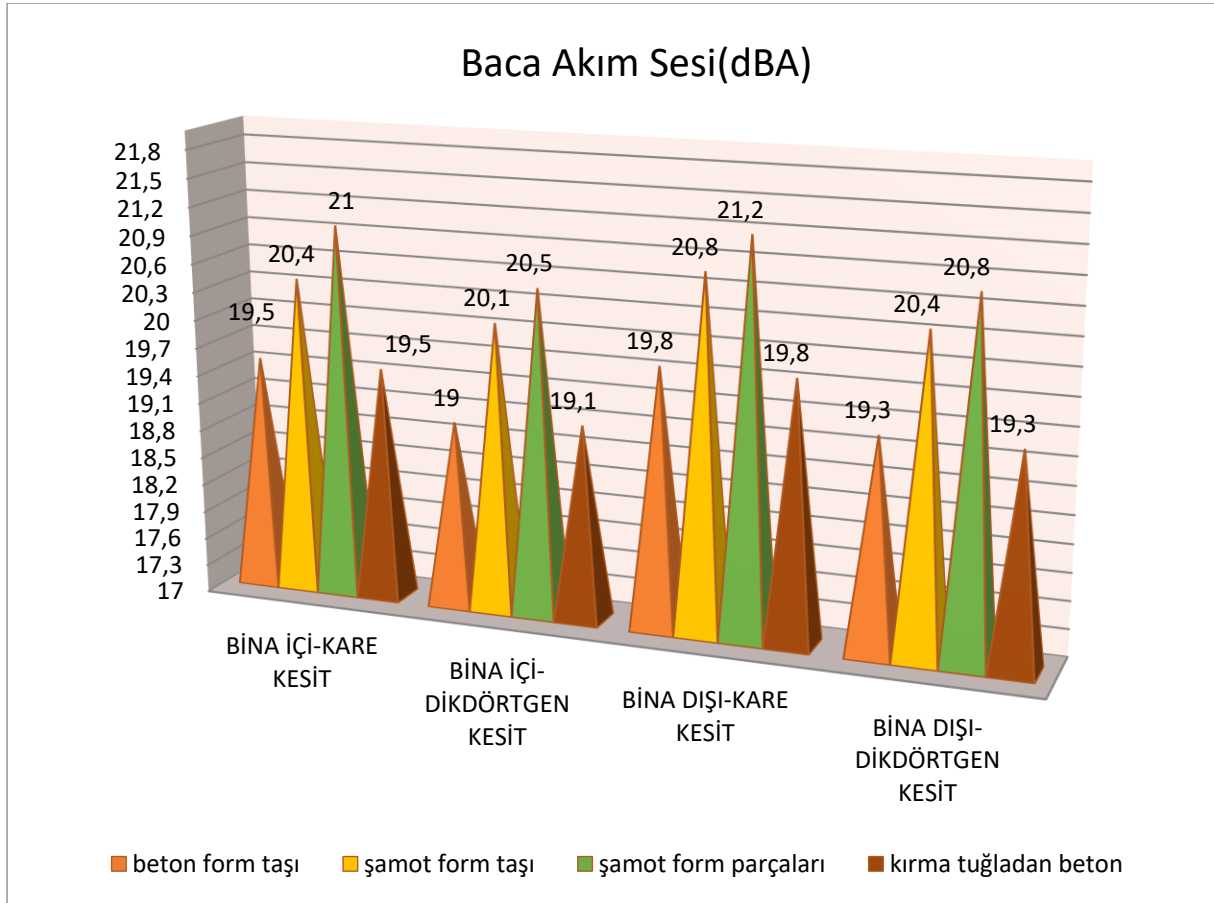
Şekil 2. Baca akım hızı

Baca akım hızı kıyası Şekil 2’de gösterilmiştir. Baca akımı hızının en yüksek değerleri şamot form parçaları malzeme ile bina dışı kare formda bacada 3.67 m/s ve bina içi kare formda bacada 3.64 m/s olarak belirlenmiştir.



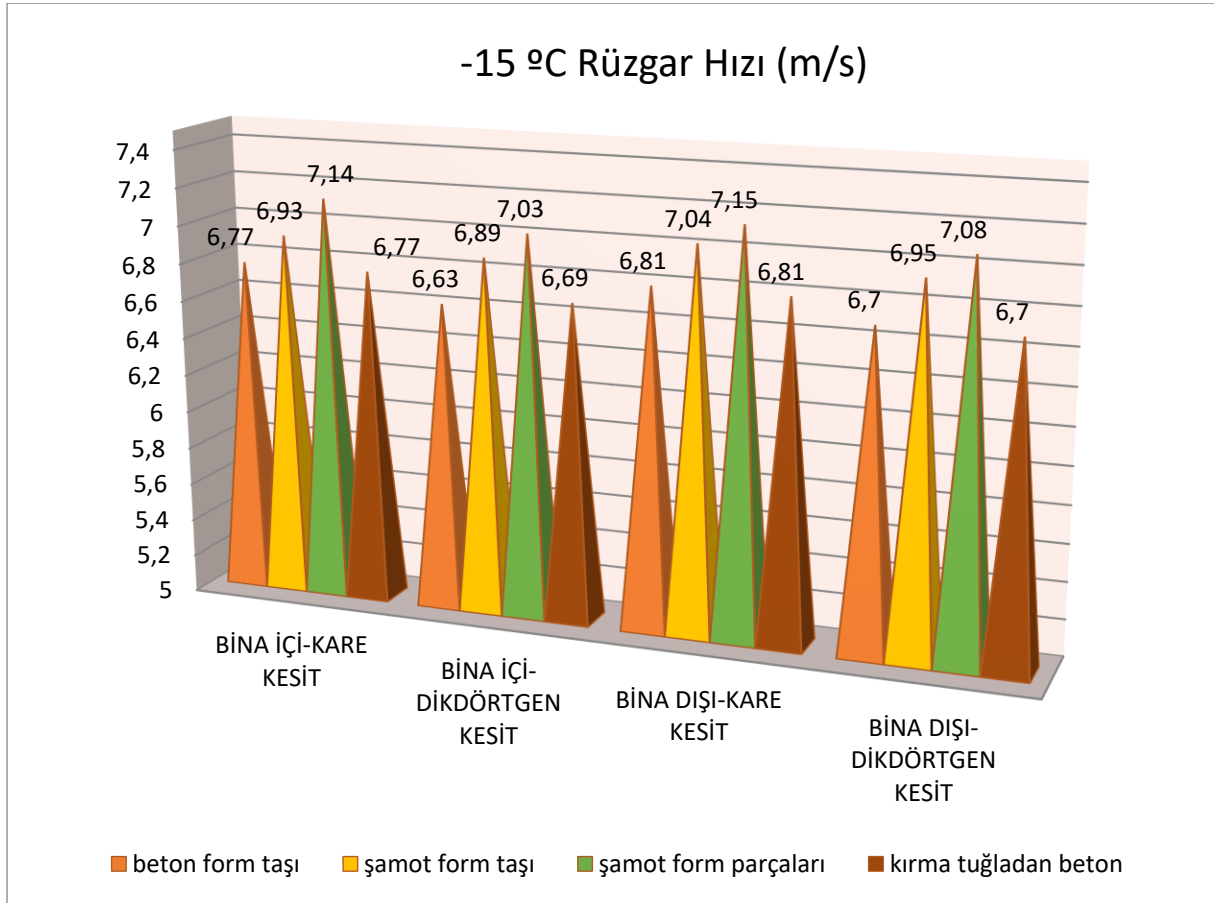
**Şekil 3.** Baca atık gaz yoğunluğu

Baca atık gazın yoğunluk kıyası Şekil 3’de verilmiştir. Baca atık gazının en düşük yoğunluk değerleri bina dışı kare formlu bacada şamot form parçaları malzeme ile 0.726 kg/m<sup>3</sup> ve şamot form taşı malzeme ile 0.729 kg/m<sup>3</sup> olarak rapor edilmiştir.



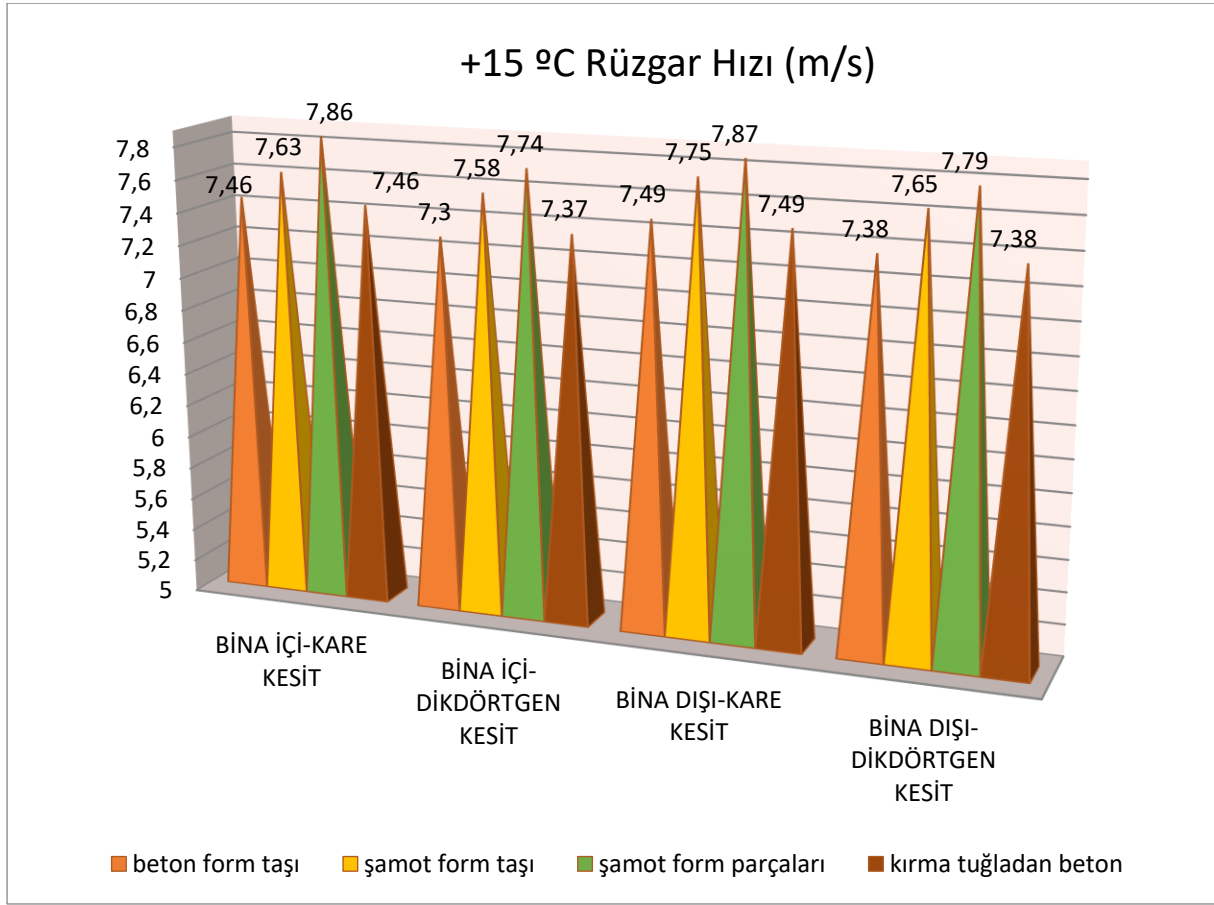
**Şekil 4.** Baca akım sesi

Baca akımı sesinin kıyası Şekil 4’de gösterilmiştir. Baca akımı sesinin en yüksek değerleri, bina içi kare formlu bacada şamot form parçaları malzeme ile 21.2 dBA ve bina içi kare formlu bacada şamot form parçaları malzeme ile 21 dBA olarak bulunmuştur.



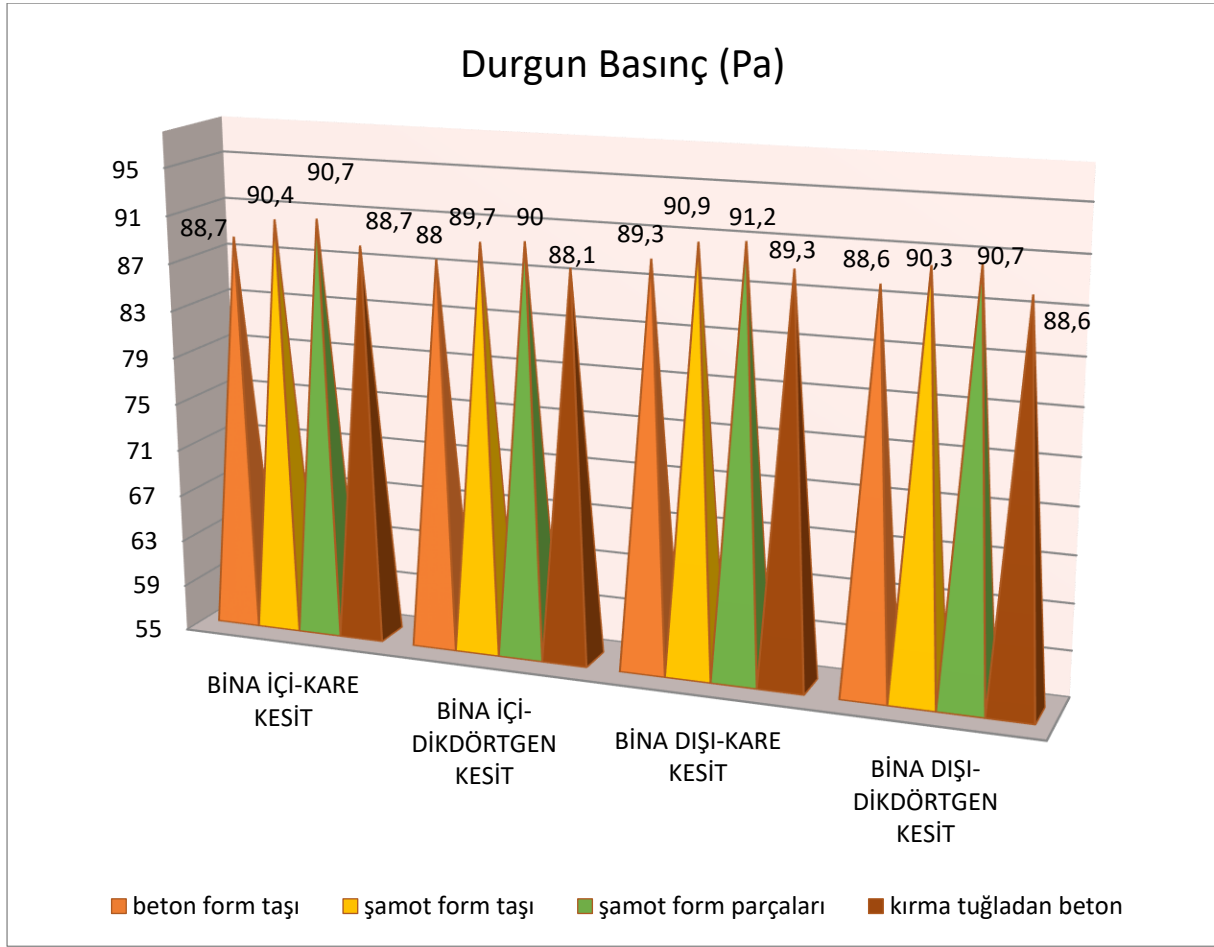
Şekil 5. Baca -15°C rüzgar hızı

Baca -15°C’de rüzgarın hız kıyası Şekil 5’de sunulmuştur. -15°C’de rüzgarın en yüksek hız değeri bina dışı kare formlu bacada şamot form parçaları malzeme ile 7.15 m/s olarak bulunmuştur. En düşük değer ise bina içi dikdörtgen formlu bacada beton form taşı malzeme ile 6.63 m/s olarak tespit edilmiştir.



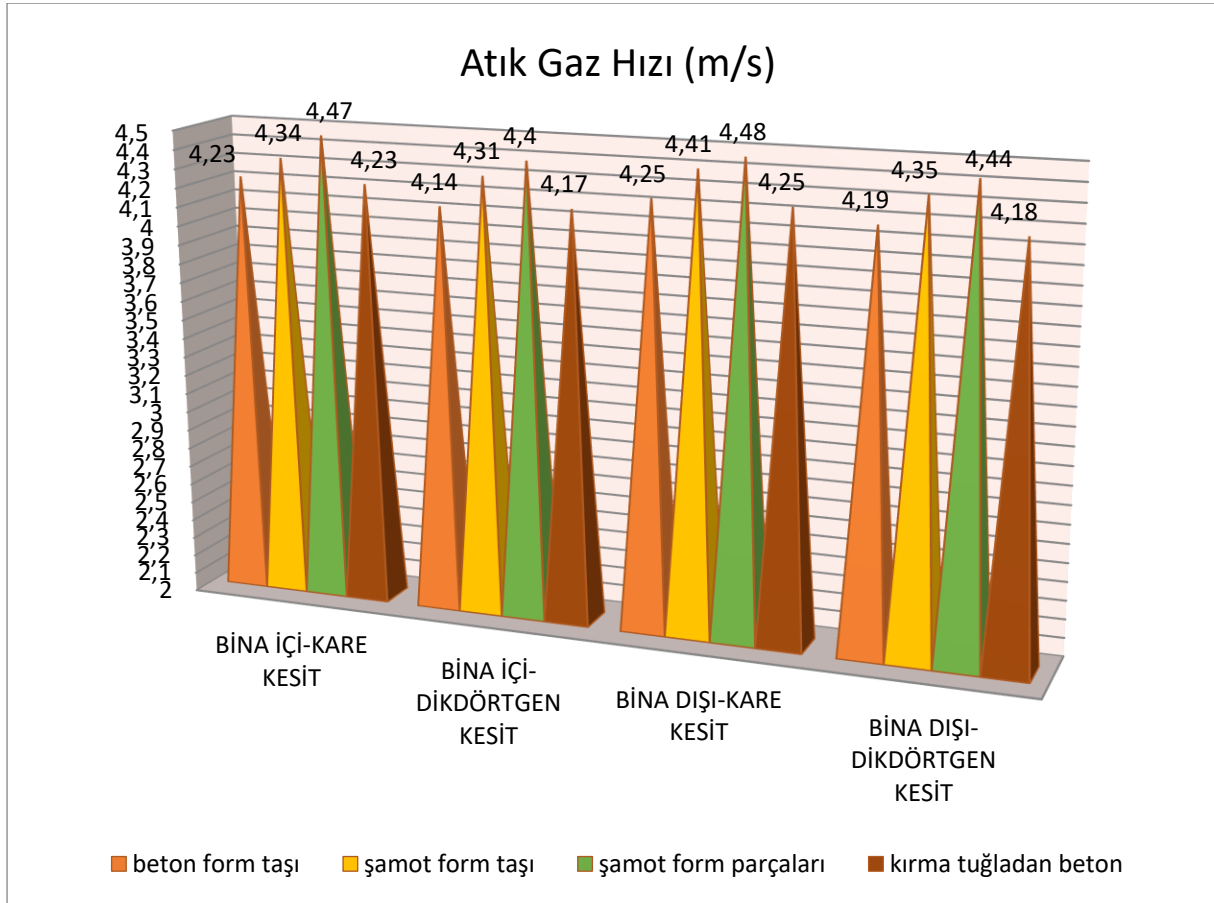
**Şekil 6.** Baca +15°C rüzgar hızı

Bacanın +15°C rüzgarın hız kıyası Şekil 6'da gösterilmiştir. +15°C'de rüzgarın en yüksek hız değeri bina dışı kare formlu bacada şamot form parçaları malzeme ile 7.87 m/s olarak bulunmuştur. En düşük değer ise bina içi dikdörtgen formlu bacada beton form taşı malzeme ile 7.3 m/s olarak tespit edilmiştir.



Şekil 7. Baca durgun basınç

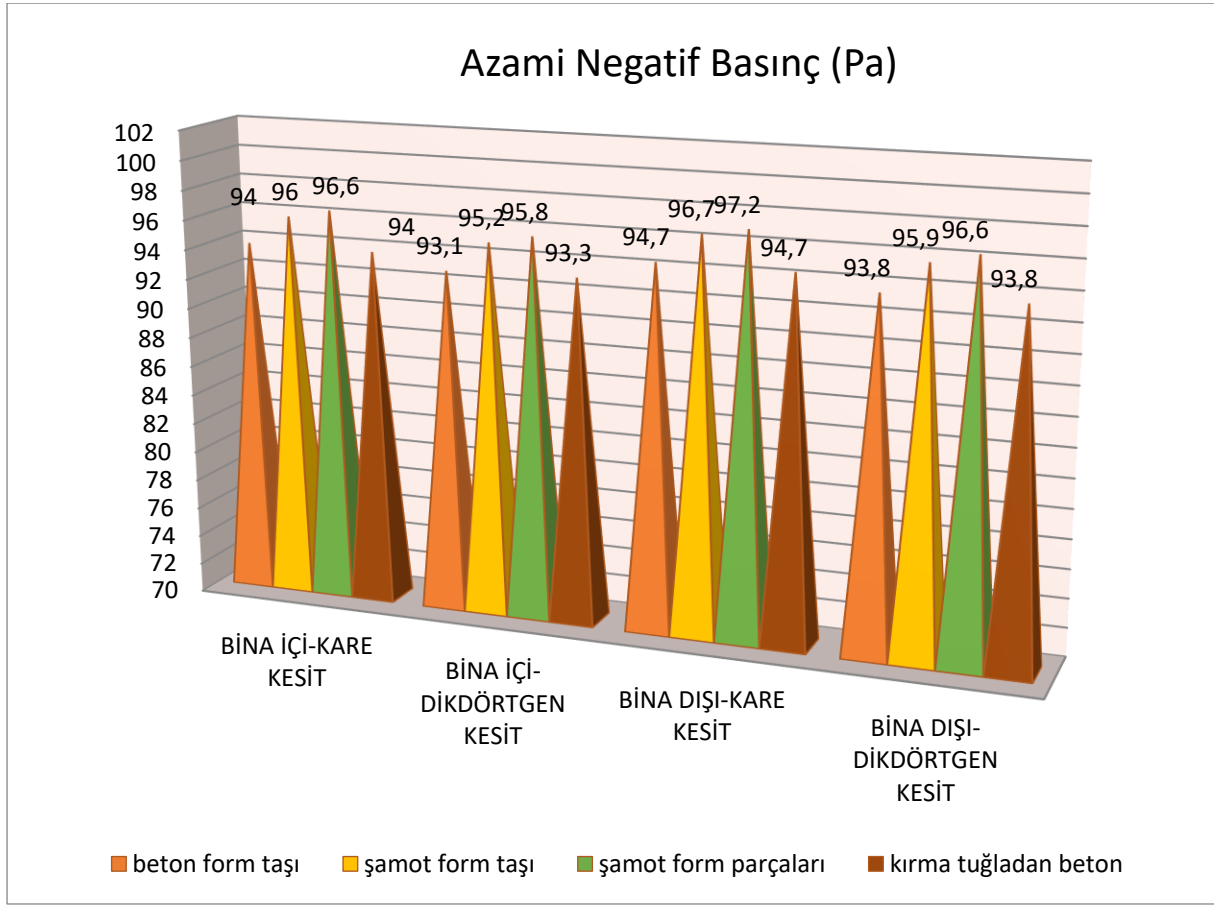
Bacalarda durgun basıncın kıyası Şekil 7’de gösterilmiştir. En düşük durgun basınç değerleri bina içi dikdörtgen formlu bacada; beton form taşı malzeme ile 88 Pa, kırma tuğla beton malzeme ile 88.1 Pa olarak elde edilmiştir.



**Şekil 8.** Baca atık gaz hızı

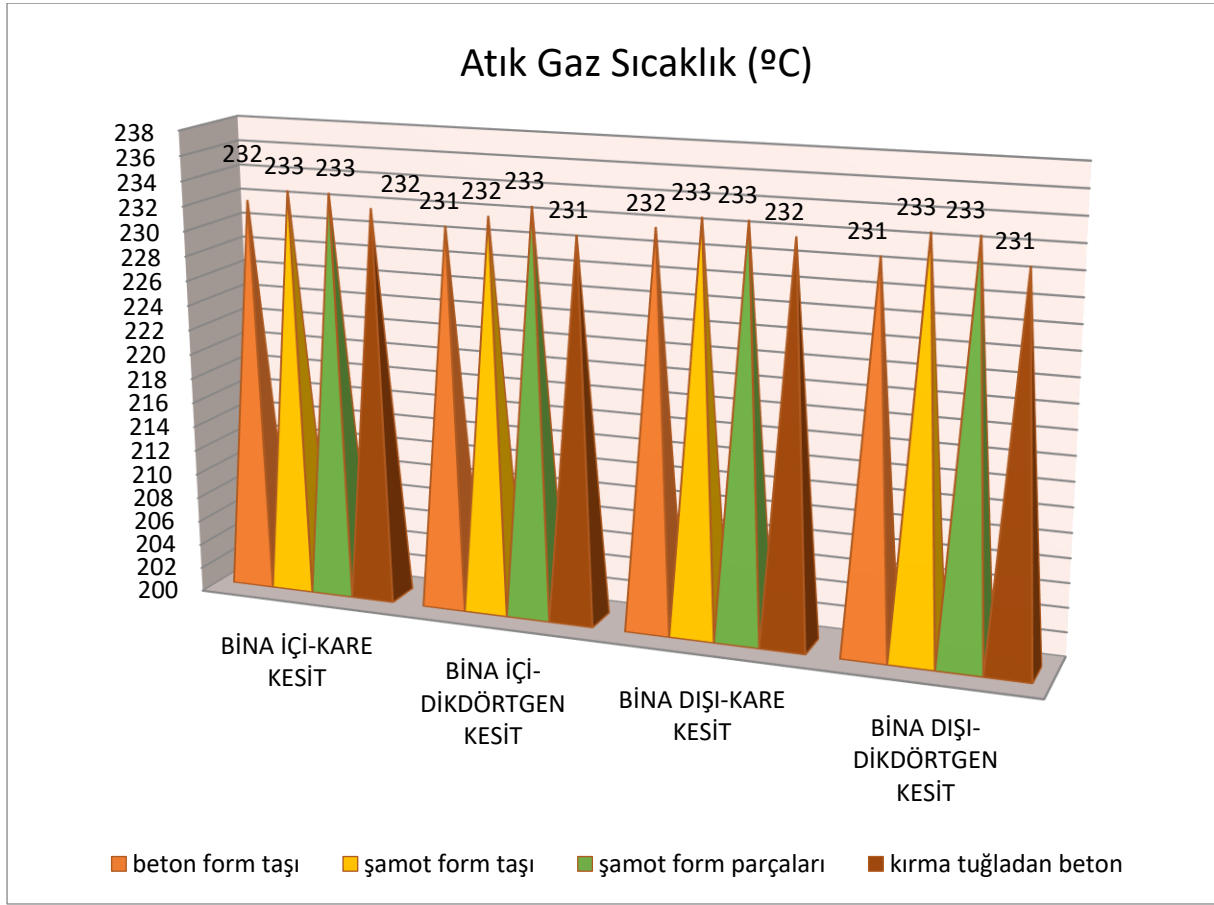
Bacadaki atık gazın hız kıyası Şekil 8’da sunulmuştur. Bacadaki atık gazın en düşük hız değerleri bina içi dikdörtgen formlu bacada; beton form taşı malzeme ile 4.14 m/s, kırma tuğla beton malzeme ile 4.17 m/s olarak belirlenmiştir.





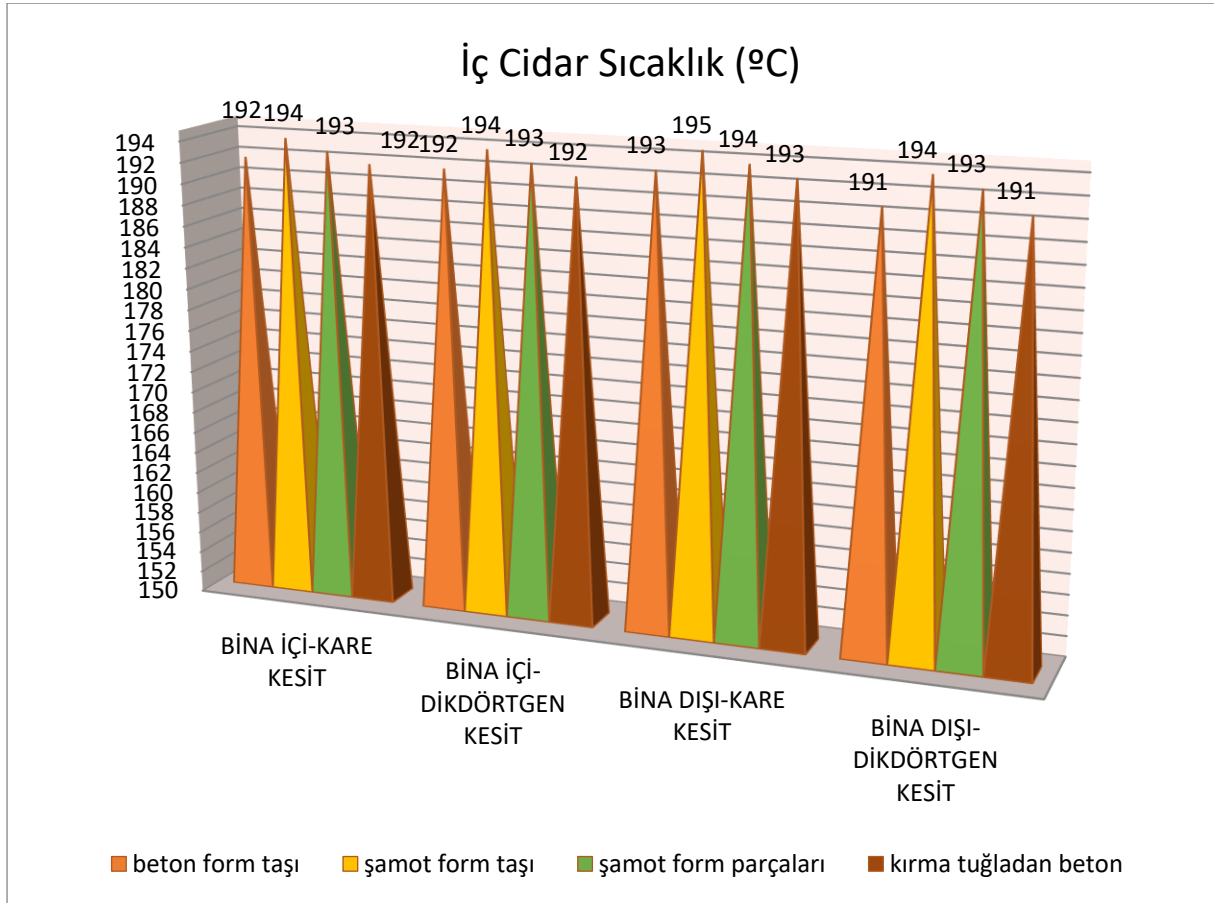
**Şekil 9.** Bacada negatif azami basınç

Bacada negatif azami basınç kıyası Şekil 9’de sunulmuştur. Baca azami negatif basıncının en düşük değerleri bina içinde dikdörtgen formlu bacada beton form taşı malzeme ile 93.1 Pa, ve kırma tuğla beton malzeme ile 93.3 Pa olarak belirlenmiştir



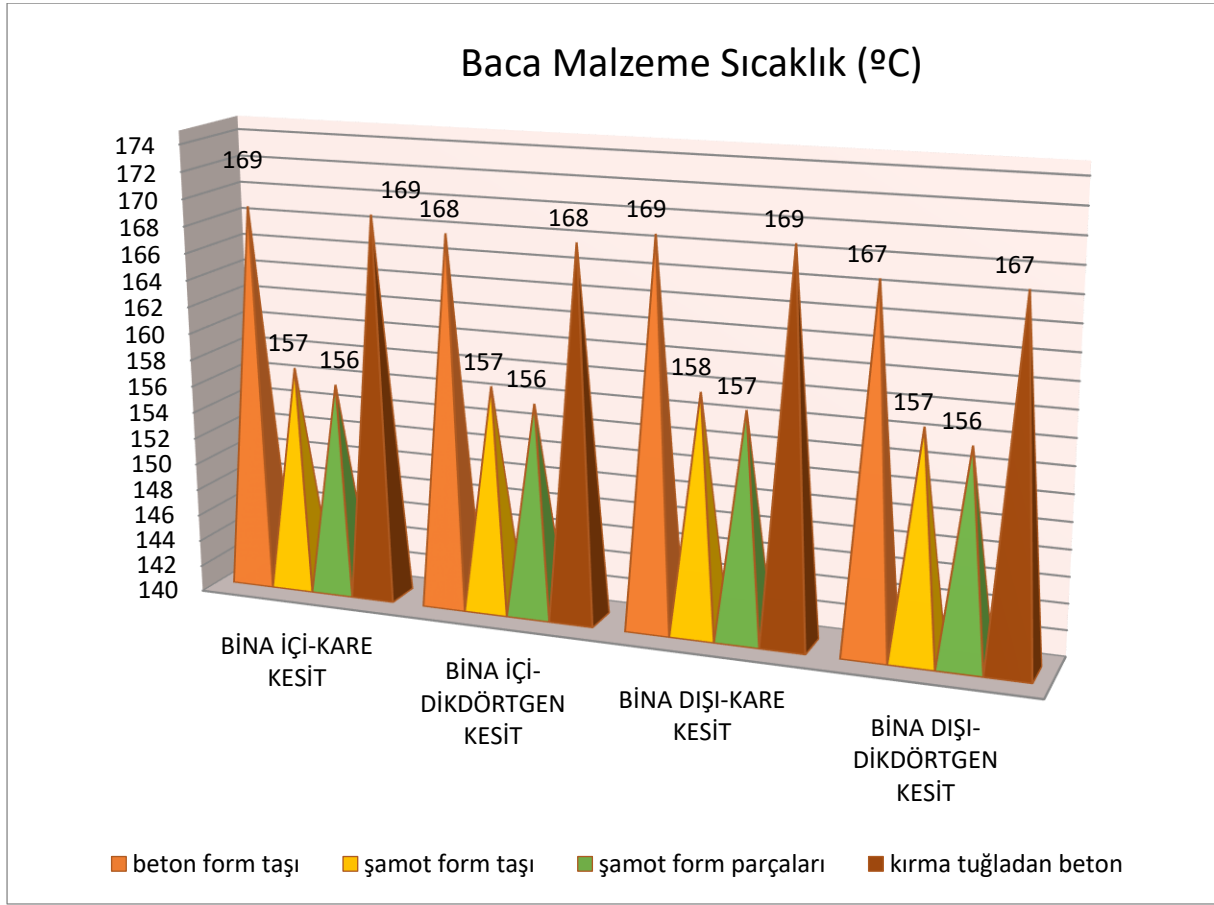
**Şekil 10.** Baca atık gaz sıcaklık

Bacadaki atık gazın sıcaklık kıyası Şekil 10'de detaylandırılmıştır. Bacadaki atık gazın sıcaklığına ait en yüksek değerleri her baca tasarımında şamot form parçaları malzeme ve şamot form taşı malzeme ile 233 °C olarak tespit edilmiştir. Sadece bina içi dikdörtgen formlu bacada 232 °C olarak bulunmuştur.



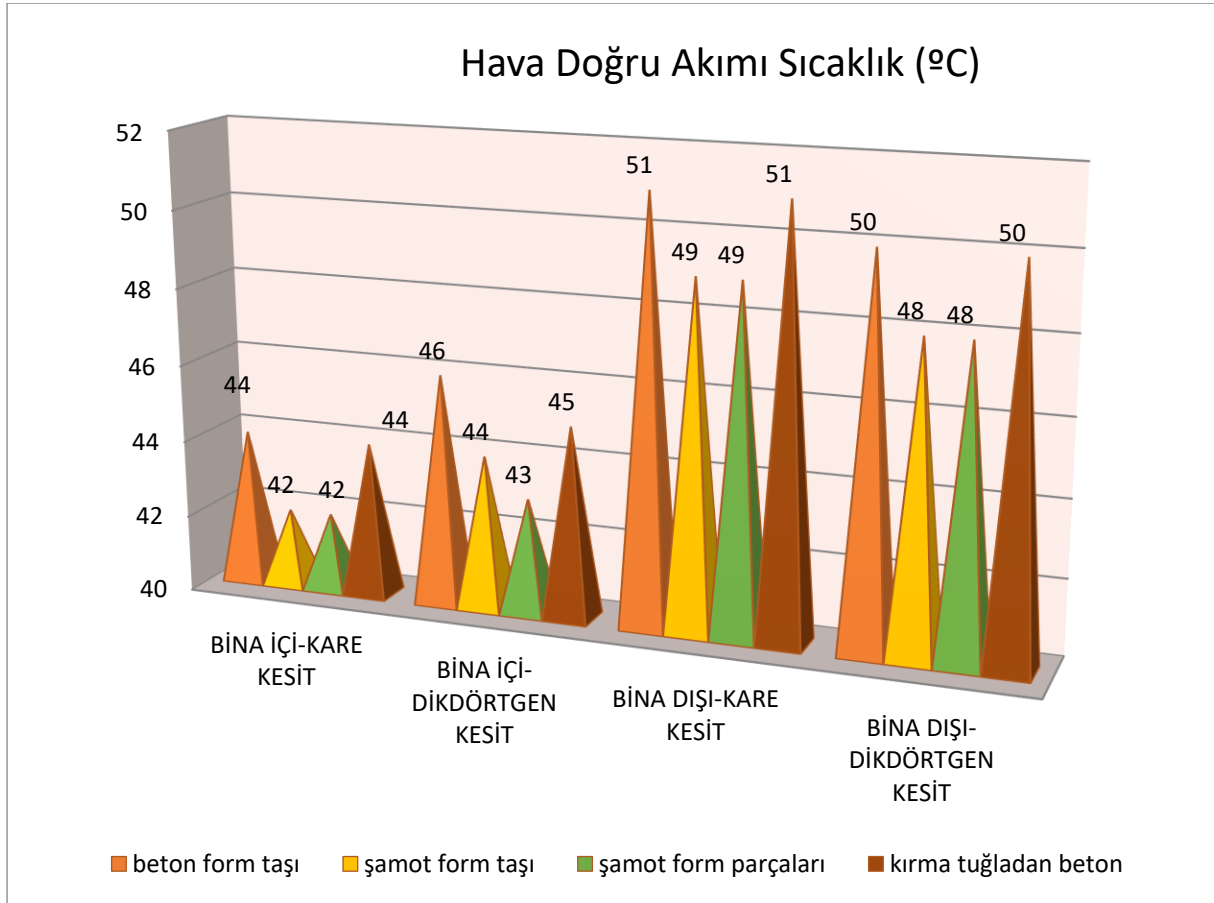
**Şekil 11.** Bina içi-bina dışı bacanın iç cidar sıcaklık

Bina içi-bina dışı bacanın iç cidar sıcaklık kıyası Şekil 11’de mevcutlandırılmıştır. Bina içi-bina dışı bacanın iç cidar sıcaklığının en düşük değerleri bina dışı dikdörtgen formlu bacada beton form taşı malzeme ve kırma tuğla beton malzeme ile 191 °C olarak belirlenmiştir.



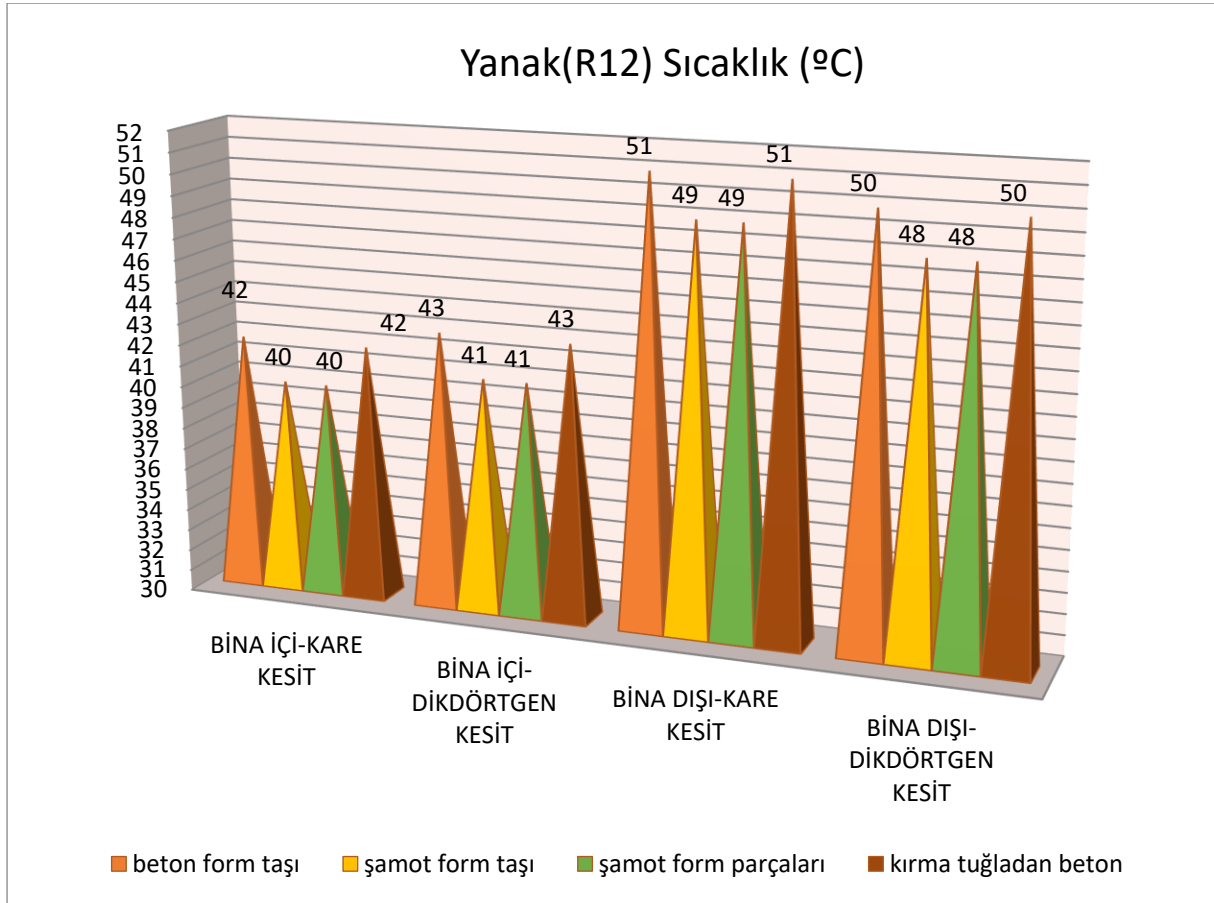
**Şekil 12.** Baca malzemesi sıcaklık

Baca malzemesi sıcaklığının kıyası Şekil 12’de grafikte gösterilmiştir. Baca malzemesi sıcaklığının en yüksek değeri bina içi kare formlu bacada ve bina dışı bina içi kare formlu bacada; beton form taşı ve kırma tuğla beton malzeme ile 169 °C olarak analiz edilmiştir.



Şekil 13. Baca hava doğru akımının sıcaklığı

Baca hava doğru akımının sıcaklığının kıyası Şekil 13'da gösterilmiştir. Baca hava doğru akımının sıcaklığının en düşük değeri, bina içi kare formlu bacada şamot form parçaları ve şamot form taşı malzeme ile 42 °C olarak analiz edilmiştir.



**Şekil 14.** Baca yanak (R12) sıcaklığı kıyası Şekil 14’de sunulmuştur. Bina içi kare formulu bacada şamot en düşük değerleri şamot form parçaları ve şamot form taşı malzeme ile 40 °C olarak belirlenmiştir. En yüksek değerler bina dışı kare formulu bacada beton form taşı ve kırma tuğla beton malzeme ile 50 °C olarak analiz edilmiştir.

### 3. Sonuç

Bu çalışmada, Elazığ ilindeki bir un üretim binasının ısı enerjisi ihtiyacını karşılamaya yönelik tasarlanan baca sisteminin, farklı malzeme ve kesit kombinasyonlarıyla çevresel etkileri değerlendirilmiştir. Yapılan analizler sonucunda, çevre kirliliğinin azaltılması ve enerji verimliliğinin artırılması açısından en uygun baca bileşenlerinin belirlenmesine odaklanılmıştır. Çalışmada kullanılan farklı baca malzemeleri ve kesit biçimlerinin, bina içi ve bina dışı tasarım durumlarına göre çevre üzerindeki etkilerinin önemli ölçüde değişiklik gösterdiği tespit edilmiştir. KesaAladin yazılımı yardımıyla yapılan analizlerle optimal tasarım için baca malzemesi olarak şamot form parçaları malzeme ile, baca formu olarak bina dışı kare kesit kullanılarak bina içinde oluşturulan tasarım çevresel yönetim açısından en olumlu tasarım olarak belirlenmiştir.

Çalışma sonuçlarının, çevre kirliliğini önlemek amacıyla yönelik baca tasarımıyla ilgilenen uzmanlara faydalı olacağı düşünülmektedir.

### TEŞEKKÜR

Bu çalışma, Fırat Üniversitesi MF.24.38 no’lu proje tarafından desteklenmiştir.

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**January 21-28, 2025 / Havana, CUBA**

**BAĞCILIKTA YENİLİKÇİ AMBALAJLAMA TEKNİKLERİ ve LOJİSTİK  
SİSTEMLER**

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**Özet**

Bağcılık sektörü, tarım üretiminin önemli bir kolu olarak hem ekonomik hem de sosyal açıdan büyük bir önem arz etmektedir. Türkiye gibi bağcılık potansiyeli yüksek olan ülkelerde bu sektör, ihracat gelirlerinin önemli bir bölümünü oluşturmakta ve yerel ekonomilere katkıda bulunmaktadır. Çok düşük metabolik aktiviteye sahip, soğuk zararlarına karşı yüksek duyarlılık gösteren üzüm taneleri, hasat sonu yaşamlarının uzun olması için iyi bir potansiyele sahiptirler. Sofralık üzümlerin hasat sonu buzulma ve çürümelerin en önemli ilk iki faktörü olan patojen ve üzüm tanelerinin sap kısmındaki lentiseller yoluyla su kaybının olmasıdır. Bununla birlikte, bağcılık ürünlerinin uzun mesafelere taşınma ihtiyacı, ürün kalitesinin korunması ve ekonomik kayıpların önlenmesi açısından önemli zorluklar oluşturmaktadır. Geleneksel muhafaza yöntemleri, artan talepler ve global pazar dinamikleri karşısında yetersiz kalmakta, bu da yenilikçi ambalajlama ve lojistik sistemlere duyulan ihtiyacı artırmaktadır. Bağcılık ürünleri, hasat sonrası kalite kayıplarının minimize edilmesi için özel muhafaza tekniklerine ihtiyaç duymaktadır. Bu ürünler, genellikle çabuk bozulabilir olduklarından dolayı etkili muhafaza yöntemleri kullanılmalıdır. Son yıllarda, teknolojik gelişmeler sayesinde daha dayanıklı, çevre dostu ve fonksiyonel ambalaj malzemeleri geliştirilmiş olup ayrıca lojistik süreçlerinin daha entegre ve verimli bir yapıya ulaştığı gözlemlenmiştir. Bu yenilikler, sadece ekonomik verimliliği artırmakla kalmayıp aynı zamanda tüketicilere daha kaliteli ve güvenli ürünler sunabilmektedir. Bağcılık, yüksek kaliteli ve taze ürünler üretmeyi amaçlayan bir sektör konumundadır. Ancak bu ürünlerin tüketicilere sağlıklı ve taze bir şekilde ulaştırılabilmesi için teknolojik gelişmelere açık etkili lojistik sistemlerinin kullanılması büyük bir önem taşımaktadır. Lojistik; bağcılıkta üzümlerin ve diğer bağcılık ürünlerinin hasat sonrası tüm süreçlerinde etkin olup kalitenin korunmasında büyük bir rol üstlenmektedir. Etkili lojistik; doğru taşıma, depolama ve dağıtım sistemleri ile ürünlerin tazeliğini, kalitesini ve güvenliğini korumayı amaçlamaktadır.

**Anahtar Kelimeler:** Bağcılık, Muhafaza, Lojistik



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**INNOVATIVE PACKAGING TECHNIQUES and LOGISTIC SYSTEMS in  
VITICULTURE**

**Abstract**

The viticulture sector, as an important branch of agricultural production, is of great importance both economically and socially. In countries with high viticulture potential such as Turkey, this sector accounts for a significant portion of export revenues and contributes to local economies. Grape berries with very low metabolic activity and high susceptibility to cold damage have a good potential for long post-harvest survival. The first two most important factors of post-harvest frost damage and rotting of table grapes are pathogens and water loss through the lenticels on the stem of the grape berries. However, the need to transport viticultural products over long distances poses significant challenges in terms of maintaining product quality and preventing economic losses. Traditional preservation methods are inadequate in the face of increasing demands and global market dynamics, which increases the need for innovative packaging and logistics systems. Viticulture products require special preservation techniques to minimise post-harvest quality losses. Since these products are generally perishable, effective preservation methods should be used. In recent years, thanks to technological developments, more durable, environmentally friendly and functional packaging materials have been developed and it has been observed that logistics processes have reached a more integrated and efficient structure. These innovations not only increase economic efficiency but also provide consumers with better quality and safer products. Viticulture is a sector that aims to produce high quality and fresh products. However, in order to deliver these products to consumers in a healthy and fresh way, it is of great importance to use effective logistics systems that are open to technological developments. Logistics is effective in all post-harvest processes of grapes and other viticulture products in viticulture and plays a major role in maintaining quality. Effective logistics aims to protect the freshness, quality and safety of the products with the right transport, storage and distribution systems.

**Keywords:** Logistics, Storage, Viticulture

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## Giriş

Üzüm, dünya çapında yetiştiriciliği yapılan önemli meyve türlerinden biri olup 2020 yılında yaklaşık 28 milyon tonu sofralık üzüm olmak üzere toplam 78 milyon ton küresel üretime ulaşmıştır (FAO, 2021). Üzüm, hasattan sonra nispeten düşük fizyolojik aktiviteye sahip iklimlerik olmayan bir meyve olmasına rağmen, salkım çürümesi, ağırlık kaybı, meyve yumuşaması, renk kaybı, salkımın kurumması ve kararması nedeniyle oldukça çabuk bozulabilen bir meyvedir (Champa, 2015). Meyve çürümesi, sofralık üzümlerde hasat sonrası kaybın başlıca nedenini oluşturmaktadır (Marquenie ve ark., 2002, Ahmed ve ark., 2018). Gri küfün etkeni olan *Botrytis cinerea* Pers. ex Fr., yüksek gelişme hızı ve soğuk depolamanın düşük sıcaklıklarında bile çeşitli meyveleri enfekte etme yeteneği nedeniyle sofralık üzümün dünya çapında en yaygın hasat sonrası patojeni konumundadır (Youssef ve ark., 2020) (Lichter ve ark., 2006, Youssef ve Roberto, 2021).

Uygun paketleme ve soğuk depolama, yüksek kalitedeki sofralık üzümleri taşıma ve depolama esnasında mekanik hasarlardan ve çürüme gibi mikrobiyolojik bulaşmalardan koruyarak raf ömrünü uzatabilmektedir (Cerqueira ve ark., 2011).

Tüketiciler üzümlerin taze olmasını ve meyve kalite özelliklerini korumasını her geçen gün daha fazla talep etmektedir ancak salkımların taşıma sırasında zarar görmesi, su kaybı ve patojen saldırısına maruz kalması nedeniyle bu tür pazar taleplerini karşılamak zorlaşmaktadır. Bu faktörler ürünün kalitesini azaltmakta ve sofralık üzümün pazara sunulmasını olumsuz etkilemektedir (Higuchi ve ark., 2024).

Sofralık üzümler tamamen olgunlaştığında elle hasat edilmektedir ve yüksek meyve kalitesini korumak amacıyla uygun şekilde taşınmaktadır. Zarar görmüş meyveler ayıklanmakta ve çoğu durumda salkımlar hasattan hemen sonra tarlada veya yakınında bulunan bir tesiste paketlenerek gerekli işlemler yapılmaktadır. Genellikle üzüm salkımları karton kutularda muhafaza edilmekte ve taşınmaktadır ayrıca su kaybını en aza indirmek için mümkün olan en kısa sürede 0-1 °C'de ön soğutmaya tabi tutulmaktadır. Üzüm çeşidine bağlı olarak, salkımlar donmadan kaynaklanan önemli bir hasar olmaksızın -2 °C'ye kadar düşük depolama sıcaklıklarını tolere edebilmektedir (Aguiar ve ark., 2023). Sıcaklık ve nemin kontrol edilebildiği soğutma odalarında depolama gibi hasat sonrası koruma teknolojilerinin kullanılması, bozulmanın etkilerini azaltmak, pazarlama periyodunu artırmak ve meyve kalitesini korumak amacıyla büyük önem taşımaktadır (Cerqueira ve ark., 2011).

Son yıllarda, polimer bazlı gıda ambalaj malzemeleri, pazarın giderek karmaşıklaşan ihtiyaçlarına, dağıtım sürelerine ve koşullarına ayrıca tüketicilerin güvenliğine yanıt olarak sürekli bir değişim içerisinde. Bu nedenle, yeni malzemelerin üretilmesinde bilim ve teknolojinin hızlı gelişimi sayesinde paketleme sistemleri giderek daha gelişmiş hale gelmektedir (Bugatti ve ark., 2019).

## Üzümlerin Muhafazası

Üzümlerde hasat sonrası kalite kayıplarını en aza indirmek için özel muhafaza teknikleri önem arz etmektedir. Üzümler genellikle çabuk bozulabilir yapıda olduğundan, etkili muhafaza sistemleriyle yönetilmelidir. Soğuk zincir uygulamaları, hasattan tüketiciye kadar sürekli sıcaklık kontrolü sağlayarak bozulmayı önlemektedir (Pedro ve ark., 2023). Kontrollü atmosfer (KA) teknolojisi, oksijen ve karbondioksit seviyelerini dengede tutarak meyvelerin solunum hızını azaltmakta ve bu sayede ürünlerin daha uzun süre taze kalmasını sağlamaktadır. Bunun yanı sıra, ozon bazlı koruma sistemleri, mikroorganizma faaliyetlerini baskılayarak ürünlerin hijyenik kalitesini artırmada etkili bir yöntemdir (Rozman ve ark., 2022).

Yenilikçi teknolojiler arasında vakumlu paketlemeler de oldukça önemli bir yer edinmektedir.

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Bu yöntem, ambalaj içindeki hava miktarını azaltarak oksidasyonu ve mikrobiyal büyümeyi en aza indirmektedir. Ayrıca nem kontrollü ambalaj malzemeleri ürünlerin çürümesini ve bozulmasını önlemektedir.

Hasat sonrası uygulamaların zamanlaması üzüm muhafazasında kritik bir rol oynamaktadır. Hızlı soğutma sistemleri hasattan hemen sonra devreye girerek meyvenin metabolik faaliyetlerini yavaşlatmakta ve tazeliğini korumaktadır. Tüm bu teknikler sadece ekonomik kayıpları azaltmakla kalmamakta aynı zamanda tüketici memnuniyetini de artırmaktadır (Akram ve ark., 2023). Üzümlerde ambalajlama, hasattan tüketiciye kadar üzümün kalite ve tazeliğinin korunmasında kritik bir rol oynamaktadır. Ambalajlama ürünleri fiziksel zararlardan, mikroorganizmalardan ve çevresel faktörlerden koruyarak raf ömrünü uzattığından pazarlama açısından oldukça önemli bir yere sahiptir (Klimchuk ve Krasovec, 2013).

## Ambalaj Çeşitleri

### **Birincil Ambalaj (Primary Packaging)**

Ürünün doğrudan temas ettiği ve tüketiciye sunulan ambalajdır. Örnekler arasında plastik, cam şişeler, kutular ve torbalar bulunmaktadır.

### **İkincil Ambalaj (Secondary Packaging)**

Birincil ambalajları bir araya getiren ve genellikle taşıma veya depolama amacıyla kullanılan ambalajlardır. Karton kutular ve koliler bu gruba girmektedir.

### **Nakliye Ambalajı (Transport Packaging)**

Ürünlerin taşınması sırasında koruma sağlayan ambalajlardır. Paletler, büyük kutular ve streç filmler bu amaçla kullanılmaktadır.

## Ambalaj Malzemeleri

### **Plastik Ambalajlar**

Polietilen (PE), polipropilen (PP) ve polietilen tereftalat (PET) gibi malzemelerden üretilmektedir. Hafif, dayanıklı ve şeffaf olmaları nedeniyle tercih edilmektedir (Barlow ve Morgan, 2013).

### **Karton ve Kağıt Ambalajlar**

Geri dönüştürülebilir ve çevre dostu özellikleri bulunmaktadır. Karton kutular, kağıt torbalar ve oluklu mukavva gibi çeşitleri bulunmaktadır (Özden ve Sönmez 2024).

### **Metal Ambalajlar**

Alüminyum ve çelik gibi metallere üretilmektedir. Özellikle konserve ürünlerde kullanılmaktadır ve yüksek koruma sağlamaktadır (Debeaufort ve ark., 2021).

## Yenilikçi Ambalajlama Sistemleri

### **Akıllı Ambalajlar**

Ürünün tazeliğini izleyebilen, sıcaklık ve nem değişimlerini algılayabilen sensörlerle donatılmış ambalajlardır.

### **Aktif Ambalajlar**

Ürünün raf ömrünü uzatmak için ambalajın içine antimikrobiyal maddeler veya oksijen emiciler eklenmektedir.

### **Biyobozunur Ambalajlar**

Çevre dostu malzemelerden üretilen ve doğada kolayca çözünebilen ambalajlardır.

Bu yenilikçi ambalajlama sistemleri, ürünlerin kalitesini korumanın yanı sıra çevresel sürdürülebilirliğe de katkı sağlamaktadır (Beikzadeh ve ark., 2020).

## Lojistik Sistemler

### Lojistik Sistemlerin Temel Bileşenleri

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Lojistik sistemleri, bağıcılık sektöründe ürünlerin tarladan tüketiciye kadar taşınması sürecinde verimliliği artırmayı hedeflemektedir. Bu süreç, aşağıdaki temel bileşenler üzerine kuruludur.

## **Taşıma Yönetimi**

Taşıma, lojistik süreçlerin temel taşıma oluşturmaktadır. Ürünlerin hasat alanından işleme tesislerine, depolama alanlarına veya doğrudan tüketicilere taşınması, hız ve maliyet optimizasyonu gerektirmektedir. Bu süreçte, taşıma araçlarının seçimi, rota optimizasyonu ve yük güvenliği gibi faktörler dikkate alınmaktadır. Doğru taşıma yöntemleri, ürünlerin tazeliklerini korurken, maliyetleri de önemli ölçüde azaltmaktadır (Pak, 2021).

## **Depolama ve Stok Yönetimi**

Depolama, bağıcılık ürünlerinin kalite kaybını önlemek için uygun ortamların sağlanmasını içermektedir. Ürünlerin sıcaklık, nem ve hava dolaşımı gibi koşullara duyarlılığı göz önüne alınarak uygun depolar seçilmektedir. Stok yönetimi ise, talep dalgalanmalarına karşı esneklik sağlamak ve stok fazlasını önlemek için önem arz etmektedir. Modern depolama sistemleri, dijital izleme teknolojileriyle desteklenmektedir (Daneshjo ve Stollmann, 2013).

## **Sipariş İşleme**

Siparişlerin alınması, işlenmesi ve hazırlanması, lojistik süreçlerde önemli bir adımı oluşturmaktadır. Müşteri siparişlerinin doğru bir şekilde işlenmesi, müşteri memnuniyetini artırmaktadır. Bu süreçte, bilgi yönetim sistemleri kullanılarak siparişler hızlı ve hatasız bir şekilde tamamlanabilmektedir (Daneshjo ve Stollmann, 2013).

## **Bilgi Sistemleri ve Teknoloji Kullanımı**

Lojistik süreçlerin verimli bir şekilde yönetilmesi için bilgi teknolojilerinin entegrasyonu gerekli olmaktadır. Bu sistemler, tedarik zinciri boyunca izleme, raporlama ve karar verme süreçlerinde kullanılmaktadır. Örneğin, rota optimizasyonu için yapay zekâ tabanlı sistemler veya depo yönetiminde kullanılan otomasyon teknolojileri, operasyonel verimliliği artırmaktadır (Daneshjo ve Stollmann, 2013).

## **Bağıcılıkta Lojistik Sistemlerin Önemi**

Bağıcılık, yüksek kaliteli ve taze ürünler üretmeyi amaçlayan bir sektördür. Ancak, bu ürünlerin tüketicilere sağlıklı ve taze bir şekilde ulaştırılabilmesi için etkili lojistik sistemlerinin kullanılması büyük önem taşır. Lojistik, bağıcılıkta, üzümün ve diğer bağıcılık ürünlerinin hasattan sonrasındaki tüm süreçlerde rol oynar ve kaliteyi korur. Etkili lojistik, doğru taşıma, depolama ve dağıtım sistemleri ile ürünlerin tazeliğini, kalitesini ve güvenliğini korumaktadır. Ayrıca, yenilikçi lojistik yaklaşımların benimsenmesi, maliyetlerin azaltılması ve müşteri memnuniyetinin artırılmasına katkı sağlamaktadır.

## **Ürün Tazeliğinin Korunması**

Bağıcılık ürünleri, özellikle üzüm ve şarap, yüksek hassasiyete sahip ürünlerdir. Bu nedenle, lojistik süreçlerde soğuk zincir yönetimi, taşımadan depolamaya kadar her aşamada ürünün tazeliğini koruyacak önlemler gerekmektedir. Soğutmalı taşıma sistemleri, üzümün yüksek sıcaklıklara maruz kalmasını engelleyerek kalite kaybını önlemektedir. Ayrıca, doğru depolama koşulları sağlanarak raf ömrü uzatılabilmektedir (Alessandri ve ark., 2024).

## **Zamanında Teslimat ve Dağıtım**

Bağıcılıkta lojistik, ürünlerin hızlı bir şekilde pazara ulaşmasını sağlamayı amaçlamaktadır. Üzüm ve şarap gibi ürünlerin zamanında teslim edilmesi, tazeliklerinin korunmasının yanı sıra pazarda rekabetçi avantaj oluşturmaktadır. Etkili dağıtım ağları, ürünlerin depolardan perakendecilere, mağazalara ve nihai tüketicilere kadar sorunsuz bir şekilde ulaşmasını sağlamakta. Bu, aynı zamanda müşteri memnuniyetini artırmaktadır (Capone ve ark., 2014).

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**Maliyet Verimliliği**

Lojistik, bağcılıkta maliyetlerin optimize edilmesine de yardımcı olmaktadır. Etkili stok yönetimi ve taşımacılık, gereksiz harcamaların önüne geçerek işletme maliyetlerini düşürmektedir. Ayrıca yenilikçi lojistik çözümleri, örneğin rota optimizasyonu ve dış kaynak kullanımı gibi yaklaşımlar, iş gücü ve enerji tüketimi gibi maliyetleri azaltmaktadır (Neto ve ark., 2013).

**Çevresel Sürdürülebilirlik**

Bağcılıkta çevresel sürdürülebilirlik, özellikle ambalajlama ve lojistik süreçlerde büyük bir öneme sahiptir. Lojistikte yeşil çözümler, karbon ayak izini azaltma ve çevre dostu taşıma yöntemlerinin kullanılması, sektörde çevre bilincinin artmasına katkı sağlamaktadır. Elektrikli taşıma araçları, çevreye duyarlı ambalajlama materyalleri ve optimizasyon süreçleri, lojistik sistemlerde çevre dostu uygulamalar arasında yer almaktadır (McKinnon ve ark, 2015).

**Rekabet Avantajı**

Bağcılık sektöründe lojistik süreçlerin etkin yönetimi, işletmelerin rekabet avantajı kazanmasına olanak tanımaktadır. Lojistik operasyonlarını optimize eden işletmeler, maliyetleri düşürürken müşteri taleplerine daha hızlı yanıt vermektedir. Bu da markanın prestijini ve pazardaki yerini güçlendirmektedir (Capone ve ark., 2014).

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**MEDICAL TOURISM IN TURKEY: A SWOT ANALYSIS**

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**Abstract**

Today, governments must keep a close eye on developments in the concept of tourism and take the lead by investing in high-potential sectors like medical tourism, which has changed dramatically over the past several decades in tandem with economic expansion. Turkey's thermal resources, temperate climate, accessibility, natural resources, and cultural diversity make it one of the most attractive tourist destinations in the region. Turkey stands out in the rapidly growing global medical tourism market because of its state-of-the-art medical facilities and reasonably priced treatment costs. Through a research technique based on information acquired from national and international news, government statistics, and academic research on medical tourism, this study seeks to give the SWOT analysis of the state of medical tourism in Turkey. The analysis of the causal relationships of this research showed that the medical tourism in Turkey is determined by the availability of modern infrastructure and JCI accreditation, as well as the possibility of undergoing treatment at reasonably priced services. It has a very strong geographical location and has an aeronautical infrastructure that allows international patients to easily reach it. On the other hand, the industry is challenged by the scarcity of multilingual health practitioners and inadequate marketing. Based on the results, this study makes managerial recommendations for managing the risks and weaknesses of medical tourism as well as its strengths and future prospects. These recommendations include promoting medical tourism and health tourism in general, improving the ability of professionals to speak multiple languages, and encouraging collaboration between the public and private sectors. These measures will help attract more international patients and establish Turkey's reputation as a reliable destination for healthcare.

**Keywords:** Medical tourism, SWOT analysis, health tourism, Healthcare



**MEDICAL TOURISM IN TURKEY: A SWOT ANALYSIS**

**Özet**

Bugün, hükümetler turizm kavramındaki gelişmeleri yakından takip etmeli ve son birkaç on yılda ekonomik büyümeyle paralel olarak büyük değişimler geçiren medikal turizm gibi yüksek potansiyele sahip sektörlerle yatırım yaparak öncülük etmelidir. Türkiye'nin termal kaynakları, ılıman iklimi, ulaşılabilirliği, doğal kaynakları ve kültürel çeşitliliği, onu bölgedeki en cazip turistik destinasyonlardan biri haline getirmektedir. Türkiye, son teknoloji tıbbi tesisleri ve makul fiyatlı tedavi maliyetleri sayesinde hızla büyüyen küresel tıbbi turizm pazarında öne çıkmaktadır. Ulusal ve uluslararası haberlerden, hükümet istatistiklerinden ve tıbbi turizm üzerine yapılan akademik araştırmalardan elde edilen bilgilere dayanan bir araştırma tekniği aracılığıyla, bu çalışma Türkiye'deki medikal turizmin durumunun SWOT analizini sunmayı amaçlamaktadır. Bu araştırmanın nedensel ilişkilerinin analizi, Türkiye'deki tıbbi turizmin modern altyapısının ve JCI akreditasyonunun mevcut olması ile makul fiyatlı hizmetlerde tedavi olma olasılığı tarafından belirlendiğini göstermiştir. Çok güçlü bir coğrafi konuma sahip olup, uluslararası hastaların kolayca ulaşmasını sağlayan bir havacılık altyapısına sahiptir. Öte yandan, sektör çok dilli sağlık uzmanlarının kıtlığı ve yetersiz pazarlama ile karşı karşıya kalmaktadır. Sonuçlara dayanarak, bu çalışma medikal turizmin risklerini ve zayıflıklarını yönetmek için yönetsel önerilerde bulunmaktadır; ayrıca güçlü yönleri ve gelecekteki beklentileri de dikkate almaktadır. Bu öneriler arasında medikal turizmin ve genel olarak sağlık turizminin teşvik edilmesi, profesyonellerin birden fazla dil konuşabilme becerilerinin geliştirilmesi ve kamu ile özel sektör arasında işbirliğinin teşvik edilmesi yer almaktadır. Bu önlemler, daha fazla uluslararası hastayı çekmeye ve Türkiye'nin sağlık hizmetleri için güvenilir bir destinasyon olarak itibarını pekiştirmeye yardımcı olacaktır.

**Anahtar kelimeler:** Medikal turizm, SWOT analizi, sağlık turizm, Sağlık hizmetleri

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## Introduction

Everyone has a fundamental right to health. Everyone, regardless of religion, nationality, or gender, has the right to get high-quality, safe healthcare. This right, which is guaranteed by many state constitutions, is also acknowledged as a social state fundamental (Tengilimoğlu, 2021). The practice of traveling to another nation in order to receive medical care—such as elective surgery, dental care, reproductive treatment, organ transplants, and medical examinations—is known as medical tourism, while wellness tourism, which includes going to spas, receiving homoeopathic treatments, or using traditional therapies, is not included (Smith, R. et al. 2011). According to Letunovska et al. (2020), medical tourism is becoming more and more important for both domestic and foreign travel economies. Turkey, Thailand, Italy, and China all have high average tourism revenue as a percentage of GDP (12.1%, 21.6%, 13.3%, and 11.05%, respectively). The target demographic for medical tourism is middle-class and up in industrialised countries, but it is primarily upper-class people in poorer countries. (Tontuş, 2019). According to the World Tourism Organization (World Tourism Barometer 2023), health tourism has seen the most significant development in recent years, with 1.3 billion of health tourists in 2023 against 1.4 million in Turkey as outlined by the Turkish Statistical Institute (2023). The relevance of health tourism is increasing as more individuals travel between nations for medical care. Many nations have made significant investments in health tourism in recent years, and it has become a key political issue in their governments. Health tourism encompasses the growth of continents, governments, regions, destinations, and hundreds of services. It is a vast worldwide commercial business in which servers compete with one another (Zsarnoczky, 2018).

**Table 1.** Tourism industry Statistics in the world (Letunovska, N. et al 2020)

<i>Country</i>	<i>Number of tourists, million people</i>	<i>Average % of yields from tourism in the country's GDP</i>	<i>Average employment in tourism, million jobs</i>
Turkey	46	12.1	2.16
China	63	11.05	28.25
Italy	62	13.3	3.5
Mexico	41	8.7	4.7
Germany	39	10.4	3.1
Thailand	38	21.6	2.5
United Kingdom	36	7.2	1.7
France	89	9.7	2.9
Spain	83	12	3.0
USA	80	2.8	7.8

Medical tourism, which has an advantage over other forms of tourism, generates more foreign currency income for countries and contributes to the closure of the current account deficit and better services for local patients And off course gaining foreign currency (Pourkhaghan Z. et al, 2013). Tontuş (2019) indicated that some researches found that a patient traveling to Turkey spends an average of \$5000-6000 to acquire medical care. When non-treatment expenses such as transportation, leisure activities, companions, and so on are included, the economic significance of medical tourism becomes evident (Tontuş, 2019).

Along with globalization, economic, demographic, and lifestyle variables all influence the growth of health tourism. Furthermore, long wait times in the health systems of the countries

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where health tourists live, rising health costs and the narrowing of insurance coverage by insurance institutions, as well as difficulties in accessing health services, all contribute significantly to health tourism mobility (García-Altés, 2005).

By applying SWOT analysis to evaluate Turkey's strengths, weaknesses, opportunities, and threats in the medical tourism sector, this study investigates the expanding field in Turkey. The goal of the study is to comprehend how Turkey's cutting-edge healthcare system, highly qualified medical staff, and affordable prices support the country's rising appeal as a destination for medical tourists. Determining how Turkey may strengthen its competitive edge in this sector in the face of global competition and providing workable recommendations for future development and expansion constitute the main research challenge. The approach is based on data gathered from academic research on medical tourism as well as national and international publications. Along with highlighting the industry's internal strengths and weaknesses, the SWOT analysis also identifies external opportunities and threats.

### **Materials and Methods**

A SWOT analysis, to put it simply, is a brainstorming session on the key elements influencing a company's or industry's performance. (Henricks, 1999; Houben, Lenie, & Vanhoof, 1999).

The following techniques for gathering data were used in the study: In order to get background information on medical tourism, the literature was examined. This study employed a qualitative research approach and primarily used secondary data sources. Information was obtained from relevant academic research and official TÜRSAB and TÜİK papers. These sources provided useful details regarding the primary factors affecting medical tourism to Turkey. Using the SWOT analysis framework to identify strengths, weaknesses, opportunities, and threats was the main goal of the data collection process. The selected papers and scholarly materials were carefully examined in order to ensure consistency and reliability in the findings. This approach allowed for a thorough understanding of Turkey's position in the global medical tourism market while also highlighting areas for improvement.

### **Findings and Discussion**

TÜİK's statistics from 2003 to 2019 show that health tourism has expanded more quickly in the area than general tourism. In the same time frame, the number of foreign visitors increased from 103,403 to 560,520. The fact that the revenue per visitor is higher than the average for tourism is one of the most alluring features of health tourism when compared to traditional tourism revenues. In 2019, the average income per passenger was \$1,609 for health tourism and \$796 for general tourism (TÜİK, 2020). TÜİK reports that between 2002 and 2023, health tourism revenues grew. Health tourists brought in \$3,006,092 thousand USD for Turkey in 2023 (TÜİK, 2024).

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**Table 2. Health Tourism Revenues, 2002 - 2024(TUIK, 2024)**

<b>Tourism Revenues by Expenditure Types, Health (Thousand \$)</b>	
2002	147 843
2003	203 703
2004	283 789
2005	343 180
2006	382 411
2007	441 676
2008	486 342
2009	447 295
2010	433 398
2011	488 442
2012	627 862
2013	772 900
2014	837 796
2015	638 621
2016	715 437
2017	827 330
2018	363 307
2019	1 459 132
2020	1 371 189
2021	2 016 262
2022	2 206 750
2023	3 006 092
2024	1 621 922

The "Turkey Medical Tourism Assessment Report 2013" from the Ministry of Health states that there were 1,393 hospitals in Turkey in 2012, comprising 499 private hospitals, 831 public hospitals (764 state and 67 training and research hospitals), and 63 university institutions (50 state and 13 foundation). International patients received medical care from 899 facilities in the same year, according to Table 1.

Public hospitals, education and research hospitals, public university hospitals, and foundation university hospitals were the next most common types of hospitals in 2012. It is evident that foreign patients prefer private healthcare facilities when comparing the number of patients who visit public and private hospitals. In terms of medical tourism, public hospitals are thought to advertise less frequently than private hospitals. This is due to the fact that private hospitals engage in medical tourism advertising campaigns more frequently than state hospitals (Kaya, Yıldırım, Karsavuran, & Özer, 2013).

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**Table 3.** Turkey's 2012 International Patient Count by Hospital Type (Kaya, Yıldırım, Karsavuran, & Özer, 2013)

Special Hospital		State Hospital		Education and Research Hospital		State University Hospital		Foundation University Hospital	
Number of Hospitals	Number of Hospitals	Number of Hospitals	Number of Hospitals	Number of Hospitals	Number of Hospitals	Number of Hospitals	Number of Hospitals	Number of Hospitals	Number of Hospitals
499	218.095	308	27.355	66	13.042	21	2.755	5	752

According to a GlobeNewswire press release, the Association of Turkish Travel Agencies (TÜRSAB) that, the country's health tourism industry is anticipated to generate \$3 billion in income by 2024, with a goal of drawing in 2 million visitors. Turkey's competitive healthcare services and strategic integration of the tourist and health industries are the main drivers of this expansion. TÜRSAB expects to continue growing after 2024, with a compound annual growth rate of 10.51% until 2029, propelled by effective marketing initiatives and high-quality healthcare services (GlobeNewswire & TÜRSAB, 2024).

A number of factors, including the availability of modern, high-quality hospitals with ISO-9001 certification, the ease and accessibility of transportation, and the ability to access high-quality medical care at affordable prices due to exchange rate fluctuations, are some of the main reasons Turkey is a leader in the medical tourism sector, as stated in the aforementioned report. Moreover, Turkey employs highly qualified and experienced doctors and healthcare staff who are fluent in several foreign languages, and its medical system model is similar to that of the United States (Çinar & Özkaya, 2020). Turkish hospitality, the country's rich cultural heritage, its tourist infrastructure, as well as its natural, cultural, and historical beauty also contribute to the growth of medical tourism. Another advantage for Turkey is that it is visa-free for visitors from over 110 countries. The country is becoming one of the most sought-after destinations for medical tourists in various fields, including hair transplantation, eye surgery, IVF treatments, cardiac disease treatment, dentistry, orthopedics, and oncology. Medical visitors prefer Istanbul for eye disorders, as well as for gynecology and obstetrics. The second most popular province is Antalya (Kilavuz, 2018). Antalya is particularly popular among medical tourists in various specialties, including internal medicine, orthopedics and traumatology, ENT disorders (ear, nose, and throat), general surgery, as well as neurosurgery and oral, dental, and maxillofacial diseases. Medical tourists also choose cities such as Ankara, Izmir, Bursa, Muğla, and Aydın (Saridemir, 2021).

Tontuş and Nebioğlu's (2018) study analysed medical tourism in Turkey, specifically the number of patients treated in 2015 and 2016, as well as their countries of origin. In 2015, Turkey welcomed 98,702 medical tourists, accounting for about half of total patients. Libya was the biggest source nation, accounting for 37,470 visitors, followed by Iraq (18,993) and Germany (7,261).

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**Table 4.**Top 10 Countries Visiting Turkey for Medical Tourism and Tourist Health in 2015  
(Tontuş & Nebioğlu, 2018)

Country	Medical Tourism	Tourist Health	Total
Libya	37.470	7.648	45.118
Irak	18.993	13.632	32.625
Germany	7.261	23.105	30.366
Azerbaijan	17.668	10.944	28.612
Russia	4.350	11.502	15.852
Syria	2.419	12.587	15.006
Turkmenistan	4.166	7.941	12.107
England	1.543	8.128	9.671
Afghanistan	3.169	6.094	9.263
Netherlands	1.663	6.268	7.931
<b>Total</b>	<b>98.702</b>	<b>107.849</b>	<b>206.551</b>
<b>%</b>	<b>%48</b>	<b>%52</b>	<b>%100</b>

Turkey's close ties with Libya have enabled thousands of Libyan nationals to receive free treatment in Turkey. These patients' medical expenses are funded by their respective governments. Libyans feel more at ease in Turkey because the two countries share religious and cultural values. One of the causes for the high number of people visiting Germany for medical tourism is the promotion that has come from the settlement of an average of 4.5 million Turkish inhabitants who have relocated to Germany. It should also be emphasised that millions of visitors visit Turkey from Germany each year. Furthermore, promotional activities by Turkish public and commercial health institutions in countries such as Germany and Libya have resulted in an increase in the number of tourists. (Akbolat & Deniz, 2017).

In 2016, around 76000 people obtained tourist health services, including 52,866 travelling to Turkey for medical reasons. With 21,759 residents in total, Germany led the ten nations in medical tourism arrivals with 4,863, while the remaining 16,896 received care under the tourist health umbrella. Iraq, Libya, and Azerbaijan come after Germany. Although 12,855 medical tourists travelled from Libya to Turkey in 2016, this number was 65.7% lower than the previous year (Tontuş & Nebioğlu, 2018).

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**Table 5.** Top 10 Countries Visiting Turkey for Medical Tourism and Tourist Health in 2016  
(Tontuş& Nebioğlu, 2018)

Country	Medical Tourism	Tourist Health	Total
Germany	4.863	16.896	21.759
Azerbaijan	12.318	8.496	20.814
Iraq	11.026	7.973	18.999
Libya	12.855	6.140	18.995
Syria	1.919	12.589	14.508
Turkmenistan	2.684	5.944	8.628
England	1.266	6.864	8.130
Netherlands	1.385	5.711	7.096
Netherlands	2.371	4.387	6.758
Saudi Arabia	2.179	3.568	5.747
<b>Total</b>	<b>52.866</b>	<b>78.568</b>	<b>131.434</b>
<b>%</b>	<b>%40</b>	<b>%60</b>	<b>%100</b>

Many people visiting Turkey from other countries can have treatment at a lower cost than in Western countries. While a US citizen can get in vitro fertilisation therapy in his or her native country for \$15,000, the cost in Turkey is around \$3,000. In Turkey, heart valve replacement surgeries cost an average of \$17,000, whereas in the United States, they can cost anything from \$170,000 to \$200,000. The cost savings also apply to European citizens. While lasik procedures in Europe cost between 4,000 and 8,000 euros, they only cost 600 euros in Turkey. As can be seen from this, medical surgeries charges in Turkey are more advantageous than those in North America, Europe, and the United Kingdom, with prices being from 70% to 90% lower(İçöz, 2019).

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**Table 6.** Cost Comparison of Aesthetic and Cosmetic surgeries in Turkey, the US, and the UK (Dollars) (Medikal Tourism Review, 2021)

Procedures	Turkey	USA	UK
Nose Surgery	2.500	5.000-7.000	5.000
Facelift	3.200	8.000	7.000
Breast Augmentation	3.800	7.000	6.500
Breast Reduction	3.200	6.000	5.600
Liposuction	2.500	4.500	4.000
Eyelid Aesthetics	2.000	4.000	4.000
Buttock Aesthetics	4.200	6.500	6.000
Abdominal Stretching	2.500	5.500	5.000
Aestheticsof Motherhood	9.000-15.000	10.000-20.000	13.000-18.000

India's low medical tourism costs give it the biggest competitive advantage. However, compared to other countries, therapy in Turkey is less expensive. It costs \$170,000 in the US, \$39,900 in South Korea, and \$17,200 in Turkey to replace a heart valve. In the US, spinal fusion surgery can cost \$110,000; in Turkey, it can cost \$16,800; and in India, it can cost \$10,300. Therefore, it may be said that the United States has the highest costs for medical care(Dinçer, Çifçi, & Karayılan, 2016).



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**Table 7. Comparison of Selected Countries' Treatment Costs with Turkey's (Dollars)  
(Kilavuz, 2018)**

<b>Procedures</b>	<b>USA</b>	<b>Turkey</b>	<b>India</b>	<b>Thailand</b>	<b>Malaysia</b>	<b>Singapore</b>	<b>S. Korea</b>
Heart Bypass	123.000	13.900	7.900	15.000	12.100	17.200	26.000
HeartCoverChange	170.000	17.200	9.500	17.200	13.500	16.900	39.900
Angioplasty	28.200	4.800	5.700	4.200	8.000	13.400	17.700
HipProsthesis	40.364	13.900	7.200	17.000	8.000	13.900	21.000
HipSurfaceReplacement	28.000	10.100	9.700	13.500	12.500	16.350	19.500
Knee Replacement	35.000	10.400	6.600	14.000	7.700	16.000	17.500
SpinalFusion	110.000	16.800	10.300	9.500	6.000	12.800	16.900
Dental Implant	2.500	1.100	900	1.720	1.500	2.700	1.350
StomachClamp	14.000	8.600	7.300	11.500	8.150	9.200	10.200
Gastric Sleeve	16.500	12.900	6.000	9.900	8.400	11.500	9.950
StomachBypass	25.000	13.800	7.000	16.800	9.900	13.700	10.900
Hysterectomy	15.400	7.000	3.200	3.650	4.200	10.400	10.400
Chest Implant	6.400	4.500	3.000	3.500	3.800	8.400	3.800
NoseAesthetics	6.500	3.100	2.400	3.300	2.200	2.200	3.980
Facelift	11.000	6.700	3.500	3.950	3.550	440	6.000
Liposuction	5.500	3.000	2.800	2.500	2.500	2.900	2.900
Abdomen Stretching	8.000	4.000	3.500	5.300	3.900	4.650	5.000
Lasik (Two Eye)	4.000	1.700	1.000	2.310	3.450	3.800	1.700
Cornea(One Eye)	17.500	7.000	2.800	3.600	-	9.000	-
Cataract(One Eye)	3.500	1.600	1.500	1.800	3.000	3.250	-
InVitro FertilizationTreatment	12.400	5.200	2.500	4.100	6.900	14.900	7.900

The outcomes of a SWOT analysis can be used to evaluate opportunities and transform them into strengths, determine ways to lessen threats and weaknesses, and create plans to fortify them by making the best use of the strengths. SWOT analysis can help design a roadmap for the medical tourism industry and is essential to its growth. (Tontuş Ö. , 2019). According to the findings of these sources, the strengths, weaknesses, opportunities, and threats of medical

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tourism in Turkey might be stated as follows:

## Strengths

**Affordable Cost:** Medical treatments in Turkey are offered at more competitive prices compared to industrialized countries and many developing countries.

**International Accreditation:** Turkey is involved in the international organization JCI, with 34 accredited healthcare facilities, ensuring high quality standards.

**Localisation:** Turkey is easily accessible to an audience from Europe, the Middle East and Central Asia.

**Air Accessibility:** The flag carrier of Turkey is Turkish Airlines with numerous international routes making it easy for patients to travel.

**Technological Infrastructure:** Turkish healthcare centers possess high technological facility that surpasses that of many nations.

**Tourist Appeal:** Turkey has a favorable climate throughout the year and a number of tourism sites.

**Recognition of Transplants:** There are acceptable international standards for the procedures for transplants that are performed in Turkey.

**Young Population:** A young population provides the energy needed for the life of the medical industry.

**Combination Care and Leisure:** There is an alternative of medical tourism that combines vacations and medical treatment.

**Reliability and Hygiene:** Care in Turkey is rendered in an environment that is clean and of good quality.

**Government Support:** Turkish authorities are making regulations aimed at enhancing medical tourism in the country.

## Weaknesses

**Language Barrier:** Language is often a problem for many international patients especially when dealing with health care professionals who are not multilingual.

**Hospital Recognition:** Integration in the international healthcare market is limited because few Turkish public hospitals want to be recognized internationally.

**Safeguard Lack of Marketing:** There hasn't been adequate marketing especially advertising and going to international forums to promote medical tourism abroad.

**Price Problem:** This could tarnish the image of the medical sector in the region.

**Deficiency in Medical Staff:** There's a brain drain problem which has created a vacuum of the qualified personnel in that sector.

**Limitations in Comprehension of Global Laws:** A lack of adequate knowledge about international health law and patients' rights can create issues for practitioners from Turkey.

**Bad Image:** Previous events of the Turkey's security situation have influenced negatively the outlook which some parts of the world have for Turkey.

**Low Coordination:** The level of coordination between the organizations which deal with medical tourism is wanting and this has a negative impact on the quality of services rendered.

**Not Enough Information Available on Internet:** Given that the site of the hospitals does not always contain information considered necessary by prospective patients.

**Too Little Regulation:** In an environment where adequate regulation and controls are lacking, there are risks for patients.

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## Opportunities

**Long Waiting List in Developed Countries:** The lengthy waiting lists and better still expensive medical treatment offered in countries such as Canada or the US give a chance to draw more clients to Turkey.

**Ease of Access to Developed Markets:** Living in such close radius to the developed world gives one the chances of having medical treatment in turkey other than the developed world.

**Low Epidemic Impression:** Turkey in comparison with some Asian countries which are also targeting the medical tourism shows lesser prevalence of the epidemic disease.

**Aging Population:** Because of the increase in number of Old Aged people in rich countries, there emerges a good potential for medical tourism in Turkey.

**Services Designed for Muslim Tourists:** The provision of services specifically designed for meeting the needs of Muslim tourists is an interesting gap.

**Improvement of International Relations:** Bettering diplomatic relations with other countries can make medical tourism in Turkey more appealing.

**Tax Incentives:** The introduction of tax incentives for the medical tourism industry is likely to foster its growth.

**Facilitating Technologies:** With the advancement of technology, there is an enhancement of interaction between clients and establishment providing healthcare services.

**Interest of Turks Living Abroad:** A good number of Turkish expatriates can, and are ready to come, back to Turkey for medical care which is an extra opportunity.

## Threats

**Threats Brain Drain to the Private Sector:** Salary disparities encourage qualified professionals to leave the public sector for the private sector, thus creating a shortage in certain specialties.

**Regional Political Instability:** Political unrest in neighboring countries can have a negative impact on medical tourism in Turkey.

**Disorganized Pricing:** The absence of a clear pricing policy can lead to confusion and dissatisfaction among patients.

**Discrimination against Local Residents:** Some medical establishments prioritize foreign patients over local residents, which can create social tensions.

**Lack of Shared Database:** The absence of a comprehensive database on the services offered by medical facilities complicates access to information for potential patients.

**Emphasis on Cost rather than Quality:** An excessive focus on cost reduction at the expense of quality could harm the long-term reputation of the Turkish medical sector.

## **Conclusion and Recommendations**

Millions of individuals worldwide are currently employed in the medical tourism sector, which has grown to be a substantial source of income for national economies. To boost their income and get a share of this market, numerous countries have been developing innovative strategies. The medical tourism industry has grown steadily over the last 20 years, and countries who want to take advantage of this market are now include it in their strategic development plans (Tosun, Demir, & Sağlık, 2020). According to data from the top countries that sent medical tourists to Turkey in 2015 and 2016, the country's medical tourism business is growing rapidly due to low treatment costs compared to countries like the US and the UK as well as a consistent increase in foreign patients. Even while Turkey offers excellent value for the money, there are

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still problems, particularly the language barrier and the lack of all-inclusive packages that combine medical treatment with tourism activities.

**Thanks and Information Note**

The report examines the Turkish medical tourism industry critically, focussing on its growth, essential services, and competitive position in the international market. The data included in the study are all culled from a wide range of reliable sources including the Association of Turkish Travel Agencies (TURSAB) and the Turkish Statistical Institute (TUIK) and, therefore, imply critical insights on the trends in medical tourism, treatment costs, etc., and the foreign patient count. The information reviews, and suggestions relate to previous work based on Polina Toncu's master's thesis, commanded inclusive propensities toward the understanding of medical tourism internationally.

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**QUBADA 1918-Cİ İL SOYQIRIMINA ŞAHİD OLAN ETNİK QRUPLARIN  
İFADƏLƏRİ**

**Abidova Səriyyə Elşən qızı**

“Quba şəhərində Soyqırımı Memorial Kompleksi”nin  
Elmi Araşdırmalar, Ekspozisiya və fondu-  
əməkdaşı.

**Xülasə**

1918-ci il soyqırımından sonra Stepan Şaumyan Bakıda, demək olar ki, siyasi və hərbi hakimiyyətə tam sahib olduqdan sonra öz hakimiyyətini Azərbaycanın digər qəzalarında da yaymağa başlamışdı. Bakı Sovetinin apardığı siyasətin nəticəsi olaraq Şaumyan Bakı quberniyasının qəzalarına bolşevik bayrağı altında ermənilərdən ibarət hərbi quldur dəstələri göndərməsi on minlərlə azərbaycanlının soyqırımı qurbanı olmasına səbəb oldu. Bu günahsız insanların həyatları “böyük Ermənistan” ideologiyasının gerçəkləşdirilməsi naminə qurban verildi.

**Açar sözlər:** soyqırımı, etnik qruplar, şahid, Azərbaycan, Quba.

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**TESTIMONIES OF ETHNIC GROUPS WHO WITNESSED THE 1918 GENOCIDE  
IN GUBA**

**Summary**

After the 1918 genocide, Stepan Shaumyan, having nearly full political and military control in Baku, began extending his authority to other regions of Azerbaijan. As a result of the policies carried out by the Baku Soviet, Shaumyan dispatched Armenian-led armed gangs under the Bolshevik banner to the districts of the Baku Governorate, leading to the massacre of tens of thousands of Azerbaijanis. The lives of these innocent people were sacrificed in the name of realizing the ideology of a "Great Armenia."

**Keywords:** genocide, ethnic groups, witness, Azerbaijan, Guba.



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1918-ci ildə Quba qəzasında sayına görə üstünlük təşkil edən Azərbaycan türkləri, ləzgi, tat, avar, buduq, qırız və digər müsəlman əhalisi ilə bərabər ruslar (o cümlədən sektantlar), yəhudilər, ermənilər və digər xalqların nümayəndələri kompakt şəkildə yaşayırdılar. Quba qəzasında etnik düşmənçilik azərbaycanlılarla yanaşı, həm də digər millətlərə qarşı yönəlmişdir. [2.s.382] Bu məqalə Quba qəzasında yaşayan etnik qrupların soyqırım haqqında olan şahid ifadələrindən bəhs edir.

Bolşeviklərin siyasi hakimiyyətdə olduğu müddətdə, yəni 1917-ci il noyabrın 2-dən 1918-ci il iyulun 31-dək, Azərbaycanın Bakı, Şamaxı, Quba, Kürdəmir, Salyan və digər yaşayış bölgələrində apardıqları anti-azərbaycan siyasətindən ən çox əziyyət çəkən dinc türk-müsəlmanları olmuşdur. Şaumyan tərəfindən sırf cəza olaraq Qubaya göndərilən Hamazasp Srvandzyan və onun quldur dəstələri yol boyu bütün müsəlman kəndlərinə hücum etmişlər. Kəndləri talan edən, dağıdan, yandıran, qaçmağa macal tapmayan qocaları, qadınları və uşaqları vəhşicəsinə qıran S.Hamazasp Qubada məscidin qarşısında əhalini hədələyərək demişdir: "Mən əslən Ərzurumdanam. Uzun müddət türklərlə vuruşmuşam. Mən erməni xalqının qəhrəmanıyam və onun mənafeələrinin müdafiəçisiyəm. Qisasçı dəstəmlə burada qayda-qanun yaratmağa göndərilmişəm... Mənə əmr edilmişdir ki, dənizdən Şahdağa kimi bütün müsəlmanları məhv edim, onların yaşayış yerlərini Şirvanda olduğu kimi tamamilə dağıdıb, torpaqla bərabərləşdirim..." [7]

Hamazaspın quldur dəstəsi Quba qəzasına aid olan Dəvəçi, Sadan, Çarxana, Dərə Zarat, Zağlıcan, Əlixanlı, Eynibulaq, Ərəb Əlməmmədli, Kolani, Tuğay, Nardaran, Siyəzən, Rəhimli, Surra, Qulamlar, Butbut, Xəlillər, Qaraqaşlı, Aşağı Quşçu, Sirvan, Tura, Aygün, Qubla Qırız, Qara Qurtlu, Qaraça Nərdican, Xudat, Aşağı Buduq və başqa yaşayış məskənlərini dağıtmışdır. Bu kəndlərin dağıdılması zamanı qadın, uşaq baxmadan ermənilər dinc əhaliyə qarşı qətlər törətmişlər. Tarixi məlumatlara əsasən Hamazaspın "Cəza dəstəsi" Quba qəzasının 167 kəndini darmadağın etmiş, on altı mindən çox insanı - kişi, qadın və uşaqı qətlə yetirmişdir və həmin kəndlərin əhalisinə, ümumi dəyəri 58.121.059 manatlıq (rubl) ziyan vurulmuşdu. Eyni zamanda evlər, ictimai binalar və başqa tikililər dağıdılmış, mal-qara və əmlakları qarət olunmuşdur. [1.s.16]

Bu hadisələrə şahid olan 43 yaşlı, Müşkür nahiyəsinin Cek kəndinin kəndxudası İsrail Məmməd oğlu ifadəsində söyləmişdir: "Mən 18 kiçik kəndin daxil olduğu Cek icmasının kəndxudasıyam. Bu kəndlər dəmiryolundan 6 verst qədər aralıdadır. İcmada 140 ev və hər iki cinsdən olan 560 nəfər əhali var idi. Yazın axırlarında ermənilər Bakıdan Quba şəhərini tarmar etmək üçün gələndə onlar dəmiryolunun yaxınlığında yerləşən bütün müsəlman kəndlərinə hücum etdilər, taladılar və od vurub yandırdılar. Bizim icmaya da basqın olundu. Ermənilər evlərin çoxunu yandırdılar, əmlakı taladılar və bir neçə adamı öldürdülər. Mən bu ermənilərin heç birini tanımıram və adlarını da deyə bilmərəm. Məscidə də od vurulub və onun bir hissəsi yanıb. Yanmış evləri də göstərməklə, dəymiş zərər haqqında hökmü təqdim etmişəm." [4.s.174] Daha bir şahid isə Quba qəzası Müşkür nahiyəsinin Qaraqurdlu kəndinin tat sakini, Şeyda Şıx Əli oğlu öz ifadəsində belə demişdir: "Mən yeddi kəndin daxil olduğu Qaraqurdlu cəmiyyətinin starşinasıyam. Talana qədər cəmiyyətdə hər iki cinsdən min nəfərə yaxın əhalisi olan 128 ev var idi. Kəndlər hər iki tərəfdən dəmir yolu boyu yerləşmişdir. Bu il yazın sonunda yalnız ermənilərdən ibarət olan cəza dəstəsi Bakıdan Qubaya hərəkət edərkən müsəlman kənlərinə hücum edir, onları dağıdır, yandırır, sakinlərini isə qırırdılar. Bu dəstə bizim cəmiyyətə də basqın etmiş, bütün kəndləri bünövrəsindək yandırmış, yalnız bir neçə kənd salamat qalmışdır. Məscidə od vurulmuş və qismən yanmışdır, bütün daşınan əmlak qarət edilmişdir. Kənddə qaçmağa macal tapmamış 7 nəfər qalmışdı, onların hamısı öldürülmüşdür: bir hissəsi

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kəndin özündə, qalanı isə yollarda. Mən yandırılmış evlərin və qətlə yetirilənlərin sayı, dəymiş zərərin həcmi haqqında məlumat vermişəm. Əlavə heç nə göstərə bilmərəm.”[3. s.210]

Şahidin ifadəsindən belə məlum olur ki, ermənilər bütün kəndlərdə eyni ssenari üzrə vəhşiliklər həyata keçirmişlər. Dinc əhalini amansızlıqla qətlə yetirib, mal- mülkləri qarət etməklə yanaşı din ocaqlarını darmadağın edən daşnaklar islam dininə, şərq tarixinə və ədəbiyyatına aid minlərlə qiymətli kitabları da yandırmışlar. Məlumatlara əsasən Digah məscidində təxminən 600-700 il əvvələ aid, alban və ərəb əlifbası ilə yazılmış kitablar var idi. Ermənilər həmin kitabları məhv etməklə yanaşı, kənd məscidinin təxminən 1 kilometrliyində yerləşən pirin daşını da partlatmışdılar. Bu, üstündə alban yazıları olan çox nəhəng daş idi. Fövqaladə Təhqiqat Komissiyasının sənədlərindən məlum olur ki, Digah məscidində qızıl suyuna çəkilmiş çoxsaylı Quran kitabları yandırılmışdır. [5.s128] Bu barədə Quba qəzası 5-ci Fəthibəy nahiyəsi Alpan cəmiyyəti Digah kənd sakini 60 yaşlı Ömər Şıx Kərim oğlu qeyd etmişdir: “Bizim Digah kəndi Quba şəhərinin 5 verstliyində yerləşir. Ermənilər Quba şəhərini ikinci dəfə talan edən zaman, oradan bizim kəndə ermənilərdən ibarət olan böyük qoşun dəstəsi gəldi. Biz hamımız qaçıb dağılıxdıq, yalnız üç qoca və iki qarı qaldı ki, onları sonradan ermənilər öldürdülər. Ermənilər bizim kəndimizi talan etdilər: 2-3 ev istisna olmaqla, bütün evləri yandırdılar, kənddə cəmi 84 ev vardı, məscidi və Quran kitabını da yandırdılar, daşınan qiymətli əmlakın hamısı qarət edildi, qalanları isə istifadəyə yararsız vəziyyətə salındı. Ermənilər bizim kəndi iki dəfə talan etmişlər: birinci dəfə Qusara gedərkən, ikinci dəfə ordan geri qayıdarkən. Əlavə heç nə deyə bilmərəm.” [3.s.218]

Daha bir şahid ifadəsinə nəzər salaq. Molla Seyfəddin Hidayət oğlu, 50 yaş, Quba qəzasının Müşkür nahiyəsinin Qiblə Qrız icmasının mollası: Mən Quba qəzasının Müşkür nahiyəsinin Qiblə Qrız icmasının gəlmə mollasıyam. İcmaya 200 evi olan 11 kiçik kənd daxildir. Kəndlər dəmiryolundan 5 verst aralıdadır. Amazaspın başçılıq etdiyi cəza dəstəsi Bakı şəhərindən Quba şəhərinə gələndə, həmin dəstənin ermənilərdən ibarət olan erməni Nikolayın başçısı olduğu bir hissəsi bizim icmaya basqın etdi: 5 kəndi yandırdı, qalanlarını talan etdi, əmlakını apardı, üç məscidi və iki məktəbi yandırdı. Bir məscid məktəblə eyni binada yerləşirdi və o, bizə 15 min manata başa gəlmişdi. Ermənilər tərəfindən 10 adam öldürülmüşdür. Yandırılmış evlərin sayı və dəymiş zərərlə bağlı hökmü təqdim etmişəm. [4.s.175]

Ermənilər müsəlmanlarla yəhudilər arasına nifaq salmaq üçün ən fitnəkar vasitələrə əl atırdılar. Qeyd etmək lazımdır ki, həm Gelovaninin, həm də Hamazaspın Qubada olduğu dövrdə bir sıra yəhudilər onların əməllərinə etiraz etmiş, hətta bəzi hallarda Azərbaycanın milli qüvvələrinə kömək belə edirdilər. Ümumiyyətlə qəzanın yəhudi əhalisi bolşevik-daşnak qüvvələrinin sərt təzyiqi altında idilər. Buna baxmayaraq onların əksəriyyəti həmin hadisələrdə soyuqqanlı davranaraq öz qonşuları azərbaycanlılarla tarixi qarşılıqlı münasibətlərinin əzilməsinə imkan verməmişdilər. Məsələn İfrazimov adlı birisi yəhudilər tərəfindən Slobodada gizlənmiş qırmızı qvardiyaçıların milli qüvvələrə təslim edildiyini təsdiq edirdi. [5. s.129-130]Yəhudilərin Qubadan kütləvi surətdə qaçmasını isə, yəqin ki, yaşadıkları yerlərdə baş verən bütün qiyam və iğtişələr zamanı bir qayda olaraq günahsız qurbana çevrilən yəhudi xalqının qəlbində onilliklər boyu kök salmış qorxu hissi ilə izah etmək olardı. Bu baxımdan təkcə Qubada baş vermiş məlum hadisələr zamanı həlak olmuş yəhudilər deyil, sərgərdanlıq zamanı xəstəlikdən, aclıqdan və əziyyətdən ölmüşdür. Yəhudi qubalılar da öz müsəlman həmyerliləri kimi ermənilərin təcavüzkar millətçilik siyasətinin qurbanları sayılırlar. [6]

Bu qanlı faciəni törədən ermənilərə müqavimət göstərərək layiqli cavab Quba rayonunun Digah kəndində “Qanlı dərə” adlandırılan ərazidə verilmişdir. Hətəm ağa Cağarvi, Möhübəli Əfəndi, Əli bəy Zizikski, Xaçmazın Şıxlar kəndinin bəyləri, Həmdulla əfəndi, Qaçaq Mayıl və

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başqaları bu döyüşlərdə əsl qəhrəmanlıq nümayiş etdirmişlər. “Qanlı dəre”də azərbaycanlılar, ləzgilər, tatlar və bu bölgədə yaşayan digər xalqlar əl-ələ verərək erməniləri məhv etmiş, mart-aprel soyqırımını törədən daşnaklara layiqli cavab verilmişdir. Yerli əhalinin mütəşəkkil müqavimətinə rast gələn Hamazasp istəyinə nail ola bilməmişdi. [7]

### **Nəticə**

Quba qətliaamları Azərbaycanın çoxmillətli cəmiyyətinin qarşılaşdığı böyük faciə idi və tariximizin ən çətin məqamlarında bu xalqların birliyi unudulmaz iz buraxdı. Azərbaycan Respublikasının Prezidenti İlham Əliyevin vurğuladığı kimi: “Azərbaycanda bütün xalqlar bir ailə kimi yaşayırlar. Bu, bizim böyük üstünlüyümüzdür, böyük dəyərimizdir. Biz bunu qiymətləndirməliyik və ölkəmizdə yaşayan bütün xalqlar arasında bu qardaşlığı, dostluğu daha da möhkəmləndirməliyik. Bu, bəlkə də, bizim ən böyük sərvətimizdir. Əsrlər boyu Azərbaycanda yaşayan bütün xalqlar bərabər hüquqlara malik idilər. Bu gün də bu gözəl ənənələr yaşayır. Hər bir vətəndaş dinindən, dilindən, millətindən asılı olmayaraq Azərbaycanın qiymətli, dəyərli vətəndaşdır”.

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## MODEL OF EDUCATION MANAGEMENT IN HIGHER MILITARY EDUCATIONAL INSTITUTIONS

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### **Abstract**

The article discusses the model of teaching management in higher military educational institutions. Thus, the student-centered curriculum in higher military educational institutions should be implemented by teaching subjects and tasks with communicative content. At the same time, the behavioral goals and psychological characteristics of students should be developed and analyzed in the program content. This imposes additional requirements on students to make the right choice and creates an opportunity for teachers to ensure the independence of students.

Pedagogical management has its own characteristics and regularities. Taking this into account, research in education recommends many new approaches, strategic methods and techniques that form managerial skills and abilities in new creative searches in students. These are always desirable models and expected examples in education in higher military educational institutions. The specificity of management skills includes the formation of abilities to be achieved on subjects and goals, reflective activity, critical thinking and evaluation.

It is known that traditional activities cannot connect independent learning activities, the sequence of cognitive activities is not systematically applied. For this purpose, there are specific pedagogical approaches that connect the individual activities of students with each other, which can help in the formation of students' independence and communicative skills. The best way to learn management skills in higher military educational institutions in various contexts and to acquire them in higher education is a set of various activities and approaches. The researchers' proposals evaluate a large part of the differences in students' behavior as a result of successful instructions and show their application within the framework of activities with various contexts.

**Keywords:** higher military educational institutions, educational process, training, cadets, training model

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## INTRODUCTION

The new content of the curriculum in higher military education institutions should support strategies and components that reflect the independence, research, and activity of students. In this regard, the curriculum aimed at developing management skills in students should have new content, design, and organization. When the program is effectively designed, the teacher builds his or her activity more successfully, and the skills that students will acquire are described sequentially.

## METHOD

The following elements should create the basis for the development of an innovative curriculum centered on students in the new design. In the curriculum:

- 1) The educational needs and learning outcomes of students should be determined;
- 2) Professional goals at the bachelor's level should be selected;
- 3) The psychological state and educational experiences of students should be explained;
- 4) Topics that are in line with the interests of students should be arranged sequentially;
- 5) Training strategies should be applied in the areas of critical thinking, communication, and creative activity;
- 6) Topics should be taught in an integrative manner;
- 7) The tasks given in the modules should be taught in accordance with the requirements of the taxonomy;
- 8) Learning methods and techniques should be explained separately;
- 9) The use, role and sources of technological tools should be briefly explained;
- 10) The mechanisms for formative and summative assessment of each topic should be described.

The student-centered curriculum in higher military educational institutions should be implemented by teaching topics and tasks with communicative content. At the same time, the behavioral goals and psychological characteristics of students should be developed and analyzed in the program content. A.B.Erikson (Ericsson A.B, 2012) writes that adapting education to the needs of students of the 21st century, designing a flexible curriculum means self-regulated learning. This places additional demands on students to make the right choice and creates an opportunity for teachers to ensure the independence of students.

Pedagogical management has its own characteristics and regularities. Taking this into account, research in education recommends many new approaches, strategic methods and techniques that form managerial skills and abilities in new creative searches in students. These are always desirable models and expected examples in education in higher military educational institutions. The specificity of management skills includes the formation of abilities to be achieved on topics and goals, reflective activity, critical thinking and evaluation. In the management of the educational process, the manager's field of work is the activity of the management subject, and the ultimate goal is literacy, upbringing, proper behavior, culture and level of development.

Active listening, reading comprehension, note-taking, stress management, effective time management, and critical thinking activities should be taught to students in a new pedagogical approach. Classroom management practices should partially promote students' learning and self-development.

It is known that traditional activities cannot connect independent learning activities, and the sequence of cognitive activities is not systematically applied. For this purpose, there are

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specific pedagogical approaches that connect the individual activities of students with each other, which can help students develop their independence and communicative skills. The best way to learn management skills in higher military educational institutions in different contexts and to acquire them in higher education is a set of different activities and approaches.

The researchers' proposals evaluate a large part of the differences in students' behavior as the result of successful instructions and show their application within the framework of activities with different content. Modern pedagogical approaches propose to develop management skills in learners through the following learning methods:

- Direct Instruction (low-tech);
- Agile learning method (high-tech);
- Kinesthetic learning (low-tech);
- Differential learning (low-tech);
- Game-based learning (high-tech);
- Inquiry-based learning (high-tech);
- Expeditionary learning (high-tech);
- Individual Learning (high-tech).

From this it becomes clear that learners freely participate in the selection of topics and textbooks, the organization of group work, and the application of methods and techniques.

Demonstrating competence in training in higher military educational institutions is first noted as a product of cognitive (cognitive) skills. Simply put, cognitive skills teach learners to remember, understand the reasons for what is happening, apply what they know, think correctly in solving problems, research, analyze the ways they read and learn, evaluate ideas correctly, and discover new creative products. In order for the above sequence to be reflected in the tasks and activities of learners, the teacher must prepare appropriate instructions. The development of cognitive skills in a knowledge society paves the way for the acquisition of metacognitive skills - competencies and is realized as a management culture. Competence is a set of knowledge, skills, habits, qualities, and values. Competencies provide learners with an open, measurable, and transferable learning opportunity. In this regard, both competencies, cognitive and metacognitive, help determine the academic results and high abilities of the learner.

## RECOMMENDATIONS

The management skills of students in higher military education institutions are considered most valuable when they use evidence-based research and their own professional judgment.

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**DEEP LEARNING ARCHITECTURE FOR DATA-DRIVEN DAMAGE DETECTION  
IN NON-LINEAR DYNAMIC SYSTEMS: A SYSTEMIC REVIEW ON  
STRUCTURAL HEALTH MONITORING**

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**Abstract**

Damage detection in non-linear dynamic systems is a challenging task in structural health monitoring and civil engineering due to the complex behaviour of these systems. Traditional methods rely on analytical models and sensor data, which may not accurately capture the non-linear dynamics of the system. This can lead to inaccurate or delayed detection of damage, which can have serious consequences for the safety and integrity of the structure. Therefore, there is a need for a data-driven approach that can effectively detect damage in non-linear dynamic systems. The methodology for this systematic review involves a comprehensive search of relevant studies published in peer-reviewed journals and conference proceedings. The search strategy includes keywords related to deep learning, structural health monitoring, damage detection, and non-linear dynamic systems. The inclusion criteria for the studies are based on their relevance to the topic and the quality of the research methodology. The data extraction process involves summarizing key findings, methodologies, and results from each study. The synthesis of the findings is conducted to identify common themes, trends, and gaps in the literature. The findings from the systematic review indicate that deep learning architecture shows promising results in detecting damage in non-linear dynamic systems. Convolutional neural networks have been widely used for image-based damage detection, while recurrent neural networks have shown potential for time-series data analysis. Auto-encoders have also been applied for feature extraction and anomaly detection in structural health monitoring. The studies reviewed demonstrate high accuracy and efficiency of deep learning techniques in detecting damage, compared to traditional methods. Although deep learning architecture holds great promise for enhancing the reliability and effectiveness of structural health monitoring systems, challenges remain in terms of data acquisition, model

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training, and interpretability.

**Keywords:** Deep learning, structural health monitoring, damage detection, non-linear dynamic systems

### **Introduction**

Deep learning architecture is a subset of machine learning that focuses on the development of artificial neural networks with multiple layers, allowing for the extraction of high-level features from raw data (Sengupta et al., 2020; Khan et al., 2020). This architecture has gained significant attention in recent years due to its ability to automatically learn representations of data through the use of deep neural networks. The defining characteristic of deep learning architecture is the presence of multiple layers of interconnected nodes, also known as neurons, which are organized in a hierarchical fashion. Each layer of neurons processes the input data and passes the output to the next layer, with the final layer producing the desired output (Shrestha & Mahmood, 2019; Aniekan Ikpe et al., 2024). This process of passing information through multiple layers allows the network to learn complex patterns and relationships in the data, leading to more accurate predictions and classifications. Deep learning architecture refers to a class of machine learning algorithms that are inspired by the structure and function of the human brain. These algorithms consist of multiple layers of interconnected nodes, or neurons, that process input data and learn to extract relevant features through a process known as training (Khampariam & Singh, 2019; Ekanem et al., 2024). Data-driven damage detection in non-linear dynamic systems is a critical area of research that has gained significant attention in recent years. This approach involves using data collected from sensors to detect and assess damage in structures or mechanical systems, without relying on traditional analytical models. In other words, data-driven damage detection can be defined as a process of using data collected from sensors to identify and assess damage in non-linear dynamic systems. This approach relies on statistical and machine learning techniques to analyze the data and detect changes in the system's behaviour that may indicate the presence of damage (Pouyanfar et al., 2018; Taye, 2023). Unlike traditional analytical models, data-driven methods do not require a priori knowledge of the system's dynamics or material properties, making them particularly useful for complex and non-linear systems. Deep learning architecture has emerged as a powerful tool for data-driven damage detection in non-linear dynamic systems. This technology leverages artificial neural networks to automatically learn and extract features from raw data, enabling accurate and efficient detection of structural damage (Ghadami & Epureanu, 2022). In the context of damage detection in non-linear dynamic systems, deep learning architecture has the ability to automatically learn and extract features from raw sensor data, eliminating the need for manual feature engineering. This not only reduces the time and effort required for data processing, but also enables the detection of subtle and complex patterns that may be difficult to capture using conventional techniques. Furthermore, deep learning architecture is well-suited for handling large and high-dimensional datasets, which are common in structural health monitoring applications (Wang & Wu, 2020). By leveraging the scalability and parallel processing capabilities of deep learning algorithms, large amounts of sensor data in real-time can efficiently be analyzed, enabling timely detection of structural damage and potential failure.

### **Key Milestones on the Deep Learning Architecture for Data-Driven Damage Detection in Non-Linear Dynamic Systems**

Deep learning architecture has emerged as a powerful tool for data-driven damage detection in non-linear dynamic systems. Recent innovative milestones in this field have significantly advanced the capabilities of deep learning models to accurately identify and localize damage in complex structural systems. The key milestones in deep learning architecture for data-driven

damage detection in non-linear dynamic systems are highlighted as follows:

- i. The development of convolutional neural networks (CNNs) specifically designed for analyzing structural health monitoring data: CNNs have shown great promise in automatically extracting features from sensor data and identifying patterns associated with damage in structural systems (Azimi et al., 2020; Sony et al., 2021). By leveraging the hierarchical structure of CNNs, researchers have been able to achieve high levels of accuracy in detecting damage in non-linear dynamic systems.
- ii. The development of recurrent neural networks (RNNs): RNNs are well-suited for analyzing time-series data, making them ideal for monitoring the dynamic behaviour of structures over time. By capturing the temporal dependencies in the sensor data, RNNs can detect anomalies that may indicate structural damage, such as changes in vibration patterns or irregularities in response to external stimuli (Weerakody et al., 2021; Mienye et al., 2024).
- iii. The integration of recurrent neural networks (RNNs) with CNNs to capture temporal dependencies in structural health monitoring data: RNNs have the ability to model sequential data and capture long-term dependencies, making them well-suited for analyzing time-series data from sensors. By combining CNNs with RNNs, researchers have been able to improve the accuracy of damage detection algorithms and enhance the robustness of deep learning models in non-linear dynamic systems (Bui-Tien et al., 2022; Rahim et al., 2024).
- iv. The development of attention mechanisms in deep learning architecture has enabled researchers to focus on relevant features in structural health monitoring data, improving the interpretability and efficiency of damage detection algorithms. Attention mechanisms allow deep learning models to selectively attend to important regions of the input data, enabling more accurate and reliable detection of damage in non-linear dynamic systems (Rezaeianjouybari & Shang, 2020; Malekloo et al., 2022).
- v. The use of generative adversarial networks (GANs) in deep learning architecture has opened up new possibilities for data augmentation and synthetic data generation in structural health monitoring (Alqahtani et al., 2021; Ikpe et al., 2024). GANs have the ability to generate realistic sensor data that can be used to train deep learning models on a larger and more diverse dataset, improving the generalization and robustness of damage detection algorithms in non-linear dynamic systems.

Recent innovative milestones in deep learning architecture have significantly advanced the capabilities of data-driven damage detection in non-linear dynamic systems. By exploring CNNs, RNNs, attention mechanisms, and GANs, interpretability, and efficiency of deep learning models for detecting damage in complex structural systems have improved greatly.

### **Data-Driven Damages in Non-Linear Dynamic Systems**

Data-driven damages in non-linear dynamic systems are a critical area of study in the field of engineering and applied mathematics. Non-linear dynamic systems are characterized by complex interactions between variables, making them difficult to predict and control. When these systems experience damages, the consequences can be severe and far-reaching. The detailed highlights of data-driven damages in non-linear dynamic systems are as follows:

- i. The phenomenon of bifurcation: Bifurcations occur when a small change in a system parameter leads to a qualitative change in the system's behaviour. This can result in sudden and unexpected shifts in the system's dynamics, leading to instability and

- potential failure. Bifurcations are particularly problematic in non-linear systems, where small perturbations can have disproportionately large effects (Dercole & Rinaldi, 2011).
- ii. The occurrence of chaos: Chaos is a state of disorder and unpredictability in a system's behaviour, characterized by sensitive dependence on initial conditions. In non-linear systems, chaotic behaviour can arise from simple deterministic rules, making it difficult to predict and control. Chaos can lead to erratic and unpredictable system responses, making it challenging to design and operate non-linear systems effectively.
  - iii. Non-linear dynamic systems are also susceptible to data-driven damages such as resonance and hysteresis: Resonance occurs when a system is excited at its natural frequency, leading to large oscillations and potential structural damage. Hysteresis, on the other hand, refers to the phenomenon where a system's response depends on its previous history, leading to memory effects and non-linear behaviour. Both resonance and hysteresis can have detrimental effects on the performance and reliability of non-linear dynamic systems (Godarzi & Hejazi, 2025).
  - iv. Non-linear dynamic systems can experience data-driven damages such as parameter identification errors and model uncertainty: Parameter identification errors occur when the true values of system parameters are not accurately known, leading to inaccuracies in system modeling and control (Ma et al., 2020).
  - v. Model uncertainty, on the other hand, refers to the inherent limitations in modeling complex non-linear systems, leading to errors and inaccuracies in predicting system behaviour. Both parameter identification errors and model uncertainty can result in suboptimal system performance and potential damages (Galbally et al., 2010).

Data-driven damages in non-linear dynamic systems are a critical concern for engineers. Bifurcations, chaos, resonance, hysteresis, parameter identification errors, and model uncertainty are just a few examples of the challenges faced in understanding and mitigating risks in non-linear systems. By developing advanced modeling techniques, data-driven analysis methods, and robust control strategies, damages in non-linear dynamic systems can better predict, prevent, and mitigate

### **Causes of Data-Driven Damages in Non-Linear Dynamic Systems**

Understanding the causes of data-driven damages in non-linear dynamic systems is crucial for developing effective strategies to prevent and mitigate their impact. The key factors that contribute to data-driven damages in non-linear dynamic systems are discussed as follows:

- i. The presence of complex interactions and feedback loops: Non-linear systems are characterized by their sensitivity to initial conditions and the potential for small changes to have disproportionate effects on the system as a whole. When data is used to model and control these systems, inaccuracies or errors in the data can lead to unexpected outcomes and disruptions (Rial et al., 2004; Azar, 2012). For example, a slight deviation in sensor readings or input parameters can result in a cascade of errors that destabilize the system and cause damage.
- ii. The presence of uncertainties and variability: Non-linear systems are inherently unpredictable, and their behaviour can be influenced by a wide range of factors, including external disturbances, environmental conditions, and internal dynamics. When data is used to make decisions or predictions in these systems, it is essential to account for uncertainties and variability to avoid making incorrect assumptions or

taking inappropriate actions. Failure to do so can result in data-driven damages, such as equipment failures, production delays, or even accidents Balasis et al., 2023; Tang & Ahmad, 2024).

- iii. The complexity of non-linear dynamic systems can also pose challenges for data-driven decision-making: Non-linear systems often exhibit emergent properties and non-intuitive behaviours that are difficult to predict or understand using traditional analytical methods. When data is used to model and analyze these systems, it is essential to consider the limitations of the data and the underlying assumptions of the models (Bayrak et al., 2021). Failure to do so can lead to erroneous conclusions and decisions that may exacerbate existing problems or create new ones.
- iv. Measurement noise: This can arise from various sources such as sensor inaccuracies, environmental disturbances, or signal processing errors. Measurement noise can introduce uncertainties into the data used for system identification and control, leading to inaccurate modeling and suboptimal performance (Khan et al., 2009). In non-linear dynamic systems, where small perturbations can have significant effects, even low levels of measurement noise can result in substantial degradation of system performance (Bies et al., 2023).
- v. Parameter drift: Parameters in non-linear models are often assumed to be constant over time, but in practice, they can vary due to factors such as aging, wear and tear, or changes in operating conditions. Parameter drift can lead to inaccuracies in the model predictions and control actions, resulting in reduced system performance and potentially catastrophic failures (Hossain et al., 2024; Muhammad et al., 2024).
- vi. Data-driven damages can also arise from model simplifications and approximations: Non-linear dynamic systems are often highly complex and may involve a large number of variables and interactions. To make the system more tractable, engineers often resort to simplifying assumptions and approximations in the model. However, these simplifications can lead to inaccuracies in the model predictions and control strategies, especially in the presence of non-linearities and uncertainties (Rega, 2022; Wang et al., 2023).
- vii. Data-driven damages in non-linear dynamic systems can also be caused by external disturbances and uncertainties: Non-linear systems are inherently sensitive to external perturbations, such as changes in operating conditions, disturbances in the environment, or uncertainties in the system parameters (Castillo & Melin, 2012; Hou et al., 2016). These disturbances can disrupt the system dynamics, leading to unexpected behaviours and performance degradation.

Data-driven damages in non-linear dynamic systems can be caused by a variety of factors, including complex interactions, uncertainties, variability, system complexity etc. To prevent and mitigate these damages, it is essential to adopt a holistic approach that integrates data analytics, system dynamics, and risk management principles. By addressing the root causes of data-driven damages and developing robust strategies for managing them, organizations can enhance the resilience and reliability of their non-linear dynamic systems.

### **Principles of Deep Learning Architecture in Data-Driven Non-Linear Dynamic Systems**

Deep learning architectural data analytics has emerged as a powerful tool for analyzing data-driven non-linear dynamic systems. This technology leverages advanced algorithms and neural networks to extract meaningful insights from complex datasets, enabling engineers and

practitioners to better understand and predict the behaviour of dynamic systems (Rane et al., 2024; Agrawal et al., 2024). At the core of deep learning architectural data analytics is the concept of neural networks, which are computational models inspired by the structure and function of the human brain. These networks consist of interconnected nodes, or neurons, that process and transmit information through weighted connections. By adjusting these weights based on input data, neural networks can learn to recognize patterns and make predictions with a high degree of accuracy. In the context of data-driven non-linear dynamic systems, deep learning architectural data analytics works by training neural networks on historical data to identify patterns and relationships that can be used to predict future outcomes (Taherdoost, 2023; Bishnu et al., 2023). This process involves feeding the network with input data, such as time series data or sensor readings, and adjusting the network's parameters through a process known as backpropagation. Through this iterative process, the network learns to make accurate predictions based on the patterns it has identified in the training data. Deep learning architectural data analytics can handle non-linear relationships and complex interactions within dynamic systems. Traditional linear models often struggle to capture the nuances of non-linear systems, leading to inaccurate predictions and limited insights (Shome et al., 2024; Filippi-Mazzola & Wit, 2024). In contrast, deep learning models excel at capturing these complex relationships, allowing researchers to uncover hidden patterns and make more accurate predictions. Furthermore, deep learning architectural data analytics can adapt to changing data patterns and dynamics, making it well-suited for analyzing dynamic systems that evolve over time. By continuously updating the network's parameters with new data, researchers can ensure that their models remain accurate and up-to-date, even as the underlying system changes.

### **Procedure for Detecting Data-Driven Damages in Non-Linear Dynamic Systems Using Deep Learning Architectures**

Detecting data-driven damages in non-linear dynamic systems using deep learning architectures is a critical task that requires a systematic and detailed procedure. The procedure for identifying damages in non-linear dynamic systems using deep learning architectures are as follows:

- i. **Data Collection:** The first step in detecting data-driven damages in non-linear dynamic systems is to collect relevant data. This data may include sensor readings, operational parameters, and historical performance data of the system under consideration. It is essential to ensure that the data is accurate, complete, and representative of the system's behaviour (Chen et al., 2022).
- ii. **Data Preprocessing:** Once the data is collected, it needs to be preprocessed to remove noise, outliers, and inconsistencies. This step involves data cleaning, normalization, and feature extraction to prepare the data for input into the deep learning model. Proper preprocessing is crucial for the model to learn effectively and accurately detect damages (Brewick & Masri, 2016).
- iii. **Model Selection:** The next step is to select an appropriate deep learning architecture for detecting damages in non-linear dynamic systems. Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and Long Short-Term Memory (LSTM) networks are commonly used for this purpose due to their ability to capture complex patterns in sequential data (Mousavi et al., 2020).
- iv. **Model Training:** Once the deep learning architecture is selected, the model needs to be trained using the preprocessed data. This involves feeding the data into the model,

adjusting the model's parameters through backpropagation, and optimizing the model's performance using techniques such as gradient descent. Training the model is a crucial step in ensuring its ability to accurately detect damages in the system.

- v. **Damage Detection:** After the model is trained, it can be used to detect data-driven damages in the non-linear dynamic system. This involves inputting new data into the model and analyzing the model's output to identify any anomalies or deviations from normal behaviour. The model can provide insights into the type, severity, and location of damages in the system. **Monitoring and Maintenance:** To ensure the continued effectiveness of the deep learning model in preventing data-driven damages, it is crucial to monitor its performance in real-time and make necessary adjustments as needed. This may involve retraining the model on updated data or fine-tuning its parameters to improve its performance (Hajializadeh, 2023).
- vi. **Integration with Control Systems:** The deep learning model should be integrated with the existing control systems in the non-linear dynamic system to enable real-time decision-making and intervention. By combining the predictive capabilities of the deep learning model with the control mechanisms of the system, organizations can effectively prevent and control data-driven damages before they escalate (Zhang et al., 2024).
- vii. **Model Evaluation:** The performance of the deep learning model in detecting data-driven damages needs to be evaluated. This can be done by comparing the model's predictions with ground truth data, calculating metrics such as accuracy, precision, recall, and F1 score, and conducting statistical tests to assess the model's reliability and robustness (Li & Spence, 2022).

Detecting data-driven damages in non-linear dynamic systems using deep learning architectures requires a systematic and detailed procedure. By following the aforementioned steps, the damages in complex systems can be effectively identified and mitigated, contributing to the advancement of predictive maintenance and system reliability.

### **Modeling and Prediction of Non-Linear Dynamic Systems**

Deep learning architectures have shown great potential in modeling and predicting non-linear dynamic systems. However, the performance and effectiveness of these architectures can be influenced by the following factors:

- i. **Quality and quantity of the training data:** Deep learning models require a large amount of data to effectively learn the underlying patterns and relationships in the data. If the training data is limited or of poor quality, the performance of the deep learning architecture may be compromised. Therefore, it is essential to ensure that the training data is representative of the underlying dynamics of the system and is free from noise and outliers (Zhang et al., 2023).
- ii. **Choice of architecture and hyper-parameters:** Different deep learning architectures, such as convolutional neural networks (CNNs) and recurrent neural networks (RNNs), have different strengths and weaknesses in modeling non-linear dynamic systems. The choice of architecture and hyper-parameters can significantly impact the performance of the model. It is important to carefully select the architecture and tune the hyper-parameters to achieve the best performance (Ghadami & Epureanu, 2022).
- iii. **Complexity of the non-linear dynamic system:** Deep learning models may struggle to capture the complex dynamics of the system if it is highly non-linear or chaotic. In such



cases, it may be necessary to use more sophisticated architectures or techniques, such as attention mechanisms or ensemble learning, to improve the performance of the model (Cartagena et al., 2021).

- iv. The presence of noise and uncertainty in the data: Noise and uncertainty can introduce errors and inaccuracies in the model predictions, leading to reduced performance. It is important to preprocess the data and incorporate techniques, such as regularization and dropout, to mitigate the effects of noise and uncertainty.

The performance and effectiveness of deep learning architectures in data-driven non-linear dynamic systems can be influenced by various factors, including the quality and quantity of the training data, the choice of architecture and hyper-parameters, the complexity of the system, and the presence of noise and uncertainty. By carefully considering these factors and implementing appropriate strategies, it is possible to improve the performance of deep learning architectures in modeling non-linear dynamic systems.

### Classifications of Deep Learning Architectures for Detection of Data-Driven Damages in Non-Linear Dynamic Systems

There are several deep learning architectures that have shown promising results in various fields, including structural health monitoring and damage detection. These includes the following:

- i. Convolutional neural networks (CNNs): These are particularly well-suited for image processing tasks, making them ideal for analyzing sensor data and images in structural health monitoring applications as seen in Figure 1. By using convolutional layers to extract features from input data, CNNs can effectively identify patterns and anomalies that may indicate structural damage. This makes them a powerful tool for detecting cracks, deformations, or other forms of damage in non-linear dynamic systems (Kiranyaz et al., 2021; De Caro et al., 2023).

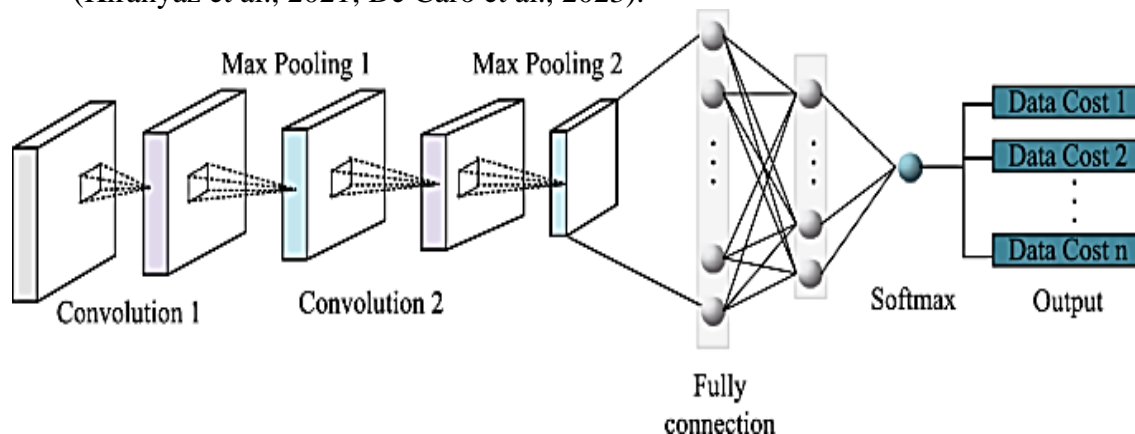


Figure 1: Convolutional neural networks (Zhao et al., 2024)

- ii. Recurrent neural networks (RNNs): These are designed to handle sequential data, making them suitable for time series analysis in structural health monitoring. By incorporating feedback loops that allow information to persist over time, RNNs can capture temporal dependencies in sensor data and detect changes in system behaviour that may signal damage. This makes them well-suited for monitoring the evolution of damage in non-linear dynamic systems over time (Nguyen et al., 2020; Barzegar et al., 2022).

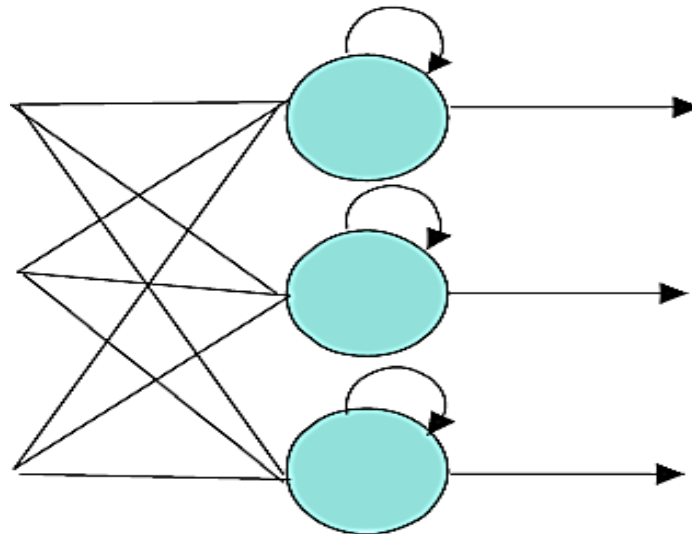


Figure 2: Recurrent neural networks (Kanagachidambaresan et al., 2021)

- iii. Long short-term memory (LSTM): networks, a type of RNN with additional memory cells, are particularly effective for capturing long-term dependencies in sequential data. This makes them well-suited for detecting subtle changes in system behaviour that may indicate early stages of damage in non-linear dynamic systems. By remembering important information over longer time periods, LSTM networks can effectively track the progression of damage and provide early warnings before catastrophic failures occur as shown in Figure 3 (Lindemann et al., 2021; Hajializadeh, 2023).

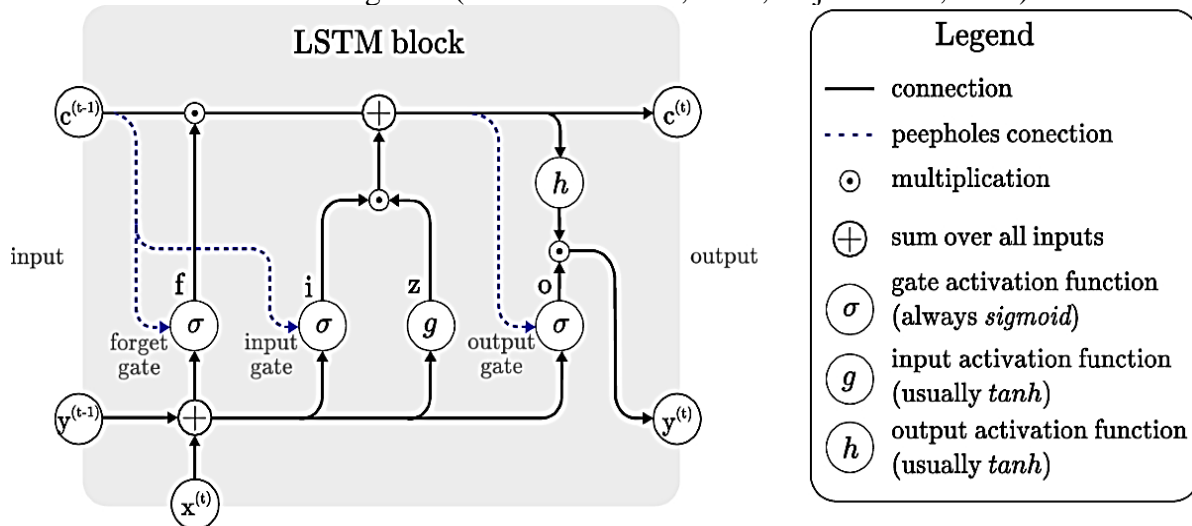


Figure 3: Long short-term memory (Van Houdt et al., 2020)

- iv. Auto-encoder: This is a type of neural network that is trained to reconstruct its input data. Auto-encoders have been used for anomaly detection in non-linear dynamic systems by learning the normal behaviour of the system and flagging any deviations from this behaviour as potential damage. This approach has been shown to be effective in detecting damage in structures such as bridges and buildings (Jakovlev & Voznak, 2022).

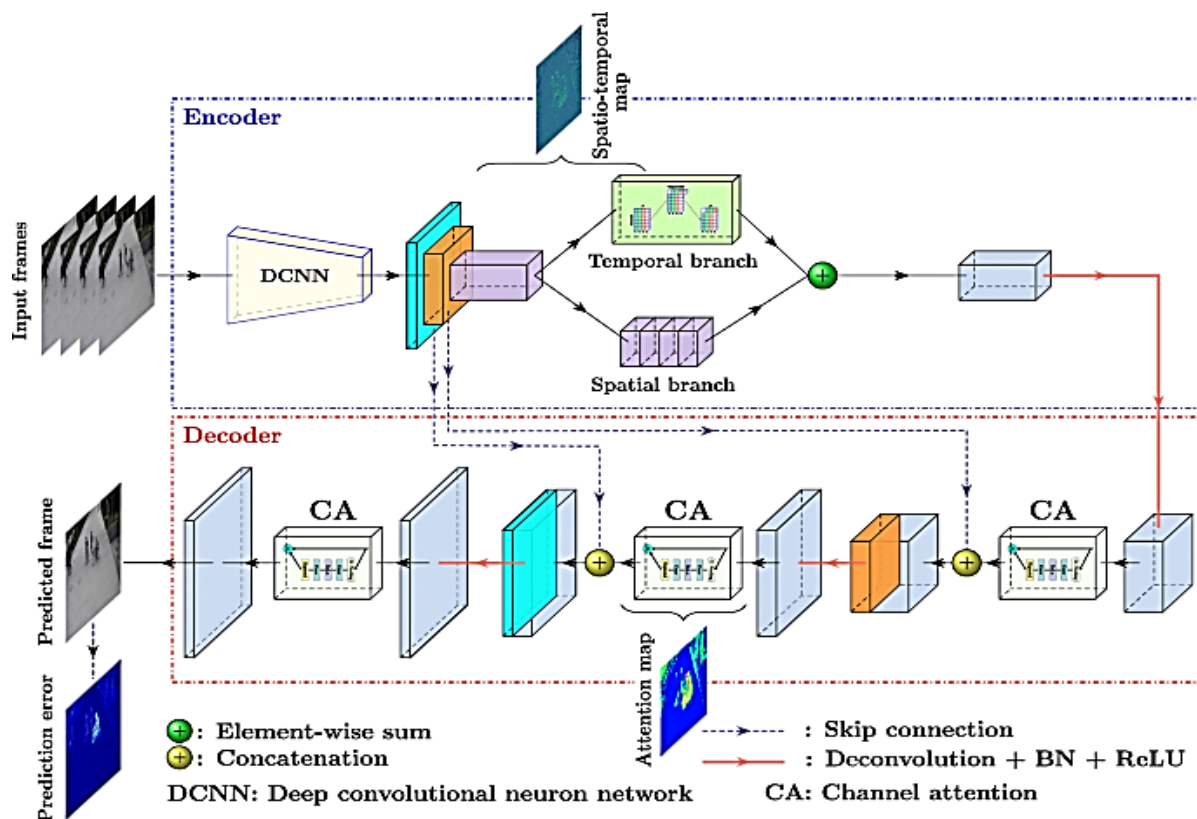


Figure 4: Auto-encoder (Le and Kim, 2023)

- v. Generative adversarial network (GAN): GANs consist of two neural networks – a generator and a discriminator – that are trained simultaneously. The generator generates synthetic data samples, while the discriminator distinguishes between real and synthetic data (see Figure 5). GANs have been used for anomaly detection in non-linear dynamic systems by generating synthetic data samples that mimic the normal behaviour of the system and flagging any deviations from this behaviour as potential damage (Alqahtani et al., 2021).

Latent space

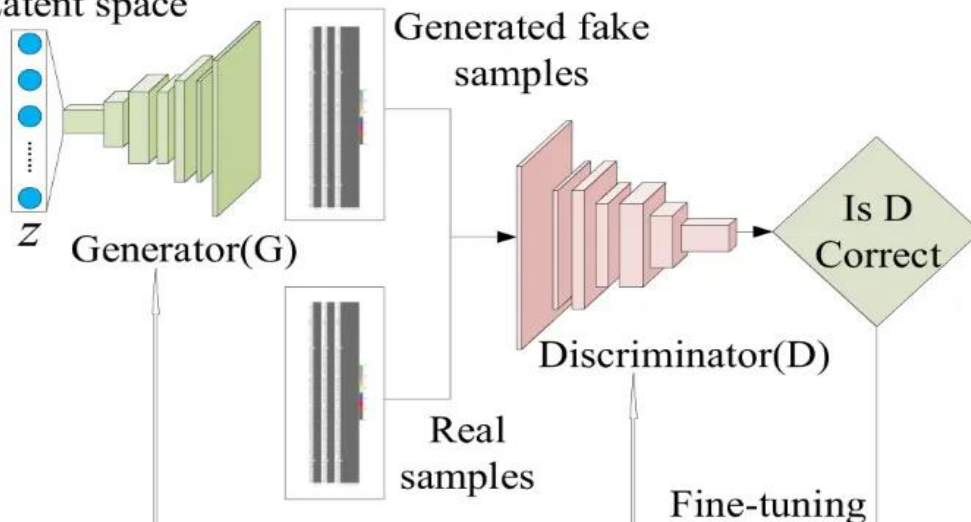


Figure 5: Generative adversarial network (Sharma et al., 2024)

- vi. Deep belief networks (DBNs): This have also been used for damage detection in non-linear dynamic systems. DBNs are a type of deep learning architecture that consists of multiple layers of probabilistic models. DBNs have been used for anomaly detection in non-linear dynamic systems by learning the probability distribution of the normal behaviour of the system and flagging any deviations from this distribution as potential damage (Etim et al., 2024).

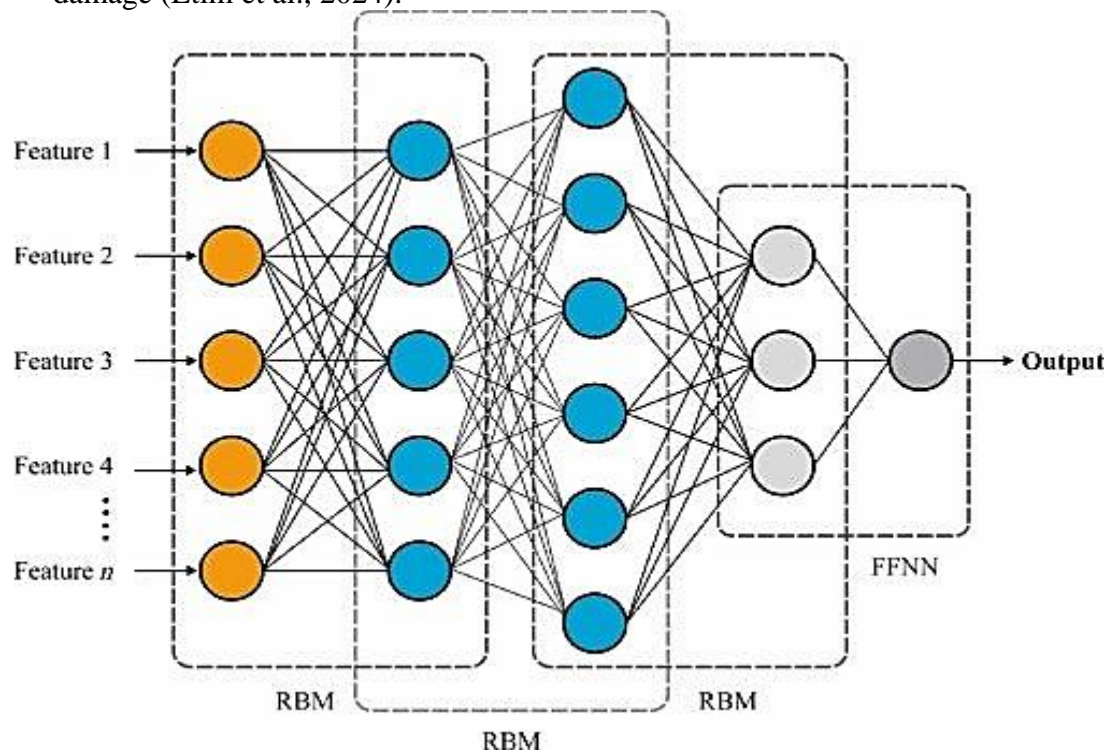


Figure 6: Deep belief networks (Dash et al., 2023)

While CNNs, RNNs, and LSTMs are the most commonly used deep learning architectures for damage detection in non-linear dynamic systems, auto-encoders, GANs, and DBNs have also shown great potential in this area. By exploring their unique capabilities in feature extraction, sequential data analysis, and long-term memory retention, these advanced neural network architectures can provide accurate and timely assessments of structural health. Conversational studies in this field continues to integrate these networks into structural health monitoring systems for improving the safety and reliability of critical infrastructure.

### Applications of Deep Learning in Detecting Data-Driven Damages in Non-Linear Dynamic Systems

Deep learning architectures have emerged as powerful tools for detecting data-driven damages in non-linear dynamic systems. These architectures, which are inspired by the structure and function of the human brain, have shown great potential in various areas of application which includes the following:

- i. Structural health monitoring involves the continuous monitoring of structures such as bridges, buildings, and pipelines to detect any signs of damage or deterioration. Deep learning architectures can be trained on sensor data collected from these structures to learn the patterns associated with different types of damages. By analyzing this data,

deep learning architectures can accurately detect and classify damages in real-time, allowing for timely maintenance and repair (Mishra et al., 2022).

- ii. Predictive maintenance involves using data from sensors and other sources to predict when equipment is likely to fail so that maintenance can be performed before a breakdown occurs. Deep learning architectures can be trained on historical data to learn the patterns that precede equipment failures. By analyzing real-time data, these architectures can predict when a piece of equipment is likely to fail, allowing for proactive maintenance to prevent costly downtime (Gohel et al., 2020; Serradilla et al., 2022).
- iii. In addition to structural health monitoring and predictive maintenance, deep learning architectures can also be used for anomaly detection in non-linear dynamic systems. Anomaly detection involves identifying patterns in data that deviate from normal behaviour, which may indicate the presence of a fault or damage. Deep learning architectures excel at detecting complex patterns in data, making them well-suited for identifying anomalies in non-linear dynamic systems. By continuously monitoring data from sensors and other sources, deep learning architectures can quickly detect anomalies and alert operators to potential issues (Erhan et al., 2021; Huang, 2024).

Deep learning architectures play a vital role in detecting data-driven damages in non-linear dynamic systems. Their ability to learn complex patterns from data makes them well-suited for applications such as structural health monitoring, predictive maintenance, and anomaly detection. By exploring the power of deep learning in these fields, more effective and efficient systems can be developed for detecting and mitigating damages in non-linear dynamic systems.

### **Integration of Advanced Techniques into Deep Learning Architectures for Damage Detection in Non-Linear Dynamic Systems**

The integration of advanced techniques into deep learning architectures play a crucial role in enhancing the accuracy and efficiency of damage detection algorithms, ultimately leading to improved structural health monitoring and maintenance practices. These techniques include the following:

- i. Feature extraction is a fundamental component of deep learning architectures for damage detection, as it involves identifying and extracting relevant information from raw data. In the context of non-linear dynamic systems, feature extraction techniques such as wavelet transforms, principal component analysis, and auto-encoders can help capture the underlying patterns and characteristics of structural damage. By extracting meaningful features from sensor data, deep learning models can effectively differentiate between normal operating conditions and damage-induced anomalies (Khan & Yairi, 2018; Shenfield & Howarth, 2020).
- ii. Sequential data analysis is another key aspect of deep learning architectures for damage detection, particularly in the context of time-series data collected from sensors. Recurrent neural networks (RNNs) and long short-term memory (LSTM) networks are commonly used to analyze sequential data and capture temporal dependencies. By modeling the sequential nature of sensor data, deep learning models can effectively detect subtle changes in system behaviour that may indicate the presence of damage (Chintaiah et al., 2024).
- iii. Long-term memory retention is essential for deep learning architectures to effectively learn and adapt to evolving patterns in non-linear dynamic systems. Memory-

- augmented neural networks, such as the neural Turing machine and the memory network, enable deep learning models to store and retrieve information over extended periods of time. By incorporating long-term memory retention mechanisms, deep learning models can maintain a comprehensive understanding of system dynamics and detect damage with greater accuracy (Durstewitz et al., 2023).
- iv. Computer vision techniques have also been integrated into deep learning architectures for damage detection, particularly in the analysis of visual data from cameras and imaging sensors. Convolutional neural networks (CNNs) are well-suited for extracting features from images and identifying visual patterns associated with structural damage. By combining computer vision with deep learning, researchers can develop robust damage detection algorithms that leverage both sensor data and visual information (Munawar et al., 2021; Ekanem et al., 2024).
  - v. Natural language processing (NLP) is another powerful tool for enhancing the capabilities of deep learning architectures in damage detection. By analyzing textual data, such as maintenance reports, inspection records, and historical data logs, NLP techniques can extract valuable insights and contextual information related to structural health. By incorporating NLP into deep learning models, researchers can improve the interpretability and explain-ability of damage detection algorithms, enabling stakeholders to make informed decisions based on textual data (Torfi et al., 2020; Lauriola et al., 2022).
  - vi. Speech recognition technology has also been leveraged in deep learning architectures for damage detection, particularly in the analysis of audio data collected from sensors and microphones. By transcribing spoken language into text, deep learning models can extract valuable information related to system performance, maintenance activities, and anomaly detection. By integrating speech recognition with deep learning, researchers can develop comprehensive damage detection systems that leverage multiple modalities of data for enhanced accuracy and reliability (Latif et al., 2020; Kumar et al., 2022).

The integration of feature extraction, sequential data analysis, long-term memory retention, computer vision, natural language processing, and speech recognition in deep learning architectures have significantly advanced the field of data-driven damage detection in non-linear dynamic systems. These advanced techniques can aid the development of robust and efficient algorithms for monitoring structural health, detecting anomalies, and predicting potential damage before it escalates. As deep learning continues to evolve, the integration of these techniques will play a crucial role in enhancing the reliability and effectiveness of damage detection systems in a wide range of engineering applications.

### **Consequences of Data-Driven Damages in Non-Linear Dynamic Systems**

Non-linear dynamic systems are complex systems that exhibit behaviour that is not easily predictable. These systems are often used in various fields such as engineering, economics, and biology. With the advent of data-driven approaches, there has been an increasing reliance on data to model and predict the behaviour of these systems. However, the use of data-driven approaches in non-linear dynamic systems can have unintended consequences and lead to damages. The effects of these damages are as follows:

- i. **Potential for model overfitting:** Overfitting occurs when a model is trained too closely to the data, capturing noise rather than the underlying patterns in the data. This can lead

to inaccurate predictions and poor performance of the model. In non-linear dynamic systems, overfitting can result in the model making incorrect predictions about the behaviour of the system, leading to costly errors and damages (Torres-Arredondo et al., 2013).

- ii. Potential for model bias: Model bias occurs when the model is trained on biased or incomplete data, leading to inaccurate predictions. In non-linear dynamic systems, model bias can result in the model failing to capture the true behaviour of the system, leading to incorrect predictions and damages. For example, in a financial system, biased data used to train a model could lead to incorrect predictions about market trends, resulting in financial losses (Noël & Kerschen, 2017).
- iii. Data-driven damages in non-linear dynamic systems can also result from the misuse of data: Data can be manipulated or misrepresented to achieve a desired outcome, leading to inaccurate predictions and damages. For example, in a healthcare system, data on patient outcomes could be manipulated to show false improvements in patient care, leading to incorrect decisions and potential harm to patients (Xu et al., 2014).

The use of data-driven approaches in non-linear dynamic systems can have unintended consequences and lead to damages. Model overfitting, bias, and misuse of data are some of the potential consequences of data-driven damages in non-linear dynamic systems. It is important to be aware of these consequences and take steps to mitigate them. By carefully considering the limitations and potential risks of data-driven approaches, it can be ensured that non-linear dynamic systems are accurately modeled and predicted, leading to better outcomes and reduced damages.

### **Conclusion**

Deep learning architecture has emerged as a powerful tool for data-driven damage detection in non-linear dynamic systems. This study have shown that deep learning models, such as convolutional neural networks (CNNs) and recurrent neural networks (RNNs), can effectively analyze complex data patterns and identify structural damage with high accuracy. Some of the key findings from this study are:

- i. The performance of deep learning models for damage detection is heavily dependent on the quality and quantity of training data. By training the models on a large dataset of sensor measurements from healthy and damaged structures, researchers have been able to achieve impressive results in terms of detection accuracy and reliability.
- ii. This study have highlighted the importance of feature extraction and selection in deep learning-based damage detection. By designing appropriate input features that capture the relevant information about the structural health, researchers have been able to improve the performance of deep learning models significantly.
- iii. Another important conclusion drawn from this study is the need for interpretability and explain-ability in deep learning models for damage detection. While deep learning models are known for their black-box nature, researchers have developed techniques to visualize and interpret the learned features, making it easier to understand the decision-making process of the models.

Conventional studies on deep learning architecture for data-driven damage detection in non-linear dynamic systems have demonstrated the effectiveness of deep learning models in accurately detecting structural damage. By leveraging large datasets, designing informative input features, and ensuring interpretability, significant strides have been achieved in

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advancing the field of structural health monitoring using deep learning techniques. However, further research is needed to explore the potential of deep learning in real-world applications and to address challenges such as model generalization and robustness.



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**INDUSTRIAL EFFLUENTS AND THEIR IMPACT ON PUBLIC HEALTH:  
EXPLORING SOCIO-LEGAL CHALLENGES AND SOLUTIONS**

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**Abstract**

Industrial effluents, consisting of hazardous chemicals, heavy metals, and organic pollutants, are a significant source of water pollution, posing grave risks to ecosystems and public health. These pollutants contaminate water bodies, leading to severe health outcomes such as waterborne diseases, developmental disorders, and chronic illnesses in affected populations. This paper explores the multi-faceted socio-legal challenges associated with managing industrial effluents, emphasizing the gaps in existing legislative frameworks, weaknesses in enforcement mechanisms, and limitations in societal and institutional responses.

Drawing from case studies and comparative analyses across various jurisdictions, this research highlights the critical role of law and governance in regulating industrial waste. It examines the enforcement of environmental laws, the impact of judicial interventions, and the contributions of community-based initiatives in addressing effluent pollution. Particular attention is given to the interplay between environmental sustainability, public health rights, and legal accountability.

The paper proposes a series of recommendations to address these challenges, including strengthening regulatory frameworks, enhancing institutional capacities for monitoring and enforcement, and fostering greater public participation in environmental governance. By integrating socio-legal insights with technical and community-driven approaches, the study underscores the need for a holistic strategy to mitigate industrial effluent pollution and protect public health, ensuring sustainable development and environmental justice for future generations.

**Keywords:** Industrial Effluents, Water Pollution, Public Health, Socio-Legal Challenges, Legal Accountability

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## **Introduction**

Industrialization has been a cornerstone of economic development, transforming societies through advancements in technology, infrastructure, and livelihoods. However, the environmental costs of industrialization often remain overlooked, with one of the most critical issues being water pollution caused by industrial effluents. These effluents, which include a mix of organic pollutants, heavy metals, toxic chemicals, and non-biodegradable substances, are frequently discharged into rivers, lakes, and other water bodies without adequate treatment. This practice severely disrupts aquatic ecosystems, compromises the availability of clean water, and poses significant threats to public health.

Water pollution due to industrial effluents is not merely an environmental issue; it is also a pressing socio-legal concern. Contaminated water sources are linked to a myriad of health problems, ranging from gastrointestinal disorders and developmental issues in children to chronic illnesses such as cancer and organ failure. These impacts disproportionately affect marginalized communities that often rely on untreated water sources for drinking, irrigation, and daily activities, exacerbating social inequalities.

From a legal standpoint, addressing industrial water pollution involves navigating complex challenges. Many nations have established laws and regulations aimed at controlling pollution, such as effluent standards, permits, and penalties for violations. However, enforcement often falls short due to resource constraints, institutional inefficiencies, and lack of political will. Moreover, the interplay between economic interests and environmental protection creates a contentious space where industrial growth is often prioritized over ecological sustainability.

This study delves into the socio-legal dimensions of industrial effluents and their impact on water pollution. It investigates the adequacy of existing legal frameworks and their enforcement, examines the role of community engagement in pollution control, and explores innovative approaches to mitigate the adverse effects of effluents. By analyzing case studies and drawing from comparative experiences, the research seeks to propose actionable solutions to bridge the gaps in policy, practice, and public awareness.

In addition, the study underscores the importance of recognizing the right to clean water as a fundamental human right, as articulated in international declarations and domestic legal frameworks. Ensuring access to uncontaminated water is not only essential for public health but also for achieving sustainable development goals. This paper calls for a paradigm shift toward integrating socio-legal, environmental, and technological approaches to tackle the multifaceted issue of industrial water pollution, aiming to create a balance between industrial progress and ecological preservation.

## **The Problem of Industrial Effluents**

Industrial effluents, byproducts of manufacturing processes, contain a range of hazardous materials such as heavy metals (e.g., lead, mercury, and cadmium), organic pollutants, and toxic chemicals. These substances are often discharged into nearby water bodies with inadequate treatment, if any, causing widespread environmental degradation and severe risks to human health. The unchecked release of these effluents disrupts aquatic ecosystems by altering water chemistry, reducing oxygen levels, and killing aquatic flora and fauna. Biodiversity loss, a direct consequence of such pollution, diminishes ecosystem resilience and exacerbates environmental instability.

For instance, in Purbalingga, Indonesia, the industrial sector, including wig and artificial eyelash manufacturing, has significantly polluted local rivers and groundwater sources. The

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lack of effective waste management systems has resulted in the contamination of drinking water supplies, leading to adverse health outcomes and deteriorating community well-being. Similar cases have been reported globally, underlining the urgent need for comprehensive and enforceable pollution control measures.

## **Public Health Impacts**

Water pollution from industrial effluents has devastating consequences for public health, particularly in communities dependent on untreated water sources. Pathogens and chemical contaminants in polluted water lead to a host of health issues, including:

1. **Waterborne Diseases:** Cholera, dysentery, and typhoid are common in areas with polluted water, leading to high morbidity and mortality rates, particularly among children and the elderly.
2. **Chronic Illnesses:** Long-term exposure to heavy metals like lead and mercury can result in neurodevelopmental disorders, kidney damage, and cardiovascular issues.
3. **Cancer and Genetic Mutations:** Persistent organic pollutants (POPs) and carcinogenic substances in effluents can lead to cancers and hereditary mutations, posing a generational health risk.

In India, the socio-legal framework recognizes the right to public health under Article 21 of the Constitution, which guarantees the right to life and personal liberty. The judiciary has expanded this interpretation to include the right to a clean and healthy environment, obligating the state to protect water resources from pollution. Despite these provisions, enforcement gaps and systemic inefficiencies hinder the effective realization of these rights, leaving vulnerable populations disproportionately affected.

Efforts to address these challenges require robust legal frameworks, strict enforcement of pollution controls, and active public engagement in environmental governance. Strengthening institutional capacities and integrating technological advancements for pollution monitoring and waste treatment are essential steps to mitigate these impacts.

## **Socio-Legal Challenges**

The management of industrial effluents is fraught with socio-legal challenges that undermine efforts to control pollution effectively. These challenges arise from deficiencies in legislative frameworks, enforcement mechanisms, and governance structures, as well as inadequate community engagement.

## **Legislative Gaps**

One of the primary barriers to addressing industrial effluents is the lack of comprehensive legal frameworks in many countries. Laws regulating industrial discharges often lack specificity, clarity, or enforceability. Moreover, the absence of binding international standards for effluent management exacerbates the problem, leaving countries to rely on piecemeal or outdated legislation.

For example, in Kurdistan, environmental laws such as Law No. 8 (2008) for Environmental Protection and Improvement, and Law No. 4 (2022) for Water Management, aim to curb industrial pollution. However, weak institutional frameworks and poor coordination between government agencies hinder their effective implementation. Institutional fragmentation leads to overlapping responsibilities and inefficiencies, allowing industrial polluters to exploit loopholes. To address these gaps, countries must develop integrated legislative frameworks



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that clearly define accountability, set stringent pollution standards, and align with international best practices.

## Implementation and Enforcement

Even when robust legal frameworks exist, their implementation and enforcement often fall short. Environmental criminal laws, which are intended to deter industrial polluters through punitive measures, are frequently underutilized or ineffectively applied. This is due to factors such as lack of technical expertise among enforcement agencies, corruption, insufficient penalties, and bureaucratic inefficiencies.

Studies in Indonesia highlight these issues, where industrial pollution continues unabated despite the presence of environmental laws. For instance, in Tegal District, mercury contamination from battery smelting industries has severely polluted groundwater, yet enforcement measures remain weak. Insufficient penalties fail to create a deterrent effect, and lack of public accountability allows industries to evade responsibility. Strengthening enforcement mechanisms requires enhancing the capacity of regulatory bodies, ensuring adequate funding and training, and establishing transparent monitoring systems to hold violators accountable.

## Community and Governance

Effective pollution management also hinges on active community participation and governance reforms. Local communities, often the first to experience the adverse effects of industrial effluents, have valuable insights and stakes in resolving pollution issues. Community-based dispute resolution mechanisms offer a promising approach by integrating societal values and fostering consensus.

For example, in Indonesia, the traditional practice of *rembugan*—a form of community mediation—has been employed to address environmental conflicts in industrial areas like Purbalingga. *Rembugan* reflects local wisdom by promoting open dialogue and mutual understanding among stakeholders, including industries, regulators, and affected communities. It leverages the cultural preference for consensus and harmony, ensuring that solutions are contextually relevant and widely accepted.

Such models demonstrate the potential of participatory governance in enhancing the effectiveness of environmental laws. Governments can institutionalize these practices by providing legal recognition, training mediators, and integrating community-led mechanisms into formal dispute resolution systems.

## Addressing Socio-Legal Challenges

Tackling these socio-legal challenges requires a multifaceted approach:

- **Legislation:** Updating and harmonizing environmental laws to close regulatory gaps and align with global standards.
- **Enforcement:** Building institutional capacity, enhancing transparency, and imposing strict penalties to ensure compliance.
- **Community Involvement:** Strengthening participatory governance through community-based mechanisms like *rembugan* and ensuring that local voices shape environmental policies.

By addressing these socio-legal dimensions, societies can effectively combat industrial effluent pollution and safeguard both public health and the environment.

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## Proposed Solutions

Addressing the challenges posed by industrial effluents requires a multi-pronged approach involving legislative reforms, robust enforcement mechanisms, and active community participation. The following solutions aim to create a comprehensive framework for mitigating water pollution and safeguarding public health.

## Strengthening Legislation

Legal frameworks must evolve to address the complexities of industrial pollution effectively. Stricter and more comprehensive laws are essential to regulate industrial discharges, emphasizing prevention, monitoring, and accountability. Existing laws often lack enforceable provisions or detailed guidelines on pollution control, allowing industries to circumvent compliance.

The Tanjero River pollution case in Kurdistan illustrates the need for legal reforms. Existing legislation, such as Law No. 4 (2022) for Water Management, provides a foundation but requires amendments to address industrial discharges specifically. Proposed legislative reforms could include:

1. **Specific Effluent Standards:** Define clear, measurable standards for permissible pollutant levels.
2. **Mandatory Treatment Protocols:** Require industries to adopt advanced effluent treatment technologies before discharge.
3. **Incentives and Penalties:** Implement tax benefits for compliance and stringent penalties for violations to ensure accountability.

These measures can create a legal environment that prioritizes pollution prevention over reactive mitigation.

## Enhancing Enforcement

Effective enforcement is crucial to translating legislation into action. Institutional capacity-building, coupled with technological advancements, can significantly enhance the monitoring and control of industrial effluents. Traditional enforcement methods often fall short due to resource constraints and corruption, but innovative tools and strategies can bridge these gaps.

Key measures include:

1. **Digital Tracking Systems:** Real-time monitoring technologies, such as Internet of Things (IoT)-enabled sensors, can track pollutant levels and flag violations immediately.
2. **Integrated Data Systems:** Establish centralized databases for monitoring effluent data, accessible to regulatory authorities and stakeholders.
3. **Capacity Building:** Provide technical training and resources to enforcement agencies to improve compliance checks.

These measures not only improve regulatory oversight but also foster transparency, enabling communities and NGOs to hold industries accountable.

## Public Participation

Empowering communities is essential for sustainable pollution management. Local populations often bear the brunt of industrial pollution and have valuable insights into its impacts. Participatory governance mechanisms can ensure that their voices shape policies and solutions.

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Case studies from India and Bangladesh demonstrate the transformative potential of community involvement in pollution control. Effective strategies include:

1. **Environmental Education Campaigns:** Educate communities about the health impacts of industrial effluents and their rights under environmental laws.
2. **Participatory Monitoring:** Involve local stakeholders in pollution monitoring activities to ensure transparency and accountability.
3. **Conflict Resolution Mechanisms:** Institutionalize traditional practices, such as *rembugan* in Indonesia, to mediate disputes between industries and communities.

Such initiatives create a sense of environmental stewardship, motivating individuals to advocate for cleaner practices and hold polluters accountable.

## Conclusion

Industrial effluents pose a multifaceted challenge that threatens environmental integrity and public health, requiring immediate and comprehensive intervention. Addressing these challenges demands a synergistic approach that balances legal, social, and technical strategies. The effective management of industrial pollution hinges on three critical pillars: robust legal frameworks, stringent enforcement mechanisms, and active community participation.

Strengthening legal frameworks is essential to establish clear guidelines and accountability for industrial practices. Comprehensive legislation should address gaps in existing laws, enforce strict effluent standards, and mandate the use of advanced treatment technologies. These laws must be backed by international cooperation to establish uniform standards and ensure global compliance. Countries like Kurdistan, which have begun reforming water management laws, provide valuable lessons on the importance of legislative clarity and institutional coherence in combating pollution.

Enforcement mechanisms must complement legislative efforts to ensure compliance. Without robust enforcement, even the most stringent laws will fail to achieve their intended outcomes. Investment in institutional capacity and technological innovations can revolutionize monitoring and enforcement. Digital tools such as IoT sensors, centralized databases, and AI-driven analytics offer unprecedented opportunities for real-time pollutant tracking and transparency. Such innovations not only strengthen regulatory oversight but also enhance public confidence in governance.

Equally important is the empowerment of communities. Local populations are often the most affected by industrial pollution, yet they are also a critical part of the solution. Engaging communities through education, participatory governance, and dispute resolution mechanisms like *rembugan* in Indonesia can create a culture of environmental stewardship. Public participation ensures that policies and practices are grounded in the lived experiences of those directly impacted, fostering trust and cooperation between stakeholders.

Furthermore, a socio-legal approach that integrates technical solutions with ethical and cultural considerations can drive sustainable change. This involves recognizing water as both a legal and social right, ensuring equitable access to clean water for all while holding industries accountable for environmental harm. The recognition of clean water as a human right under frameworks like Article 21 of India's Constitution highlights the transformative potential of aligning legal principles with societal needs.

As global industrialization continues to grow, the urgency to address effluent pollution will only increase. Governments, industries, and civil societies must collaborate to create a cohesive response that prioritizes long-term sustainability over short-term gains. By integrating legal

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reforms, technological advancements, and community-driven initiatives, societies can mitigate the harmful effects of industrial pollution, protect public health, and safeguard ecosystems for future generations.

This comprehensive approach not only addresses the immediate challenges of industrial effluents but also sets the foundation for achieving broader environmental and public health goals, aligning with global efforts such as the United Nations Sustainable Development Goals (SDGs). By fostering innovation, collaboration, and accountability, we can move toward a future where industrial growth and environmental conservation coexist harmoniously.

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**FACTORS INFLUENCING STUDENT'S ENROLMENT IN TVET PROGRAMMES:  
A STUDY OF MALAYSIAN POLYTECHNICS**

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**Abstract**

Programs for Technical and Vocational Education and Training (TVET) are available all over the world to assist people in gaining the abilities and information required to succeed in a variety of employment environments. The purpose of this study is to explore the key factors influencing students' enrolment in TVET programmes at Malaysian polytechnics. There is still a lack of knowledge regarding the basic factors that influence students to enrol in TVET programs, despite its crucial importance. Furthermore, limited research has been conducted specifically on Malaysian polytechnic students' participation in TVET programmes. This research employed a systematic approach by randomly distributing a structured survey questionnaire via Google Forms to current polytechnic students across Malaysia. A total of 380 valid responses were collected. The data gathered were subjected to quantitative analysis using Jeffreys's Amazing Statistics Program (JASP), ensuring robust and reliable findings. The study focused on three independent variables: interest, job prospects, and peer influence, which were analysed in relation to the dependent variable, students' enrolment in TVET programmes. The results of the analysis revealed that all three factors including interest, job prospects, and peer influence, significantly impact students' decisions to enrol in TVET programmes. These findings highlight the need for stakeholders, including government bodies, educators, parents, and community leaders, to actively promote and foster students' interest in TVET. Special emphasis should be placed on improving awareness and understanding of the programmes' career opportunities, particularly among non-Bumiputera students, to ensure a more diverse and inclusive enrolment. By addressing these factors, the study aims to contribute to the enhancement of TVET programme participation, supporting Malaysia's economic goals and the development of a skilled, competitive workforce. Policymakers, educators, and business executives can use these insights to help them develop policies that will increase TVET's attractiveness and efficacy in Malaysia.

**Keywords:** Student enrolment, TVET programmes, Malaysian polytechnics, interest, career prospects, peer influence.

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## 1.0 SUMMARY

The main determinants of student enrolment in Technical and Vocational Education and Training (TVET) programs in Malaysian polytechnics are examined in this study. Given that TVET is essential to Malaysia's goal of having a competent population and a high-income economy, the study focusses on three main factors: interest, job prospect, and peer influence. The lack of knowledge about the factors that influence students' decision to participate in TVET programs and the fact that enrolment rates are dropping relative to other nations served as the motivation for the study. 380 current polytechnic students in Malaysia were given a survey as part of a quantitative approach. Jeffreys's Amazing Statistics Program (JASP) was used to examine the data, with a focus on multiple regression analysis, correlation, and descriptive statistics.

The results showed that student enrolment in TVET programs is highly impacted by all three factors: interest, career prospect, and peer influence. When students are inspired by their peers, believe they will have good professional prospects after graduation, and have a sincere interest in experiential, skill-based learning, they are more likely to register. Demographic factors like gender, race, and academic discipline are also highlighted in the study.

The public still views TVET as a secondary option, despite significant government funding and rebranding initiatives to promote it. The report suggests specific tactics including government agencies, educators, parents, and businesses to address this and enhance TVET's accessibility and reputation. To improve employment results, further focus is advised on involving non-Bumiputera students and strengthening industrial connections.

In addition to offering useful insights for educators and policymakers seeking to enhance TVET's place in Malaysia's educational system, this research advances scholarly knowledge of enrolment factors.

## 2.0 INTRODUCTION

TVET, or technical and vocational education and training, is essential for giving people the information and skills they need to fulfil the ever-changing needs of the modern workforce. With the goal of creating a highly trained workforce that can support the country's aspirations to becoming a high-income economy, TVET has been positioned as a major engine of economic development in Malaysia (Marzuki et al., 2022). TVET's role in improving students' access to high-quality education and promoting employability through industry-relevant skills is highlighted in the Malaysian Education Blueprint 2015–2025 (MOE, 2012).

The Teacher Technical School, Malaysia's first technical institution, was founded in 1906, marking the beginning of TVET in the nation (Nizam et al., 2020). With over a thousand institutions currently providing a wide range of programs at the certificate, diploma, and degree levels, the TVET environment has changed dramatically over time. With programs in engineering, business, information technology, and other fields, polytechnics in particular have grown to be significant contributors to Malaysia's skilled workforce (Marzuki et al., 2022).

Enrolment rates have fallen short of expectations in spite of the government's massive efforts to support TVET, which have included increased funding and strategic alliances with businesses. In 2023, only 6.1% of Malaysian students were enrolled in TVET institutes, compared to higher percentages in South Korea (14.2%) and Singapore (23.8%), according to UNESCO (Toh, 2023). This disparity prompts questions regarding the variables affecting students' choices to follow TVET pathways.

The low enrolment rates are caused by a number of issues. The idea that TVET is a less



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prestigious choice than traditional academic pathways is one major problem. The idea that TVET is mainly for students from lower-income families or those with poor academic performance frequently serves to reinforce this stigma (Aziz & Subramaniam, 2023). Students are often discouraged from selecting TVET programs by a lack of knowledge regarding the high employability of graduates and the possible employment options.

Understanding the main factors impacting students' enrolment in TVET programs is crucial to addressing these issues. Peer influence, job prospect, and personal interests have all been found to be important predictors of enrolment decisions in earlier research (Abdul-Aziz et al., 2020; Shi & Bangpan, 2022). While the notion of solid career prospects and work stability makes these programs more appealing, students may be motivated to choose TVET by an interest in practical learning and technical abilities. Furthermore, students' educational decisions are greatly influenced by peer influence, which includes support from friends and family (Sunday et al., 2024).

The purpose of this study is to investigate these factors within the framework of Malaysian polytechnics. The study looks at how students' decisions to register in TVET programs are influenced by their interests, job prospect, and peer influence in an effort to offer insightful information to stakeholders, educators, and policymakers. Knowing these elements can help design focused plans to raise TVET enrolment rates, improve TVET education's reputation, and eventually help Malaysia achieve its objective of producing a trained, competitive workforce.

In conclusion, TVET plays a critical role in creating a skilled workforce as Malaysia works to achieve its economic development objectives. The expansion and sustainability of TVET programs depend on addressing the issues that affect student enrolment. This study contributes to the larger conversation on the value of TVET and provides useful suggestions to improve its attractiveness and effectiveness in the Malaysian educational system.

### 3.0 RESEARCH AND FINDINGS

#### 1. Overview

The main conclusions of the study on factors influencing students' enrolment in Technical and Vocational Education and Training (TVET) programs at Malaysian polytechnics are presented in this section. Descriptive statistics, reliability analysis, correlation, and multiple regression analyses are all used in this study to determine how interest, employment opportunities, and peer pressure affect TVET enrolment.

#### 2. Characteristic Data

The demographic traits of the participants and their answers to the questionnaire items were compiled using descriptive statistics. 380 students in all, representing a range of backgrounds in terms of gender, age, ethnicity, academic year, and subject of study, took part in the survey.

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Table 1: Demographic Profile of Respondents

Demographic Variable	Category	Frequency	Percentage (%)
Gender	Male	163	42.9
	Female	217	57.1
Age	17-19	159	41.8
	20-22	201	52.9
	23 and above	20	5.3
Ethnicity	Malay	271	71.3
	Indian	92	24.2
	Chinese & Others	17	4.5
Field of Study	Business & Management	156	41.1
	Engineering	113	29.7
	Others	111	29.2

According to the descriptive analysis, the majority of respondents (57.1%) were female, and 52.9% were between the ages of 20 and 22. The majority were enrolled in engineering programs (29.7%) and business and management programs (41.1%).

### 3. Analysis of Reliability

Cronbach's alpha was used in a reliability study to evaluate the questionnaire's internal consistency. For every variable, the results demonstrated great dependability.

Table 2: Reliability Coefficients (Cronbach's Alpha)

Variable	Number of Items	Cronbach's Alpha
Student's Interest (SI)	4	0.85
Career Prospect (CP)	4	0.88
Peer Influence (PI)	4	0.83
Enrolment in TVET (ET)	2	0.81

All variables achieved a Cronbach's alpha above 0.80, indicating strong reliability (Hee, 2014).

### 4. Correlation Analysis

Pearson's correlation analysis examined the relationships between the independent variables (interest, career prospects, peer influence) and the dependent variable (student enrolment in TVET).

Table 3: Correlation Matrix

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Variable	SI	CP	PI	ET
Student's Interest (SI)	1.000	0.653**	0.621**	0.712**
Career Prospect (CP)	0.653**	1.000	0.589**	0.698**
Peer Influence (PI)	0.621**	0.589**	1.000	0.675**
Enrolment in TVET (ET)	0.712**	0.698**	0.675**	1.000

Note:  $p < 0.01$  (2-tailed)

The results show significant positive correlations between all variables, with the strongest correlation observed between student interest and enrolment in TVET ( $r = 0.712$ ,  $p < 0.01$ ).

#### 5. Multiple Regression Analysis

Multiple regression analysis was conducted to determine the predictive power of interest, career prospects, and peer influence on student enrolment in TVET programs.

Table 4: Multiple Regression Analysis Summary

Predictor Variable	B	SE B	Beta	t	p
Student's Interest (SI)	0.391	0.056	0.412	6.98	0.000
Career Prospect (CP)	0.328	0.048	0.367	6.83	0.000
Peer Influence (PI)	0.274	0.052	0.322	5.27	0.000
R-squared			0.658		
Adjusted R-squared			0.653		

The regression model was statistically significant ( $p < 0.001$ ), with an R-squared value of 0.658, indicating that approximately 65.8% of the variance in TVET enrolment can be explained by the three independent variables. Interest had the strongest predictive power ( $\beta = 0.412$ ), followed by career prospects ( $\beta = 0.367$ ) and peer influence ( $\beta = 0.322$ ).

#### 4.0 CONCLUSION

The factors influencing students' enrolment in Technical and Vocational Education and Training (TVET) programs at Malaysian polytechnics were investigated in this study. The study found that students' decisions to enrol in TVET programs are greatly influenced by three important factors: interest, career prospect, and peer influence. The results of a quantitative study of information gathered from 380 polytechnic students offered important new information on how these factors interact to influence enrolment trends.

According to the data, the biggest factor influencing registration decisions is student interest. Students are more likely to pursue TVET pathways if they demonstrate a genuine passion for practical learning and technical skills. This result is consistent with other research that highlighted the importance of intrinsic motivation in educational decisions (Abdul-Aziz et al., 2020). Therefore, increasing enrolment rates can be greatly aided by promoting interest in technical education through early exposure, stimulating learning environments, and successful job counselling.

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Career opportunities were found to be the second most important aspect. Perceived obvious, achievable career options with high employment stability and growth potential encourage students to engage in TVET programs. This supports other studies that emphasise the significance of employability and labour market alignment in shaping school choices (Shi & Bangpan, 2022). In order to make sure that graduates have the necessary abilities, the study emphasises the necessity of closer industry relationships and a better fit between TVET courses and hiring needs.

Though not as much as interest and job prospects, peer influence also showed a considerable impact on enrolment decisions. Perceptions of TVET as a feasible educational pathway are greatly influenced by social networks, which include friends, family, and neighbours (Sunday et al., 2024). TVET graduates' success stories and positive peer experiences might help eradicate the stigma attached to vocational education and inspire additional students to think about enrolling in these programs.

Additional context was given by the demographic analysis, which showed that enrolment decisions are also influenced by factors including gender, age, ethnicity, and field of study. For example, opinions of TVET differed by ethnic group, and female students were more likely to enrol in several subjects. These results highlight the significance of focused approaches to meet the needs of particular populations and advance inclusivity in TVET programs.

Given these results, a number of suggestions are proposed:

1. Increase Knowledge and Interest: Introduce students to TVET alternatives by implementing early exposure programs in secondary schools. Interest in technical disciplines can be stimulated by interactive workshops, career fairs, and practical exercises.
2. Boost Industry Collaborations: Work together with businesses to make sure TVET programs meet the needs of the labour market both now and in the future. Mentorship programs, industry visits, and internships can all help students better grasp their career options.
3. Encourage Good Peer Influence: Share TVET graduates' success stories and good experiences by utilising peer ambassadors and alumni networks. This has the potential to change how society views TVET and establish it as a worthwhile educational path.
4. Address Social Perceptions: Run public education initiatives to eliminate the stigma attached to technical and vocational education. Emphasising TVET graduates' accomplishments and employability helps change attitudes and attract more diverse students.
5. Creating Inclusive Policies: To encourage diversity and inclusivity in TVET institutions, create policies that cater to the unique requirements of under-represented groups, such as non-Bumiputera students.

In summary, this research contributes to the expanding data of information regarding TVET enrolment in Malaysia. Through the identification and comprehension of the primary factors, interested parties can put specific plans into action to raise enrolment rates, improve technical education standards, and help Malaysia achieve its objective of producing a workforce with the necessary skills for a competitive global economy. The results provide a basis for future study and policy development in the field of vocational education by highlighting the crucial roles that interest, job prospects and peer influence play a significant role in influencing students' educational choices.

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GÖZLEM VE İNANÇ: KUANTUM MEKANİĞİ VE TEOLOJİDE GERÇEKLİK  
ALGISININ İNŞASI

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**Özet**

Bu makale, kuantum mekaniği ve teoloji alanlarında gözlem ve inanç arasındaki karmaşık etkileşimi incelemekte ve gerçekliğin gözlemcinin katılımıyla şekillenen dinamik bir yapı olduğunu öne sürmektedir. Kuantum mekaniği, gözlemci etkisiyle nesnel, bağımsız bir evren kavramına meydan okumakta, bunun yerine gerçekliğin ölçüm ve etkileşim yoluyla birlikte yaratıldığını öne sürmektedir. Benzer şekilde teoloji de ilahi gerçekliğin inanç yoluyla deneyimlendiğini ve yorumlandığını savunarak ruhani hakikatlerin statik olmadığını, sürekli olarak inançla şekillendiğini gösterir. Bu çalışma, her iki alanın metafizik ve epistemolojik sınırlarını inceleyerek, ampirik ve ruhani olan arasında daha derin bir bağlantı olduğunu ortaya koymakta ve bunları çatışan çerçevelerden ziyade tamamlayıcı çerçeveler olarak sunmaktadır. Varoluşçu felsefe, fenomenoloji ve teolojik çoğulculuktan yararlanan çalışma, gerçekliğin yalnızca gözlemlenmediğini, fiziksel ve ilahi olanın bir sentezi olarak hayata geçirildiğini savunmaktadır. Bu bütüncül bakış açısı, bilgi arayışımızda entelektüel alçakgönüllülüğün önemini vurgulamakta ve bizi hem bilimsel hem de ruhani araştırmanın doğasında bulunan belirsizlikleri ve gizemleri kucaklamaya teşvik etmektedir. Nihayetinde makale, gerçekliğin geleneksel ikilikleri aşan akışkan, çok yönlü bir süreç olarak yeni bir yorumunu sunmakta ve varoluşu anlamaya yönelik bütüncül bir yaklaşımı teşvik etmektedir.

**Anahtar Kelimeler:** Gözlem, İnanç, Kuantum mekaniği, Metafizik, Teoloji

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**OBSERVATION AND FAITH: QUANTUM MECHANICS AND THE  
CONSTRUCTION OF REALITY IN THEOLOGY**

**Abstract**

This article explores the complex interplay between observation and belief in the fields of quantum mechanics and theology, arguing that reality is a dynamic construct shaped by the participation of the observer. Quantum mechanics challenges the notion of an objective, independent universe with observer influence, arguing instead that reality is co-created through measurement and interaction. Similarly, theology argues that divine reality is experienced and interpreted through faith, demonstrating that spiritual truths are not static but are continually shaped by faith. By examining the metaphysical and epistemological boundaries of both fields, this study reveals a deeper connection between the empirical and the spiritual and presents them as complementary rather than conflicting frameworks. Drawing on existential philosophy, phenomenology and theological pluralism, the study argues that reality is not merely observed but realized as a synthesis of the physical and the divine. This holistic perspective emphasizes the importance of intellectual humility in our quest for knowledge and encourages us to embrace the ambiguities and mysteries inherent in both scientific and spiritual inquiry. Ultimately, the article offers a new interpretation of reality as a fluid, multifaceted process that transcends traditional binaries and encourages a holistic approach to understanding existence.

**Keywords:** Belief, Metaphysics, Observation, Quantum Mechanics, Theology



### **Giriş: Gerçekliği Yorumlamak ve İnanç ile Kuantum Mekaniği Arasındaki İlişki**

Gerçeklik kavramı, felsefi ve bilimsel söylemin temel taşlarından biridir. En eski metafizik sorgulamalardan kuantum mekaniğinin modern gelişmelerine kadar, gerçekliğin tanımı gözlem ve inanç tarafından şekillendirilmiş, bu da onu karmaşık ve çok katmanlı bir yapı haline getirmiştir. Kant ve Descartes gibi düşünürler, insan algısı ve bilişi yoluyla gerçekliği anlamının temellerini atarken, kuantum mekaniği bu anlayışı gözlemcinin etkisi bağlamında yeniden şekillendirmiştir (Kant, 1781; Descartes, 1641). Bu bağlamda, gerçeklik yalnızca nesnel bir yapı değil, aynı zamanda gözlemci ve inanç ile etkileşim içinde olan dinamik bir süreçtir. Teolojide ise inanç, ruhani gerçeklikleri şekillendiren öznel bir filtre görevi görerek, gözlemin fiziksel dünyayı şekillendirdiği süreçlerle paralellik gösterir (Barth, 1960).

Kuantum mekaniği, gözlemci etkisi kavramıyla fiziksel evren anlayışında devrim yaratmıştır. Özellikle ölçüm eyleminin bir deneyin sonucunu temelinden değiştirdiği keşfi, gerçekliğin gözlemciye bağımlılığı hakkında derin felsefi sorular gündeme getirmiştir (Heisenberg, 1958). Benzer şekilde, teolojide inanç, ilahi olanın bireysel algısını etkileyen bir “gözlemci” rolü oynar. Bu disiplinler arası bağlantı, gerçekliğin durağan değil, aksine etkileşimle şekillenen bir olgu olduğunu vurgular (Rovelli, 2015; Zurek, 2003). İnsan bilişinin sınırlılıklarını ve öznelliğini ortaya koyan bu anlayış, gözlemcinin yalnızca fiziksel deneylerde değil, aynı zamanda teolojik bağlamlarda da sistemin ayrılmaz bir parçası olduğunu gösterir.

Kopenhag Yorumu, kuantum sistemlerinin gözlemlenene kadar süperpozisyonda bulunduğunu ve dolayısıyla gerçekliğin doğasının gözlem anına kadar olasılıksal olduğunu öne sürer (Bohr, 1958). Öte yandan, teoloji, ruhani gerçekliklerin inanç ve kültürel bağlamlara bağlı olarak farklı algılanabileceğini vurgular (Tillich, 1951). Bu iki alan arasındaki bu öznel paralelliği, özgür irade ve determinizm üzerine yeni tartışmaların yolunu açmıştır. Eğer gözlemci kuantum durumlarını “çökertme” gücüne sahipse, ilahi müdahaleye olan inanç da ruhani gerçekliklerin algılanan tek bir hakikate dönüşmesine neden olabilir mi? (Chalmers, 1996; Penrose, 1994).

Gerçekliğe ilişkin modern sorgulamalar, çağdaş bilim tarafından şekillendirilse de gözlem ve inanç arasındaki dinamik ilişkiyi araştıran tarihsel geleneklerde derin köklere sahiptir. Örneğin İslam felsefesi, gerçekliğin ampirik ve metafizik boyutlarını bütünleştirir. Farabi ve İbni Sina gibi düşünürler maddi dünyanın daha derin, aşkın hakikatleri yansıttığını vurgulayarak gözlem ve ilahi anlayış arasındaki boşluğu doldurmuşlardır. Buna karşılık, Batı gelenekleri, özellikle de Aydınlanma döneminde, ampirik sorgulamayı metafizik spekülasyondan ayırarak bunları farklı alanlar olarak çerçevelemiştir. Bu farklılıklara rağmen, her iki gelenek de gerçekliğin ilişkisel olduğu ve ister bilimsel araştırma ister ruhani tefekkür yoluyla olsun insan etkileşimi tarafından şekillendirildiği konusunda birleşmektedir (Al-Farabi, 1985; Al-Ghazali, 2000).

Kuantum mekaniği ve teolojinin bu birleşimi, bilim ve din arasındaki geleneksel ayrımı aşan bir anlayış sunar. Gerçekliği tamamen ampirik veya tamamen ruhani olarak görmek yerine, her iki disiplin de daha karmaşık ve bağlantılı bir gerçeklik görüşünü savunmaktadır (Feynman, 1965; Polkinghorne, 1989). Bu bütünsel yaklaşım, fizik yasaları ve metafizik inançların birleşerek daha eksiksiz bir dünya anlayışı oluşturduğu bir model sunmaktadır. Böylelikle, disiplinler arası bir perspektif, yalnızca kuantum teorisinin sınırlarını değil, aynı zamanda bu sınırların varoluşun doğasına dair metafizik sorgulamalarla nasıl kesiştiğini araştırmak için yeni yollar açmaktadır (Barbour, 2000; Tegmark, 2014).

Bu makale, kuantum mekaniği ve teoloji arasındaki kesişim noktalarını inceleyerek, bu iki alanın gerçekliğin bütüncül bir şekilde anlaşılmasını nasıl sağladığını keşfetmeyi amaçlamaktadır. Tartışmalar, bilimin gözleme ve teolojinin inanca dayalı bakış açılarının varoluş algısını nasıl etkilediğine odaklanacaktır. Bu bağlamda, disiplinler arası bir yaklaşım,

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dünyanın daha incelikli bir şekilde yorumlanmasına olanak tanır ve bilimin ampirik sınırlarını teolojinin metafizik boyutlarıyla harmanlayarak yeni bir perspektif sunar.

## **Ontolojik Belirsizlik: Kuantum Dünyasında Gözlemin Metafiziksel Sonuçları**

Kuantum mekaniğindeki belirsizlik ilkesi belki de modern bilimin ortaya çıkardığı felsefi açıdan en kışkırtıcı kavramlardan biridir. Werner Heisenberg tarafından ortaya atılan belirsizlik ilkesi, bir parçacığın konumu gibi bir özelliğini ne kadar kesin olarak bilirsek, momentumunu o kadar az kesin olarak bilebileceğimizi ve bunun tersinin de geçerli olduğunu ileri sürer. Bu kavram yalnızca klasik deterministik fiziğe meydan okumakla kalmaz, aynı zamanda gerçekliğin doğası hakkında daha derin soruları da gündeme getirir. Kuantum mekaniğinde gözlem sadece pasif değildir; gözlemlenen gerçekliği aktif olarak şekillendirir. Parçacıkların ölçülene kadar birden fazla durumda var olması, derin bir ontolojik belirsizlik düzeyi ortaya çıkarır- fiziksel olanın ötesine ve varoluşun metafizik alemlerine uzanan bir belirsizlik (Heisenberg, 1927). Bu belirsizlik, gerçekliğin özünde deterministik olmaktan ziyade olasılıksal olabileceğini öne sürerek, kesinlik ve öngörülebilirliğin çok önemli olduğu Newton mekaniğine dayanan yüzyıllar süren felsefi düşünceyi bozmaktadır (Patton, 1994).

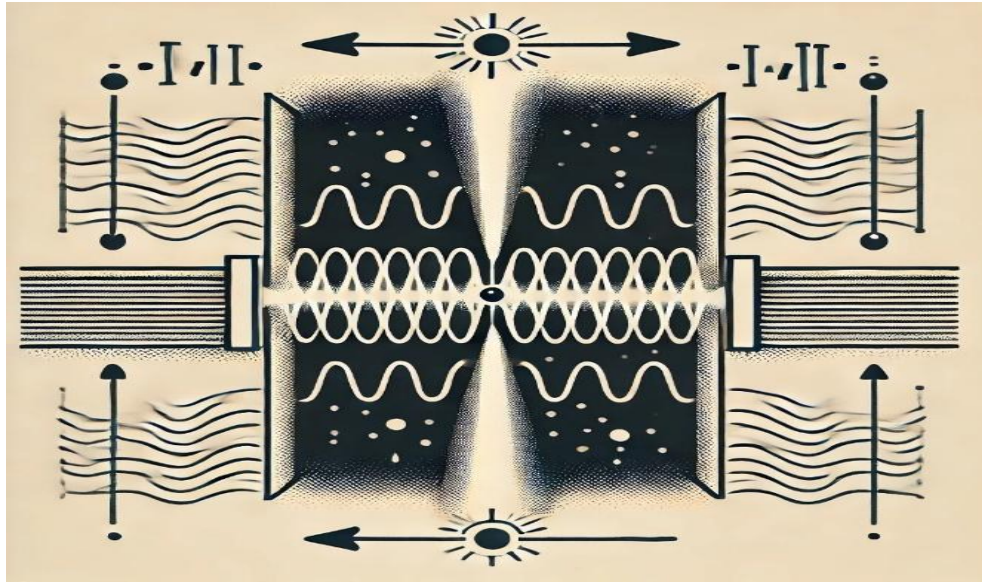
Bu ontolojik belirsizliğin, varoluşçu ve fenomenolojik felsefede derin yankılar uyandıran metafizik sonuçları vardır. Eğer fiziksel dünya gözlemlenene kadar belirsizse, bu durum gerçekliğin kendisinin etkileşime bağlı olduğunu ve özne ile nesne arasındaki çizgileri bulanıklaştırdığını göstermektedir. Varoluşsal açıdan bu, Jean-Paul Sartre tarafından ortaya atılan, varoluşun özden önce geldiği düşüncesiyle paralellik gösterir. Kuantum sistemlerindeki parçacıkların gözlem yoluyla tanımlanması gibi, insan varlığı da benliği tanımlayan eylemler ve kararlar tarafından şekillendirilir. Bu kuantum belirsizliğinin metafizik çıkarımları, varlığı statik veya önceden belirlenmiş bir durum olarak değil, dünya ile etkileşimden etkilenen dinamik ve sürekli gelişen bir süreç olarak anlamak için yeni bir çerçeve sunar (Sartre, 1943). Dahası, gözlemci ve gerçeklik arasındaki bu etkileşim, Martin Heidegger'in çalışmasındaki ana temaları yankılamaktadır; burada varlığın kendisi yalnızca bir olgu değil, deneyim ve bağlam tarafından şekillendirilen gelişmekte olan bir olaydır (Heidegger, 1927).

Dahası, kuantum gözleminin metafizik çıkarımları özgür irade ve determinizm sorularına kadar uzanmaktadır. Deterministik bir evrende, her olay nedensel olarak önceki olaylar tarafından belirlenir, ancak kuantum mekaniği, doğasında var olan belirsizlik ve olasılıksal sonuçlarıyla bu görüşe meydan okur. Gözlem eylemi, tüm olayların önceki koşullar tarafından belirlenmediğini öne sürerek bir öngörülemezlik unsuru ortaya koyar. Bu durum bazı fizikçi ve filozofların kuantum mekaniğinin özgür iradeye yer bıraktığını savunmasına yol açmış, kuantum durumları gibi insan kararlarının da tamamen önceden belirlenmemiş olabileceğini ancak sonuçları öngörülemeyen şekillerde etkileyebileceğini öne sürmüştür (Popper, 1982). Bu tartışma, "yaratıcı evrim" kavramıyla yaşamın ve dolayısıyla evrenin katı bir determinizmden ziyade kendiliğindenlik ve özgürlüğe izin verecek şekilde işlediğini savunan Henri Bergson'un çalışmalarını yansıtmaktadır (Bergson, 1911).

Kuantum belirsizliğinin sonuçları bilgi sorununa ve gerçeklik hakkında neyin bilinebileceğine de uzanmaktadır. Klasik mekanikte varsayım, yeterli bilgi ile fiziksel sistemlerin davranışlarını mutlak bir kesinlikle tahmin edebileceğimizdi. Ancak kuantum mekaniği, belirli özelliklerin aynı anda kesin olarak bilinmeyeceği kavramını ortaya atarak bu varsayımı altüst eder. Bu ontolojik belirsizlik, bilginin kendisinin gözlem eylemi tarafından kısıtlandığı epistemolojik sınırlamalara dönüşür. Immanuel Kant gibi filozoflar uzun zamandır insan kavrayışının, özellikle de noumenal dünya (algıdan bağımsız olarak var olan gerçeklik) açısından sınırları olduğunu savunmaktadır. Kuantum mekaniği, algıladığımız gerçekliğin daha derin, erişilemez

bir hakikatin yalnızca kısmi bir yansıması olduğunu öne sürerek bu fikri onaylıyor gibi görünmektedir (Kant, 1781). Çağdaş filozof Michel Bitbol, kuantum mekaniğinin yalnızca gerçekliği bilme yeteneğimizi değil, aynı zamanda etkileşim yoluyla onu inşa etmedeki rolümüzü de sorguladığını savunarak bunu geliştirmektedir (Bitbol, 2008).

Özetle, kuantum mekaniğinin belirsizlik ilkesinin ontolojik sonuçları fiziksel alanın çok ötesine uzanmaktadır. Gerçekliğin gözlemden etkilendiği düşüncesi bizi klasik varoluş, bilgi ve özgür irade fikirlerini yeniden gözden geçirmeye zorlar. Kuantum dünyası sadece parçacıkların davranışlarını ortaya koymakla kalmaz, aynı zamanda özünde belirsiz olan bir evrende var olmanın ne anlama geldiğine dair metafizik ve varoluşsal soruların yeniden düşünülmesine davet eder. Kuantum teorisinin derinliklerine indikçe, belirsizliğin sadece bilim için bir meydan okuma değil, gerçekliği, varoluşu ve onun içindeki yerimizi nasıl tanımladığımızı yeniden düşünmeye yönelik felsefi bir çağrı olduğunu kabul etmek zorunda kalıyoruz. Bu düşünceleri daha iyi anlamak için, kuantum mekaniğinin gözlemlerle nasıl etkileşime girdiğini gösteren klasik bir deney olan Çift Yarık Deneyi'ni inceleyelim. Aşağıdaki şekil, bu deneyin, gözlemin gerçeklik üzerindeki etkisini nasıl ortaya koyduğunu görselleştirmektedir.



Şekil 1: Çift Yarık Deneyi- Kuantum Mekaniğinde Gözlem ve Girişim Deseni

Şekil 1, kuantum mekaniğinin temel deneylerinden biri olan Çift Yarık Deneyi'ni görselleştirir. Deneyde, ışık veya elektronlar gibi parçacıklar, iki yarıklı bir bariyere doğru yönlendirilir. Şekil, bu parçacıkların iki yarıktan geçtikten sonra ekran üzerinde oluşturduğu girişim desenini gösterir. İlk bakışta, parçacıkların her birinin sadece bir yarıktan geçmesi beklenirken, ekranda görülen dalga benzeri desen, parçacıkların aynı anda iki yarıktan geçerek girişim oluşturduğunu gösterir. Bu dalga-parçacık ikiliği, kuantum mekaniğinin temel özelliklerinden biridir.

Deneyin en ilginç yönü, gözlemcinin etkisiyle sonuçların değişmesidir. Şekilde, gözlemin varlığının parçacıkların davranışını nasıl değiştirdiği de betimlenmiştir. Gözlem yapılmadığında, parçacıklar dalga fonksiyonu gibi davranır ve ekranda girişim deseni

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oluşturur. Ancak, gözlem cihazları kullanılarak parçacıkların hangi yarıktan geçtiği incelendiğinde, dalga fonksiyonu "çöker" ve parçacıklar tıpkı klasik fizik kurallarına uyarak tek bir yarıktan geçer, ekranda bir girişim deseni değil, iki net çizgi oluşturur. Bu, gözlemin gerçekliği doğrudan etkilediğini ve kuantum dünyasının belirsizliğini ortaya koymaktadır. Şekil 1, bu nedenle, gözlemin ontolojik ve epistemolojik sonuçlarını anlamada önemli bir rol oynar; gerçekliğin gözlemlerimizle nasıl şekillendiğini ve bilginin doğasının nasıl dinamik bir süreç olduğunu gösterir.

## **Epistemolojik Gerilim: Gözlem ve İnanç Sistemleri Aracılığıyla Bilginin İnşası**

Gözlem yoluyla bilginin inşası, deneysel kanıtların doğal dünyayı anlamının temelini oluşturduğu bilimsel yöntemin merkezinde yer almıştır. Kuantum mekaniğinde bu kavram, gözlemci etkisi ve ölçümlerin doğasında var olan belirsizlik nedeniyle daha karmaşık bir hal alır. Gözlem artık pasif bir faaliyet değil, sonucun şekillendirilmesinde aktif bir katılımcıdır. Bu durum, gözlemcinin rolü ile nesnel bilgi kavramı arasında temel bir gerilim yaratır. Gözlem yoluyla elde edilen bilgi, bir anlamda gözlemci ve gözlemlenen tarafından birlikte yaratılır ve bu da gerçekliğin doğası ve insan anlayışının sınırları hakkında derin epistemolojik sorular ortaya çıkarır. Fizikçi John Wheeler'ın belirttiği gibi, "kaydedilene kadar hiçbir temel olgu bir olgu değildir" (Wheeler, 1983) ve gözlemin bilgi inşasındaki rolünü vurgulamaktadır.

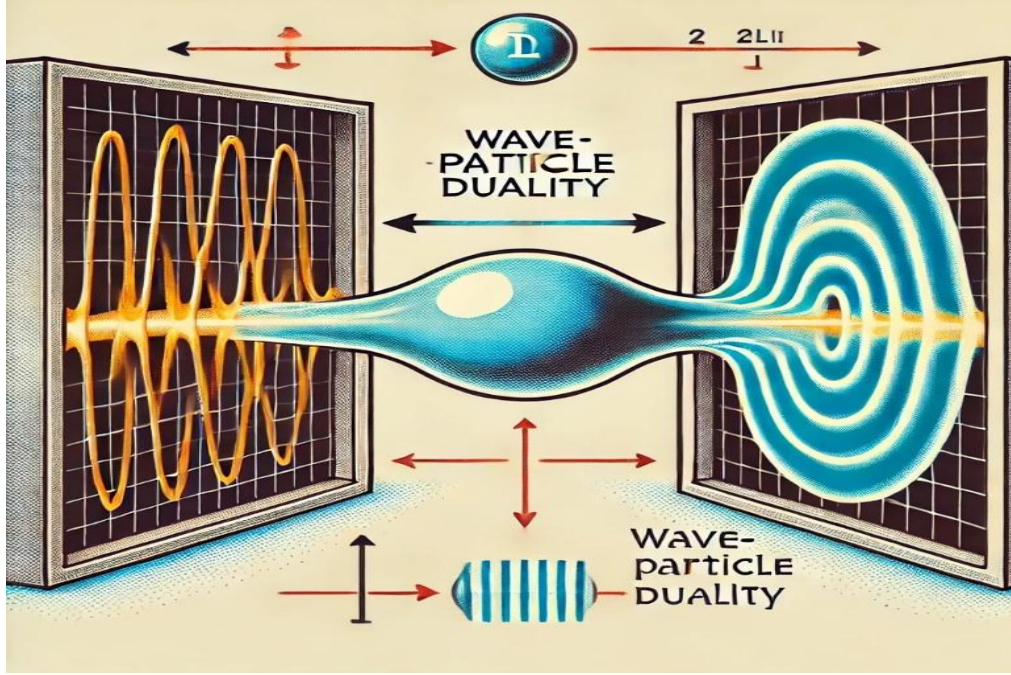
Bilginin gözlem yoluyla birlikte yaratılması, inancın genellikle ampirik kanıtlardan bağımsız olarak işlediği birçok dini ve teolojik sistemle tezat oluşturmaktadır. Teolojide inanç sıklıkla duysal algıyı ve rasyonel gözlemi aşan bir bilgi biçimi olarak anlaşılır. Søren Kierkegaard gibi teologlar, inancın aklın ötesine bir "sıçrama", ampirik olarak doğrulanamayan hakikatlerin kabulü olduğunu savunmuştur. Bu durum bilim ve dinin epistemolojik çerçeveleri arasında bir gerilim yaratmaktadır. Bilim bilgiyi tekrarlanan gözlemler ve deneyler yoluyla inşa ederken, din genellikle vahye ve ampirik doğrulama gerektirmeyen görünmeyene olan inanca dayanır (Kierkegaard, 1843).

İnanç ve gözlem arasındaki bu epistemolojik gerilim, bilginin inşasında otorite sorununa da uzanır. Bilimsel disiplinlerde otorite, tekrarlanabilir deneylerden ve hakemli doğrulamadan gelir. Dini sistemlerde ise otorite genellikle kutsal metinlerden veya ilahi vahiyden kaynaklanır. Gerilim, bir sistem diğerini açıklamaya ya da itibarsızlaştırmaya çalışıldığında ortaya çıkar. Örneğin, yaratılışçılık ve evrimsel biyoloji arasındaki çatışma bu epistemolojik ayrımı vurgular. Evrim deneysel kanıtlara ve fosil kayıtlarına dayanırken, yaratılışçı inançlar kutsal kitapların teolojik yorumlarına dayanır. Bu ikilik, kanıt gerektiren bilimsel bilgi ile genellikle kanıt yokluğunda inanç gerektiren dini inancı uzlaştırmamanın zorluğunu göstermektedir (Gould, 1999).

Bu epistemolojik gerilimi daha da karmaşık hale getiren, filozof Thomas Kuhn tarafından tartışılan ölçülemezlik kavramıdır. Kuhn, bilim ve dinde bulunanlar gibi farklı bilgi paradigmalarının ölçülemez olabileceğini, yani yöntem ve varsayımlarının doğrudan karşılaştırılmayacak veya uzlaştırılmayacak kadar temelden farklı olduğunu ileri sürmüştür (Kuhn, 1962). Bu da bilimsel ve teolojik bilgi arasındaki gerilimin basitçe bir ortak zemin bulma meselesi olmayabileceğini, bunun yerine temelde farklı bilme biçimlerini yansıtılabileceğini göstermektedir. Kuhn'un teorisi, bilim ve din arasındaki uçurumu kapatmaya yönelik girişimlerin, uyumsuz epistemolojik temelleri nedeniyle doğal olarak sınırlı olabileceğini ima etmektedir.

Sonuç olarak, bilimde gözleme dayalı bilgi ile dinde inanca dayalı bilgi arasındaki gerilim karmaşık bir epistemolojik zorluk teşkil etmektedir. Bilim, evreni ampirik kanıtlar ve gözlem yoluyla anlamaya çalışırken, dini inanç genellikle ölçülebilir olanın ötesinde, inanç ve vahiy

temelli bir alanda faaliyet gösterir. Bu durum, her bir bilgi sisteminin kendi çerçevesi içinde geçerli olabileceği, ancak diğeriyle uzlaştırılmasının zor olduğu, ikisi arasında süregelen bir gerilim yaratır. Bu gerilimi daha iyi kavrayabilmek için, kuantum mekaniğinin dalga-parçacık ikiliğini inceleyen ve gözlemin bilgi üzerindeki rolünü görselleştiren şekli ele alalım.



**Şekil 2:** Dalga-Parçacık İkiliği- Kuantum Mekaniğinde Gözlem ve Gerçeklik İnşası

Şekil 2, kuantum mekaniğinin temel prensiplerinden biri olan dalga-parçacık ikiliğini görselleştirmektedir. Kuantum dünyasında, ışık veya elektronlar gibi temel parçacıklar hem dalga hem de parçacık özellikleri sergileyebilir. Şekilde, bir parçacığın iki yarıklı bir engelden geçerken nasıl davrandığı gösterilmektedir. Parçacık, gözlemlenmediğinde dalga fonksiyonu gibi davranır ve ekranda girişim deseni oluşturur. Bu dalga benzeri desen, parçacıkların aynı anda iki yarıktan geçtiğini ve birbirleriyle etkileşime girerek girişim yarattığını gösterir.

Ancak, şekil 2 aynı zamanda gözlem yapıldığında dalga fonksiyonunun nasıl çöktüğünü ve parçacıkların klasik fizik kurallarına uygun olarak tek bir yarıktan geçtiğini de göstermektedir. Bu, kuantum mekaniğinde gözlem ve bilgi inşası arasındaki karmaşık ilişkiyi vurgular. Gözlemin varlığı, parçacıkların davranışını belirler; bu da bilgiye dayalı gerçeklik inşasının her zaman gözlemin doğasından etkilendiğini gösterir.

Şekil 2, bilginin sadece gözlemlenmesiyle oluşturulduğunu değil, aynı zamanda gözlemcinin varlığının, bilginin kendisini nasıl şekillendirdiğini ortaya koymaktadır. Aynı şekilde, inanç sistemlerinin de gerçekliği nasıl şekillendirdiği düşünüldüğünde, bu ikilik, bilimsel gözlem ve dini inanç arasında var olan epistemolojik gerilimi daha anlaşılır kılmaktadır.

#### **İnanç, Gözlem ve Tanrı'nın Çoklu Gerçeklikleri: Teolojik ve Felsefi Bağlam**

Hem teolojide hem de felsefede Tanrı kavramı, ilahi sıfatların karmaşıklığını ve çokluğunu yansıtan farklı mercekler aracılığıyla anlaşılmalıdır. Bu çokluk, tekil ve değişmez bir ilah kavramına meydan okumakta ve kültürel, tarihsel ve kişisel bakış açılarına göre değişen yorumlara kapı açmaktadır. Teolojik olarak, birçok gelenek Tanrı'yı, her biri Tanrı'nın farklı bir "yüzü" olarak görülebilecek çeşitli sıfatlar -adalet, merhamet, her şeye gücü yetme, her şeyi

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bilme- aracılığıyla anlamıştır. Bu sıfatlar statik değildir; gözlemcinin inancına ve kültürel bağlamına bağlı olarak değişir. Bu durum, gerçekliğin, hatta ilahi gerçekliğin bile yekpare değil, algı ve etkileşimle şekillenen dinamik bir yapı olduğu yönündeki felsefi düşünceyle uyumludur (Tillich, 1951).

Felsefede, Tanrı'nın çoklu gerçeklikleri veya yönleri kavramı farklı metafizik çerçeveler aracılığıyla araştırılmıştır. Örneğin, Alfred North Whitehead gibi filozoflar, Tanrı'nın sabit bir varlık değil, evrenle birlikte gelişen bir varlık olduğu bir süreç teolojisini savunmuşlardır. Bu görüşe göre, Tanrı'nın "çoklu gerçeklikleri" yaratılışla olan ilahi etkileşimin bir sonucudur ve sürekli olarak gelişip değişmektedir. Bu teolojik duruş, gözlem eyleminin potansiyel durumları tekil bir sonuca indirgediği, ancak bu sonucun daha fazla değişime ve gözleme açık kaldığı kuantum mekaniği ile rezonansa girer (Whitehead, 1929). Tıpkı kuantum sistemlerinin gözlemlenene kadar süperpozisyon halinde var olabilmesi gibi, Tanrı'nın sıfatları da inanç merceğinden algılanana kadar çokluk halinde var olabilir.

İnanç ile ilahi gerçekliklerin gözlemlenmesi arasındaki ilişki teolojik çoğulculuk kavramı aracılığıyla da anlaşılabilir. John Hick'in çoğulcu hipotezi, tüm dini deneyimlerin, farklı inançların kültürel ve ruhani çerçeveleri tarafından şekillendirilen ilahi olanın geçerli algıları olduğunu öne sürer. Hick'e göre bu çoklu algılar farklı tanrıları değil, aynı nihai gerçekliğin farklı yönlerini yansıtmaktadır. Bu görüş kuantum teorisindeki gerçekliğin sabit olmadığı ancak gözlemcinin bakış açısına göre şekillendiği fikrini yansıtmaktadır. Tıpkı parçacıkların gözlemlenene kadar durumların süperpozisyonunda var olması gibi, Hick'in teolojik çoğulculuğu da ilahi olanın her biri gözlemcinin ruhani çerçevesine bağlı olarak çeşitli şekillerde tezahür edebileceğini öne sürer (Hick, 1989).

Kuantum mekaniğindeki gözlem ile teolojideki inanç arasındaki bağlantı, fiziksel gerçeklik gibi ilahi gerçekliğin de etkileşim yoluyla birlikte yaratıldığını göstermektedir. Tanrı'nın çoklu gerçekliği kavramı, ilahi niteliklerin nasıl algılandığı ve deneyimlendiğine dair yeniden düşünmeye davet eder. Tekil, nesnel bir Tanrı anlayışı yerine, teolojik ve felsefi çerçeveler ilahi olanın gözlemcinin inanç sistemine bağlı olarak farklı algılandığını öne sürmektedir. Bu, ilahi olanın yalnızca gözlemlenmediği, gözlemci ile gözlemlenen arasındaki ilişkiyle aktif olarak şekillendiği daha akışkan ve ilişkisel bir Tanrı anlayışını yansıtmaktadır. Bu, gözlemci ve gözlemlenenin ayrılmaz bir şekilde birbirine bağlı olduğu kuantum mekaniğinin ilişkisel doğasını yansıtır (Zohar, 1990).

Sonuç olarak, ilahi gerçekliklerin çokluğu, inanç ve gözlemlerle şekillenen dinamik bir varlık olarak Tanrı'ya dair daha geniş bir felsefi ve teolojik anlayışı yansıtmaktadır. Kuantum mekaniğinin gerçekliğin gözleme bağlı olduğunu öne sürmesi gibi, teolojik çerçeveler de ilahi gerçekliğin inanç sistemleri ve ruhani etkileşim tarafından şekillendirildiğini öne sürmektedir. İnanç ve gözlemin bu kesişimi, fiziksel dünyayı ve ilahi olanı nasıl anladığımız arasındaki derin bağlantıları ortaya koymakta ve her ikisine de daha incelikli ve çok yönlü bir yaklaşımı teşvik etmektedir.

### **Kuantum Mekaniği ve Teoloji Arasındaki Diyalektik İlişki: Gerçeklik İnşasının Yeni Bir Yorumu**

Kuantum mekaniği ve teoloji arasındaki ilişki, ilk bakışta, biri ampirik gözlemlere, diğeri metafizik inanca dayanan çelişkili paradigmalara dayanıyor gibi görünebilir. Ancak, diyalektik bir mercekten incelendiğinde, bu iki alan karşıt güçler olarak değil, gerçekliğin doğasına ilişkin tamamlayıcı perspektifler olarak görülebilir. Kuantum mekaniği, doğasında var olan belirsizlik ve parçacıkların ilişkisel görünümü ile klasik fiziğin deterministik, mekanik dünya görüşüne meydan okur. Benzer şekilde teoloji de ilahi gerçekliğin statik anlayışını sorgulamakta, bunun

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yerine ilahi olan ile yaratılış arasında dinamik bir etkileşim önermektedir. Bu iki alanın sentezlenmesiyle, gözlem ve inancı, bilim ve maneviyatı bütünleştiren yeni bir gerçeklik anlayışı ortaya çıkar (Capra, 1982).

Kuantum mekaniğinde gözlemci, bir deneyin sonucunu belirlemede temel bir rol oynar. Kuantum mekaniğinin ilişkisel doğası, gerçekliğin gözlemciden bağımsız olmadığını, etkileşim yoluyla birlikte inşa edildiğini öne sürer. Bu ilişkisellik, Tanrı'nın uzak, müstakil bir varlık değil, dünyayla aktif bir şekilde etkileşime giren bir varlık olduğu teolojik ilahi anlayışları yansıtır. Örneğin süreç teolojisi, Tanrı'nın doğasının sürekli bir oluş halinde olduğunu ve yaratılışla olan etkileşimler tarafından şekillendirildiğini öne sürer (Hartshorne, 1970). Bu diyalektik yaklaşım, ilahi olan ile evreni birbirine bağlı olarak görür ve gerçeklik bu süregelen ilişki sayesinde ortaya çıkar.

Kuantum mekaniği ve teoloji arasındaki diyalektik ilişki tamamlayıcılık merceğinden de anlaşılabilir. Niels Bohr'un kuantum fiziğindeki tamamlayıcılık ilkesi, parçacıkların nasıl gözlemlendiklerine bağlı olarak hem dalga benzeri hem de parçacık benzeri davranış sergilediklerini öne sürer. Bohr'a göre bu ikilik çelişkili değil tamamlayıcıdır; gerçekliğin doğasını tam olarak anlamak için her iki yön de gereklidir (Bohr, 1934). Benzer şekilde teoloji de ilahi olanı anlamada Tanrı'nın hem içkin hem de aşkın olması gibi paradoksları benimser. Bu paradokslar birbirini olumsuzlamaz, aksine ilahi olanın daha eksiksiz, daha kapsamlı bir şekilde anlaşılmasını sağlar. Kuantum mekaniği ve teolojinin bu diyalektik çerçeve aracılığıyla sentezlenmesi, hem fiziksel hem de metafiziksel olanı içeren daha sağlam bir gerçeklik yorumuna olanak tanır (Polkinghorne, 1998).

Kuantum mekaniği ve teolojinin entegrasyonu nedensellik kavramına da yeni bir bakış açısı getirmektedir. Klasik fizik doğrusal, deterministik bir sebep-sonuç modeli üzerinde çalışır. Buna karşılık kuantum mekaniği, olayların önceden belirlenmediği ancak bir dizi olasılıktan ortaya çıktığı olasılıksal nedensellik kavramını ortaya koyar. Bu, Tanrı'nın dünya ile etkileşiminin katı bir şekilde deterministik olarak görülmediği, ancak değişime ve olasılığa açık olduğu ilahi eylem hakkındaki teolojik perspektiflerle uyumludur. Örneğin açık teizm, Tanrı'nın evrendeki her olayı kontrol etmediğini, ancak ilahi plan dahilinde insan özgürlüğüne ve öngörülemezliğe izin verdiğini savunur (Pinnock, 1994).

Ayrıca, kuantum mekaniğindeki parçacıkların uzak mesafeler boyunca bağlı kaldığı dolanıklık kavramı, tüm yaratılışın birbirine bağlı olduğuna dair teolojik fikirlerle yankılanmaktadır. Hıristiyan teolojisinde Mesih'in Bedeni kavramı, kuantum dolanıklığındaki parçacıkların fiziksel olarak birbirine bağlı olması gibi, tüm inananların ruhsal olarak birbirine bağlı olduğunu öne sürer. Bu birbirine bağlılık fikri Budizm gibi Doğu dinlerinde de bulunur; burada karşılıklı bağımlılık kavramı tüm varlıkların bir ilişkiler ağı aracılığıyla birbirine bağlı olduğunu öne sürer. Hem kuantum dolanıklığı hem de teolojik birbirine bağlılık, izole varlıklardan ziyade ilişkilerin gerçekliğin temel yapı taşları olduğu bir evrene işaret etmektedir (Zohar & Marshall, 1994).

Sonuç olarak, kuantum mekaniği ve teoloji arasındaki diyalektik ilişki hem bilimin hem de dinin sınırlarını aşan yeni bir gerçeklik yorumu sunmaktadır. Kuantum mekaniğinin ilişkisel, olasılıksal ve birbirine bağlı yönlerini ilahi etkileşim, nedensellik ve birbirine bağlılık gibi teolojik kavramlarla bütünleştirerek evrene dair daha kapsamlı bir anlayışa ulaşıyoruz. Bu sentez, her iki alanın da kendine özgü katkılarını azaltmamakta, aksine geliştirmekte ve gerçekliğe dair daha zengin, daha incelikli bir bakış açısı sunmaktadır.

### **Varoluşsal Bağlamda Gerçekliğin İnşası: Gözlem ve İnancın Kesişimi**

Gerçekliğin varoluşsal bir çerçevede inşası, gözlem ve inancın birleşik bir varoluş anlayışı

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oluşturmak üzere nasıl bir araya geldiğine dair soruları gündeme getirmektedir. Varoluşçu felsefe, özellikle Jean-Paul Sartre ve Martin Heidegger gibi düşünürlerin çalışmalarında, gerçekliğin önceden verilmiş, statik bir varlık değil, insan katılımı ve deneyimi ile şekillenen bir süreç olduğu fikrini vurgular. Bu görüşe göre, gözlemci gerçekliğin yalnızca pasif bir alıcısı değil, onun inşasında aktif bir katılımcıdır. Benzer şekilde hem kuantum mekaniğinde hem de teolojide, gözlem ve inanç, gerçeklik algımızı şekillendirmede önemli unsurlar olarak hizmet eder ve varlığın gözlemcinin bilincinden bağımsız olmadığını, onunla yakından bağlantılı olduğunu öne sürer (Heidegger, 1962). Bu fikir, gerçekliği genellikle nesnel, dışsal bir varlık olarak gören geleneksel metafiziğe meydan okur. Bunun yerine, gerçekliğin gözlemci ve gözlemlenen arasında süregelen bir etkileşim olduğunu, gerçek olarak algılanan şeyi sürekli olarak şekillendiren ve yeniden şekillendiren bir etkileşim olduğunu ileri sürer. Bu anlayış ister bilimsel gözlem ister ruhani tefekkür olsun, varoluşun kendisinin dinamik olduğunu ve insan etkileşimi yoluyla sürekli olarak yeniden tanımlandığını öne sürer.

Kuantum mekaniğinde gözlemci etkisi, ölçüm eyleminin bir parçasının durumunu belirlemede önemli bir rol oynadığını göstermektedir. Bu olgu, varoluşçu felsefenin gerçekliğin insan müdahalesi ve yorumuyla oluşturulduğu iddiasıyla uyumludur. Fiziksel dünya insan eylemi için sabit bir zemin değildir, gözlem eylemi tarafından sürekli olarak yeniden şekillendirilir. Bunun sonuçları derindir; eğer gerçeklik gözlemleniyorsa, o zaman insan bilinci dünyanın ortak yaratıcısı haline gelir. Bu kavram, inancın kişinin ilahi olana dair deneyimini şekillendirdiği yönündeki teolojik fikri yankılayarak, manevi gerçekliklerin, tıpkı kuantum durumları gibi, inanç merceğinden gözlemlenene kadar potansiyel bir durumda var olduğunu öne sürer (Tillich, 1952). Dahası, kuantum mekaniği ve teoloji arasındaki bu paralellik, bilimsel ve ruhani gerçekliklerin ayrı alanlarda işlediği varsayımına meydan okumaktadır. Bunun yerine, hem ampirik gözlemin hem de ruhani içgörünün varoluşun bütüncül bir şekilde anlaşılmasına katkıda bulunduğu birleşik bir gerçeklik modeline işaret eder.

Gerçekliğin inşasında gözlem ve inancın bir araya gelmesi fenomenolojide, özellikle de Edmund Husserl'in çalışmalarında bir paralellik bulur. Husserl'in "yaşam dünyası" kavramı, gerçekliğe dair birincil deneyimimizin bilinç ve niyetlilik tarafından şekillendirildiğini öne sürer. Yaşam dünyası, tüm bilimsel ve felsefi araştırmaların üzerine inşa edildiği teorik öncesi temeldir ve gözlemin her zaman insan algısı ve inancı tarafından dolaymlandığını ima eder. Bu fenomenolojik bakış açısı, kuantum mekaniğinin gözlemcinin gözlemleneni etkilediği iddiası ve teolojinin inancın ilahi olana dair deneyimimizi şekillendirdiği iddiasıyla uyumludur (Husserl, 1936). Yaşam dünyası kavramı, insanların gerçekliğe boş bir levha gibi yaklaşmadıklarını, ancak dünya deneyimlerini filtreleyen önyargıları, kültürel normları ve manevi inançları yanlarında taşıdıklarını vurgular. Bu da gerçekliği doğası gereği öznel, gözlemcinin iç dünyası ile karşılaştığı dış fenomenler arasında bir ortak yaratım haline getirir. Dahası, Gabriel Marcel gibi varoluşçu teologlar, inanç eyleminin özünde gerçeklikle varoluşsal bir ilişki biçimi olduğunu savunur. Marcel'e göre inanç yalnızca entelektüel bir tasdik değil, varoluşun gizemine aktif bir katılımdır. Bu, kuantum mekaniğindeki gözlemin nesnel bir durumun pasif bir kaydı olmaktan ziyade bir sistemle etkileşim olduğu fikriyle örtüşmektedir. Her iki durumda da gerçeklik ister bilimsel ölçüm ister ruhani yansıma yoluyla olsun, insan müdahalesine yanıt olarak ortaya çıkan bir şey olarak anlaşılmaktadır (Marcel, 1949). Marcel'in bakış açısı aynı zamanda inanç ve gözlemin birbirinden ayrı eylemler değil, birbirine bağlı süreçler olduğu fikrini de ortaya koymaktadır. Fiziksel dünyayı gözlemlerken, bireyler inançlarını, inançlarını ve varoluşsal kaygılarını bu eyleme katarak her gözlemi hem ampirik veriler hem de manevi bağlam tarafından şekillendirilen benzersiz bir karşılaşma haline getirir.



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Gerçekliğin inşasında gözlem ve inancın bütünleştirilmesi, nesnel ve öznel gerçeklikler arasındaki geleneksel ikiliğe de meydan okumaktadır. Varoluşçu felsefede gerçeklik, varoluşun tam olarak anlaşılabilmesi için her iki unsurun da gerekli olduğu, öznel ve nesnel arasında bir süreklilik olarak görülür. Kuantum mekaniği, gözlemci ve gözlemlenenin içsel olarak bağlantılı olduğunu gösterdiğinden bu görüşü destekler. Teoloji de ilahi gerçekliğin kişisel ve ilişkisel bir bağlamda deneyimlendiğini ve inancın kişinin ilahi anlayışı şekillendirmede kilit bir rol oynadığını öne sürer. Dolayısıyla ister fiziksel ister ruhani olsun, gerçeklik gözlem ve inanç arasındaki etkileşimden ortaya çıkar ve varoluşun inşasının insan ve aşkın olan arasında paylaşılan bir çaba olduğunu öne sürer (Levinas, 1961). Gerçekliğin bu ortak inşası, ister bilimsel ister ruhani olsun, bilginin her zaman kısmi ve gelişmekte olduğunu ima eder. Dünyayı gözlemledikçe ve onunla ilişki kurdukça, gerçeklik anlayışımızı sürekli olarak yeniden şekillendirir, yeni içgörü ve deneyimlerin mümkün olduğunu düşündüğümüz şeylerin sınırlarını genişletmesine izin veririz.

Sonuç olarak, gözlem ve inancın varoluşsal bir bağlamda bir araya gelmesi ne tamamen nesnel ne de sadece öznel olan bir gerçekliğe işaret etmektedir. Hem bilimsel gözlem hem de ruhani inanç, sürekli akış halinde olan çok yönlü bir varoluşun inşasına katkıda bulunur. Kuantum mekaniği ve teolojik düşüncenin bu sentezi, gözlemcinin dünyayla etkileşimi tarafından şekillendirilen bir oluş süreci olarak varoluşun karmaşıklığını ve akışkanlığını kucaklayan daha incelikli bir gerçeklik anlayışı sunar. Gerçekliği gözlemci ile gözlemlenen, ampirik olan ile ruhani olan arasında süregelen bir diyalog olarak gören bir perspektif çağrısında bulunarak, hakikat arayışının geleneksel bilginin sınırlarını aşan ve sürekli gelişen bir yolculuk olduğunu öne sürer.

## **Sonuç: Metafizik ve Epistemolojinin Sınırlarında Gözlem ve İnanç**

Gözlem ve inancın yaklaşması, metafizik ve epistemoloji arasındaki liminal alanlarda gezinerek bilim ve teolojiyi uzun süredir ayıran geleneksel sınırlara meydan okuyor. Bu keşif boyunca, gerçekliğin keşfedilmeyi bekleyen statik, önceden var olan bir varlık değil, gözlemcinin bilinci ve gözlem nesnesinin karşılıklı etkileşimiyle sürekli olarak yeniden şekillenen dinamik bir yapı olduğu ortaya çıkmaktadır. Kuantum mekaniğinde gözlemci etkisi, insanın fiziksel dünya ile etkileşiminin derin etkisinin bir kanıtı olarak hizmet eder ve evrenin kendisinin bizim sorgulamalarımıza kayıtsız olmadığını öne sürer. Benzer şekilde, teolojik söylem de ilahi gerçekliğin pasif bir şekilde karşılaşılan değil, aktif bir şekilde deneyimlenen ve inanç merceği aracılığıyla yorumlanan bir şey olduğunu ileri sürer. Dolayısıyla, her iki alan da ister maddi ister manevi olsun, gerçekliğin gözlemcinin varlığından ayrılamayacağı fikrinde birleşir (Stapp, 2009). Bu bakış açısı, gerçekliğin ayrı, nesnel bir varlık olduğu yönündeki geleneksel görüşün yeniden değerlendirilmesini zorunlu kılmaktadır. İnsanlar dış dünyanın pasif alıcıları olmaktan ziyade, gerçekliğin ortak yaratıcılarıdır ve ona anlam, değer ve yapı katarlar. Bunun bilgi, hakikat ve varoluş anlayışımız üzerinde derin etkileri vardır ve bilme eyleminin ayrılmaz bir şekilde var olma eylemiyle bağlantılı olduğunu öne sürer.

Bu sentez, hakikat arayışının nesnel ve öznel ikiliğini aşması gerektiğini öne sürmektedir. Gerçekliğin inşası ne yalnızca ampirik bir gözlem meselesidir ne de yalnızca manevi inancın alanıdır; bilgi ve deneyim arasında süregelen diyalektik tarafından şekillendirilen akışkan ve ortaya çıkan bir süreçtir. Varoluşçu felsefe ve fenomenoloji hem bilimsel hem de teolojik hakikatlerin ifade edildiği zemin olarak yaşam dünyasını ortaya koyarak bu tabloyu daha da karmaşık hale getirir. O halde gerçeklik anlayışımız, her bir gözlemin, her bir inanç eyleminin varoluşun ortaya çıkan anlatisına katkıda bulunduğu çok katmanlı bir olgu haline gelir. Bu anlamda, gözlemci ve inanan, anlamaya çalıştıkları gerçeklikten ayrı değil, onun oluşumunun

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ayrılmaz bir parçasıdır (Merleau-Ponty, 1964). Bu, her bilme eyleminin aynı zamanda bir yaratma eylemi olduğunu gösterdiğinden, epistemolojinin radikal bir şekilde yeniden düşünülmesini gerektirir. Her bilimsel gözlem veya teolojik içgörü, gerçekliğin karmaşık dokusuna yeni bir katman ekleyerek hakikatin statik değil, algı ve inancın karşılıklı etkileşimi yoluyla dinamik olarak inşa edildiğini öne sürer.

Ancak gözlem ve inanç arasındaki etkileşim, bilimsel ve teolojik paradigmaların kusursuz bir şekilde kaynaşmasına yol açmaz. Bunun yerine, her birinin doğasında var olan sınırlamaları ve paradoksları ortaya çıkarır. Kuantum mekaniği, deterministik kesinliklere meydan okuyan bir evren ortaya koyar ve gözleme bağlı olan olasılıksal bir gerçeklik sunar. Öte yandan teoloji bizi, ilahi gerçekliğin ampirik incelemeye direndiği ve bir inanç sıçraması talep ettiği aşkın alana davet eder. Ancak bu sınırlamalar engel olarak değil, daha derin bir sorgulamaya davet olarak görülmelidir. Bizi, ister bilimsel gözlem ister teolojik düşünme yoluyla olsun, bilgi arayışımızın sürekli olarak tamamlanmamış olduğunu kabul etmeye zorlarlar - sürekli uzaklaşan bir anlayış ufkuna doğru bir yolculuk (Torrance, 1985). Bu sınırlılık kabulünün kendisi bir bilgelik biçimidir; insan anlayışının güçlü olmakla birlikte doğası gereği sonlu olduğunun kabulüdür. Bu sonluluğu kucaklayarak, kendimizi gerçekliğin daha alçakgönüllü ve geniş kapsamlı bir keşfine açarız; sorulara cevaplar kadar, gizeme de kesinlik kadar değer veren bir keşfe.

Bu bakış açısından, gözlem ve inanç arasındaki ilişki yalnızca epistemolojik bir mesele değil, varoluşsal bir öneme sahip bir mesele haline gelir. Hem fiziksel hem de ruhani boyutlarıyla dünyayla olan ilişkimizin bir yaratma eylemi olduğunu öne sürer. Önceden var olan bir gerçekliği basitçe ortaya çıkarmayız; onun süregelen oluşumuna katılırız. Bu bakış açısı, bilim ve teolojinin birbirine karşıt çerçeveler olarak değil, birbirini tamamlayan sorgulama biçimleri olarak görüldüğü daha bütünleştirici bir yaklaşımı gerekli kılmaktadır. Kuantum mekaniği bize evrenin bir karşılıklı ilişkiler ağı olduğunu ve gözlemcinin her zaman gözlemlenene dahil olduğunu öğretir. Benzer şekilde teoloji, inancın ilahi olanla karşılaşılan yorumlayıcı bir merceğe görevi gördüğü varoluşun birbirine bağlılığına işaret eder. Birlikte, insan bilinci ve aşkın olan tarafından ortaklaşa inşa edilen bir gerçekliği, ampirik ve metafizik olanın ayrı alanlar değil, birleşik bir bütünün iç içe geçmiş yönleri olduğu bir dünyayı önerirler (Barad, 2007). Bu birlik, modern düşüncenin ikiliklerini aşan yeni bir paradigma olasılığına işaret etmektedir. Bu paradigmada bilim ve maneviyat, çeşitliliği ve birliği, karmaşıklığı ve basitliği kutlayan bütüncül bir vizyonda birleşerek varoluşun gizemleriyle daha zengin, daha derin bir etkileşime davet eder.

Sonuç olarak, metafizik ve epistemolojinin sınırlarında gözlem ve inancın araştırılması, gerçekliğin tekil, nesnel bir olgu değil, etkileşim, yorumlama ve katılımı şekillenen, ortaya çıkan bir süreç olduğunu ortaya koymaktadır. Hem kuantum mekaniği hem de teoloji, farklı ancak kesişen yollarla, gözlemcinin gerçekliğin doğasını şekillendirmedeki aktif rolünü vurgular. Bu anlayış bizi basit ikiliklerin ötesine geçmeye ve daha bütüncül bir varoluş görüşünü benimsemeye teşvik eder; fiziksel olanla ruhani olan, ampirik olanla aşkın olan arasındaki derin bağlantıyı kabul eden bir görüş. Bu ışık altında, gerçeklik yalnızca insan eylemleri için bir zemin değil, gözlem ve inanç, bilinç ve ilahi olanın ipliklerinden dokunmuş, sürekli gelişen bir goblen haline gelir. Bu dinamik gerçekliği tam olarak kavramak için, anlayışımızın her zaman kısmi ve geçici olduğunu kabul ederek entelektüel bir tevazu duruşu benimsemeliyiz. Kesinlik ve belirsizlik, bilgi ve gizem arasındaki gerilimde varoluşun gerçek zenginliği bulunur.

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**KARSTIC DEPRESSIONS OF WESTERN ANATOLIA (TURKEY):  
DISTRIBUTIONAL CHARACTERISTICS AND TECTONISM**

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**Abstract**

Dolines and other karstic depressions are essential components of hydrological and geomorphological systems. Because of its wide karst terrains and active tectonics, Turkey's Western Anatolia is a geologically significant region. This research explores the relationship between tectonism and karstification as well as the distributional features of karst depressions in western Anatolia. Active Western Anatolian tectonics has had a significant impact on the area, which is mostly made up of Mesozoic and Cenozoic carbonate lithologies. The diverse morphologies of karstic depressions in western Anatolia, which reflect differences in geological, hydrological, and structural factors, range from modest, shallow dolines to large polyes. Their tight alignment with fracture zones and fault networks in space suggests that tectonic forces influenced the genesis of karst. Groundwater movement is facilitated by normal faulting and related joint systems, which also promote chemical weathering and the formation of subsurface voids. These mechanisms cause surface sinking and depression development throughout time. Furthermore, by changing drainage patterns, tectonic activity can have an even greater impact on karst processes. These fields should be investigated and assessed in connection with geomorphological, hydrological, and tectonic investigations in order to gain a better understanding of karst dynamics in tectonically active settings. For the management of water supplies, sustainable land use, and the reduction of geological dangers in karst zones worldwide, a deeper comprehension of these processes is crucial. In conclusion, the formation of dolines in western Anatolia is greatly influenced by tectonic activity since the region's extensional tectonics creates faults and fractures that encourage karstification and water penetration, resulting in the depressions that characterize the region's geomorphology.

**Keywords:** Karstic depressions, Western Anatolia, Dolines, Tectonism, Karst geomorphology

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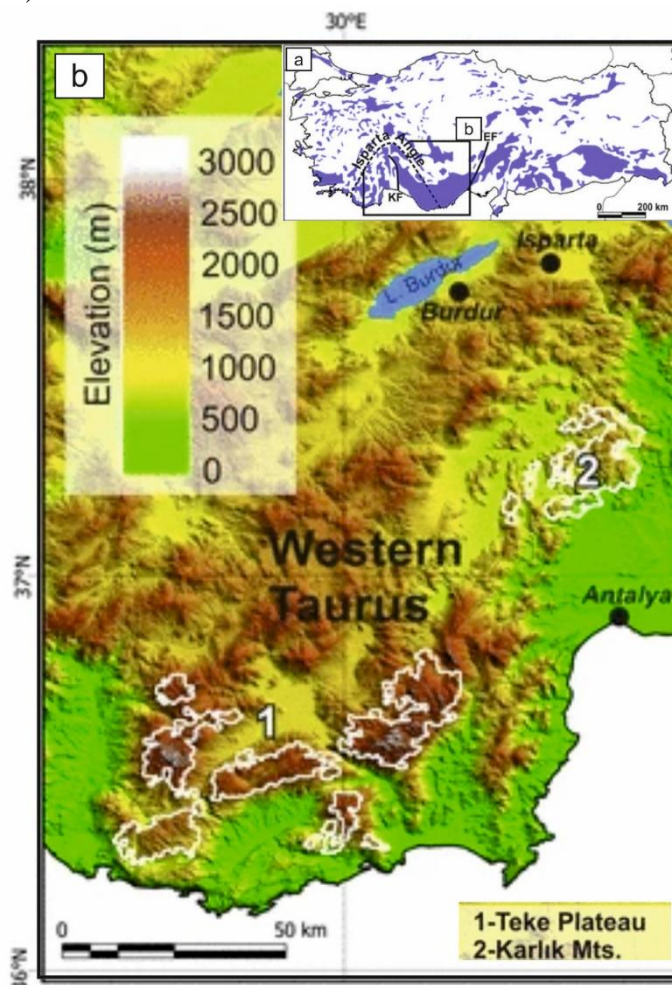
**Özet**

Dolinler gibi karstik çöküntüler, jeomorfolojik ve hidrolojik sistemlerinin ayrılmaz bir parçasıdır. Batı Anadolu, Türkiye, aktif tektoniği ve geniş karstik arazileri nedeniyle jeolojik açıdan önemli bir bölgedir. Bu çalışma, Batı Anadolu'daki karstik depresyonların dağılımsal özelliklerini araştırmakta ve karstlaşma ile tektonizma arasındaki etkileşimi incelemektedir. Ağırlıklı olarak Mesozoyik ve Senozoyik karbonat litolojilerinden oluşan bölge, aktif Batı Anadolu tektoniğinden oldukça etkilenmiştir. Batı Anadolu'daki karstik çöküntüler, jeolojik, hidrolojik ve yapısal kontrollerdeki varyasyonları yansıtan küçük, sık dolinlerden geniş polyelere kadar çeşitli morfolojiler sergiler. Mekansal dağılımları fay sistemleri ve kırık zonları ile yakından uyumludur, bu da karstik evrim üzerinde tektonik etkilere işaret etmektedir. Normal faylanma ve ilişkili eklem sistemleri, yeraltı suyu akışı için yollar oluşturarak kimyasal ayrışmayı ve yeraltı boşluklarının gelişimini artırır. Zamanla bu süreçler yüzey çökmesi ve çöküntülerin oluşmasıyla sonuçlanır. Ayrıca, tektonik aktivite drenaj modellerini değiştirerek karstik süreçleri daha da etkileyebilir. Tektonik olarak aktif ortamlardaki karst dinamiklerini daha iyi anlamak için söz konusu alanlar jeomorfoloji, hidroloji ve tektonik çalışmalar la birlikte incelenmeli ve değerlendirilmelidir. Bu süreçlerin daha iyi anlaşılması, küresel olarak karstik bölgelerde sürdürülebilir arazi kullanımı, su kaynakları yönetimi ve jeolojik tehlikelerin azaltılması için gereklidir. Sonuç olarak, Tektonik aktivitenin Batı Anadolu'daki dolin gelişimi üzerinde önemli bir etkisi vardır çünkü bölgenin genişleme tektoniği, karstlaşmayı ve su sızmasını teşvik eden faylar ve kırıklar üreterek bölgenin jeomorfolojisini tanımlayan çöküntüleri oluşturmaktadır.

**Anahtar Kelimeler:** Karstik çöküntüler, Batı Anadolu, Dolinler, Tektonizma, Karst jeomorfolojisi

### Introduction

Surface and subsurface landforms, as well as hydrology, are unique to karstic terrain. Carbonate rocks gave rise to karst, which is found beneath large portions of the ice-free continental portion of the Earth, particularly in the Northern Hemisphere and Mediterranean region (Ford and Williams 2007). Nearly all of Turkey is covered in karstic topography, which makes up about 40% of the country (Nazik and Poyraz 2017). The Taurus Mountains, which form a continuous karst belt throughout southern Turkey, are the largest and most significant karstic terrain (Fig. 1a).



**Figure 1.** Outcrops of carbonate rocks in **a** Türkiye (Nazik and Tuncer 2010), **b** western Taurus

Karstic land development in the Taurus Mountains has been significantly influenced by the presence of carbonate rocks, lateral and vertical tectonic movements, and current and historical climate, particularly during the Quaternary glacial and interglacial eras (Klimchouk et al. 2006). The majority of the karstic landforms in this area follow structural and orographic lineaments, and they comprise caves, poljes, gorges, dry valleys, dolines, uvalas, ponors, and springs (Gunn and Günay 2004; Figs. 1b).

Particularly in mid-latitude zones (Sauro, 2013) on young, folded mountains like the Taurus and Dinaric Mountains (Öztürk et al. 2018), the most distinctive surface forms of bare karstic

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regions are circular or semicircular solution dolines (closed depressions) with diameters ranging from a few meters to 1 km (Veress 2017). Paleozoic, Mesozoic, and Tertiary limestones that were highly fractured and joined, and had a thickness of up to 5000 meters (Koçyiğit 1984), produced the right lithological conditions for doline formation (Erinç 1960). Topographic circumstances that were favorable for the formation of dolines were also produced by the gently sloping surface of high karstic plateaus that lacked active drainage (Öztürk et al. 2015; Fig. 2).

Solution dolines have a significant impact on hydrology, soil, vegetation, and human activity. They also offer vital information on the morphotectonic development of karstic terrain, as previously mentioned. Accordingly, one of the karstic landforms that is most frequently researched is the solution doline (Daura et al. 2014). It is unknown how many dolines there are and where they are distributed, although several research highlighting how many dolines are found in the Western and Central Taurus Mountains. This study intends to (1) identify the total number of dolines and their distribution, (2) explain the relationship between doline density and slope conditions, and (3) show how doline orientation changes on the high karstic plateaus of the Taurus Mountains.

## Study Area

Nearly all dolines formed on neritic limestone, based on the lithology of the research area. From the Jurassic (Mesozoic) to the Miocene (Tertiary), this neritic limestone was deposited. Beginning in the Middle Cretaceous, a carbonate platform in the Neo-Tethys Ocean between the African–Arabian and European plates was compressed north–south, forming the Taurus Mountains (Livermore and Smith 1984; Yazgan and Chessex 1991). Following this time, the Taurus Mountains were subjected to compression, thickening, and uplift, while the African plate was subducted to the north (Akay and Uysal 1988; Schildgen et al. 2014; Karaoğlan 2016). Following the Late Miocene, the carbonate rocks were exposed to air conditions (Ekmekci 2003). Rapid uplift clearly damaged the Western and Eastern Taurus, where the Miocene units are eroded (Fig. 2).

The eastern region of Central Taurus, which experienced a modest rate of uplift, was also impacted by extensional tectonics (Koçyiğit 1984). As a result, the Miocene-aged units in this region of Taurus were not sufficiently removed by erosion. Tectonic movements caused tilts from north to south throughout the Early Pliocene-Late Pleistocene epoch (Koçyiğit 1984). All of this tectonic action contributed to the formation of karstic landforms and dolines by lowering the karst base levels.



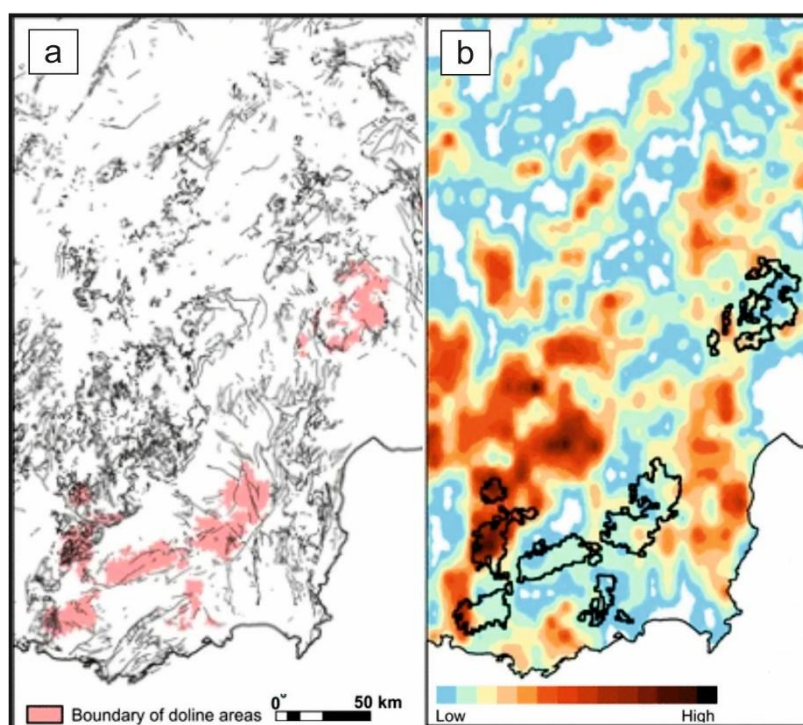


Figure 2. a faults map, and b. fault density map of Western Taurus Mountains

### Method

In this study, the spatial distribution of doline density was determined using topographic maps at a resolution of 1/25,000 (Telbisz et al. 2009; Benac et al. 2013). The highermost closed contour lines of dolines were drawn as polygons in a GIS using the traditional method. Doline elevations were calculated using topographic maps and the highest closed contour values. These altitudes were used to create a histogram that displayed the variation in the number of dolines by elevation. In addition, the following values are computed to assess the elevation characteristics of dolines: minimum, 5%, 25%, average, 75%, 95%, and maximum.

The centroid X and Y coordinates of these polygons were used to construct a point map. To calculate doline density (doline/km<sup>2</sup>) in 1 km<sup>2</sup> grids, the point data set was analyzed. Furthermore, to explain the connection between doline density and slope conditions, average slope values are computed for 1 km<sup>2</sup> grids (Öztürk et al. 2017). In addition, long axis lines were constructed connecting the two polygons' furthest points. These lines were then used to calculate the orientation angle of each doline. Using graphical software, rose diagrams were made for each of the five Central Taurus plateaus and then replaced on the map.

### Result and Discussion

Marble, carbonates, clastic rocks, and neritic limestone make up karstic plateaus. Nonetheless, neritic limestone is the most significant lithological unit. From the Maastrichtian to the present, compressional forces between the African and Arabian plates caused this shallow marine limestone, known as the Taurus Carbonates Platform, to be raised and destroyed (Özgül 1984). Shallow coastal limestone with intensely extensional joints made up the primary lithological unit of high karstic plateaus at the end of this compressional phase. Neritic limestone covers over 80% of each plateau.

In spite of this, the percentage of neritic limestone (PNL) does not correlate with the mean

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doline density (MD), maximum doline density (MxD), or total number of dolines (TND). The areal percentage of neritic limestone (PNL) is not correlated with the number of dolines, mean doline density, or maximum doline density, despite the fact that neritic limestone is a crucial unit in doline development. This is due to the fact that the tectonic characteristics, drainage, joint intensities on the neritic limestone, and topographic conditions (slope) all affect these variables (TND, MD, and MxD). High slope conditions (steep slopes) and active surface drainage density are significant determinants of doline densities (Öztürk et al. 2017).

Thus, doline density is highest on gently sloped high karstic plateaus that are badly failed and joined, particularly in the western region of Central Taurus. However, in the eastern Central Taurus, extensional joint systems have a greater effect on doline formation than faults (Öztürk et al. 2017).

The direction of the doline long axes' azimuths offers crucial hints regarding their joint systems, and dolines are employed as a sensitive indication of tectonic activity in a karstic area. Many studies have therefore used rose diagrams of dolines (Pardo-Igúzquiza et al. 2013; Bauer 2015; Kobal et al. 2015; Öztürk et al. 2015, Jeanpert et al. 2016). Two directions (NW–SE and NE–SW) are prevalent in doline orientations, according to the rose diagram created by the azimuths of the long axis of the dolines on the Central Taurus (Anamas, Gidengelmez, Geyik, Ermenek, and Bolkar).

Dolines directions are parallel to the Taurus Mountains' overall orographic elongation when orientations for each mountain are closely inspected. In center Taurus, the dominant directions are NE-SW in the eastern section, NE-SW and NW-SE in the center part, and NW-SE in the western part. Based on these elongations, doline orientations create an arc that is the result of the Central Taurus's tectonic history.

## **Conclusion**

Because of this, dolines form on high karstic plateaus made of neritic limestone, and the topographic conditions (slope and elevation) and the intensity and direction of tectonics—particularly joint intensity and direction—control the spatial distribution of doline density on this lithology.

Numerous other factors, including the total and layer thickness of limestone, tectonic and morphological evolution, the severity of faults and joints, current and historical climatic features, the composition of limestone, particularly the amount of CaCO<sub>3</sub> and clay, altitude, slope angle, active and paleo-drainage density, and sea level changes, all affect the distribution and density of dolines.

On the high karstic plateaus of the Taurus Mountains, which are made of neritic limestone and are severely faulted and joined as a result of tectonic activity, polygonal karst structures have proliferated. Only 5% of dolines are found below 1330 meters, with 90% of dolines falling between 1300 and 2270 meters with the largest density being between 1850 and 1900 meters (8.2%). This finding indicates that the alpine and periglacial zone above the treeline is the densest doline zone.

This study serves as the foundation for additional karstic research and is the first finding regarding the overall quantity and density of dolines throughout the Western and Central Taurus Mountains. The total number of dolines and the doline density will probably increase if doline areas in this study are investigated utilizing new techniques and more depth. Furthermore, in contrast to topographic or structural aspects, more research should be done on the karst genesis and its idiosyncrasies in terms of morphology or morphometry.

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**CURRENT APPROACHES IN SMOKING CESSATION TREATMENT**

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**Abstract**

Smoking is one of the leading causes of preventable diseases and deaths. Every year, nearly seven million people die from smoking-related diseases. Therefore, helping individuals quit smoking has become one of the primary goals of healthcare professionals. In this study, cognitive-behavioral and pharmacotherapeutic methods used in smoking cessation treatment are discussed. In addition, follow-ups, relapse and factors that increase success in smoking cessation treatment were also examined. The implementation of evidence-based treatment methods and innovative strategies in smoking cessation significantly increases success rates. This study aims to enhance healthcare professionals' knowledge of smoking cessation and contribute to the development of effective strategies in smoking cessation treatments.

**Keywords:** smoking addiction, smoking cessation, smoking cessation treatment

CURRENT APPROACHES IN SMOKING CESSATION TREATMENT

**Özet**

Önlenebilir hastalık ve ölümlerin en önemli sebeplerinden birisi sigara kullanımınıdır. Her yıl yedi milyona yakın kişi sigara kullanımına bağlı hastalıklar nedeniyle hayatını kaybetmektedir. Bu nedenle sigara bırakılması sağlık profesyonellerinin en önemli hedeflerinden biri haline gelmiştir. Bu çalışmamızda, sigara bırakma tedavisinde kullanılan bilişsel davranışçı ve farmakoterapik yöntemler ele alınmaktadır. Ayrıca sigara bırakma tedavisinde izlemler, nüks ve başarıyı arttıran faktörler de incelenmiştir. Sigara bırakmada kanıta dayalı tedavi yöntemlerinin ve yenilikçi stratejilerin uygulanması başarı oranlarını arttırmaktadır. Bu çalışmamız, sağlık profesyonellerinin sigara bırakma konusundaki bilgi düzeylerini arttırmayı ve sigara bırakma tedavilerinde etkin stratejilerin geliştirilmesine katkı sağlamayı hedeflemektedir.

**Anahtar Kelimeler:** sigara bağımlılığı, sigara bırakma, sigara bırakma tedavisi

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## Introduction

One of the most significant causes of preventable diseases and deaths is smoking (Onen et al., 2010). Each year, nearly seven million people die due to smoking-related illnesses, while approximately 1.3 million people lose their lives due to diseases caused by exposure to tobacco smoke (Cornelius et al., 2020). Smoking addiction, a serious public health problem with economic, social, medical, and legal dimensions, has become one of the key targets for healthcare professionals seeking solutions. Smokers, on average, lose about ten years of life compared to non-smokers. Most smoking-related deaths are attributed to cancer (34%), followed by cardiovascular diseases (32%) and respiratory diseases (21%). Smoking is directly linked to the development of cancers in the lungs, oropharynx, larynx, esophagus, stomach, liver, pancreas, kidneys, colon, cervix, and bladder. Approximately 90% of lung cancer cases and around 80% of deaths due to COPD are caused by smoking (Rigotti et al., 2022).

Substances like nicotine found in cigarette smoke are highly addictive. Nicotine rapidly reaches the brain, triggering the release of mediators such as noradrenaline, dopamine, tryptamine, GABA, and acetylcholine (Haustein, 2000). During nicotine withdrawal, symptoms such as decreased concentration, hunger, depression, restlessness, and insomnia may occur (Rennard & Daughton, 2000). The Fagerström Nicotine Dependence Test (FNDDT) is used to assess addiction levels (Table 1). The FNDDT primarily evaluates the duration a smoker can refrain from smoking and the number of cigarettes consumed (Sönmez et al., 2017). This test consists of six questions, where a score of 8 or above indicates very high dependence, 6–7 indicates high dependence, 5 indicates moderate dependence, 3–4 indicates low dependence, and 0–2 indicates mild dependence.

**Table 1.** Fagerström Nicotine Dependence Test (FNDDT)

How soon after you wake up do you smoke your first cigarette?	After 60 minutes	0
	31-60 minutes	1
	5-30 minutes	2
	Within 5 minutes	3
Do you find it difficult to refrain from smoking in places where it is forbidden	No	0
	Yes	1
Which cigarette would you most hate to give up?	All others	0
	The first one in the morning	1
How many cigarettes do you smoke daily?	10 or less	0
	11-20	1
	21-30	2
	31 or more	3
Do you smoke more frequently during the first hours after waking than during the rest of the day?	No	0
	Yes	1
Do you smoke if you are so ill that you are in bed most of the day?	No	0
	Yes	1

Smoking cessation success is defined as refraining from using cigarettes and other tobacco products for at least six months (Campbell, 2003). Although smokers often think about quitting, many struggle to achieve it due to the complex interplay of physical and psychological dependencies characteristic of nicotine addiction (Edwards, 2004). Evidence-based treatment

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methods for smoking cessation succeed in less than a third of cases (Devonish et al., 2022). Approximately 80% of individuals attempting to quit relapse within the first month (Benowitz, 2009). Consequently, smoking cessation is characterized by a course of relapses and remissions, like chronic diseases (Dale et al., 2000).

Smoking cessation treatments address both physical and psychological dependencies. Cognitive-behavioral methods aim to help individuals cope with nicotine withdrawal symptoms and modify smoking-related behaviors and habits, while physical dependency is managed using nicotine replacement therapies (NRT), bupropion, cytisine and varenicline. Combining these methods improves success rates (Kapusta et al., 2010).

## **Cognitive-Behavioral Methods**

Cognitive-behavioral methods aim to identify and alter the thought and behavior patterns that contribute to maintaining smoking habits. Since smoking addiction encompasses physical, psychological, and behavioral dimensions, cognitive-behavioral methods provide comprehensive support during the smoking cessation process.

These methods play a significant role in smoking addiction treatment and are based on various principles. First, they help individuals recognize the situations that trigger their smoking behavior and the automatic thoughts associated with it (Nian et al., 2023; Onwuzo et al., 2024). Unrealistic thoughts related to smoking urges are questioned and replaced with more functional and positive alternative thoughts (Alshehri, 2024; Rigotti et al., 2022). Individuals are taught coping strategies to reduce smoking urges, such as stress management, problem-solving, and emotional regulation techniques (Davis et al., 2023). Additionally, behavioral adjustments are made to reduce smoking habits and environmental triggers (Altunsoy et al., 2024; VanFrank et al., 2024).

## **Nicotine Replacement Therapies (NRT)**

By providing the body with a low dose of nicotine, nicotine replacement therapies (NRT) suppress withdrawal symptoms and reduce the urge to smoke. A wide range of products is available, including nicotine gum, transdermal patches, nasal sprays, lozenges, and inhalers. These products aim to meet the body's nicotine needs, helping to break the smoker's habitual cycle (Onwuzo et al., 2024).

While smoking cessation rates are below 10% with placebo treatments, they have been reported to be around 15-20% with NRT (Altunsoy et al., 2024; Saylan et al., 2021). The effectiveness increases further when combined with pharmacotherapeutic agents, achieving success rates of approximately 25% (Altunsoy et al., 2024; Rigotti et al., 2022).

These methods are easy to use, safe, and well-tolerated. However, they may cause mild side effects such as local skin reactions or mild headaches. They are contraindicated in individuals with a recent myocardial infarction, uncontrolled arrhythmias, unstable angina, chronic skin diseases, and in pregnant or breastfeeding women (Şahbaz & Kılınç, 2005).

Nicotine patches are applied to clean and dry skin and used for 16-24 hours. The initial dose is proportional to the level of dependence. Nicotine gum is chewed slowly and intermittently to allow absorption through the oral mucosa, with a typical daily dose of 4-10 pieces adjusted based on the smoker's habits. Nasal sprays and inhalers are suitable for daily use, with 8-40 inhalations recommended per day. Lozenges are used similarly to gum, with a daily dose of 4-8 lozenges adjusted according to the smoker's habits (Altunsoy et al., 2024).



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### **Varenicline**

Varenicline is a partial agonist of nicotinic acetylcholine receptors. While it competitively inhibits these receptors, it also exerts a low level of activation. Through this mechanism, it regulates dopamine release and blocks the effects of nicotine, thereby mitigating withdrawal symptoms and reducing the urge to smoke (Saylan et al., 2021).

It is indicated for use in people who have not been able to quit smoking with nicotine replacement therapies or bupropion use, and in people with a medium addiction level or higher addiction level. Studies have reported that smokers using varenicline achieve higher cessation rates compared to those using bupropion or nicotine replacement therapies (Davis et al., 2023; Rigotti et al., 2022). Furthermore, it has been shown to increase the success rate of smoking cessation by 2.27-fold over a six-month period (Cahill et al., 2016; Uzaslan, 2016).

The recommended dosage regimen is 0.5 mg once daily for the first three days, followed by 0.5 mg twice daily from days four to seven. Thereafter, 1 mg twice daily is continued for 12 weeks. Typically, during the second week of treatment, a specific quit date is chosen, and the patient continues smoking until that predetermined date (Tütün Kontrolü ve Sigara Bırakma Tedavisi, 2013).

The most common adverse effect is nausea. Other adverse effects include insomnia, dyspeptic complaints, and abnormal dreams. Patients should be informed that varenicline may exacerbate neuropsychiatric symptoms and potentially worsen existing mental health conditions. It is contraindicated in pregnant or breastfeeding women and in patients with end-stage renal disease. In individuals with a history of neuropsychiatric disorders, the risks associated with its use should be carefully evaluated (Davis et al., 2023).

### **Bupropion**

Bupropion is an antidepressant that inhibits the reuptake of dopamine and norepinephrine. It is hypothesized to exert an antagonistic effect on nicotinic acetylcholine receptors and to block nicotine-related reward mechanisms. Moreover, it alleviates psychological symptoms such as depression and anhedonia associated with nicotine withdrawal (Rigotti et al., 2022).

When used as monotherapy, it has been shown to increase smoking cessation success by a factor of 1.94 (Hughes et al., 2014). It can be used together with nicotine replacement therapies in cases where nicotine withdrawal symptoms are dominant or monotherapy is insufficient. (Hurt et al., 1997).

Bupropion is available in 150 mg tablet form. After a three-day period of 150 mg daily, the dose is increased to 300 mg daily. Typically, a designated quit date is set during the second week of treatment, and therapy is continued for approximately eight weeks. In certain cases, treatment can be extended up to six months.

Dry mouth and insomnia are the most commonly observed side effects. Although rare, seizures and severe allergic reactions may occur. The risk of seizure development is significantly elevated in individuals with a history of epilepsy, anorexia nervosa, or bulimia (Hezer, 2016). Therefore, its use is contraindicated in this patient group. Other contraindications include the use of medications that lower the seizure threshold, a history of central nervous system trauma or tumors, uncontrolled hypertension, hepatic insufficiency, concurrent use of monoamine oxidase inhibitors, breastfeeding, and pregnancy (Hurt et al., 1997).

### **Cytisine**

Cytisine is a partial agonist of nicotinic acetylcholine receptors. It reduces nicotine withdrawal

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symptoms while suppressing the urge to smoke. By increasing dopamine levels, it also affects the reward system, reducing nicotine-associated rewarding behaviors (Etter, 2006).

Compared to placebo, cytisine increases smoking cessation success by a factor of 2.65 (Puljević et al., 2024). Studies suggest it is more effective than nicotine replacement therapies (Puljević et al., 2024; Walker et al., 2014). However, it has been shown to be less effective when compared to varenicline (Oreskovic et al., 2023; Puljević et al., 2024).

The cytisine in 1.5 mg tablet form is used six times a day for the first three days. Between days 4-12, it is taken five times a day, with the 5th day generally designated as the quit smoking day. The dosage is then reduced to four tablets daily from days 13 to 16, three tablets daily from days 17 to 20, and two tablets daily from days 21 to 25 (Wang et al., 2024).

Cytisine is generally well-tolerated. However, it may cause gastrointestinal complaints, sleep disturbances, dizziness, and headaches. Its low incidence of side effects enhances treatment adherence. It is contraindicated in pregnant or breastfeeding women and in individuals with severe cardiovascular disease, renal failure, or liver failure (Hersi et al., 2024).

## **Follow-up, relapse and factors enhancing smoking cessation success**

Regular follow-up plays a critical role in increasing success rates in smoking cessation treatments. Consistent monitoring helps maintain the motivation of individuals who have quit smoking and reduces the risk of relapse. Objective measures such as carbon monoxide monitoring during follow-ups improve adherence to treatment and help prevent relapse (Onwuzo et al., 2024).

Studies indicate that the risk of relapse can reach up to 50% within the first three months. Stress and smoking habits are significant contributors to relapse risk. Educational and awareness programs, behavioral interventions combined with pharmacotherapy, and supportive social environments are crucial for preventing relapses (VanFrank et al., 2024).

Individual motivation is one of the most important factors in enhancing smoking cessation success. Cognitive-behavioral therapies and motivational interviewing techniques help smokers cope with the challenges encountered during the cessation process (Selcuk et al., 2015). Technology-based applications such as online support groups and mobile apps are innovative methods that have been shown to increase smoking cessation rates (Lengel & Kenny, 2023). Additionally, expanding smoking cessation programs at the community level facilitates access to treatment and improves cessation success. Studies such as support provided in smoking cessation clinics and community centers, training and awareness for healthcare professionals also increase quit rates (Alshehri, 2024).

In conclusion, smoking addiction is a preventable public health issue that poses severe adverse effects on individual health. Implementing effective treatment strategies through a multidisciplinary approach can increase smoking cessation success while contributing positively to public health.

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**ANALYSIS OF CAPERS (*CAPPARIS SPINOSA* AND *CAPPARIS OVATA*)  
MEDICINAL AND AROMATIC PLANTS BY GC-MS FTIR and SEM-EDX**

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**Abstract**

Caper is a medicinal and aromatic plant that grows spontaneously in different regions of Türkiye and is widely used in health, its fruits and buds consumed as nutrients. In this study, it is aimed to obtain high added value products that will contribute to the Turkish economy from the caper plant, which is a medicinal aromatic plant. Volatile components were obtained using the Clevenger system extraction method and library screening was performed on GC-MS. By GC-MS, saturated and medium chain fatty acids are Hexanoic acid (Caproic acid), Octanoic acid (Caprylic acid), Decanoic acid (Capric acid), Dodecanoic acid (Lauric acid), Tetradecanoic acid (Myristic acid), Hexadecanoic acid (Palmitic acid). Octadecanoic acid (Stearic acid) was analyzed. With the elemental analyzer, the percentages of C, H, O, N, S, the basic elements of enzymatic reactions, which are the building blocks of organic substances, in dried capers, buds and seeds were examined. A library search was performed with FTIR for information about the structure of organic substances in capers. L-Glyceraldehyde, Tomatin, Digitonin, n-Octyl- $\beta$ -D-glucopyranoside, Catechin, Carrageenan substances were found. As a result of GC-MS and FTIR analysis, the usage areas and chemical properties of each component in the health, food, cosmetics, industry and pharmaceutical sectors were examined. Macro and micro element scanning was performed in SEM-EDX. The ratios of K, Cl, S, Na, P, Mg, Zn, Al, Ca and Fe elements in dried capers, buds and seeds were compared. The health effects of deficiency and excess of these elements were investigated. Capers contain high levels of flavonoids, making them widely used in the paint, food, cosmetics and pharmaceutical industries.

**Key Words:** Caper, volatile component, GC-MS, FTIR, SEM-EDX

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## Introduction

Throughout history, people have used medicinal aromatic plants in the treatment of some diseases, which they believe contain important compounds in their structures Schippmann U,(2002). Medicinal plants are still used in the pharmaceutical and food industries today. Studies on plant-based nutrition and the active components found in the structure of plants are increasing.

Caper (*Capparis* spp.), with an average of 350 species in the world, is one of the medicinal and aromatic plants and belongs to the Capparidaceae family. Capers, which grow naturally in many regions with tropical and semi-tropical climates, are widely consumed with their rich nutritional content and aroma. There are two different types of capers in our country: *Capparis spinosa* and *Capparis ovata*, which have a high level of economic and commercial importance. Although it grows in the temperate climate zone, the caper plant is also very resistant to harsh climatic conditions. Spain, Morocco, Italy and Türkiye are the world's leading countries in terms of caper production. Caper, which grows naturally, has a height varying between 30 cm and 100 cm, and is a long-lived plant species with thorns and thick-deep roots. Capers have therapeutic properties with their expectorant and antirheumatic tonic effects and are used in traditional medicine practices [2]. The root shells and other parts of the caper plant, whose buds are very rich in vitamins, minerals and protein content, are very effective in protecting against diseases. It is stated that the extracts of the flower, fruit, root bark and root parts of the caper plant have antihypertensive, antiatherosclerosis, anti-asthma, analgesic, anti-inflammatory, hepatoprotective, antifungal agent and antihyperlipidemic effects. Lorestani, A. N. (2012), Chahlia, N. (2009). Essential oils obtained from aromatic plants are used in the food industry to alleviate flavorful, sharp and intense tastes as well as their pleasant taste and smell. It has been determined to have antioxidant, antiviral, anti-tumor, antimicrobial, antiviral, anti-inflammatory and analgesic effects. Thanks to their biological effects, essential oils can prevent the reproduction of pathogenic organisms, increase the shelf life of foods, increase the storage quality and, accordingly, reduce the use of synthetic food preservatives .

In cases where antioxidants produced by the body are insufficient, antioxidant substances such as ascorbic acid (vitamin C), flavonoids,  $\alpha$ -tocopherol (vitamin E),  $\beta$ -carotene and lycopene are taken from outside the body, preventing the emergence of free radicals/and oxidative stress. Studies in the literature have stated that the caper plant contains bioactive molecules and antioxidant components such as quercetin, glucosinolates, flavonoids, phenolic compounds, routine and alkaloids Chahlia, N.at.al. (2009)., Özcan, M. at.al. (2004).

## Findings And Discussion

In the research, dried fruits and buds of the caper plant were used to analyze it. In our study, in order to obtain volatile components of the Caper plant, 200 grams of each dried fruit, bud and dried samples were weighed and extracted with 300 mL of water in the Hydrodistillation (HD) Clevenger system for 4 hours. After boiling, the essential oil obtained by following the process was taken into vials and made ready for GC-MS analysis. In Figure 1. GC-MS results of bud, dry and dried caper samples are given. In this study, it was aimed to determine the volatile components of the caper (*Capparis spinosa* and *Capparis ovata*) plant by GC-MS and to determine the chemical compound structure with the FTIR device.

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Figure 1. GC-MS results of bud, dry and dried caper samples

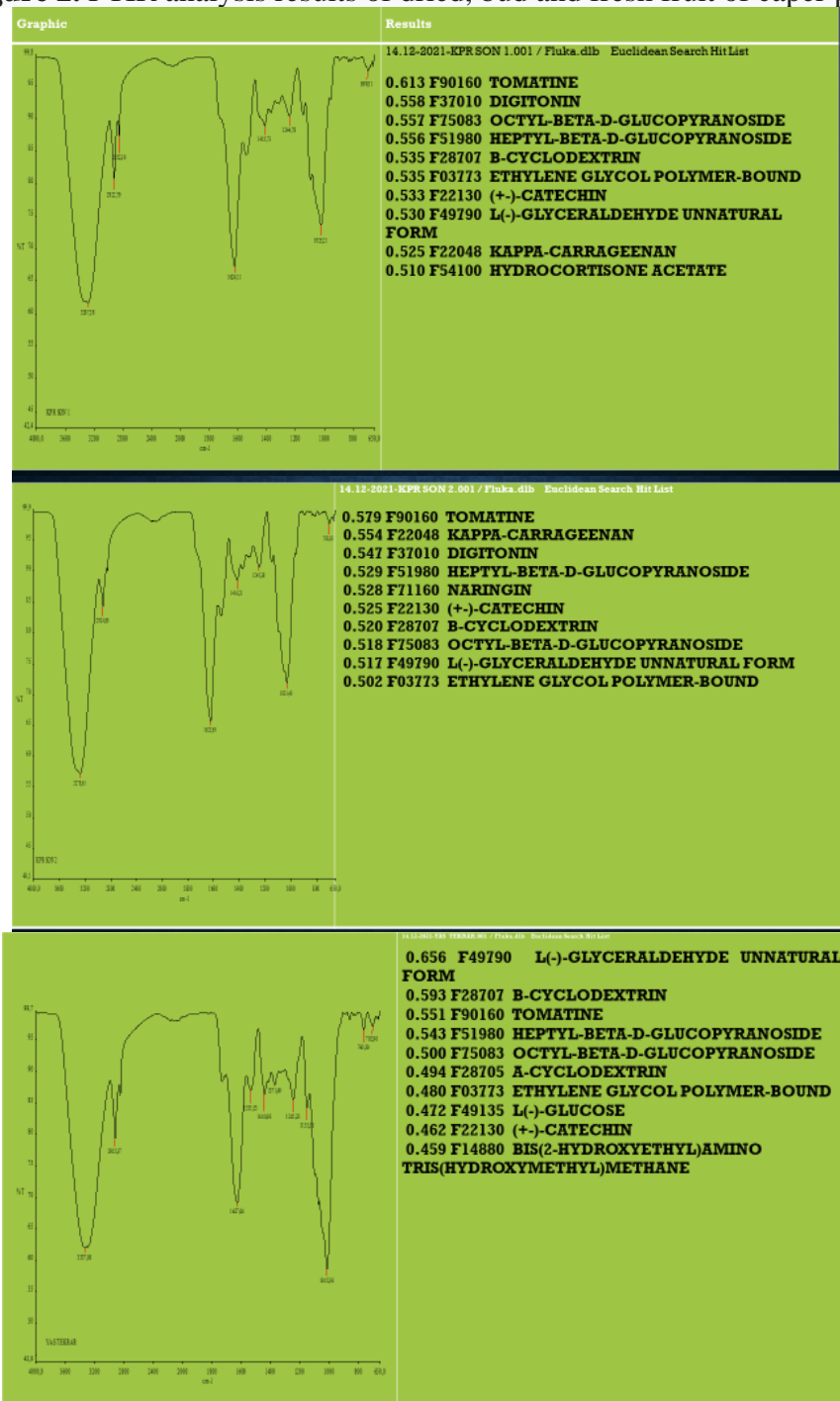
GC-MS RESULTS OF THE DRIED CAPER SAMPLE		
Rt (Retatation time)	Component name	%Compound
19.632	Asetik asit	2,60
22.018	1H-pirazol 1,5-dimetil	0,15
22.716	Propiyonik asit	0,10
23.654	Tetrametilpirazin	0,55
26.057	3-metil bütanoik asit	0,17
35.379	Metil-2-pirol keton	0,20
54.501	Metil-p-tert-bütill fenil asetat	0,06
55.016	2,4 di-tert-bütill fenol	0,07
56.298	2-asetil-4-etoksikarbonil-3-okza-2-aza-3,3 propilen	0,05
57.254	Etilen oksid heptamer	0,08
57.814	Oktaetilen glikol	0,10
60.784	2-[2-[2-[2-[2-(2-Hidroksietoksi)etoksi]etoksi]etoksi]etoksi]etoksi] etoksi] etoksi] etanol	0,06
68.246	18,18'-Bi-1,4,7,10,13,16-hekza oksasiklododekan	47,53
68.772	1,4,7,10,13,16-hekzaoksasilooktadekan	47,23
GC-MS RESULTS OF THE CAPER BUD SAMPLE		
Rt(Retatation time)	Component name	%Compound
6.591	Izosiyanotan	0,08
24.152	1,6-oktadien-3-ol-3,7-dimetil	0,09
24.404	Benzaldehid	0,25
26.063	Metil tridekanoat	0,25
26.676	Benzen asetaldehit	0,40
27.631	Sikloheksanon, 5-metil-2-(1-metiletiliden)-	0,69
31.802	Benzen metanol	0,15
36.912	2-izopropil-5-metil-2-sikloheksen	0,31
38.989	Oktaetilen asit	0,58
40.013	2-metil-4-(1-metil etil)-2-sikloheksanon	0,42
44.276	2-(4-Nitrofenil)-2-fenil siklopentanon	0,14
50.027	Oktaedkametil-siklononasiloksan	0,17
53.735	3-(2,5,8,11,14-Penta oksasiklo Heksadesil)-1,5,8,11,14,1 hekso oksasiklono dekan	0,04
54.484	1,1,3,3-Tetrametil-1,3-difenildisiloksan	0,05
55.005	2-Nitro-1,3-indandion	0,04
56.304	N-(4,4-didoteryo-4-fenil-bütill)ftalimid	0,24
57.197	1,4,7,10,13,16-Heksanoksasikil okta dekan	0,18
57.815	6-Aza-5,7,12,14-Tetrapentaten	0,30
58.993	Oktaetilen glikol	1,76
60.784	7-Tetrahidro-1,2,9,10-Tetra Metoksi-5-Metil-	0,56
61.179	Silan (2-metoksi etoksi) trimetil	0,06
63.397	1,4,7,10,13- pentaoksasilokpentadekan	7,00
66.761	1,4,7,10,13,16- hekzaoksasilooktadekan	66,39
71.965	2-bromo-3-metilfenil dikloro arsin	5,30
GC-MS RESULTS OF THE CAPER SAMPLE DRIED ON ITS BRANCH		
Rt(Retatation time)	Component name	%Compound
19.609	6-metil-5-hepten-2-one	0,15
22.052	Nonanal	0,38
24.947	Nonil kloroasetat	0,11
27.328	Trilokloroasetik asit nonil ester	0,05
28.003	5-metil-2-(1-metiletilliden)sikloheksanon	0,02
37.139	2-izopropil-5-metil-2-sikloheksen-1-one	0,38
46.056	1,1,7-trimetil-4-metilendekahidro-1H-siklopropaazulen-7-ol	0,97
49.970	2-pentadecanone, 6,10,14-trimetil	0,39
53.363	Dekanoik asid	0,14
54.152	Hekzadekanoik asit, metil ester	0,09
55.108	Etanon, 1-(2,3-dihidro-6-(metil tio)-1H-inden-5-YL	0,07
55.903	3,3'-izopropiliden bis(1,5,8,11-tetra oksasikloheksan)	0,06
56.739	(2S,4R,5S,6R)-5-[(2'-metoksi etoksi metil)oksi]-2,4,6-Trimetil-8-(tert-bütildimetilsilil)oksi]-1,1-(propan-1',3'-ditio)oktan	0,09
57.282	1,4,7,10,13,16- hekzaoksasilooktadekan	45,6
58.243	7-(1-metil-eteni)-1-hidroksi-1,4-dimetil-1,2,4,5-[3H, 6H] oktahidroazulen	0,66
59.096	3-(1,3-dihidroksi izopropil)-1,5,8,1,1,1,4-penta oksa sikloheksadekan	0,09
59.502	Oktaetilen glikol	0,34
60.235	Dodekanoik asit	0,37
61.339	Oktaetilen glikol monododesil eter	0,14
63.136	Dokosan	0,48
63.971	Benzil benzoat	0,76
64.767	Tetradekanoik asit	1,74
66.969	Pentadekanoik asit	3,19
68.11	n-hekzadekanoik asit	25,92
68.995	Etilen oksid heptamer	5,44
70.466	1,4,7,10,13- pentaoksasilokpentadekan	3,59
72.485	Oktaetilen asit	2,76



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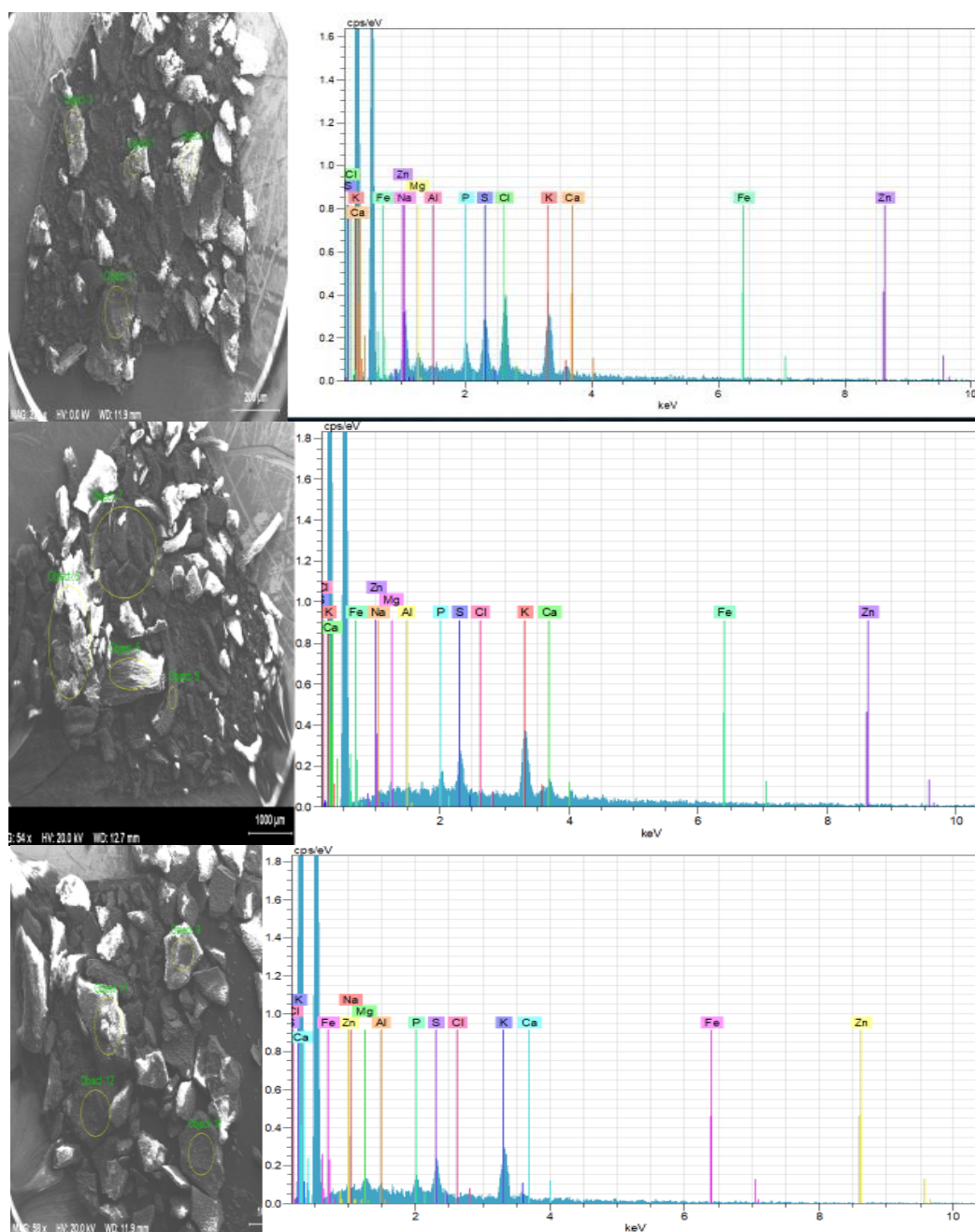
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**Figure 2.** FTIR analysis results of dried, bud and fresh fruit of caper plant



The results of the FTIR analysis performed to determine the components of the dried, bud and fresh fruit of the caper plant are given in Figure 2. SEM-EDX results are given in Figure 3 and a comparison of the results is given in Figure 4.

Şekil 3. SEM-EDX results of caper seed bud and fruit



The commercial uses of the components contained in the caper plant, which has many benefits, especially in the health and food sectors, were examined. SEM-EDX (LEO-EVO 40 Cambridge England- Bruker-125 eV Berlin/Germany FTIR device (Perkin Elmer: Universal Atr Sampling Accessory) was used in the analysis. The essential oils obtained were analyzed using GC-MS Agilent 6890 GC and 5973 HP – INNOWAX column and Library scanning was performed on a device with a selective detector, with an increase in column temperature of 3°C/min. Library scanning was performed at specific times and temperatures, starting from 50°C.

**Conclusion and Recommendations**

Macroelements required for plants are N, P, S, K, Mg, Ca and microelements Fe, Mn, Zn, Cu, B, Mo, Ni, Na, Si and Co. When the SEM-EDX results of the caper plant are evaluated in general, it is seen that K is the element that the fruit, bud and seed contain the most after C, H and O elements.

**Figure 4.** Comparison of SEM-EDX results of caper seed bud and fruit

Mass Means and Standard Deviations (%) for K, Cl, S, Na, P, Mg, Zn, Al, Ca, Fe in analysis with SEM-EDX			
Element	Caper seed	Caper bud	Caper fruit
<b>K</b>	7,48±0,35	6,13±0,28	8,65±0,35
<b>Cl</b>	3,86±0,23	0,46±0,08	1,16±0,13
<b>S</b>	3,71±0,23	2,26±0,15	4,37±0,23
<b>Na</b>	1,70±0,80	0,02±0,03	0,03±0,05
<b>P</b>	1,93±0,15	0,96±0,10	2,31±0,15
<b>Mg</b>	1,70±0,20	0,68±0,08	1,55±0,15
<b>Zn</b>	2,35±0,28	1,62±0,20	1,48±0,20
<b>Al</b>	1,43±0,15	0,32±0,05	1,41±0,15
<b>Ca</b>	1,60±0,13	1,75±0,10	1,60±0,13
<b>Fe</b>	1,44±0,20	1,11±0,10	1,28±0,15

The four elements most contained in the seed part are K, Cl, S and Zn; K, S, Ca and Zn of the bud part; It is seen that the fruit part contains K, S, P and Ca. Calcium and phosphorus deficiency can cause osteoporosis in adults and rickets in children. Zinc, which strengthens the immune system, also plays an important role in hair, nail and skin health, like sulfur. In zinc deficiency, disorders such as weakening of the immune system, loss of appetite, night blindness, blurred vision, and increased healing time of wounds on the body can be observed. Considering the importance of minerals for body health, it can be said that capers can be effective in the prevention and treatment of nervous system, skeletal system, dental and bone diseases and skin diseases due to their rich mineral content. As a result of elemental analysis, C, H, S and N percentages were examined. The dry matter ratio in N plants should be between 1.5% and 6%. The sufficiency level for the plant varies between 2.5%-3.5%. It was found between 3.7% and 5.5% in the caper plant. The critical level of nitrogen for plants varies depending on the parts of the plant. Nitrogen is high in the young fruit parts of the plant, and the amount of nitrogen decreases as the plant ages. Since the caper plant is a 150-200 year old plant, its nitrogen level is quite high. Since the water content of the leaves increases in excess nitrogen, the plant cannot protect itself against frost, diseases and insect pests. The nitrogen form in the nutrient solution affects root development. The drought-resistant roots of the caper plant are very strong and can go up to 40 meters deep. Thanks to its roots and its spread on the soil, it should be used effectively to prevent landslides in areas at risk of erosion. Caper plant, which stands out with its chemical composition, rich mineral structure, nutritional and protective properties, should be included in the diet in the form of fresh fruit, pickled fruit and jam. Its high level of flavonoid content makes it widely used in the paint, food, cosmetics and pharmaceutical industries.

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**PEG İLAVESİNİN PLA/ BOR KARBON NİTRÜR FİLMLEİNİN KRİSTALİNİTE,  
ISIL VE MEKANİK ÖZELLİKLERİNE ETKİSİ**

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**Özet**

Plastik atıkların çevreye etkileri biyobozunur malzemelere olan ilgiyi arttırmıştır. Polilaktik asit (PLA) nişasta kökenli biyobozunur ve biyouyumlu bir malzeme olarak bu alanda öne çıkmaktadır. PLA, tarım sektöründen medikal uygulamalara, ambalaj malzemelerinden elektronik ürünlere geniş bir yelpazede kullanılmaktadır. Kolay işlenebilmesi, toksik olmaması, çevre dostu olması PLA'nın sunduğu avantajlardan bazılarıdır. Ancak PLA'nın kırılğan yapısı tek başına kullanımını sınırlamaktadır. Bu nedenle PLA sıklıkla diğer polimerlerle ve/veya plastikleştiricilerle birlikte kullanılmaktadır. Polietilen glikol (PEG), bu problemin üstesinden gelmek için PLA ile birlikte kullanılan polimerlerden biridir. Bu çalışmada, çözültiden dökme yöntemi kullanılarak %5 PLA ve %1 bor karbon nitrür (BCN) içerikli çözültilere farklı oranlarda (çözültideki PLA miktarının %10, 20 ve 30'u olacak şekilde) PEG ilavesi yapılmış ve filmler elde edilmiştir. Filmlerin ısıl özellikleri diferansiyel taramalı kalorimetre (DSC), kristalinitesi ise hem DSC hem de X-ışını kırınımı (XRD) analizleri ile incelenmiştir. Filmlerin mekanik özellikleri çekme testi ile belirlenmiştir. Isıl özellikler incelendiğinde PEG ilavesinin camsı geçiş sıcaklığı ( $T_g$ ) değerinde düşüşe neden olduğu görülmüştür. Yarı kristalin fazlar XRD analizi ile ortaya konulmuştur. PEG ilavesinin kristallenmeyi tetikleyici şekilde davrandığı sonucuna ulaşılmıştır. Mekanik özellikleri incelendiğinde en yüksek kopmada uzama değerinin %20 PEG ilavesi ile gerçekleştiği görülmüştür.

**Anahtar kelimeler:** PLA, BCN, PEG, film, çözültiden dökme yöntemi

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**EFFECT OF PEG ADDITION ON CRYSTALLINITY, THERMAL AND  
MECHANICAL PROPERTIES OF PLA/BORON CARBON NITRIDE FILMS**

**Abstract**

The environmental impacts of plastic waste have increased interest in biodegradable materials. Polylactic acid (PLA) stands out in this field as a starch-based biodegradable and biocompatible material. PLA is used in a wide range of applications, from the agricultural sector to medical applications, packaging materials to electronic products. Some of the advantages of PLA include its ease of processing, non-toxicity, and environmental friendliness. However, the brittle structure of PLA limits its use on its own. Therefore, PLA is often used in combination with other polymers and/or plasticizers. Polyethylene glycol (PEG) is one of the polymers used with PLA to overcome this issue. In this study, solutions containing 5% PLA and 1% BCN were prepared, and PEG was added in different amounts (10%, 20%, and 30% of the PLA content in the solution). Films were obtained using the casting method. Thermal properties of the films were investigated by differential scanning calorimeter (DSC), and crystallinity properties were investigated by both DSC and X-Ray diffraction (XRD) analysis. The mechanical properties of the films were determined by tensile testing. The thermal properties showed that the addition of PEG caused a decrease in the glass transition temperature ( $T_g$ ) value. Semi-crystalline phases were revealed by XRD analysis. It was concluded that the PEG addition induced the PLA crystallization. Regarding the mechanical properties, the highest elongation at break was observed with the addition of 20% PEG.

**Keywords:** PLA, BCN, PEG, film, solution casting methods

## 1. GİRİŞ

Son dönemde, biyobozunur poli(laktik) asit (PLA) petrol türevli polimerlerin yerini yenilenebilir malzemelerin alması için bir alternatif olarak sunulmaktadır. Ancak, petrol bazlı polimerlere kıyasla zayıf ısıl ve mekanik direnç özellikleri, PLA'nın kullanım alanlarını sınırlamaktadır (Abdulkhani ve ark., 2015). Yüksek çekme mukavemeti ile karakterize edilen PLA çok sert ve kırılmandır, sertliği ve düşük sünekliği PLA'nın polietilen glikol (PEG) gibi plastikleştiricilerle kullanılması ihtiyacını ortaya çıkarmaktadır (Park et al., 2011). PEG'in PLA'ya eklenmesinin camsı geçiş sıcaklığını ( $T_g$ ) düşürdüğü bildirilmiştir.  $T_g$ 'nin altındaki sıcaklıklarda, polimer kırılman camsı bir formda bulunmaktadır.  $T_g$ 'nin üzerinde ısıtıldığında ise, polimer zincir hareketliliği artarak kauçuksu bir forma dönüşmektedir.  $T_g$  sıcaklığının azalması, PLA polimer zincir hareketliliğini ve zincir paketlenmesini artıran PEG'nin plastikleştirici etkisini ifade etmektedir (Atıqah ve ark., 2019; Pivsa-art ve ark., 2016; Hashim ve ark., 2015; Phuphuak ve ark., 2013). Plastikleştiricilerin gelişmiş zincir hareketliliği nedeniyle kristallliği desteklediği de bildirilmiştir (Park ve ark., 2011). Ayrıca, PLA'ya göre PEG daha esnek yapıdadır (Rodríguez-Llamazares ve ark., 2012). Bu sayede PEG, PLA zincirleri arasına nüfuz edebilmektedir. Böylece plastikleştirici PEG, PLA'nın plastik deformasyona karşı yeteneğini geliştirerek çekme gerilimini azaltmakta ve kopma anındaki uzamasını arttırmaktadır (Sheth ve ark., 1997; Jacobsen ve Fritz., 1999). Wang ve arkadaşları %30 PEG içeren PLA'nın en az uzamaya sahip olduğunu ve bu yüzden yüksek PEG plastikleştirici katkısının PLA yapısını bozmuş olabileceğini bildirmiştir. Böylece, plastikleştirici PEG katkı oranlarının PLA/PEG karışımı malzemenin mekanik özellikleri üzerinde belirgin bir etkiye sahip olduğu sonucuna ulaşılmıştır (Wang ve ark., 2012). Ayrıca, malzemelerin mekanik ve ısıl özelliklerini artırmak amacıyla bor nitür ve karbon nitür esaslı katkı maddelerinin polimer yapısına eklendiği de literatürde raporlanmıştır (Shin ve ark., 2022). Grafen, bor nitür ve karbon nitür türevlerinin analoğu olarak bilinen bor karbon nitür (BCN) yüksek ısıl özelliklere ve yüksek kimyasal kararlılığa sahip bir malzeme olduğu bildirilmiştir (Shakunthala ve ark., 2024).

Bu çalışmada PLA konsantrasyonu ve BCN oranı sabit tutulup hazırlanan karışımlara farklı oranlarda PEG eklenerek çözeltilerin hazırlanması ve çözeltiden döküm yöntemi kullanılarak filmlerin elde edilmesi amaçlanmıştır. Böylece PLA-BCN karışımı filmlerin elastikiyet özelliklerinin PEG varlığında geliştirilmesi hedeflenmiştir. Elde edilecek mekanik test sonuçlarına göre PLA/BCN kompozitinde kullanılacak en uygun PEG oranının belirlenmesi planlanmıştır.

## 2. MATERYAL VE METOT

### 2.1. Materyal

4043D ile kodlanan PLA ve P2139 ile kodlanan PEG sırasıyla Nature Works ve Aldrich Chemistry'den satın alındı. Kloroform (CF) çözücüsü Carlo Erba Reagents'tan temin edildi. Bor Karbon Nitür sentezinde kullanılan borik asit ( $H_3BO_3$ ), ve sitrik asit ( $C_6H_8O_7$ ) Merck firmasında, melamin ( $C_3H_6N_6$ ) ise Sigma Aldrich firmasından temin edildi.

### 2.2. Metot

#### 2.2.1. Bor Karbon Nitür (BCN) sentezi

Bor Karbon Nitür (BCN), sitrik asit ( $C_6H_8O_7$ ), melamin ( $C_3H_6N_6$ ) ve borik asidin ( $H_3BO_3$ ) birlikte çöktürülmesi yöntemi uygulanarak sentezlenmiştir (Zhang ve ark., 2019). Öncelikle 1.55 g  $H_3BO_3$ , ve 4.80 g  $C_6H_8O_7$  50 mL distile su içerine eklenerek karıştırılmıştır. Ardından 3.15 g  $C_3H_6N_6$  reaksiyon ortamına yavaş yavaş eklenerek elde edilen beyaz renkli süspansiyon

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90 °C’de 30 dakika boyunca 500 rpm karıştırma hızında manyetik karıştırıcıda karışmaya bırakılmıştır. Reaksiyon tamamlandıktan sonra elde edilen BCN, vakum filtrasyonu ile süspansiyondan ayrılarak 60 °C’de 12 saat süre ile kurutulmuştur. Kurutma işleminin ardından elde edilen BCN örnekleri seramik krozelere alınarak 550 °C’de 5 °C/dk’lık ısıtma hızıyla 3 saat boyunca kül fırında kalsine edilmiştir.

## 2.2.2. PLA filmlerin hazırlanması

PLA polimer granülleri üzerindeki olası nemi gidermek için 18 saat boyunca 80°C’de vakumlu bir etüvde kurutuldu. Ardından PLA-BCN-PEG filmleri Rhim’in 2009 yılında gerçekleştirdiği çalışmada kullandığı üretim prosedürüne göre elde edildi (Rhim ve ark., 2009). %5 konsantrasyonlu bir PLA çözeltisi hazırlamak için hacimce CF çözücü (v) ölçüldü ve ağırlıkça PLA (w) tartıldı. %1 BCN oranı sabit tutuldu ve ağırlıkça PLA miktarına göre tartılarak eklendi. Benzer şekilde, tartılan PLA katı miktarının %10, %20 ve %30’u da PEG polimeri olarak çözeltilmeye eklendi. Kloroformun buharlaşmasını önlemek için, PLA, BCN ve farklı oranlardaki PEG karışım çözeltilerini içeren her bir beherin ağzı alüminyum folyo ve parafilm ile sıkıca kapatıldı. Daha sonra, hazırlanan çözeltiler oda sıcaklığında manyetik karıştırıcıda karıştırılmaya bırakıldı. 18 saatin sonunda çözeltiler 10 ml olarak 8,5 cm çapındaki petri kaplarına eşit olarak döküldü ve ardından 72 saat boyunca oda sıcaklığında kurumaya bırakıldı. Daha sonra filmlerin yapısında olabilecek kloroformun tamamen uzaklaştırılması için petri kapları 60°C sıcaklıktaki vakumlu etüvde 24 saat bekletildi. Bu sürenin sonunda filmlerin karakterizasyon çalışmaları ile kristal yapısı, ısıl ve mekanik özellikleri incelenmesi amacıyla analizler uygulanmıştır. Üretilen filmlerin kodları Tablo 1’de verilmiştir.

**Tablo 1.** Hazırlanan filmlerin kodları

Örnekler	PLA konsantrasyonu (%)	BCN katkısı (PLA toplam katı miktarına göre) (%)	PEG katkısı (PLA toplam katı miktarına göre) (%)
5PLA	5	1	-
5PLA-1BCN-10PEG			10
5PLA-1BCN-20PEG			20
5PLA-1BCN-30PEG			30

## 2.2.3. Karakterizasyon

Filmlerin artan PEG miktarına bağlı olarak değişen ısıl özelliklerini ve % kristallik değerlerini belirlemek için, 25–250°C sıcaklık aralığında ve 10°C/dk ısıtma hızıyla Mettler Toledo Instrument marka cihazla diferansiyel taramalı kalorimetri (DSC) analizi yapıldı. Test sırasında ortamı inert hale getirmek için sisteme 30 mL/dk akış hızında azot gazı gönderildi. Filmlerin % kristallik oranı (% X<sub>c</sub>), "Denklem (1)" kullanılarak %100 PLA'nın (93,7 J/g) (Samatya Yılmaz ve Aytaç, 2021) erime entalpi değerine göre hesaplandı. Formüldeki " $\Delta H_m$ " her bir filmin erime ısıdır ve " $\Delta H_m^0$ " %100 PLA'nın erime ısıdır.



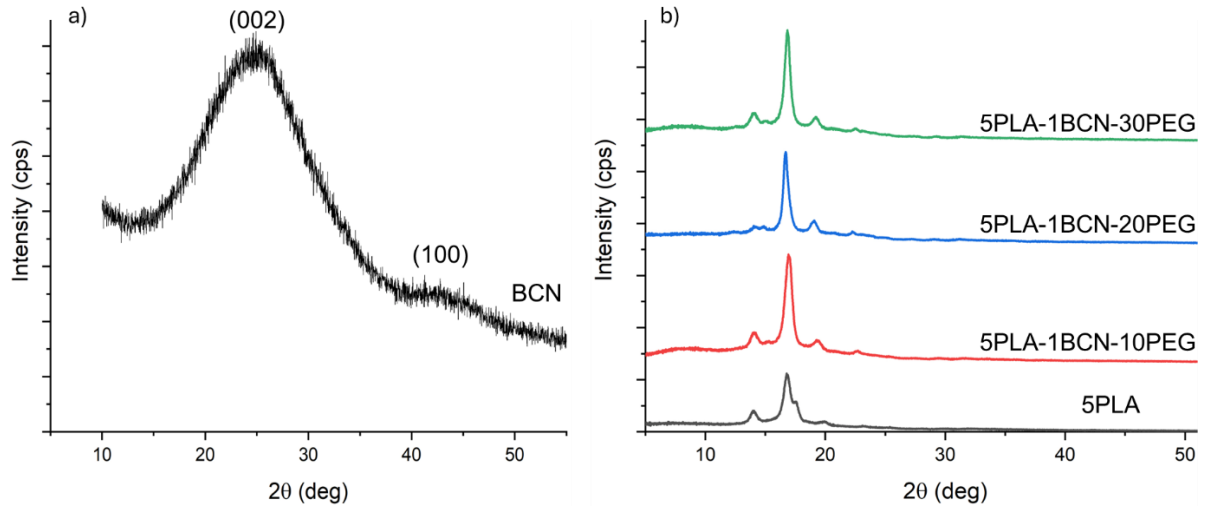
$$X_c(\% \text{crystallinity}) = \frac{\Delta H_m}{\Delta H_m^0} \times 100 \quad (1)$$

Filmlerin kristalinite özellikleri hakkında daha detaylı bilgi elde etmek için Rigaku Mini Flex II cihazı kullanılarak X-ışını kırınımı analizi (XRD) de yapıldı. Ayrıca filmlerin yapısındaki artan PEG oranına bağlı olarak değişen kristalinite değerleri ile ilgili olarak filmlerin iyileştirilmiş mekanik özelliklerini araştırmak için ASTM D882 standardına göre Instron markalı bir çekme cihazında çekme testi gerçekleştirildi.

### 3. SONUÇLAR VE TARTIŞMA

#### 3.1 XRD test sonuçları

Şekil 1a'da, sentezlenen BCN ve Şekil 1b'de PEG miktarına göre değişen filmlerin XRD spektrumu verilmiştir.



Şekil 1. XRD spektrumu a) BCN ve b) kompozitteki PEG miktarı değişimi

BCN örneğinde  $2\theta = 25^\circ$  ve  $43^\circ$  te iki pik gözlenmiştir. (002) ve (100) düzlemlerinde olan bu yapı BCN'nin grafit benzeri yapı olduğunu göstermektedir. 5PLA örneğinde tipik olan,  $2\theta = 14^\circ$ ,  $17^\circ$  ve  $19^\circ$  yansıma pikleri gözlenmektedir. Bu da hazırlanan 5PLA'nın yarı kristal yapısını göstermektedir (Inácio ve ark., 2018). PLA'ya BCN eklenmesiyle, kristal yapının değişimi kendini  $2\theta=23^\circ$ 'te gözlenen pik ile göstermektedir. Böylece, hazırlanan kompozit içinde, grafit benzeri yapıda olan BCN'nin, tek düze (uniform) bir gerilime maruz kaldığı belirlenmiştir. PLA'da, PEG artışına bağlı olarak hazırlanan tüm örneklerde pik şiddetinde artış gözlenmektedir ve bu PEG eklenmesinin kristallenmeyi tetiklemesi ile açıklanabilmektedir.

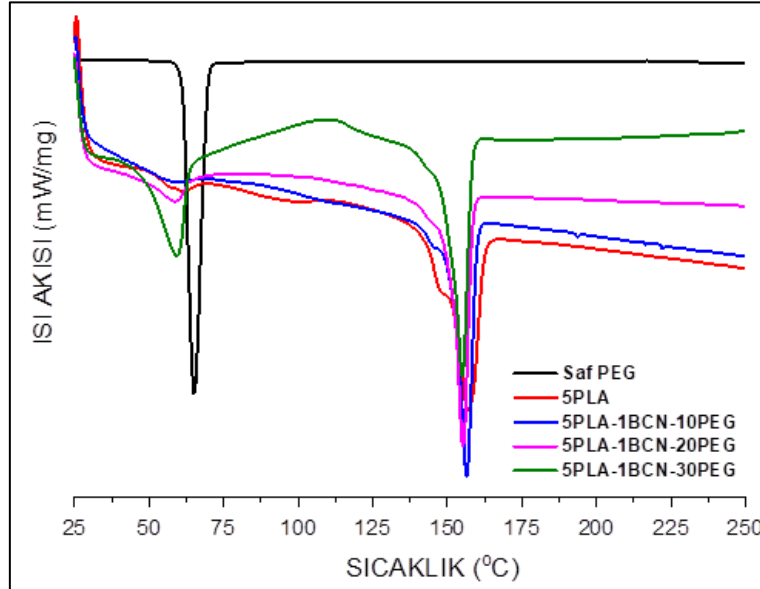
#### 3.2 DSC test sonuçları

5PLA-1BCN karışımına eklenen farklı oranlardaki PEG içeren filmlerinin DSC eğrileri Şekil 2'de ve DSC eğrilerinden elde edilen ısı özelliklerinin sayısal değerleri de Tablo 2'de verilmiştir. 5PLA-1BCN-10PEG ve 5PLA-1BCN-20PEG filmlerinin de tek bir  $T_g$  ve  $T_m$  gözlemlenmesi dolayısıyla, %10 ve %20 oranlardaki PEG ilavesinin PLA ile karışımının uyumlu karışabilir

olduđu ve faz ayrımı oluřmadığı bildirilmiştir. Ancak PEG'in katkı oranı %20'yi ařıp %30'a çıkarıldığında elde edilen 5PLA-1BCN-30PEG filmde  $T_g$  sıcaklığı görülmemiş ve PEG'e ait olan  $T_m$  sıcaklığı 59,23 °C olarak gözlemlenmiştir. İki farklı  $T_m$  sıcaklığı gözlemlendiğinden %30 oranındaki PEG katkısının PLA matrisi ile faz ayrımı oluřturduđu belirtilmiştir. Elde edilen sonuçlar literatür ile doğrulanmıştır (Wang ve ark., 2011). Literatürde, faz ayrımını önlemek için PLA'ya eklenen PEG miktarının ağırlıkça %20 veya daha az olması gerektiğı bildirilmiştir. Bu sınırlama, PEG'in PLA'nın camsı geçiř sıcaklığı üzerindeki potansiyel etkisini azaltmaktadır (Pivsa-Art ve ark., 2015).

Saf PEG polimerinin  $T_m$  sıcaklığı 63.66 °C olarak bulunmuřtur. Saf PLA filmin  $T_g$  sıcaklığı ise 60,93 °C olarak gözlemlenmiştir. 5PLA-1BCN-10PEG ve 5PLA-1BCN-20PEG filmlerin  $T_g$  deđerleri 57,15 °C ve 55,58 °C sırasıyla bulunmuřtur.  $T_g$ 'deki azalma, PEG'in plastikleştirme etkisinin neden olduđu zincirlerin artan moleküler (segmental) hareketliliğinden kaynaklanmıştır. (Wang ve ark., 2011; Sharma ve ark., 2019; Atıqah ve ark., 2019).  $T_g$ 'deki bu azalmanın plastikleştirici verimliliğıyle yakından iliřkili olduđu belirtilmiştir (Park ve ark., 2011). Ayrıca,  $T_g$ 'deki azalma, polimer zincirlerinin daha amorf bir duruma dođru artan hareketliliğine ve sonunda azalan  $T_m$  sıcaklığı ile de iliřkilendirilmiştir (Septevania ve Bhakri., 2017). Bu çalışmada da farklı oranlardaki PEG katkılı 5PLA-1BCN filmlerinin  $T_m$  PLA sıcaklığı PEG miktarının artışıyla azalmıştır.

PLA'nın yapısındaki plastikleştirici seviyesi arttıkça artan zincir hareketliliğı sebebiyle PLA'nın daha düşük sıcaklıklarda daha rahat kristalleřtiğı literatürde raporlanmıştır. Plastikleştiricilerin geliřmiş zincir hareketliliğı nedeniyle kristalliliğı desteklediğı bildirilmiştir (Park ve ark., 2011). Ancak bu çalışmada PLA'ya PEG ilavesinin filmlerin (%) kristalinite deđerlerini önce azalttığı daha sonra arttırdığı görülmüřtür. %30 PEG katkısı filmlerin kristalinitesini arttırmıştır. %10 ve %20 PEG oranı PLA filmlerinin kristalinitesini düşürmüřtür. Ayrıca buradaki düşüř BCN'nin varlığı ile iliřkilendirilmiştir.



řekil 2. Filmlerin DSC eđrileri

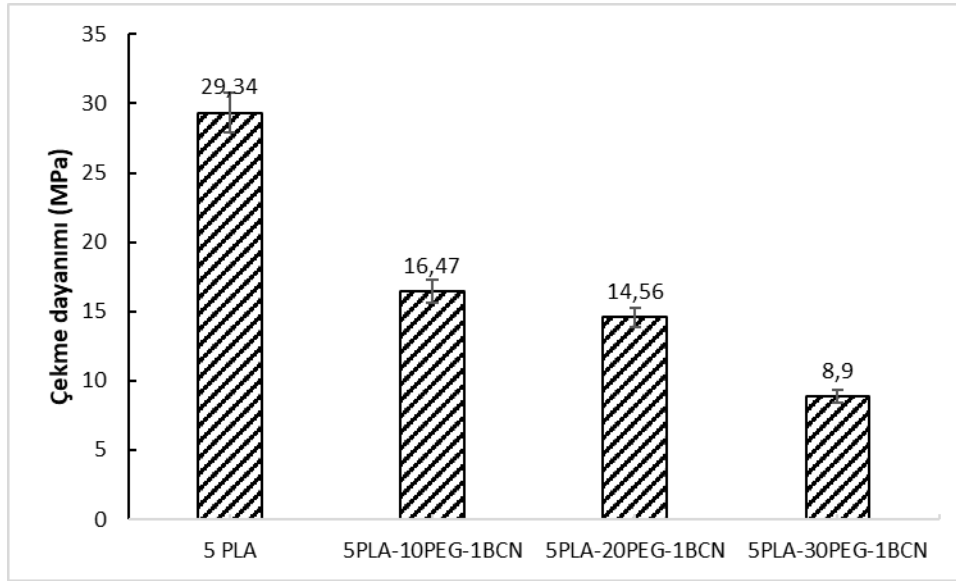
Tablo 2. DSC eğrilerinden elde edilen ısı özelliklerinin sayısal değerleri

Numuneler	T <sub>g</sub> PLA	T <sub>m1</sub> PEG	T <sub>m2</sub> PLA	T <sub>ΔH</sub> PLA (Jg <sup>-1</sup> )	%X <sub>c</sub> PLA
PEG	-	63,66	-	-	-
5PLA	60,93	-	156,58	29,71	31,70
5PLA-1BCN-10PEG	57,15	-	156,20	24,82	26,48
5PLA-1BCN-20PEG	55,58	-	155,06	23,27	24,83
5PLA-1BCN-30PEG	-	59,23	154,94	30,10	32,12

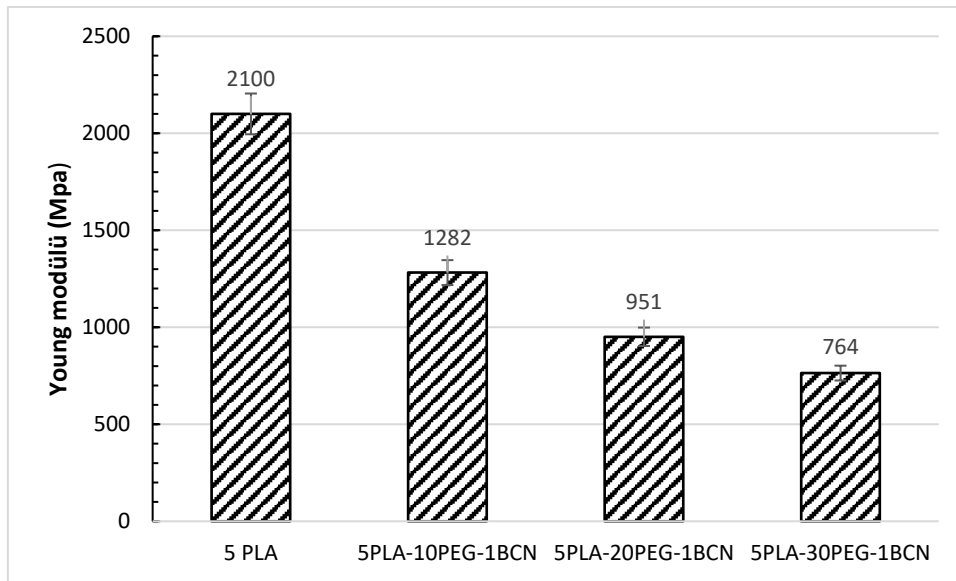
### 3.3 Mekanik Test Sonuçları

PLA bazlı filmlerin çekme dayanımı ve modül değerleri sırasıyla Şekil 3 ve Şekil 4'te, uzama değerleri ise Tablo 3'te özetlenmiştir. Buna göre BCN ve PEG katkılı filmlerde artan PEG oranı ile çekme dayanımı sistematik olarak düşmüştür. Benzer şekilde Young modülünde de saf PLA içerikli filmlere kıyasla düşüş gözlenmiştir. Polimerlerin esnekliğinin artarken çekme dayanımının bir miktar düşmesi beklenen bir durumdur. Plastikleştirici (PEG) moleküllerinin ilavesinin ana zincirdeki polimer molekülleri arası etkileşimleri zayıflatması sonucunda filmlerin gerilim altında daha kolay deformasyona uğradığı düşünülmektedir. Diğer yandan PEG, polimerlerin zincir hareketliliğini artırarak filmlerin daha esnek hale gelmesini sağlamıştır (Rezaei ve Motamedzadegan, 2015).

Diğer yandan %10 PEG ilavesi maksimum yükte uzama değerini saf PEG'e kıyasla az miktarda da olsa düşürürken %20 ve %30 PEG ilavesiyle bu değer artmakta olduğu görülmüştür. Kopmada % uzama değerleri ise, saf PLA filmlere kıyasla tüm PEG ve BCN içerikli filmlerde daha yüksektir. En yüksek kopmada uzama değeri %14,35 ile %20 PEG -1BCN içerikli filmlerde gözlenmiştir. Kopmada uzama değerlerinin %20 PEG -1BCN>%30 PEG -1BCN>%10 PEG -1BCN> 5PLA olacak şekilde gerçekleştiği görülmüştür. Buradan hareketle PEG ilavesinin genel olarak uzama değerlerini artırdığı, ancak bu uzamanın %20 PEG ilavesi ile optimum bir değer aldığı söylenebilir.



Şekil 3. Filmlerin çekme dayanımı



Şekil 4. Filmlerin Young modülü

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**Tablo 3.** Filmlerin % uzama deęerleri

<b>Örnek</b>	<b>Maksimum yükte uzama (%)</b>	<b>Kopmada uzama (%)</b>
5 PLA	2,3	3,16
5PLA-10PEG-1BCN	2,0	7,4
5PLA-20PEG-1BCN	4,5	14,35
5PLA-30PEG-1BCN	7,5	12,36

#### **4. CONCLUSION**

Bu çalışmada PLA/BCN kompozitlerine farklı oranlarda PEG eklenerek çözeltiden dökme yöntemi ile kompozit filmler üretilmiştir. Filmlerin deęişen kristal yapısı, ısıl ve mekanik özellikleri incelenmiştir. BCN, grafit benzeri yapıda sentezlenmiştir. Yarı kristalin fazda olan 5PLA yapısına, BCN ve PEG eklenmesi ile kristallenme tetiklenmektedir. Farklı oranlardaki PEG ilavesinin 5PLA-1BCN filminin  $T_g$  sıcaklığını düşürdüęü, böylece zincir hareketlilięini arttırarak filmlerin kopmada uzama davranışlarını iyileştirdięi bildirilmiştir. İleriki çalışmalarda deęişen oranlarda BCN katkı maddelerinin filmlerin mekanik özelliklerini etkileyebileceęi göz önünde bulundurularak ortalama yüksek çekme dayanımı ve yüksek kopma uzama deęerlerine sahip olan 5PLA-1BCN-20PEG filmi seçilmiştir. Sonraki çalışmalar için 5PLA-20PEG matrisinin kullanılması uygun bulunmuştur.

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**BOR KARBON NİTRÜR KATKILI PLA/PEG FİLMLERİNİN ISIL ÖZELLİKLERİ,  
ISLATILABİLİRLİĞİ VE ANTİBAKTERİYEL AKTİVİTESİNİN İNCELENMESİ**

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**Özet**

Plastik atıklarının doğada uzun süre bozunmadan kalması ve çevreye verdikleri zararlar biyobozunur malzemelere olan ilgiyi arttırmıştır. Biyobozunur polimerler, bakteri, alg, mantar gibi mikroorganizmalar tarafından doğal yollarla ayrışabilen, çevre dostu malzemelerdir. PLA biyobozunur bir polimer olup, mısır nişastası veya şeker kamışı gibi malzemelerden elde edilmesi nedeniyle çevre dostu özellikleriyle ilgi görmektedir. Düşük karbon ayak izine sahip olan PLA, aynı zamanda toksik olmayan bir malzemedir. Başta ambalaj malzemesi olmak üzere, tıbbi uygulamalar ve biyoteknoloji alanlarında kullanılmaktadır. PLA'nın yüksek dayanıma sahip olmasına rağmen düşük elastikiyeti tek başına kullanımını sınırlamaktadır. Bu nedenle PLA, istenen özelliklerin elde edilmesi için genellikle başka polimer veya katkılarla birlikte kullanılmaktadır. Polietilen glikol (PEG) sıklıkla PLA filmlerde esneklik sağlamak üzere plastikleştirici olarak kullanılmaktadır. Bu çalışmada PLA/PEG esaslı ve farklı oranlarda (%0,5, 1 ve 2) Bor Karbon Nitrür (BCN) katkılı filmler elde edilmiştir. PLA/PEG ve BCN içerikli filmler çözeltiden dökme yöntemi ile hazırlanmıştır. BCN, laboratuvar ortamında sentezlenmiştir. Filmlerin ısı özellikleri TGA analizi, ıslanabilirlik özellikleri ise statik temas açısı ölçümleri ile belirlenmiştir. Ayrıca kompozit filmlerin antibakteriyel özellikleri incelenmiştir. Filmlerin ısı dayanımı BCN ilavesi ile iyileştirilmiştir. Filmlerin %50'sinin bozunduğu sıcaklık (T50), kontrol numunesine kıyasla %0,5 BCN ilavesi ile 5°C artarken, %1 ve %2 BCN ilavesi sırasıyla 7 ve 11°C'lik artışlara neden olmuştur. Diğer yandan BCN ilavesi, filmlerin temas açısı değerlerinde düşüğe neden olmuştur. Filmlerin *E. coli* bakterisine kıyasla



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*S. aureus* bakterisine karşı daha yüksek antibakteriyel aktivite gösterdiği görülmüştür. Bu bulgular, BCN katkılı PLA/PEG esaslı filmlerin başta ambalaj malzemesi olmak üzere geniş bir alanda kullanımı için umut vericidir.

**Anahtar kelimeler:** PLA, BCN, film, kompozit, biyobozunur

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## INVESTIGATION OF THE THERMAL PROPERTIES, WETTABILITY, AND ANTIBACTERIAL ACTIVITY OF BORON CARBON NITRIDE ADDED PLA/PEG FILMS

### Abstract

Plastic waste's long-lasting presence in the environment and its harmful effects have increased the demand for biodegradable materials. Biodegradable polymers are eco-friendly materials that can break down naturally through microorganisms like bacteria, algae, and fungi. PLA (polylactic acid) is a biodegradable polymer made from materials such as corn starch or sugarcane, making it an environmentally friendly option. PLA has a low carbon footprint and is non-toxic. It is commonly used in packaging, medical applications, and biotechnology. Although PLA has high strength, its low elasticity limits its use as a stand-alone material. Therefore, PLA is often combined with other polymers or additives to improve its properties. Polyethylene glycol (PEG) is frequently added to PLA films to provide flexibility. This study obtained PLA/PEG-based films with different amounts of boron carbon nitride (BCN) (0.5%, 1%, and 2%). PLA/PEG and BCN films were prepared using the casting method, and BCN was synthesized in the lab. The thermal properties of the films were analyzed using TGA, and their wettability was measured with static contact angle tests. The antibacterial properties of the composite films were also examined. The thermal stability of the films improved with the addition of BCN. The temperature at which 50% of the films degraded (T<sub>50</sub>) increased by 5°C with 0.5% BCN, and by 7°C and 11°C with 1% and 2% BCN, respectively, compared to the control sample. Furthermore, the addition of BCN decreased the contact angle values of the films. The films showed higher antibacterial activity against *S. aureus* compared to *E. coli*. These results suggest that BCN-added PLA/PEG films have promising potential for use in various applications, particularly in packaging.

**Keywords:** PLA, BCN, film, composite, biodegradable

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## 1. GİRİŞ

Günümüzde petrol bazlı geleneksel plastiklerin yerini alabilecek, çevre dostu ve sürdürülebilir alternatif malzeme arayışı hız kazanmıştır. Polilaktik asit (PLA), yenilenebilir kaynaklardan elde edilen biyobozunur bir polimerdir. (Wu ve ark, 2023; Gao ve ark, 2017). PLA, mısır, patates ve şeker kamışı gibi %100 yenilenebilir kaynaklardan elde edilebilen biyolojik olarak çözünebilir alifatik bir polyesterdir. Geleneksel petrol bazlı kompozit malzemelerle karşılaştırıldığında, PLA düşük yoğunluk, düşük maliyet, iyi plastisite ve rijitlik gibi özelliklere sahiptir (Wu ve ark, 2023; Yusoff, ve ark, 2021). PLA, başlangıçta tıbbi ve farmasötik alanda kullanılan bir malzeme iken, iyi gaz geçirgenliği (PET'e benzer şekilde, PE'den çok daha iyi) ve olağanüstü organoleptik özellikleri sayesinde çeşitli tüketici ürünleri ve ambalaj uygulamalarında ideal bir malzeme olarak dikkat çekmektedir. PLA'nın işlenmesi, şeffaf filmler, şişeler, bardaklar, yemek kapları, tarım örtüleri ve saksılar gibi çeşitli ürünlere şekil verilmesine olanak tanıyan çok sayıda yöntem ile gerçekleştirilmektedir. Hızlı bozunabilen ve yan ürünleri çok düşük toksisiteye sahip olan PLA, ekonomik açıdan da uygulanabilir bir biyopolimer olarak öne çıkmaktadır. (Pan ve ark., 2017; Yu ve ark, 2017; Yang ve ark, 2016; Bartolucci ve ark, 2023). Diğer yandan neme karşı duyarlı oluşu, kırılğan yapısı ve düşük ısıl dayanıklılığı nedeniyle sıklıkla diğer polimerler ve/veya katkılarla birlikte kullanılmaktadır (Notta-Cuvier ve ark, 2014; Shih ve ark, 2010; Liao ve Wu, 2009).

PLA'nın mekanik ve termal özelliklerini geliştirmek için çeşitli dolgu maddelerinin eklenmesi sıkça başvurulan bir yöntemdir. Bu sayede, son kullanıcı ihtiyaçlarına göre bir dizi özelliğin geliştirilmesi mümkün olmaktadır (Raquez ve ark, 2013; Bhardwaj ve Mohanty, 2017; Murariu ve ark., 2015). Proteinler, peptitler, lipidler, polisakaritler, nişasta, kitosan vb. gibi organik katkıları, PLA'nın özelliklerini bir dereceye kadar iyileştirse de elde edilen kompozitler inorganik karışımlarına kıyasla zayıf antimikrobiyal özellikler sergilemektedir. Metal, metal oksitleri ve mineraller gibi inorganik katkıların (Ag, MgO, ZnO, TiO<sub>2</sub>, Ag-Cu, hallosit nanotüpler (HNT), hidroksil apatit, silika, alümina, manyetit, zirkonyum oksit ve kalsiyum karbonat gibi) PLA bazlı filmlerin özelliklerini önemli ölçüde iyileştirdiği bilinmektedir. Bu inorganik dolgu maddelerinin, PLA'nın özelliklerini artırarak, çeşitli gıda dışı ve gıda uygulamalarında geleneksel polimerlerin yerine geçirebileceği bildirilmiştir (Amjadi ve ark., 2019; Mulla ve ark., 2021).

Literatürde PLA esaslı matrise organik ve inorganik olmak üzere farklı katkı maddelerinin ilave edildiği çalışmalar mevcuttur. Bu çalışmada, PLA/polietilen glikol (PEG) bazlı polimerik matrise farklı oranlarda bor karbon nitrür (BCN) ilavesi yapılmış ve kompozit filmlerin ısıl dayanımı, ıslanabilirliği ve antibakteriyel özellikleri incelenmiştir.

## 2. MATERYAL VE METOT

### 2.1. Materyal

4043D kodlu PLA polimeri Nature Works'ten ve P2139 kodlu PEG polimeri Aldrich Chemistry'den temin edildi. Çözücü olarak kullanılan Kloroform (CF) Carlo Erba Reagents'tan satın alındı. Yazarların sentezlediği BCN aşağıdaki prosedüre göre elde edildi. Bor Karbon Nitrür sentezinde kullanılan borik asit (H<sub>3</sub>BO<sub>3</sub>), ve sitrik asit (C<sub>6</sub>H<sub>8</sub>O<sub>7</sub>) Merck firmasından, melamin (C<sub>3</sub>H<sub>6</sub>N<sub>6</sub>) ise Sigma Aldrich firmasından alındı.

## 2.2. Metot

### 2.2.1. Bor Karbon Nitrür Sentezi

Bor, karbon nitürür (BCN), sitrik asit ( $C_6H_8O_7$ ), melamin ( $C_3H_6N_6$ ) ve borik asid ( $H_3BO_3$ ) ile çöktürme yöntemi kullanılarak sentezlenmiştir (Zhang ve diğerleri, 2019). 50 mL distile su içerisine önce 1.55 gram  $H_3BO_3$  ve 4.80 gram  $C_6H_8O_7$  eklenmiştir. Ardından, reaksiyon ortamına yavaş yavaş 3.15 gram melamin eklenerek elde edilen beyaz süspansiyon 30 dakika boyunca 90 derece ve 500 rpm karıştırma hızında bir manyetik karıştırıcıda karıştırıldı. Reaksiyon tamamlandıktan sonra BCN, vakum filtrasyonu kullanılarak süspansiyondan ayrıldı ve 12 saat boyunca 60 °C'de kurutuldu. Kurutma işlemi tamamlandıktan sonra, BCN örnekleri seramik krozelere yerleştirilmiştir ve üç saat boyunca 5 °C/dk ısıtma hızıyla kül fırında kalsine edilmiştir.

### 2.2.2. Bor Karbon Nitrür katkılı PLA/PEG filmlerin hazırlanması

PLA granülleri 80 °C'de vakumlu etüvde 18 saat boyunca polimerin üzerindeki olası nemi gidermek için kurutuldu. Sonrasında 2009 yılındaki Rhim'in çalışmasına göre PLA-PEG-BCN filmleri üretildi (Rhim ve ark., 2009). Hacimce (v) %100 kloroform içerisinde %5 konsantrasyonlu çözelti hazırlamak için PLA polimeri ağırlıkça (w) tartıldı. Tartılan PLA katı miktarına göre çözeltiye %20 PEG polimeri eklendi. Yine aynı şekilde PLA katı ağırlığına göre %0,5, %1, ve %2 BCN katkı maddeleri eklenerek PLA-PEG-BCN karışım çözeltileri hazırlandı. Oda sıcaklığında 18 saat boyunca manyetik karıştırıcıda beherlerin ağzı alüminyum folyo ve parafilm ile sıkıca kapatılarak karıştırıldı. Homojen çözünen çözeltiler eşit miktarda aynı çaplı beherlere döküldü ve oda sıcaklığında 72 saat kurumaya bırakıldı. Kuruyan filmlerdeki olası kloroform çözücüsünü tamamen yapıdan uzaklaştırmak için petri kapları vakumlu etüvde 60°C sıcaklıkta 24 saat daha bekletildi. Ardından farklı oranlardaki BCN katkısının PLA-PEG filmlerinin ısıl dayanımı, ıslanabilirlik yüzey özellikleri ve antibakteriyel aktivitesi üzerindeki etkisinin incelenmesi amacıyla analizler gerçekleştirildi. Tablo 1'de elde edilen kompozit filmlerin bileşimi ve kodlamaları verilmiştir.

**Tablo 1.** Elde edilen kompozit filmlerin kodları

Örnekler	PLA konsantrasyonu (%)	PEG katkısı (PLA toplam katı miktarına göre) (%)	BCN katkısı (PLA toplam katı miktarına göre) (%)
PLA-PEG	5	20	-
PLA-PEG-05BCN			0,5
PLA-PEG-1BCN			1
PLA-PEG-2BCN			2

### 2.2.3. Karakterizasyon

PLA-PEG-BCN filmlerinin termogravimetrik analizi (TGA) Mettler Toledo TGA Star1 sistemi kullanılarak azot atmosferi altında 10 °C/dk ısıtma hızıyla 25°C ila 600°C arasında gerçekleştirildi.

Kompozit filmlerin yüzey ıslanabilirlik özellikleri, oda sıcaklığında (24°C±2°C) Attension Theta Lite cihazı ile Asılı Damlacık yöntemi kullanılarak statik temas açısı ölçümü ile gerçekleştirildi. Yüze 10 ml miktarda saf su damlacığı damlatıldı. Su damlası, güçlü optik

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lensle donatılmış bir kamera aracılığıyla bilgisayar ortamında görüntülendi. Young/Laplace denklemleri ile bilgisayar yazılımı kullanılarak elde edilen damla temas açısı değerinin c değeri hesaplandı. Temas açısı testi, kamera ile 9 saniye boyunca kaydedilen açı değerlerinin ortalamasının hesaplanmasıyla sonlandırıldı. Bu test, her bir film numunesi için 5 kez tekrarlandı. Ölçümlerin ortalama değeri raporlandı.

Numuneler eş boyutta hazırlanmış ve sterilizasyonları 20 dakikalık UV altında gerçekleştirilmiştir. Filmlerin bakteri büyümesi üzerindeki etkisinin belirlenmesi amacıyla, her bir numune 100 mg olacak şekilde tartılmış ve 25 mL LB broth + 1 mL bakteri ( $8 \times 10^8$  CFU/mL) içeren sıvı kültüre konulmuştur. Bakterilerin büyüme kontrolleri numune konulmamış gram pozitif olan *Staphylococcus aureus* (*S. aureus*) ve gram negatif olan *Escherichia coli* (*E. coli*) bakteri türleri ile gerçekleştirilmiştir. Tüm filmler 100 rpm'e ayarlanmış çalkalayıcı inkübatörde 37°C'de inkübasyona bırakılmış ve kontrol gruplarının belli saat aralıkları ile 600 nm'de absorbans değerleri spektrofotometre ile okunmuştur. Kontrol gruplarının OD600 değerleri 1'e geldiğinde okumalar tüm gruplar için yapılmış ve film eklenmiş örnekler ile kontrol gruplarının büyüme kapasiteleri (%) belirlenmiştir. Büyüme durdurulan film içeren ve içermeyen sıvı kültürler LB Broth ile 1:1000 oranında seyreltilerek LB agarlara 100 µL ile yayılmıştır. Gece boyu büyüme koşullarında bırakılan bakteri kültürlerinin, koloni oluşturma kapasiteleri (%) kontrol grupları ile nitel olarak karşılaştırılmıştır.

### 3. SONUÇLAR VE TARTIŞMA

#### 3.1 TGA Testi Sonuçları

Filmlerin ısı özellikleri TGA analizi ile incelenmiştir. Tablo 2'de ısı özellikleri temsilen T95, T90 ve T50 değerleri verilmiştir. Kompozit filmlerin ağırlıkça %95'inin, %90'ının ve %50'sinin korunduğu, başka bir deyişle örneklerin sırasıyla %5, %10 ve %50 ağırlık kaybına uğradığı sıcaklıklar incelendiğinde, tüm örneklerin ısı dayanımının BCN içermeyen kontrol numunesine (PLA-PEG) kıyasla arttığı görülmektedir. Artan BCN oranı ile birlikte termal dayanım belirgin şekilde artmıştır. Bu sonuç, BCN'nin yüksek termal dayanımı nedeniyle beklenen bir durumdur (Chong ve ark., 2010). BCN katkısı, matrisin yapısal bütünlüğünü koruyarak ısı bozunma hızını azaltmaktadır. BCN ilavesi ile daha düzenli bir kristal yapı oluşturabilir ve bu durum ısı özelliklerin iyileşmesine katkı sağlayabilir (Cho ve ark., 2021).

**Tablo 2.** Filmlerin ısı özellikleri

Örnek	T95 (°C)	T90 (°C)	T50 (°C)
PLA-PEG	296,86	309,68	344,07
PLA-PEG-05BCN	299,11	313,94	349,07
PLA-PEG-1BCN	302,92	316,82	351,99
PLA-PEG-2BCN	316,36	327,62	355,16

#### 3.2 Temas Açısı Testi Sonuçları

PLA-PEG-BCN filmlerinin ıslanabilirlik yüzey özelliklerini belirten temas açısı değerleri Tablo 3'te verilmiştir. Bir malzemenin Temas açısı değeri 90° ve daha da düşük olduğunda hidrofilik, 90°-150° aralığında olduğunda hidrofobik yapılı olduğu bildirilmiştir (Jhaveri ve Murthy, 2016). Literatürde PLA'nın nispeten hidrofobik yapılı olduğu belirtilmiştir (Tümer ve ark., 2022). PEG ise sahip olduğu düşük temas açısı değerleriyle yüksek hidrofilik yapılı suda

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çözünen bir polimerdir (Cong ve ark, 2020). Bu çalışmada da 65° temas açısı değeri ile PLA-PEG filmi hidrofilik özellik göstermiştir (Kia ve ark., 2024). BCN katkılı filmlerin temas açısı değerlerinde düşüş görülmüştür. Bu sonuç BCN nanopartiküllerinin doğasının hidrofilik oluşuyla ilişkilendirilmiştir (Zhang ve ark., 2023). BCN katkı oranının artışı filmlerin temas açısı değerlerini düşürerek hidrofilik özelliğin gelişmesini sağlamıştır.

**Tablo 3.** Kompozit filmlerin temas açısı değerleri

Örnekler	Temas Açısı (°) Değerleri
PLA-PEG	65
PLA-PEG-05BCN	63
PLA-PEG-1BCN	57
PLA-PEG-2BCN	50

### 3.3 Antibakteriyel test sonuçları

Kompozit filmlerinin antibakteriyel etkinlik sonuçları Tablo 4’te verilmiştir. Her iki bakteri türü için kontrolde %100 büyüme görülmüştür. Saf PLA-PEG filminde *E. coli* ve *S. aureus* bakteri türleri için sırasıyla %83,3 ve %78,5 büyüme oranları belirlenmiştir. Kontrol ile kıyaslandığında daha az büyüme değeri dolayısıyla saf PLA-PEG filminin *E. coli* ve *S. aureus* bakteri türleri için antibakteriyel aktivitesinin olduğu belirtilmiştir. PEG’in yüksek oranda özellikle sıvı ortamda (80mg/ml) antibakteriyel etkinliğinin olduğu (Steven ve Hotchkiss, 2003; Sahan ve ark., 2017) ve PLA’nın zayıf antibakteriyel aktiviteye sahip olduğu literatürde bildirilmiştir, (Karakurt ve ark., 2017; Steven ve Hotchkiss, 2003), Bu çalışmada da PEG ilavesiyle saf PLA-PEG filminin her iki bakteri türüne karşı antibakteriyel aktivite oluşturduğu belirlendi. PLA-PEG filmin *E. coli*’ye karşı diğer BCN katkılı filmlerden daha yüksek antibakteriyel etkinliğe sahip olduğu gözlemlendi. Ancak kompozit filmlerinin yapısındaki BCN katkısı arttıkça antibakteriyel aktivitenin düştüğü raporlandı. Bu sonuç BCN’nin yapısındaki karbon atomlarının bakteriler için besin görevi görmesine dayandırıldı. (Bonnet ve ark., 2020). Sadece, PLA-PEG-05BCN filmi PLA-PEG filmi bir miktar daha fazla antibakteriyel aktivite gösterdi. Bu duruma bağlı olarak, borun özellikle *S. aureus* bakterisine karşı daha duyarlı olduğunu bildirdi (Celebi ve ark., 2023).

**Tablo 3.** Kompozit filmlerin bakteri büyümesi

Numune	% Büyüme		% İnhibisyon	
	<i>E. coli</i>	<i>S. aureus</i>	<i>E. coli</i>	<i>S. aureus</i>
Kontrol	100	100	-	-
PLA-PEG	83,3	78,5	16,7	21,5
PLA-PEG-05BCN	86,8	77,2	13,2	22,8
PLA-PEG-1BCN	86,1	81,3	13,9	18,7
PLA-PEG-2BCN	91,0	82,0	9,0	18,0

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**4. SONUÇLAR**

Bu çalışma, biyobozunur PLA/PEG bazlı filmlerin deęişen BCN katkı oranları varlığında ısı, ıslanabilirlik ve antibakteriyel özelliklerini incelemiştir. Sonuçlar, BCN ilavesinin filmlerin ısı dayanımını artırdığını ve antibakteriyel özelliklerini geliştirdiğini göstermiştir. BCN katkılı filmler, *S. aureus* bakterisine karşı daha yüksek etkinlik gösterirken, *E. coli* 'ye karşı daha düşük etki sergilemiştir. Ayrıca, BCN katkısı filmlerin suya karşı ıslanabilirliğini arttırarak hidrofilik özelliğini geliştirmiştir. Bu bulgular, BCN katkılı PLA/PEG filmlerinin ambalaj ve dięer uygulamalarda potansiyel kullanımı olabileceğini göstermektedir.

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**YEDEK PARA TASARIMLARININ KORUNMASI**

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**Özet**

Birleşik ürün, en az iki değiştirilebilen parçadan oluşan ve sökülüp tekrar takılabilen parçalardan oluşan üründür. Bir birleşik ürün kazaya, hasara veya arızaya maruz kaldığında o üründeki arızalanan parçaların yedek parçalarla değiştirilmesi gerekir. Yedek para, teknik ya da görsel zorunluluk oluşturmeyen para tasarımları, must match para tasarımları ve must fit para olarak sınıflandırılmaktadır. Must fit paralar (örneğin otomobil lastiğinin yuvarlak olması) bir birleşik ürünün teknik olarak fonksiyonunu yerine getirmesi için belli bir şekilde tasarlanması zorunlu olan yedek parçalardır. Teknik ya da görsel zorunluluk oluşturmeyen paralar tasarım olarak korunurken, must fit paralar birçok ülkede tasarım olarak korunmamaktadır. Must match yedek para, birleşik ürünün orijinal görünümüyle uyumlu olması için belirli bir şekilde tasarlanması gereken parçalardır. Must match paraların tasarım olarak korunması ile ilgili olarak yıllardır süregelen tartışmalar mevcuttur. Konu otomobil üreticileri, yedek para üreticileri ve tüketicileri yakından ilgilendirdiğinden önem arz eder. Otomobil üreticileri bu paraların diğer ürün tasarımları gibi tam koruma altında olmasını isterken, tüketiciler bu paraların da zorunlu yedek para gibi aynı koruma istisnalarından faydalanması gerektiğini düşünmektedir. Türk hukukunda Sınai Mülkiyet Kanununda must match paraların onarım amacıyla kullanımı belirli şartlarla mümkün kılınmıştır. Sınai Mülkiyet Kanunundaki hükme (madde 59) göre must match paranın, birleşik ürüne orijinal görünümünü yeniden kazandırmak üzere onarım amacıyla, tasarımın piyasaya ilk sürüldüğü tarihten üç yıl sonra, üçüncü kişiler tarafından kullanılması mümkündür. Buna ek olarak Sınai Mülkiyet Kanunundaki hüküm uyarınca eşdeğer paraların piyasaya ilk sürülmesinden itibaren üç yıl içinde onarım amacıyla kullanımı tasarım hakkının ihlali sayılmaz. Avrupa Parlamentosu ve Konseyi 10 Ekim 2024 tarihinde 2024/2823 Direktifi (98/71/EC Direktifini revize ederek) madde 19'da onarım klotunu kabul etmiştir. Buna göre onarım ve orijinal görünümünün geri kazanılması amacıyla must match paraların kullanımı tasarım hakkının ihlali sayılmaz. Bu çalışmada yedek para kavramı, yedek para tasarımlarının korunmasına ilişkin Sınai Mülkiyet Kanunundaki düzenlemeler ve must match yedek paraların tasarım olarak korunmasına ilişkin doktrindeki görüşlere yer verilmiştir.

**Anahtar Kelimeler:** birleşik ürün, yedek para, must match yedek paranın korunması

**THE PROTECTION OF SPARE PARTS DESIGNS**

**Abstract**

Complex product means a product that has at least two replaceable component parts and can be disassembled and reassembled. Once that complex product suffer accidents, damages or breakdowns, parts need to be replaced with spare parts. The spare parts are classified as parts that do not constitute any technical or visual obligations, must match parts and must fit parts. Must-fit spare parts (e.g. roundness of a car tire) are spare parts that must be designed in a certain way in order to fulfill its technical function. While parts that do not constitute any technical and visual obligations generally qualify for design protection, must-fit spare parts are not protected under most countries' design laws. On the other hand, the protection of must match spare parts has been the subject of debate in the world. Must match parts are parts that must be designed in a certain way so that complex product can regain its original appearance. There have been ongoing discussions for years about the protection of must match parts as designs. The issue is important as it interests automobile manufacturers, spare parts manufacturers and consumers. While automobile manufacturers want these parts to be fully protected like other product designs, consumers believe that these parts should benefit from the same protection exceptions like must-fit spare parts. In Turkish law, Industrial Property Code allow the use of must match spare parts as to repair purposes under certain conditions. According to the provision in the Industry Property Code (Article 59), it is possible for third parties to use must match parts for repair purposes to restore complex products' original appearance three years after design is released to the market for the first time. Moreover, according to same Code, within three years after its initial release, the use equivalent parts shall not be considered as infringement of design. On 10 October 2024, the European Parliament and the Council adopted the repair clause in Article 19 of Directive 2024/2823 (revising Directive 98/71/EC). Accordingly, the use of must match parts for the purpose of repair and restoration of the original appearance is not considered an infringement of design rights. In this study, the concept of spare parts, the regulations in the Industrial Property Code and the European Union regarding the protection of spare part designs and the opinions in the doctrine regarding the protection of must match spare parts design are included.

**Key words:** complex products, spare parts, protection of must match spare parts

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## GİRİŞ

Sınai Mülkiyet Kanununda (SMK madde 55/1) tasarım, bir ürünün tümü veya bir parçasının ya da üzerindeki süslemenin çizgi, şekil, biçim, renk, malzeme veya yüzey dokusu gibi özelliklerinden kaynaklanan görünümü olarak ifade edilmiştir. Tasarımlar tescilli veya tescilsiz tasarım olarak koruma görür. Tescilli tasarımların koruma süresi başvuru tarihinden itibaren beş yıldır. Bu süre beşer beşer yenilenmek suretiyle toplam yirmi beş yıla kadar uzatılabilir (SMK madde 69/1). Tasarım ilk kez Türkiye’de kamuya sunulmuş olması halinde ise tescilsiz tasarım olarak korunabilir. Tescilsiz tasarımların koruma süresi koruma talep edilen tasarımın kamuya ilk sunulduğu tarihten itibaren üç yıldır (SMK madde 69/2).

Türk hukukunda tasarımın Sınai Mülkiyet Kanunu kapsamında korunabilmesi için yeni ve ayırt edici niteliğe sahip olması gerekir. Yenilik değerlendirmesinde, bir tasarımın aynısının daha önce dünyanın herhangi bir yerinde kamuya sunulmamış olması aranmaktadır. Bunun için tescilli tasarımlarda başvuru veya rüçhan tarihinden önce, tescilsiz tasarımlar için ise tasarımın kamuya ilk sunulduğu tarihten önce kamuya sunulmamış olması gerekir (SMK madde 56/4). Tasarımlar sadece küçük ayrıntılarda farklılık gösteriyorsa aynı kabul edilir. Kamuya sunmanın; piyasaya sürme, kullanma, tarif, yayım, tanıtım veya benzer amaçlı faaliyetleri kapsadığı belirtilmiştir (SMK madde 57/1). Yenilik bakımından mutlak yenilik (tasarımın Türkiye’de ve dünyanın herhangi bir yerinde daha önce kamuya sunulmamış olması) aranmaktadır (Yargıtay 11. HD., 20.06.2018 tarih, 2016/13287 E., 2018/4596 K.).

Tasarımın ayırt edici nitelikte olması için ise söz konusu tasarımın bilgilenmiş kullanıcı üzerinde bıraktığı genel izlenimin; tescilli tasarım için başvuru veya rüçhan tarihinden önce, tescilsiz tasarım için tasarımın kamuya ilk sunulduğu tarihten önce, kamuya sunulmuş herhangi bir tasarımın aynı kullanıcı üzerinde yarattığı genel izlenimden farklı olması gerekir (SMK madde 56/5). “‘Kullanıcı’ statüsü, ilgili kişinin, tasarımın dahil edildiği ürünü, o ürünün amaçlandığı şekilde kullandığı anlamına gelir” (22/06/2010, T-153/08, EU:T:2010:248, §46). “‘Bilgilendirilmiş’ niteleyicisi, ‘bir tasarımcı veya teknik uzman olmaksızın, kullanıcının ilgili sektörde mevcut çeşitli tasarımları bildiğini, bu tasarımların normalde içerdiği özelliklerle ilgili belirli bir düzeyde bilgiye sahip olduğunu ve ilgili ürünlere olan ilgisinin bir sonucu olarak bunları kullanırken nispeten yüksek düzeyde dikkat gösterdiğini’ ifade eder” (20/10/2011, C-281/10 P, EU:C:2011:679, § 59). Ayırt edici niteliğin değerlendirilmesinde, tasarımcının tasarımı geliştirirken sahip olduğu seçenek özgürlüğünün derecesi dikkate alınır (SMK madde 56/6).

Tasarım olarak korunmayacak haller ise aynı Kanunda belirtilmiştir. Buna göre kamu düzenine veya genel ahlaka aykırı tasarımlar, ürünün teknik fonksiyonunun zorunlu kıldığı görünüm özellikleri, tasarımın kullanıldığı veya uygulandığı ürünün, başka bir ürüne mekanik olarak monte edilmesi veya bağlanması için belirli biçim ve boyutlarda üretilmesi zorunlu ürünlerin görünüm özellikleri, Paris Sözleşmesinin 2 nci Mükerrer 6 ncı maddesi kapsamında yer alan hükümlerle alametleri ile bu kapsam dışında kalan ancak kamuyu ilgilendiren, dini, tarihi ve kültürel değerler bakımından halka mal olmuş ve ilgili mercilerin tescil izni vermediği işaretlerin, armaların, nişanların veya adlandırmaların uygunsuz kullanımını içeren tasarımlar koruma kapsamı dışındadır (SMK madde 58/4).

Birleşik ürün, sökülüp tekrar takılma yoluyla değiştirilebilen parçalardan oluşan ürün olarak tanımlanmaktadır (SMK madde 55/3). Otomobil, buzdolabı, bulaşık makinesi, bilgisayar birleşik ürünlere örnek olarak verilebilir (Suluk, 2024, s.351). Bir birleşik ürün kazaya, hasara veya arızaya maruz kaldığında o üründeki zarar gören parçaların yedek parçalarla değiştirilmesi gerekir (Suluk, 2024, s.351).

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Sınai Mülkiyet Kanunu madde 56/2 gereğince yedek parçanın tasarım olarak korunabilmesi için birleşik ürünün normal kullanımı esnasında görünür durumda olması ve bu görünür durumdaki özelliklerinin yeni ve ayırt edici nitelikte olması gerekir. Türk hukukuna göre birleşik ürünün normal kullanım sırasında görünür olmayan kısımları tasarım korunmasından yararlanamaz. Normal kullanım; bakım, servis veya onarım işleri hariç olmak üzere, son kullanıcı tarafından kullanımı ifade eder. Avrupa Birliği Hukukuna göre de birleşik ürünün normal kullanımı esnasında görünür durumda olan kısımları tasarım olarak korunur. Avrupa Birliği Hukukuna göre birleşik ürünün normal kullanımı esnasında görünür durumda olması ve bu görünür durumdaki özelliklerinin yeni ve ayırt edici olması gerekir (AB Tasarım Yönergesi (98/71/EC) madde 3/3(a)).

Yedek parça tasarımları must match parça tasarımı, must fit parça tasarımı, fonksiyonel ve görsel olarak birleşik üründen bağımsız olan parça tasarımları olarak sınıflandırılabilir (Suluk, 2001, s. 271-272). Fonksiyonel ve görsel olarak birleşik üründen bağımsız olan parçaların kendisinden beklenen fonksiyonunu yerine getirebilmesi için belli şekilde tasarlanması gerekmez. Otomobilin koltuk tasarımı örnek olarak verilebilir (Suluk, 2024, s.352). Must fit parça tasarımları ise teknik fonksiyonunu yerine getirebilmesi için belli bir şekilde tasarlanması gereken parça tasarımlarıdır (Suluk, 2024, s.352). Örneğin otomobilin lastiği işlevini yerine getirmek için yuvarlak olmak zorundadır, dörtgen veya üçgen olamaz (Suluk, 2002, s.544). Otomobilin egzoz borusuna ait tasarımı örnek olarak verilebilir (Suluk, 2024, s.352).

Must match parça tasarımları, birleşik ürünün görünümüyle uyum sağlaması için (estetik açıdan) belli bir şekilde tasarlanması zorunlu olan tasarımlardır (Suluk, 2024, s.352). Otomobilin kapısının tasarımı örnek olarak verilebilir (Suluk, 2024, s.352). Must match parça tasarımlarının tasarım olarak korunup korunmayacağı tartışma konusu olmuştur. Konu tüketicileri, otomobil üreticileri, yedek parça üreticilerini yakından ilgilendirdiğinden önem arz eder. Otomobil üreticileri bu parçaların diğer ürün tasarımları gibi tam koruma altında olmasını isterken, tüketiciler bu parçaların da zorunlu yedek parça gibi aynı koruma istisnalarından faydalanması gerektiğini düşünmektedir (Suluk, 2001, s.272; Beldiman vd., 2020, s.40; Can, 2013, s.27).

## ARAŞTIRMA VE BULGULAR

Must match parçaların tasarım olarak korunmasını savunan görüşe göre bu tür tasarımların korunması teknolojinin gelişmesine katkıda bulunduğu gibi üçüncü kişilere yedek parçayı sağlama imkânı verildiği takdirde kalitesiz yedek parça nedeniyle birleşik ürünün imajı zarar görebilir (Suluk, 2002, s.554-555).

Tasarım olarak korunmaması savunanlar ise yedek parçanın yalnızca otomobil üreticisinden alınmasının tüketicinin seçenek özgürlüğünün sınırladığı, bunun yedek parça fiyatının artıracığı, ürün üzerinde tekelleşme yaratacağı, ayrıyeten yan sanayinin ve istihdamın artması gerektiği görüşündedir (Suluk, 2002, s.557-559).

Bu konuya ilişkin Avrupa Birliği Adalet Divanı (ABAD) tarafından 2018 yılında verilen *Acacia* Kararı EC 6/2002 madde 110(1) onarım maddesi ile ilgili AB Tasarım hukuku için önemli bir karardır (*Acacia v Audi*; *Acacia v Porsche* (C-397/16 ve C-435/16)). Avrupa Birliği Tüzük (EC 6/2002) madde 110'da: "Bu Yönetmelikte, Komisyon'un bu konudaki önerisi üzerine değişiklikler yürürlüğe girinceye kadar, 19(1) maddesi anlamında birleşik bir ürünün bir bileşenini oluşturan ve bu birleşik ürünün orijinal görünümünü geri kazandırmak amacıyla onarımı amacıyla kullanılan bir tasarım için Topluluk tasarımı olarak koruma mevcut olmayacaktır." şeklinde bir hüküm yer almaktadır. Karara konu olayda *Acacia* söz konusu iki markanın tescilli tasarımına sahip olduğu jantlara karşılık gelen alaşım jantları yapmıştır

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(Cornwell, 2019, s.4). Hak sahipleri 110(1) hükmünün yalnızca birleşik ürünün görünümüne bağlı olduğu bileşen parçalara (component parts) uygulandığını, jantların aracın geri kalanının görünümüne bağlı olmadığını ileri sürdüler (Cornwell, 2019, s.6). ABAD ise 6/2002 sayılı Tüzüğün 110 (1) maddenin kapsamının birleşik ürünün genel görünümüne bağımlı olan parçalarla sınırlı olmadığını ifade etmiştir (Cornwell, 2019, s.6-7; Acacia, 53). Bileşen parça terimi, sökülüp takılabilen ve bunlar olmadan birleşik ürünün normal kullanıma tabi tutulamayacağı her türlü değiştirilebilir bileşenleri kapsar ve jantlar da buna dahildir (Cornwell, 2019, s.7; Acacia, 65,66).

2024 yılında 2024/2822 (EC) sayılı Tüzük ile (EC) No 6/2002 sayılı Tüzükte değişiklik yapılmıştır. Buna göre, (EC) No 6/2002 sayılı Tüzükte yer alan mevcut geçici onarım maddesi kalıcı bir hüküm haline gelmektedir (2024/2822 Recital 19).

2024/2822 (EC) sayılı Tüzüğün 20(a) Onarım Klozu maddesine göre, birleşik ürünün görünümüne bağımlı olan yedek parça tasarımlarının, yalnızca birleşik ürünün orijinal görünümünün geri kazandırmak üzere onarım amacıyla kullanımı tasarım koruması sağlamayacaktır. Ancak bunun için birleşik ürünün bileşen parçasının üreticisi veya satıcısına birtakım yükümlülükler getirilmiştir. Buna göre üretici veya satıcının, tüketicileri, onarım amacıyla kullanılacak ürünün ticari kökeni ve üreticinin kimliği hakkında, ürün üzerinde açık ve görünür bir gösterge veya başka uygun bir biçimde bilgilendirmesi ve böylece onarım için kullanılacak rakip ürünler arasında bilinçli bir seçim yapmalarını sağlaması gerekmektedir. Bununla birlikte must match parçanın üreticisi veya satıcısı, ürettikleri veya sattıkları yedek parçanın son kullanıcılar tarafından yalnızca birleşik ürünün orijinal görünümünün geri kazanılması amacıyla kullanılmasını garanti etmek zorunda değildir.

Avrupa Birliği Tasarım Yönergesi 98/71/EC de (Directive (EU) 2024/2823 ile) değişikliğe uğramıştır. Buna göre getirilen Madde 19 Onarım Klozu hükmünün içeriği 2024/2822 sayılı Tüzüğün 20(a) maddesi ile aynıdır. Buna göre birleşik ürünün görünümüne bağımlı olan yedek parça tasarımlarının yalnızca birleşik ürünün orijinal görünümünün geri kazandırmak üzere onarım amacıyla kullanımı tasarım hakkının ihlali sayılmaz. Bunun için birleşik ürünün bileşen parçasının üreticisi veya satıcısının tüketicileri bilgilendirmesi gerekir. Yönergede yer alıp Tüzükte yer almayan fıkraya göre 8 Aralık 2024 tarihinden önce tescil başvurusunda bulunulan tasarımlar için mevzuatında halihazırda onarım klozu hükmü içermeyen devletler 2032'ye kadar tasarım korumasının uygulanmasına devam edeceklerdir.

Türk hukukunda da onarım klozu düzenlemesi mevcuttur. SMK madde 59/4 uyarınca must match parçaların birleşik ürüne orijinal görünümünü yeniden kazandırmak üzere onarım amacıyla ve bu parçaların kaynağı konusunda yanıltıcı olmamak koşuluyla tasarımın piyasaya ilk sürüldüğü tarihten itibaren üç yıl sonra üçüncü kişiler tarafından kullanılması tasarım hakkının ihlali sayılmaz. Onarım klozunun uygulanabilmesi için must match yedek parça bulunması, parçanın üçüncü kişiler tarafından birleşik ürüne orijinal görünümünü yeniden kazandırmak üzere onarım amacıyla kullanılması ve yedek parçanın kaynağı konusunda kamu yanıltılmamalıdır. Madde gerekçesinde otomobilin tamponu veya kapısı örnek olarak belirtilmiştir. Yargıtay motor kaputu ve çamurluğun bu kapsamda olduğuna dair karar vermiştir (Yargıtay 11. HD. 18.04.2016 tarih, 2015/9033 E., 2016/4216 K.).

SMK madde 59/5 uyarınca Sanayi ve Teknoloji Bakanlığınca yayımlanacak eşdeğer parça listesinde bulunan parçalar açısından ise tasarımın piyasaya ilk sürüldüğü tarihten üç yıl bekleme de gerek yoktur. Bunlar piyasaya ilk sürüldüğü tarihten itibaren kullanılabilir.

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## SONUÇ

Bir birleşik ürün kazaya veya hasara maruz kaldığında o üründeki hasar gören parçaların yedek parçalarla değiştirilmesi gerekir. Yedek parça çeşitlerinden fonksiyonel ve görsel olarak birleşik üründen bağımsız olan parçalar tasarım olarak korunurken, must fit parçalar birçok ülkede tasarım olarak korunmamaktadır. Birleşik ürünün görünümüyle uyumlu olması için belirli bir şekilde tasarlanması gereken parçaların (must match) ise tasarım olarak korunması ile ilgili yıllardır süregelen tartışmalar mevcuttur. Avrupa Parlamentosu ve Konseyi 10 Ekim 2024 tarihinde 2024/2823 Direktifi (98/71/EC Direktifini revize ederek) madde 19'da onarım klozunu kabul etmiştir. Buna göre onarım ve orijinal görünümün geri kazanılması amacıyla must match parçaların kullanımı tasarım hakkının ihlali sayılmaz. Ancak bunun için birleşik ürünün yedek parçasının üreticisi veya satıcısının tüketicileri bu konuda bilgilendirilmesi gerekmektedir. Türk hukukunda da Sınai Mülkiyet Kanununda must match parçaların onarım amacıyla kullanımı belirli şartlarla mümkün kılınmıştır. Sınai Mülkiyet Kanunundaki hükme göre must match parçanın, birleşik ürüne orijinal görünümünü yeniden kazandırmak üzere onarım amacıyla, tasarımın piyasaya ilk sürüldüğü tarihten üç yıl sonra, üçüncü kişiler tarafından kullanılması mümkündür. Buna ek olarak Sınai Mülkiyet Kanunundaki hüküm uyarınca eşdeğer parçaların piyasaya ilk sürülmesinden itibaren üç yıl içinde onarım amacıyla kullanımı tasarım hakkının ihlali sayılmaz.



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**DESIGN AND DEVELOPMENT OF NOVEL APPROACH FOR FILE SHARING  
FOR SECURITY USING BLOCKCHAIN TECHNOLOGY**

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**Abstract**

File sharing is a fundamental aspect of data management, and it is essential for collaboration, communication, and data exchange. However, file sharing systems are susceptible to security threats and data breaches, which can compromise data confidentiality, integrity, and availability. A novel approach for file sharing using blockchain technology is required which would ensure secure and decentralized file sharing. The novel approach for file sharing would use a hybrid consensus mechanism, combining proof-of-work and proof-of-stake algorithms, to ensure network security and prevent malicious attacks.

It would use multi-layer encryption to enhance file security, where files are encrypted at the user level and the blockchain level. The proposed Novel approach would also incorporate smart contract technology for file access control, where users can set permissions for file sharing and access. The proposed approach was developed and tested using a prototype implementation, and the results show that the system is secure, efficient, and scalable. The system also provides a high level of data privacy and security, making it suitable for various applications, including healthcare, finance, and government.

**Keywords:** Novel Approach, File sharing; Security; Blockchain, Technology

## **1. Introduction**

In recent years, file sharing has become an integral part of our daily lives. It is widely used for sharing information, collaborating with colleagues, and transferring data between individuals and organizations. However, traditional file sharing systems are vulnerable to various security threats, such as data breaches, hacking, and unauthorized access. Blockchain technology offers a decentralized, secure, and tamper-proof environment for file sharing, making it an ideal solution to address the security challenges of traditional file sharing systems. This literature review provides an overview of the current state of research on blockchain-based file sharing systems, their architecture, security mechanisms, and performance.

### **Evolution of Blockchain Technology**

Blockchain technology was initially introduced as the underlying technology for the Bitcoin cryptocurrency. However, since its inception, blockchain technology has evolved significantly, and its application has expanded beyond cryptocurrency to various domains, including file sharing. Blockchain technology is a decentralized, distributed, and tamper-proof database that provides secure and transparent data sharing. The main characteristics of blockchain technology are its decentralized architecture, immutability, and consensus mechanism.

### **Architecture of Blockchain-Based File Sharing Systems**

Blockchain-based file sharing systems are designed to provide a secure and decentralized environment for file sharing. These systems are composed of three main components: the blockchain network, the user interface, and the file storage. The blockchain network is responsible for maintaining the integrity of the system, ensuring the validity of transactions, and preventing malicious attacks. The user interface provides users with an easy-to-use interface for uploading, downloading, and sharing files. The file storage component is responsible for storing and retrieving files securely.

### **Security Mechanisms of Blockchain-Based File Sharing Systems**

Security is a crucial aspect of blockchain-based file sharing systems. The security mechanisms of these systems are designed to provide data confidentiality, integrity, and availability. The security mechanisms of blockchain-based file sharing systems include network consensus, encryption, and smart contracts.

### **Network Consensus**

Network consensus is the mechanism used by blockchain-based file sharing systems to validate transactions and ensure the integrity of the system. The most commonly used consensus algorithms are proof-of-work (PoW) and proof-of-stake (PoS). PoW is used in the Bitcoin network, and it requires miners to solve a cryptographic puzzle to validate transactions. PoS is used in the Ethereum network, and it requires validators to hold a certain amount of cryptocurrency to validate transactions.

### **Encryption**

Encryption is the process of encoding data to ensure its confidentiality and integrity. Blockchain-based file sharing systems use encryption to protect files from unauthorized access and tampering. The most commonly used encryption algorithms in blockchain-based file sharing systems are AES and RSA. AES is a symmetric encryption algorithm that uses a shared

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secret key to encrypt and decrypt data. RSA is an asymmetric encryption algorithm that uses a public key to encrypt data and a private key to decrypt data.

## **Smart Contracts**

Smart contracts are self-executing contracts that are stored on the blockchain network. Smart contracts are used in blockchain-based file sharing systems to implement access control and automate file sharing. Smart contracts can be programmed to execute certain actions when specific conditions are met.

## **Performance of Block-chain-Based File Sharing Systems**

The performance of block-chain-based file sharing systems is affected by various factors, including transaction throughput, latency, and network scalability. The transaction throughput is the number of transactions that can be processed per second. Latency is the time taken to process a transaction. Network scalability is the ability of the network to handle an increasing number of users and transactions. The performance of block-chain-based file sharing systems can be improved by using efficient consensus algorithms, optimized file storage, and network optimizations.

## **II. LITERATURE REVIEW**

### **Muqaddas Naz et al (2019)**

Data sharing within a research community is crucial to maximizing the information gained from earlier work. Current data sharing solutions rely on a reliable third party. Such systems lack trust, transparency, security, and immutability because of the presence of TTP. This article proposes a blockchain-based secure data sharing platform to address these problems by using the advantages of the interplanetary file system. Owner uploads a meta data to an IPFS server, which is subsequently separated into  $n$  secret shares. By performing the access roles that the owner has defined in the smart contract, the suggested system ensures security and access control. Prior to submitting the desired amount as the fee of digital material, users must first confirm their identities using RSA signatures. The user is invited to provide feedback of the data after its successful delivery. The Watson analyzer is used to verify these reviews and weed out any bogus ones. Customers that submit truthful evaluations are rewarded. The greatest number of reviews is therefore submitted for each file. The Ethereum blockchain, decentralized storage, encryption, and an incentive system are all incorporated in this scenario. Solidity-written smart contracts are deployed on a local Ethereum test network to carry out the suggested scenario. Transparency, security, access control, owner authenticity, and data quality are all achieved by the suggested plan. In order to accurately assess the cost of implementing the implemented scenario in a real-world setting, a study of gas consumption and actual cost necessary in terms of USD is conducted in the simulation results. Also, the computational time for several encryption algorithms is plotted to show how well the implemented system, shamir secret sharing, performs.

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## **Kanayo Kizito Uka et al (2020)**

The purpose of this study is to examine how a tertiary institution uses blockchain architecture to share and manage files. It is anticipated that this technology will enable an online system that could offer a decentralized architecture for multiple file transfers and sharing among participants, design a system that can ensure data integrity and security of files using IBM Blockchain technology, and provide a system that can support multiple users and multiple transactions at once. The research was spurred on by the security issues with the current system, which include slow file transfer and sharing, giving a single user a lot of power and responsibility in a centralized system, high risk of attack and file loss, sluggish file access/retrieval speeds, and a finite number of concurrent users. The programming language used was HTML, CSS, Java, and Node Js, and the methodology utilized was Object Oriented Analysis Design Process together with IBM Blockchain Technology and Unified Modeling Language (UML). A decentralized cloud-based file sharing and management system that supports multiple-shared, replicated, and permissioned network transactions was the end outcome of the design process.

## **Tuan-Vinh Le1 and Chien-Lung Hsu (2021)**

With the advent of its first and most popular use, bitcoin, blockchain technology has gained recognition as a cryptocurrency platform. Blockchain helps to transform centralized transaction ledgers with low trust, maintained by a single entity, into decentralized ones with high trust, held by several verifying nodes. Blockchain has enormous potential for use in a variety of sectors outside of bitcoin because of its decentralized structure and security resilience. Blockchain transforms the conventional method of centrally storing data into a decentralized, trustless one. Blockchain's inherent security features open the door for large-scale applications that are coupled with cutting-edge technologies like mobile networks, edge computing, or IoT. They present and describe several blockchain security aspects in order to do this. There is a detailed taxonomy of blockchain applications in numerous areas. Also, they examine the security and performance issues with blockchains in their work and provide a number of remedies. The security features of blockchain should be acknowledged more, Work on safe energy and healthcare applications powered by blockchain should continue, and the environmental sustainability of blockchain has to be further addressed.

## **Md. Nasim Uddin et al (2021)**

Humans rely on centralized systems with trusted third-party administration for sharing material, yet these platforms lack security, trust, immutability, and clarity. By combining the Interplanetary File System and Public Key Infrastructure technologies, this study has suggested a file-sharing environment based on Blockchain, which offers benefits for resolving these issues. The predetermined access-control list is enforced using a modified version of the IPFS software, and the smart contract is used to limit access rights.

In order to secure file sharing, an application framework on a secure decentralized file sharing system is described. It works with IPFS and PKI. Every file transaction is encrypted and decrypted using PKI using public and private keys, and identities are authenticated with Metamask to cryptographically identify account ownership in the Blockchain system. On the private Ethereum network, a gas consumption-based outcome analysis is conducted, and it achieves transparency, securely regulated access, and quality of data suggesting higher effectiveness of this job.

**Pabba Sumanth et al (2021)**

The market share of cloud computing, a relatively recent technical development, has consistently grown over the previous three years. In this article, we'll outline a novel approach to sharing files safely via the cloud that combines block chain for secure transactions and file viewing. The use of file-shredding software is widespread. Some individuals use these applications to earn money by selling the files that represent their work.

Chegg, Scribd, and other platforms offering a platform for academics, researchers, and independent contractors to publish their work are well known. Yet we need to be members in order to access these programs. Even if a user want access to the files, the application—not the author—must be paid a charge. We thus developed a novel strategy called as "Cloud-based file sharing utilizing Blockchain" in order to do away with middlemen. Users may simply transfer files utilizing the cloud-based file sharing approach by using our program.

As a consequence, this technology makes it easy and efficient for users to store and distribute information over cloud networks. We often lose control of our data when we upload it to the cloud, which increases the security threats to the integrity and confidentiality of our data. Hence, to prevent this, they will talk about an encrypted secure file sharing system for the cloud in this paper. In this study, we presented a novel file-sharing technique. A block chain is used to transfer the transaction from one user to another in order to see the files.

**Yogesh M Gajmal and R. Udayakumar (2021)**

A key element in improving data security in the cloud storage system is access control. The research community has a significant difficulty due to privacy data leaks and key abuse in the present data sharing and access control methods. As a result, the cloud storage system develops an efficient technique known as Blockchain-based access control and data sharing approach to improve data security. Single-point failure in the cloud system is successfully resolved by the suggested Blockchain-based access control and data sharing strategy. By boosting throughput and decreasing cost, it offers greater advantages. With their ID and password, the Data User submits a registration request to the Data Owner, who then processes it and verifies the Data User's identity. With the encrypted master key, the data owner's information is encoded and added to the transactional blockchain. The Data Owner completes the data encryption procedure, and the Interplanetary File System receives the encrypted files. The Data owner creates the ciphertext information and is included in the transactional blockchain based on the location of the encrypted file and the encrypted key. The suggested blockchain-based solution to data exchange and access control performed better according to the metrics, with a reduced response time of 25 seconds and a higher percentage of authentic user detection of 95%.

**Xiaowei Wang (2022)**

The expansion of numerous data sharing technologies has increasingly filtered into many industries thanks to the ongoing development of technology. In order to realize the value of the data, data exchange and security are essential. Yet, the original data sharing arrangement makes it difficult to keep an eye out for signs of electronic data usage. Another issue is the data suppliers' unwillingness to release their data. This study suggests a data sharing paradigm based on blockchain technology, providing safe access to data in order to overcome the security and control challenges of conventional centralized data sharing and administration. The model's usefulness and security are also evaluated in this research. The findings demonstrate the high

degree of viability, security, controllability, and efficiency of the blockchain-based data sharing paradigm proposed in this study.

**Ajitesh Kumar et al (2022)**

The blockchain used in this study organizes network users into groups and maintains a single copy of the blockchain for each group. In contrast to the current bitcoin network and the lightweight blockchain architecture, the study offers a revolutionary blockchain method for safe healthcare sector data management. This mechanism lowers communicational and computing overhead costs. The article also explores how to use the suggested design to deal with the identified risks. The experimental findings demonstrate that the proposed design decreases network bandwidth by ten times and speeds up ledger updates by 63% as the number of nodes increases.

**III. SUMMARY**

File sharing is a fundamental aspect of data management, and it is essential for collaboration, communication, and data exchange. However, file sharing systems are susceptible to security threats and data breaches, which can compromise data confidentiality, integrity, and availability. A novel approach for file sharing using blockchain technology is required which would ensure secure and decentralized file sharing. The novel approach for file sharing would use a hybrid consensus mechanism, combining proof-of-work and proof-of-stake algorithms, to ensure network security and prevent malicious attacks.

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**NOHUT BITKISİNDE VERİM VE KİMİ PARAMETRELER ARASINDAKİ  
KORELASYONUN İRDELENMESİ**

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**Özet**

Bu çalışmanın amacı nohut bitkisinde verim ve diğer parametreler arasındaki korelasyonun irdelenmesi amacıyla nohut bitkisinin yetiştirme sezonu boyunca yürütülmüştür. Araştırmada sulama konuları; sulama suyu ihtiyacının tam olarak karşılandığı (%100) (I100 ) kontrol konusu ve tam sulamamadan %70 (I30), %30 (I70) oranında kısıntı yapılan üç sulama konusundan oluşturulmuştur. Yapılan istatistik analiz sonucunda verim ve verim parametreleri arasında istatistiksel olarak önemli düzeyde korelasyon (ilişkiler) saptanmıştır. Sulama konularının verim ve verim bileşenleri üzerine etkisi %1 düzeyinde önemli bulunmuştur. Uygulanan su kısıntısına ve iklim şartlarına bağlı olarak, nohut bitkisinin bitki su tüketimi, bitki su stres indeksi, klorofil ve verim değerleri arasında önemli oranda korelasyon saptanmıştır. Vejetasyon süresi boyunca en yüksek CWSI (Bitki Su Stres İndeksi) değeri I35 sulama konusunda 0.70 ve en düşük CWSI değeri tam sulanan I100 sulama konusunda 0.18 olarak belirlenmiştir. Sezgin genotipinin verim, CC değeri genel ortalamanın üzerinde ve CWSI değeri düşüktür. Dolayısıyla Sezgin genotipinin su stresine toleranslı olduğu ve abiotik stres koşullarına dayanıklılık çalışmalarında değerlendirilebilir özelliklere sahip olduğu belirlenmiştir. Sonuç olarak verim, CWSI ve CC değerleri arasında önemli oranda %1 düzeyinde korelasyon saptanmıştır. Verim ile CWSI arasında negatif yönlü ve verim ile CC arasında pozitif yönlü korelasyon saptanmıştır.

**Anahtar Kelimeler:** Nohut, Korelasyon, Verim

*\*Teşekkür*

*\*Bu çalışmanın bir kısmı 2024 yılında yurt dışında bir dergide yayınlanmak amacıyla gönderilmiştir*

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**INVESTIGATION OF THE CORRELATION BETWEEN YIELD AND SOME  
PARAMETERS IN CHICKPEA PLANTS**

**Abstract**

The aim of this study was to investigate the correlation between yield and other parameters in chickpea plants during the growing season. Irrigation subjects in the study consisted of the control subject where irrigation water requirement was fully met (100%) (I100) and three subjects where 70% (I30), 30% (I70) were cut from full irrigation. As a result of the statistical analysis, statistically significant correlations (relationships) were determined between yield and yield parameters. The effect of irrigation subjects on yield and yield components was found to be significant at the 1% level. Depending on the applied water deficit and climatic conditions, a significant correlation was determined between plant water consumption, plant water stress index, chlorophyll and yield values of chickpea plants. During the vegetation period, the highest CWSI (Plant Water Stress Index) value was determined as 0.70 in the I35 irrigation subject and the lowest CWSI value was determined as 0.18 in the fully irrigated I100 irrigation subject. The yield and CC values of the Sezgin genotype are above the general average and the CWSI value is low. Therefore, it was determined that the Sezgin genotype is tolerant to water stress and has features that can be evaluated in resistance studies under abiotic stress conditions. As a result, a significant correlation of 1% was found between yield, CWSI and CC values. A negative correlation was found between yield and CWSI and a positive correlation was found between yield and CC.

**Keywords:** Chickpea, Correlation, Yield

*\*Thanks*

*\* A part of this study was sent to be published in a journal abroad in 2024.*

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## Giriş

Bitkilerin içsel su durumunu; ne toprak su içeriğinin ne de atmosferik istemin, bitki su stres indeksi (CWSI) kadar doğru olarak belirleyemeyeceği bildirilmiştir (Reginato, 1983; Gençoğlan and Yazar, 1999).

Bitkiler terledikçe yaprak sıcaklığı azalmakta ve hava sıcaklığının altına düşmektedir. Taç-hava sıcaklığı farkından ve psikrometrik ölçümlerden yararlanarak bitki su stres indeksi (CWSI) belirlenmektedir (Jackson, 1982; Gençoğlan and Yazar, 1999).

Reginato (1983), günlük CWSI değerlerinin atmosferik isteme ve toprak su içeriğine bağlı olarak değiştiğini saptamıştır. Genel olarak sulamalardan önce toprak neminin azalması bitki taç sıcaklığı değerlerini artırıcı yönde etkide bulunmakta ve toprakta azalan nem ile birlikte bitki su stres indeksi (CWSI) değerleri de yüksek çıkmaktadır (Kırnak and Gençoğlan, 2001).

Bitki su stres indeksi (CWSI) düşük, klorofil içeriği yüksek olan hat veya çeşitlerin daha yüksek verim, CWSI'yi yüksek klorofil içeriği düşük olanların ise daha düşük verim verdiği önceki çalışmalarda bildirilmiştir (Ucak et al. 2016). Bahar et al. (2008) Çukurova koşullarında ekmeçlik ve makarnalık buğdaylarda yaprak taç sıcaklığı (bitki örtü sıcaklığı) değerleri ile verim arasında önemli korelasyon belirlemişler ve anılan parametrenin buğday ıslahında seleksiyon kriteri olarak kullanılabilceğini bildirmişlerdir. Kuraklık veya su stresini belirlemede kullanılacak parametrelerin kolay, hızlı, ucuz ve tekrarlanabilir olması son derece önem arz etmektedir. Egea et al. (2017) su stresinin anlık olarak belirlenmesinde, yaprak su içeriği ve klorofil değerlerinin kullanılabilceği bildirilmiştir. Öte yandan şeker mısır hatlarının su stresine dayanımını belirlemek amacıyla yapılan bir çalışmada toprak nemi ile klorofil içeriği arasında ( $r:0.58^{**}$ ) istatistiki olarak ( $p<0.01$ ) önemli pozitif yönde bir korelasyon bulunurken, CWSI ve verim arasında negatif yönlü yine önemli korelasyon saptanmıştır (Uçak et al., 2016).

Yapılan literatur çalışmalarında buğday bitkilerinde verim ve diğer parametreler arasındaki korelasyonun belşirklenmesine yönelik çalışmalar yapılmasına karşın, nohut bitkisinin verim ve arasındaki korelasyona yeterince rastlanmamıştır.

Ayrıca nohut bitkisinde su stresine karşı yapılacak agronomi çalışmalarında genotiplerin potansiyel durumlarını birbirinden ayırt etmek için etkili seleksiyon kriterlerinin tam olarak bilinmemesi, agronomi veya ıslah çalışmalarını kısıtlayan en önemli faktörlerden biri olduğu söylenebilir. Dolayısıyla bu çalışma 2024 yılında doğal tarla koşullarında, su stresli (WS:I70), aşırı su stresli (EWS:I35) ve su stressiz (SF:I100) koşullarda yetiştirilen, 3 adet nohut genotipinin (Caner, Sezgin, Onur) verim, bitki su stres indeksi ve klorofil içeriği değerleri faydalanarak verim ile aralarındaki korelasyonu belirlemek amacıyla yapılmıştır. Ayrıca araştırmanın bir diğer amacında elde edilen bulguların, nohutta yapılacak su stresine toleranslılık çalışmalarına bir taban oluşturmasıdır. Bu çalışmanın doğal tarla koşullarında yapılmasının sebebi; özellikle sera veya büyütme odaları gibi kontrollü alanlarda yapılan çalışmaların sonuçlarının pratiğe aktarılmasında bazı kaygıların bulunmasıdır.

## 2. Gereç ve Yöntem

### 2.1. Deneysel Çalışmalar

Damlama sulama yönteminin kullanıldığı deneme parsellerinde su dağıtımı, 4 atm çalışma basıncı ve 16 mm dış çapa sahip yumuşak PE lateral boru hatları kullanılarak sağlanmıştır. Araştırma alanının toprakları ağırdır ve  $7 \text{ mm h}^{-1}$  infiltrasyon oranına sahiptir. Her lateralde, sıralı tip basınç düzenleyicisi ve 1 atm çalışma basıncında  $4 \text{ L h}^{-1}$  akış hızına sahip damlaticılar

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kullanıldı ve aralarında 0.33 m boşluk kaldı. Bu nedenle, bitki damla sulama yöntemi ile sulama suyu sadece doğru miktarda uygulanmıştır. Herhangi bir sızma veya yüzey akışı meydana gelmesine izin verilmemiştir. Sırtta ekilecek tohum yatağı hazırlanmıştır. Her parsel, sıra arasında 70 cm boşluk, sıra üzeri 20 cm boşluk, parsellerin boyutları 6 m uzunluğunda ve 2,8 m genişliğinde (parsel yüzeyi = 16,8 m<sup>2</sup>) olmak üzere 4 çizgiye sahip olacak şekilde tasarlanmıştır. Tohumun 4-5 cm derinlikte ekildiğinden emin olmak için 4 hatlı pnömatik tohum makinası kullanılmıştır. Konular ve tekrarlar arasındaki etkileşimleri önlemek için 2 m tampon bölge oluşturulmuştur. Çalışmada, etkili kök derinliğinin (90 cm) nem içeriği her sulamadan önce gravimetrik yöntem kullanılarak tespit edilmiştir. Her tür için tam sulama (I100) ile kontrol parselinde 90 cm toprak derinliğinde eksik nem getirmek için sulama suyu miktarı, her bir konu için uygulanacak sulama suyu miktarını belirlemek için kullanılmıştır. Bu amaçla, sulama öncesi her sulama derinliği için 90 cm'lik toprak profilinin 0-30, 30-60 ve 60-90 cm'lik tabakalarından alınan toprak numuneleri toplanmış ve kuru toprak ağırlık yüzdesi (%Pw) olarak belirlenmiştir. Her katman için belirlenen nem içeriği, denklem 1 kullanılarak derinlemesine nem içeriğine dönüştürülmüştür.

$$d=(Pw-PwAW)*As*D/100..... (1)$$

Burada; d derinliğinde toprak nem içeriğidir (mm), Pw tarla kapasitesi (%), PwAW; her katmanın nem içeriği (%), As ,Toprak birim ağırlığı (g/cm<sup>3</sup>)

D katman derinliği (mm) olduğu gibi uygulanacak suyun hacmi aşağıdaki denklem kullanılarak hesaplanmıştır (Eşitlik. (2));

Her tabaka için hesaplanan su içeriği nin eklenmesiyle, etkili kök derinliği için toplam su miktarı (dT) bulunmuştur (Eşitlik. (2)).

$$dT=d(0-30)+ d(30-60) + d(60-90) ..... (2)$$

Her sulama konusunun aylık ve mevsimsel evapotranspirasyon değerleri, büyüme mevsiminde hasadın başlangıcında ve sonunda ölçülen toprağın nem oranı (90 cm) su bütçe yöntemi ve nem içeriği değerleri kullanılarak hesaplanmıştır (Zelege ve Wade 2012).

Bitkinin su tüketiminin hesaplanmasında aşağıdaki su dengesi denklemi kullanılmıştır (Eq. (4)) (Zelege ve Wade 2012).

$$ETa= P + I - Rf - Dp \pm \Delta S .....(Eq. (5)).$$

ETa: Evapotranspirasyon (mm),

P: yağış (mm),

I: sulama suyu miktarı (mm),

Rf: yüzey akışı (mm),

Dp: Derin infiltrasyon (mm) ve

$\Delta S$  (mm) kökündeki toprak nem değişimidir. Çalışmada tercih edilen damla akış hızı toprağın sızma hızından daha düşük olduğundan, yüzey akışı oluşmamıştır. Sulama suyu miktarı mevcut nemi saha kapasitesine getirmek için yeterli olduğu için derin bir sızma meydana gelmediği varsayılmıştır.

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Çizelge 1. Siirt iline ait uzun yıllık meteorolojik veriler (1938-2024).

Parame tre	Maksi mum Sıcakl ık (°C)	Mini mum Sıcakl ık (°C)	Ortala ma Nispi Nem (%)	Toplam Yağış Ortalama sı (mm)	Maksi mum Yağış (mm)	Ortala ma Buharla şma (mm)	Ortala ma Güneşl enme Süresi (Saat)
Rasat Süresi (Yıl)	79	79	78	78	79	79	57
Ocak	19.7	-19.3	71.9	34.6	53.4	12.0	3.6
Şubat	20.6	-16.5	67.1	29.4	53.2		4.4
Mart	28.5	-13.3	62.0	24.1	63.0	33.0	5.4
Nisan	32.9	-4.1	58.0	22.4	71.4	84.0	6.5
Mayıs	36.2	2.0	50.7	21.2	68.1	186	9.0
Haziran	40.2	8.2	34.6	15.5	16.7	284.8	11.7
Temmu z	44.4	13.1	27.4	13.5	22.2	368.0	12.2
Ağusto s	14.4	46.0	26.4	13.3	12.2	351.8	11.4
Eylül	39.9	8.5	31.2	14.4	37.5	254.3	9.9
Ekim	36.6	0.3	46.7	49.7	70.8	137.6	7.2
Kasım	25.8	-14.1	62.4	82.5	102.9	53.0	5.2
Aralık	24.3	-14.6	70.6	94.5	71.8	13.1	3.6
Yıllık	46	-19.3	50.8	719.8	102.9	1753.6	7.5

Çalışmadan elde edilen bulgular varyans analizine tabi tutulmuş ve varyans analizi sonuçlarına göre istatistiksel olarak önemli çıkan uygulamalar LSD testi ile karşılaştırılmıştır. Özellikler arasındaki ilişkiyi tespit etmek için korrelasyon analizi yapılmıştır (Der ve Everitt, 2002).

### 3. Bulgular ve Tartışma

#### Korelasyon analizi

Korelasyon katsayılarına bakıldığında tüm bu özellikler arasında istatistik olarak önemli ilişkiler ( $p \leq 0.01$  ve  $p \leq 0.05$ ) olduğu tespit edilmiştir. Verim ile bitki su stres indeksi (CWSI) arasında ise  $r = -0.90$  gibi yüksek bir azalan (negatif) ilişki bulunmaktadır. Bir başka deyişle verim arttıkça doğrusal olarak CWSI değeri azalmaktadır. Verim ile klorofil indeksi (CC) arasında  $r = 0.091$  gibi yüksek bir artan (pozitif) ilişki bulunmaktadır. Bir başka deyişle klorofil indeksi arttıkça verimde artmaktadır. Kapsül sayısı ile verim arasında ise  $r = 0.82$  gibi yüksek bir artan (pozitif) ilişki bulunmaktadır. Bir başka deyişle kapsül sayısı arttıkça verimde artmaktadır.

#### 4. Sonuç

Son zamanlarda küresel ısınmaya bağlı olarak ciddi bir tehdit olarak karşımıza çıkan ani iklimsel değişim, ülkemizdeki kısıtlı olan su kaynaklarının tükenmesine yol açmakta önemli bir oynamaktadır. Korelasyon katsayılarına bakıldığında incelenen özellikler

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arasında istatistik olarak önemli ilişkiler ( $p \leq 0.01$  ve  $p \leq 0.05$ ) olduğu tespit edilmiştir. Verim ile bitki su stres indeksi (CWSI) arasında ise  $r = -0.90$  gibi yüksek bir azalan (negatif) ilişki bulunmaktadır. Bir başka deyişle verim arttıkça doğrusal olarak CWSI değeri azalmaktadır. Verim ile klorofil indeksi (CC) arasında  $r = 0.0.91$  gibi yüksek bir artan (pozitif) ilişki bulunmaktadır. Bir başka deyişle klorofil indeksi arttıkça verimde artmaktadır. Kapsül sayısı ile verim arasında ise  $r = 0.82$  gibi yüksek bir artan (pozitif) ilişki bulunmaktadır. Bir başka deyişle kapsül sayısı arttıkça verimde artmaktadır artmaktadır. Araştırmadan elde edilen sonuçlar diğer araştırmacılar tarafından da test edilebilir.

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**STUDY ON COMPRESSIVE STRENGTH OF QUARRY DUST AS FINE  
AGGREGATE IN CONCRETE**

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**Abstract**

According to the research, one way to boost the amount of quarry dust produced by quarries is to employ it in place of fine aggregate. Quarry dust substitute can lessen the need for landfill and address the issue of a shortage of natural sand. Affordable sand is not a good choice for fine aggregate in concrete, so other sources of material must be investigated. Quarry dust not only serves as a cost-effective substitute for sand, but it also serves as an alternative material. Even the weight of dumping crusher dust in one location pollutes the ecosystem. The conclusion drawn from the practical investigations findings is that quarry dust can be employed as a fine aggregate substitute. It has been discovered that substituting 40% of the fine aggregate with quarry dust results in stronger concrete than regular concrete, with the strength decreasing after 50%.

**Keywords:** Dust, Landfill, Investigation, Strength, Regular concrete.

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## 1. Introduction

The concentrated substance known as quarry dust, which is produced as a by product of crushing, is used as aggregates for concrete, particularly fine aggregates. When rock is broken into different sizes for quarrying purposes, a dust known as quarry dust is produced, which is then disposed of as waste. Consequently, it turns into a waste item and pollutes the air. As a result, using quarry dust in construction projects will lower costs, save money on building materials, and ensure that natural resources are managed responsibly. There is pressure on the majority of emerging nations to substitute some of the fine aggregate in concrete with another material, either completely or partially, while maintaining the same level of quality.

The science of working with materials and gadgets at the atomic and molecular level is known as nanotechnology. Concrete's strength, durability, and other qualities can be enhanced by the application of nanotechnology to cement. Adding nanoparticles to concrete enhances its strength, durability, and shrinkage by reducing empty space. Materials including carbon nanotubes, titanium dioxide, and silica are frequently used to create nanoparticles. Innovative, sustainable, and more robust constructions can result from the use of nanotechnology in cement. High compressive and tensile strengths, good workability, less need for additives, lower costs per building site, and a decreased risk of silicosis are some advantages of Nano concrete.

Because of its possible uses and advantages, quarry dust—a byproduct of the crushing of stones—has drawn interest from the building sector. The need for building materials has grown as a result of the acceleration of urbanization and infrastructure development, which has prompted a quest for sustainable alternatives. The fine particles produced when stones are crushed make up quarry dust. Its granular texture is akin to that of sand since it usually contains silica, alumina, and iron oxide. Quarry dust's viability as a building material is influenced by its physical characteristics, including moisture content, specific gravity, and particle size distribution. Its angular design helps increase bonding in asphalt and concrete applications, while its fineness can make concrete mixes easier to deal with.

Inadequate quarry site management can result in habitat destruction and landscape deterioration, while dust produced during quarrying can contribute to air pollution.

The usage of quarry dust has drawbacks despite its advantages. Depending on where it comes from, quarry dust's characteristics might vary, which can impact how well it works in concrete and other uses. Furthermore, there are worries about the possible health hazards of breathing in fine dust particles, which calls for appropriate management and mitigation techniques in building procedures. Furthermore, regional differences in the legal frameworks controlling the use of quarry dust in building may have an effect on its uptake. Guidelines for its safe and efficient usage must be established through ongoing research and standardization initiatives.

In the building sector, quarry dust is a useful resource that provides a sustainable substitute for conventional materials. Its uses in the manufacturing of asphalt, cement, and concrete improve material qualities while also aiding in environmental preservation. Although there are obstacles to overcome, using quarry dust in construction is a viable way to meet the rising demand for environmentally friendly building materials. To maximize its benefits and reduce its negative effects on the environment, more research and prudent management are essential.

In the construction business, quarry dust has been used for a variety of purposes, including aggregates, bricks, tiles, building materials, and materials for developing roads. Because quarry dust can produce airborne particles during handling and processing, handling it could be hazardous to one's health if necessary precautions are not taken. Quarry dust can have different

qualities depending on where it comes from, therefore it can be difficult to grade and maintain consistency in it.

Quarry dust is a multipurpose substance that is frequently used in building projects as a more affordable option to sand. It has several advantages, but handling and using it correctly can offer some difficulties.

Quarry dust is a cost-effective substitute for sand in construction projects since it is frequently less-expensive.

It lessens the quantity of waste produced by quarrying operations by using quarry dust. Quarry dust can improve the workability of concrete mixes when it is blended and graded correctly. The current study focuses on the effects of varying sand replacement percentages with quarry dust on concrete's characteristics. The purpose of this study is to evaluate the effects of adding quarry dust to regular concrete and to determine how quickly compressive strength develops.

## **2. Literature review**

Citra R (2019) et al. paper showed every blend showed enhanced filling and passing capabilities along with good workability. According to the workability test findings, those fall within the parameters outlined in the EFNARC recommendations.

While quarry dust serves as a filler material, silica fume's fineness was crucial in enhancing SCC's flow ability characteristics. Therefore, the improved workability qualities of SCC are demonstrated by the presence of silica fume. Comparing the mixes S05Q05 and S7.5Q05 to the standard concrete CC, a 1% and 3.3% increase in compressive strength was noted. It was discovered that S7.5Q05 had a 4.04% higher percentage gain in tensile strength than CC. The S7.5Q10 was found to have a 3.5% somewhat higher percentage of flexural strength than the CC.

Jagadeesh P (2019) et al. Quarry dust, a by-product of crushed stone, is substituted as a fine aggregate in this study at 20%, 30%, 40%, and 50% substitution. By testing the sample cube, the compressive strength of the concrete is ascertained while fine material is substituted. The sample's characteristics, including its moisture content, fineness modulus, and specific gravity, are ascertained. Because quarry dust is a waste product from quarries, it is a good substitute for regular sand and is also quite temperate. Because of its superior retaining qualities, the quarry dust exhibits higher quality.

Gedela K (2023) et al. The performance of an alkali-activated binder based on sugarcane bagasse ash and quarry dust as a substitute fine aggregate is evaluated in this study. As activators, NaOH and Na<sub>2</sub>SiO<sub>3</sub> were employed. To assess the curing effect, alkali-activated specimens based on sugarcane bagasse ash were exposed to both ambient and heat curing. Five different alkali-activated concrete compositions were cast using varying amounts of quarry dust: 0, 10, 20, 30, 40, and 50%. Additionally, for quarry dust aggregates that employed alkali-activated binder, the impact of using sugarcane bagasse ash as a precursor (10, 20, and 30% SCBA as a replacement of the GGBS) was assessed. According to the study, the ideal amount of quarry dust to replace river sand is 20%. When compared to the control specimens, the 30% bagasse ash–20% quarry dust heat-cured alkali-activated specimens' compressive strength is reduced by 35.1%. Compared to the heat-cured specimens, the specimens based on ambient-cured sugarcane bagasse ash and quarry dust demonstrated superior strength. Although the alkali-activated specimens based on bagasse ash and slag have a lower compressive strength than the control specimens, the resulting strength is still significantly higher than the minimum strength needed for a number of structural applications.

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Shyam prakash K (2017) et al. Used quarry dust to replace natural fine aggregate results in the consumption of the created dust, reduces the need for land fill space, and addresses the issue of natural sand scarcity. The low cost of sand as a fine aggregate provides justification for looking for an alternative material. Additionally, it results in the saddle dumping the crusher dust in one location, which pollutes the environment. By substituting quarry dust for sand, the chemical analysis, specific gravity, sieve analysis, and compressive strength are determined for different percentages and grades of concrete.

Kaish A (2022) et al. The purpose of this study was to examine how the strength characteristics of regular concrete were affected when various industrial waste materials were used in partial replacement of fine aggregate. Utilizing some industrial waste can have many advantages for the building sector in terms of cost-effectiveness and sustainability of natural resources. However, little research has been done on the use of industrial waste to replace fine aggregate in concrete of normal strength, particularly when it comes to using alum sludge from water treatment plants. In this investigation, oven-dried alum sludge was utilized in place of fine aggregate (river sand). To determine the precise impact of oven-dried alum sludge on concrete, quarry dust and limestone dust were also used as non-reactive industrial waste materials. After being crushed to reduce their particle size, all of the materials were employed in varying quantities (5, 10, and 15%) to substitute fine aggregate. The trials' findings demonstrate that adding industrial waste material increased the concrete's density, flexural, compressive, and splitting tensile strengths. Also, the results indicate that the best replacement content of fine aggregate with industrial waste was 10% for oven-dried alum sludge and 15% for quarry and limestone dust, which enhanced all of the strength characteristics examined in this study. All of the industrial waste used as fine aggregate in this study has been shown to be an effective filler material by enhancing the strength characteristics of normal strength concrete and filling internal voids. After being crushed to reduce their particle size, all of the materials were employed in varying quantities (5, 10, and 15%) to substitute fine aggregate. The trials' findings demonstrate that adding industrial waste material increased the concrete's density, flexural, compressive, and splitting tensile strengths. Also, the results indicate that the best replacement content of fine aggregate with industrial waste was 10% for oven-dried alum sludge and 15% for quarry and limestone dust, which enhanced all of the strength characteristics examined in this study. All of the industrial waste used as fine aggregate in this study has been shown to be an effective filler material by enhancing the strength characteristics of normal strength concrete and filling internal voids.

Shyam Prakash k (2016) et al. The study's emphasis on the idea of substituting quarry dust for natural fine aggregate may increase the amount of quarry dust produced by quarries. The issue of natural sand scarcity can be resolved and the need for land fill is decreased by substituting quarry dust. Sand is not a suitable fine aggregate for concrete due to its low cost, which is why it is necessary to look for an alternate material. Quarry dust is a very inexpensive alternative material that meets the requirements for replacing sand. The study's emphasis on the idea of substituting quarry dust for natural fine aggregate may increase the amount of quarry dust produced by quarries. The issue of natural sand scarcity can be resolved and the need for land fill is decreased by substituting quarry dust. Sand is not a suitable fine aggregate for concrete due to its low cost, which is why it is necessary to look for an alternate material. Quarry dust is a very inexpensive alternative material that meets the requirements for replacing sand.

### **3. Methodology**

Crushers produce quarry dust when they work on quarries. Quarry dust was acquired from quarries in the vicinity. The purpose of the current studies is to examine the effects of partially replacing quarry dust with sand in concrete. The strength properties of the samples that were gathered from the surrounding area were examined and contrasted. Each set of three cubes in the software consists of cube specimens that are cast and tested. Standard 150 mm \*150 mm \*150 mm cubes were used to cast the cubes. For the mix, specific gravities of 2.62 and 2.70 for sand and quarry dust, respectively, are utilized for 30 grade cement. For the concrete mix, normal moist curing was used for curing. The cube specimens are tested using a 2000 KN capacity compression testing machine.



**Figure 1: Quarry dust**

### **4. Discussion of results**

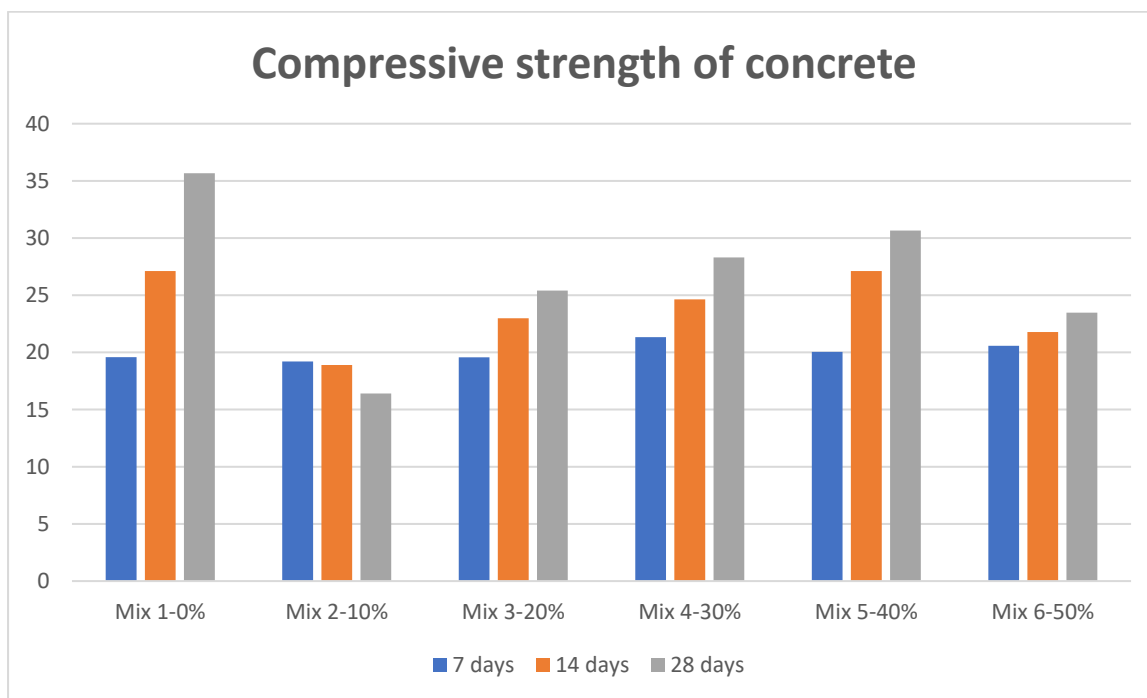
M30 grade of concrete with 20, 25, and 30 percentage replacement of quarry dust tested for 3 days, 7 days, 14 days, and 28 days is studied and the results are presented.

The samples were cast using standard materials, i.e., ordinary Portland cement (OPC) was used to cast the fine aggregate, which is naturally occurring river sand with an M30 grade.

The substitution of quarry dust as a fine aggregate by concrete with age might result in a 40% increase in compressive strength.

Conventional concrete workability is found to be 0.87 for M30 grade and w/c 0.45. Workability for 20% quarry dust is 0.84. Workability is further reduced to 0.73 for concrete that has been replaced by 30%. Workability for concrete containing 40% quarry dust is 0.83, while compacting factor was found to be 0.77 for concrete containing 50% replacement of quarry dust.

**Graph 1: Compressive strength of concrete**



**Table 1: Compressive strength of cement**

Mix	7 days	14 days	28 days
<b>0%</b>	<b>19.58</b>	<b>27.11</b>	<b>35.67</b>
<b>20%</b>	<b>19.20</b>	<b>18.9</b>	<b>16.4</b>
<b>25%</b>	<b>19.57</b>	<b>22.98</b>	<b>25.4</b>
<b>30%</b>	<b>21.33</b>	<b>24.63</b>	<b>28.31</b>
<b>40%</b>	<b>20.04</b>	<b>27.11</b>	<b>30.65</b>
<b>50%</b>	<b>20.57</b>	<b>21.78</b>	<b>23.47</b>

## 5. Conclusion

The idea presented in this inquiry to substitute quarry dust for natural fine aggregate could enhance the use of the produced quarry dust, hence lowering the need for land fill space and protecting the limited supply of natural sand for sustainable development. The bonding of the fine particles, which fills in the spaces between the coarse aggregates, is primarily responsible for the strength of the concrete.

When quarry dust is substituted, the compressive strength diminishes as the amount of water increases. This is because quarry dust has the ability to absorb water. It's common knowledge that when strength declines, the w/c ratio rises. However, there is a nonlinear difference in the compressive strength of quarry dust and sand.

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It can be observed from the experimental study that quarry dust is a suitable substitute for fine aggregate.

When compared to regular concrete, it is discovered that 40% replacement of sand with quarry dust yields the highest result in strength, which then drops from 50%. The findings demonstrated that increased compressive strength could be achieved by substituting up to 40% of the sand with quarry dust, and that as replacement increases, concrete's workability would decline. Consequently, garbage and its consequences on the environment can be greatly decreased.

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**EFFECT OF FLAKY AGGREGATES ON THE STRENGTH AND WORKABILITY  
OF CONCRETE**

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**Abstract:** The impacts of flaky aggregates on concrete's workability, tensile strength, and compressive strength have all been investigated experimentally in this research. Using a range of flaky aggregates (20%, 30%, 40%, 50%, 60%, and 70%) and water cement ratios of 0.45, concrete blocks and cylinders have been created. The M30 grade concrete mix design was completed in compliance with IS: 10262-2009. The slump test was employed to assess workability. The splitting tensile strength and compression strength of concrete cubes and cylinders were assessed. Test outcomes are contrasted and It was determined that flaky aggregates that are more than a certain amount diminish durability and use; as a result, the internal structure and shape of the aggregates have a significant impact on the strength of concrete.

**Keywords:** concrete cube, splitting tensile strength, workability, compressive strength, and flaky aggregates.

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## 1. INTRODUCTION

Concrete is a composite material made by evenly combining specific amounts of cement, water, and fine and coarse particles. The aggregate is the main component of concrete since it makes up 60–80% of the total volume of the material. One must have a deeper understanding of the aggregates in order to learn more about the concrete. Because the properties of the aggregates are essential to the concrete mixtures efficiency. It is commonly acknowledged that the shape of the aggregate has a major impact on how concrete behaves.

When creating high-quality concrete, flaky aggregate is avoided. Concrete mixtures deteriorate more quickly when flaky aggregates are present in excess of certain thresholds. The mix is harsh and challenging to work with because to the high percentage of flaky pebbles. In this case, the flaky aggregate is defined as the aggregate with a ratio of less than 0.60 between the average and shortest diameters. Typically, flaky particles align in a single plane, resulting in laminations that negatively impact the concrete's durability.

Flaky aggregate showed increased breaking and decreased compatibility. Aggregates that are extremely flaky have more voids and are less workable. Fresh concrete must be workable enough to be properly compacted, carried, and installed; it must also be cohesive, meaning that completed concrete cannot separate. There shouldn't be any bleeding or ant segregation in practical concrete. Large voids and decreased strength and durability are the results of this.

## 2. OBJECTIVES OF STUDY

The study's goals are to: Examine how flaky aggregate affects concrete's workability, splitting tensile strength, and compressive strength.

- To ascertain M30 Concrete's compressive strength with varying aggregate flakiness.
- To evaluate M30 concrete's splitting tensile strength with varying aggregate flakiness.
- To produce a graphic comparison of the compressive strength of the M30 concrete mix with varying aggregate flakiness.
- To get a visual comparison of the splitting tensile strength for M30 concrete mix with various aggregate flakiness.
- To get a visual depiction of M30 concrete's workability with varying aggregate flakiness.
- To make judgments regarding concrete's increased strength and workability.
- To ascertain the ideal proportion of flaky particles in the concrete mixtures.
- To ascertain how workability affects concrete's compressive strength.

## 3. BASIC ASPECTS

### 3.1 Materials:

- Portland pozzolana cement

Portland pozzolana cement that complied with IS: 1489-1991 (Section 1) for fly ash-based Portland pozzolana cement was utilized.

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**Table 1: Properties of PPC**

<b>Property</b>	<b>Test Results obtained</b>
Standard Consistency	30%
Initial setting time	45 min
Final setting time	285 min
Fineness	2.2%
Specific gravity	3.2

• **Fine aggregate**

Common river sand was used in the research. Specimens were prepared using the sand that passed through a 4.75 mm sieve. Sand's physical properties were evaluated in accordance with IS: 2386-1963.

**Table 2: Physical properties of Fine aggregate**

<b>Sl. No.</b>	<b>Property</b>	<b>Test Results obtained</b>
1	Specific gravity	2.63
2	Bulk density	1454 Kg/m <sup>3</sup>
3	Moisture content	0.9%

• **Coarse aggregate**

Crushed granite stone with a size of 20 mm that was obtained from quarries served as the study's rough aggregate. Physical characteristics were assessed in accordance with IS: 3286-1963.

**Table 3: Physical properties of Coarse aggregate**

<b>Sr No.</b>	<b>Property</b>	<b>Test Results obtained</b>
1	Specific gravity	2.582
2	Bulk density	1354 Kg/m <sup>3</sup>
3	Flakiness index	30%
4	Moisture content	0.5%

• **Water**

Potable water from the water supply was utilized in the mix design; it was devoid of

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organic components and suspended particulates, which could have impacted the characteristics of the freshly mixed and hardened concrete. It is undesirable to have iron compounds or tannic acid present. According to IS: 456-2000, water is often needed for concrete mixing and curing.

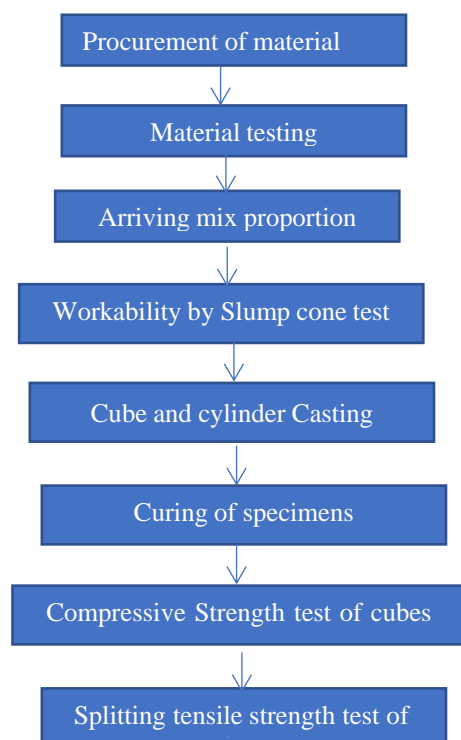
## 4. LITERATURE REVIEW:

- The impact of flakiness on concrete's workability and compressive strength has been thoroughly investigated by numerous researchers. Extremely flaky and elongated aggregates can also yield high-quality concrete that can be utilized for PCC projects, according to research by M R Vyawahare and P O Modani on the improvement of workability and strength of concrete using these aggregates.
- According to research by Jian-Shiuh Chend, M.K. Chang, and K.Y. Lin on the impact of coarse aggregate form on asphalt concrete mixture strength, flaky aggregate in a mixture led to lower resistance to shear deformation, as well as lower compactibility and higher breakage. In their study, Bambang Ismanto Siswoebrotho and Kariantoni Ginting examined the workability and resilient modulus of asphalt concrete mixtures that contained flaky aggregates. They came to the conclusion that the flaky aggregate content affected the workability index values, which decreased as the flaky aggregate content increased. Flaky aggregate does affect the properties of asphalt mixtures, so its use should be restricted to prevent unexpected mixture properties during construction.
- According to D. Sakthibalan's research on the influence of aggregate flakiness in dense bituminous macadam and semi-dense bituminous concrete mixes, both DBM and SDBC mixes' stability, flow, bitumen-filled voids, and tensile strength ratio decrease as the proportion of flaky aggregates increases. For both DBM and SDBC mixes, the characteristics such as air voids and voids in mineral aggregate increase as the ratio of flaky aggregates increases.
- In their study on the influence of coarse aggregate shape factors on bituminous mixtures, Ganapati Naidu.P. and S. Adishesu came to the conclusion that the particle shape parameter produced a higher sphericity value for cubic form aggregates and a lower value for blade form aggregates because a higher sphericity value indicates roundness of the aggregate.
- Sander Popovics and Janos Ujhelyi have conducted research on the relationship between the water-to-cement ratio and concrete strength. Aggregates make up a significant portion of the surface structure, according to research by Animesh Das on a revisit to aggregate form characteristics. The entire performance of the pavement is significantly impacted by the aggregates' technical properties, shape, and texture.

## 5. METHODOLOGY

Methodology is the process of performing any work in proper manner i.e. step by step procedure of work. This procedure of methodology is shown in following steps;

Figure 1: Methodology



## 6. RESULT AND DISCUSSION

To ascertain the concrete's tensile strength, a standard cube sample (150 mm x 150 mm) and cylinder prototype were utilized. Three samples with different percentages of aggregate flakiness index were evaluated for 7, 14, and 28 days in order to determine compressive strength. Additionally, three specimens were tested for tensile strength over a period of seven and twenty-eight days. Materials were combined in a mixer after the contents were measured. A tamping rod was used to crush the mixes. After a day, the samples were taken out of the molds and allowed to cure in water for seven, fourteen, and twenty-eight days in order to test for compressive strength, and for seven, fourteen, and twenty-eight days in order to evaluate tensile strength. then put through tests to determine its tensile and compressive strengths in accordance with Indian Standards.

In this study, M30 concrete is utilized, and concrete cubes with varying aggregate flakiness are prepared to measure the concrete's compressive strength over 7, 14, and 28 days using a compressive strength testing machine. Concrete cubes are also prepared to measure the splitting tensile strength over 7 and 28 days using a universal testing machine. The slump cone test is used to assess the workability of concrete for varying aggregate flakiness. The results have been compared using universal and compressive strength testing machines.

### Workability

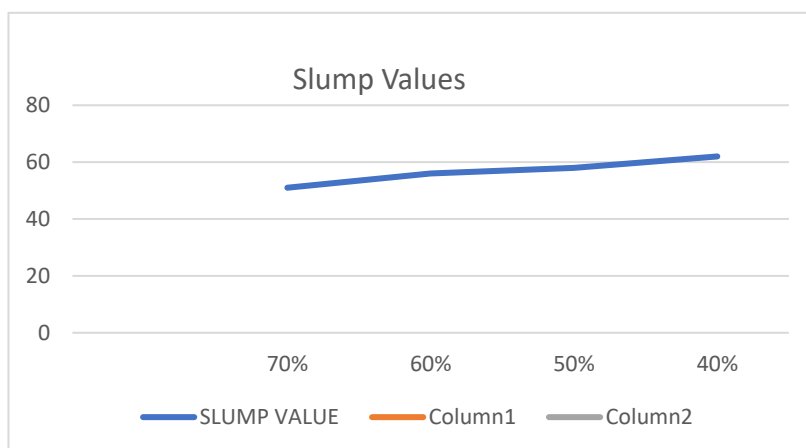
The workability of M30 (1:1:2) concrete is determined in a laboratory. When making concrete, a water-to-cement ratio of 0.5 is used, and the coarse aggregate flakiness ranges from 20% to 70%. The slump cone test is used to measure the workability of concrete prepared with varying percentages of flakiness index. The slump value of concrete for

different aggregate flakiness indices is displayed in the table. Figure 2 displays a graph that illustrates how the slump varies with initial time.

**TABLE 4: SLUMP VALUE OF CONCRETE FOR DIFFERENT FLAKINESS INDEX OF AGGREGATE**

S.NO.	Percentage Of FLAKINESS INDEX OF AGGREGATE	SLUMP VALUE
01	70%	51
02	60%	56
03	50%	58
04	40%	62
05	30%	68
06	20%	74

**Figure 2: Slump Values**



### Compression Strength

The concrete's 30% compressive strength. Flaky aggregate performed well in concrete composed of regular aggregates, but at 70% flaky aggregate, the strength significantly dropped and fell short of the projected target strength of 31.6 MPa.

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**TABLE 4: Compression Strength of concrete**

Mix proportions	Flaky aggregates (%)	Compressive strength in Mpa		
		7 days	14 days	28 days
M30	20 %	18.26	23.44	29.60
	30%	17.35	22.55	28.30
	40%	16.40	21.24	26.62
	50%	15.82	19.84	24.54
	60%	14.20	18.29	23.29
	70%	12.14	16.24	22.13

**Splitting tensile strength**

To ascertain the load under which the concrete members may fracture, the tensile strength of the concrete must be determined. Concrete members fractured under lighter loads as the percentage of flaky aggregate increased.

**TABLE 4: Split Strength of concrete**

Mix proportions	Flaky aggregates (%)	Splitting tensile strength in Mpa	
		7 days	28 days
M30	20 %	2.17	2.98
	30%	2.10	2.90
	40%	2.02	2.74
	50%	1.89	2.44
	60%	1.79	2.39
	70%	1.72	2.10

**7. CONCLUSIONS**

As the amount of flaky aggregate material increased, the workability of the M30 concrete mix utilized in this study dramatically declined.

As the percentage of flaky aggregate in M30 concrete increased, its compressive strength fell. As the percentage of flaky aggregate in M30 concrete increased, its splitting tensile strength fell.

Concrete composed of regular aggregates performed just as well as concrete that had flaky aggregate replaced by 30%.

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**EXPLORING THE SUSTAINABLE OFFICE BUILDING DESIGN FOR OPTIMAL  
DAYLIGHTING AND THERMAL COMFORT IN THE TEMPERATE DRY  
CLIMATE OF NIGERIA**

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**Abstract**

There is disagreement among numerous researchers regarding sustainable office building design especially for the ideal values of Daylighting and Passive Indoor Thermal Comfort (DPITC) in tropical countries like Nigeria. The study aims to develop a framework for a sustainable office building for optimum daylighting and passive indoor thermal comfort (DPITC) in the temperate dry climate of Nigeria. A quantitative research design using an explorative design approach was employed in the study as well as an experimental research strategy through simulation method to optimise DPITC. The study used the Bank of Industry and Bayero University Senate Building as prototypes of the closed-plan and open-plan office buildings. The Google SketchUp Pro 2022 and OpenStudio 3.3.0 simulation tools were used to evaluate the prototype buildings from January to December 2024. The data generated was analysed using MANOVA, ANOVA, column charts, graphs, and tables. The findings revealed that open-plan office building is the most sustainable office building in the temperate dry climate of Nigeria with the statistically significant difference between open-plan and closed-plan office buildings in Daylight Autonomy (DA), Useful Daylight Illuminance (UDI), Spatial Daylight Autonomy (sDA), and Relative humidity (RH) of 45.7%, 0 %, 55.2%, and 10.6% respectively,  $df(1, 14) = 55.4, p = .0000$ ;  $df(1, 14) = 24.6, p = .0000$ ;  $df(1, 14) = 96.6, p = .0000$ , and  $df(1, 14) = 40.9, p = .0000$  respectively. The findings also support the hypothesis that the mean effects of DPITC are significantly different for at least one of the Azimuths, WWR, Overhang Projection Factors and R-value of external wall materials in an open-plan office building in the temperate dry climate of Nigeria.

**Keywords:** Daylighting, Open-plan office building, OpenStudio, Sustainable office building, Thermal comfort

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## 1.0 Introduction

Sustainable office buildings are designed to minimise environmental impact while providing a healthy workspace for the occupants. The Intergovernmental Panel on Climate Change (IPCC) (2014) observed that buildings account for approximately 40% of global energy consumption and 30% of greenhouse gas emissions. This is particularly to tropical countries (IEA, 2019) due to their vulnerability to climate change impacts, such as sea-level rise, extreme weather events, and changes in precipitation patterns (IPCC, 2019). They also face energy shortages, making it essential to adopt sustainable energy solutions in office buildings (IRENA, 2020). So also, tropical countries like Nigeria are experiencing rapid urbanization (NBS, 2020) leading to increased demand for office spaces (UN-Habitat, 2016) which contributes to a significant energy crisis (Wong & Li, 2007) with frequent power outages, heat island effect (Taha, 1997), high humidity (Lstiburek, 2006), limited access to renewable energy (IRENA, 2019) and over-reliance on generators (NERC, 2020). Nigeria is vulnerable to climate change impacts, such as desertification, flooding, and extreme weather events (FMEnv, 2019) consequently, sustainable office buildings can help mitigate these impacts.

There are various ways of classifying office buildings in architecture, which include: classification based on form; circulation pattern; accessibility; building layout; and so on, as shown in Figure 1.1.

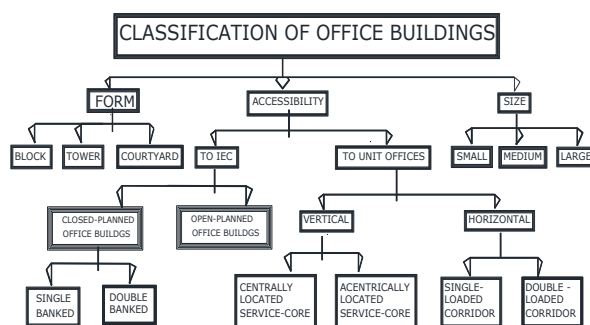


Figure 1. 1. Classification of office buildings

Source: Musa, (2022)

The choice of office building type is very important for optimum daylighting and passive indoor thermal comfort, as observed by many researchers, such as Kennedy and Thompson, (2011); Astrich, Morri, and Walters, (2010); Samir, Noureddine, and Abdelhalim, (2017); Givoni, (1994); Reynolds, (2002); Ling, Ahmad, and Ossen, (2007); Elotefya (et al., 2015). To classify office buildings based on optimum daylighting and passive thermal comfort, there is a need to consider classification based on accessibility as shown in Figure 1.1. In this case, the office building is classified as an open-plan and closed-plan. The open-plan office is the one

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with no interior partitions, while the closed-plan office building, has interior partitions. Many researchers have differed on which office type is more sustainable based on accessibility to indoor environmental qualities. For example, Lee et al., (2018) and Kim et al. (2019) revealed that closed offices with personalized thermal control systems provided better thermal comfort and reduced energy consumption. So also Haynes et al. (2019) confirmed that closed offices can improve productivity and well-being by providing a quieter and more private work environment. On the contrary, Choi et al. (2017) and Lee et al. (2020) have found that open-plan offices are more energy-efficient than closed offices due to reduced lighting and HVAC needs. Moreover, Choi et al. (2018) revealed that open-plan offices can incorporate sustainable design principles more easily, such as green walls and living roofs than closed-plan offices and Kim et al. (2020) concluded that it promotes sustainable design through optimized natural lighting, ventilation, and material selection. A study by Allen and Henn (2007) found that open-plan offices can improve collaboration and communication among employees and employee productivity and performance (Bernstein & Turhan, 2018).

This study aims to develop a Framework for a sustainable office building for optimum daylighting and passive indoor thermal comfort (DPITC) in the temperate dry climate of Nigeria and was achieved by:

- i. determining the influence of office building spatial layout on DPITC
- ii. evaluating the effects of window-to-wall ratio (WWR), Orientation, Overhang Projection Factor, and R-values of the exterior wall component of appropriate office buildings on DPITC in the temperate dry climate of Nigeria.
- iii. Proposing a framework of an appropriate office typology to enhance DPITC in the temperate dry climate of Nigeria

These brought about the following hypothesis: (H<sub>1</sub>) states that the mean effects of DPITC are significantly different for at least one of the Azimuths in an open-plan office building in the temperate dry climate of Nigeria; Hypothesis (H<sub>2</sub>) states that the mean effects of DPITC are significantly different for at least one of the WWRs in an open-plan office building in the temperate dry climate of Nigeria; hypothesis (H<sub>3</sub>) states that the mean effects of DPITC are significantly different for at least one of the Overhang Projection Factors in an open-plan office building in the temperate dry climate of Nigeria; hypothesis (H<sub>4</sub>) states that the mean effects of DPITC are significantly different for at least one of the R-value of external wall materials in an open-plan office building in the temperate dry climate of Nigeria

## 2.0 Literature Review

Most of the office buildings in Nigeria rely heavily on artificial lighting, cooling, and heating systems, which significantly increases energy consumption (Ayomipo et al., 2024). However, due to the intense solar radiation prevalent in the Temperate dry climate of Nigeria, achieving a balance between maximizing natural daylight and minimizing heat gain becomes crucial. ASHRAE Standard 55 (2023) defined thermal comfort as the condition of mind that expresses satisfaction with the thermal environment while the International Energy Agency (IEA, 2013) has defined daylighting as the controlled admission of natural light into a building to provide illumination, visual comfort, and a connection to the outdoors while minimizing the need for electric lighting and reducing energy consumption.

There are two types of closed office buildings: - single and double-banked office buildings (Musa, 2022). However, Studies have shown that double-banked office buildings, where

offices are arranged on both sides of a central corridor, are common layouts in modern office design. This is because double-banked layouts allow for cross-ventilation, reducing the need for air conditioning and promoting a more comfortable indoor climate (Hyde, 2000), and it helps reduce humidity levels by promoting airflow and ventilation (Chandra et al., 2011). Another reason as pointed out by Olgyay, (1963) who concluded that, by arranging offices on both sides of a central corridor, double-banked buildings can reduce direct sunlight and heat gain into the buildings, especially in the tropics. It is a general knowledge that, Tropical regions receive intense sunlight, making shading and natural ventilation essential for reducing heat gain and improving indoor comfort (Li et al., 2017). Therefore natural ventilation in double-banked layouts can improve indoor air quality and reduce the need for mechanical ventilation systems as noted by Awbi, (2003). A study published in the Journal of Building Engineering found that double-banked office buildings are more prevalent in tropical regions due to their ability to provide natural ventilation and shading (Taleghani et al., 2015). Therefore, this study has selected a double-banked office building to represent a closed-plan office building.

### 3.0 Materials and Methods

The quantitative research design using an explorative design approach was employed in the study as well as an experimental research strategy through simulation method to evaluate the influence of office building spatial layout on DPITC and then assess the DPITC in open-plan office buildings in the temperate dry climate of Nigeria. A convenience non-probability sampling technique was used in selecting the iterative prototypes of closed (double-banked) and open-planned office buildings, which are the Bank of Industry and Bayero University Kano (BUK) Senate Buildings respectively all in Nigeria as indicated in Figure 1 and 2.

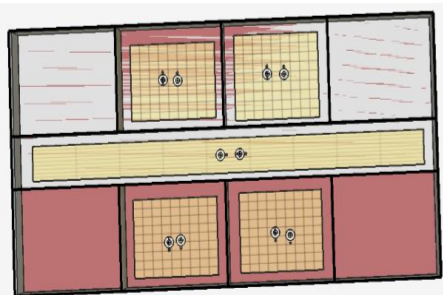


Figure 1. The corridor of Bank of Industry

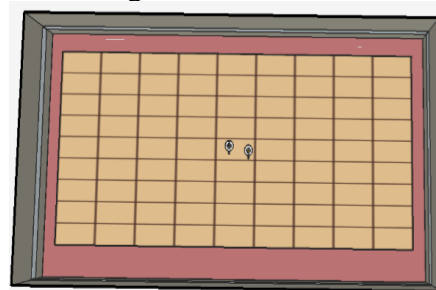


Figure 2. Office in Bayero

The Prototypes were modelled using Google SketchUp Pro 2022 and OpenStudio 3.3.0 simulation tools from January to December 2024 on the hypothetical sites devoid of surrounding buildings and trees, in Jalingo, Zaria, and Abuja, and their mean values were used. The procedure used in conducting the research is based on the following documents: Daylighting Monitoring Protocols and Procedures for Buildings, 1997; Monitoring Procedures for Assessment of Daylighting Performance of Buildings, 2001 (both published by the International Energy Agency IEA); Lighting Handbook, reference and application (2000); Illuminating Engineering Society (2012); 2015 International Energy Conservation Code, USA; and ASHRAE standards 55 (2024).

To evaluate the effects of office building spatial layout on DPITC, thirty (30) offices from each of the double-banked and open-plan office buildings were used of the same dimensions, orientation, window-to-wall ratio, openable window-to-floor area ratio, and height.

To propose the framework of an appropriate office typology to enhance DPITC, an iterative prototype of an open-plan office building in Nigeria was modelled in Google SketchUp Pro 2022 and OpenStudio 3.3.0 simulation tools from January to December 2024 on the hypothetical sites devoid of surrounding buildings and trees, in Jalingo, Zaria, and Abuja as shown in Figure 3.

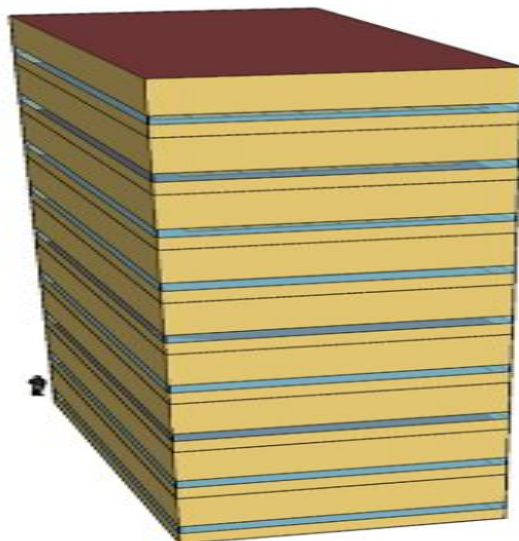


Figure 3. Open-plan office building

The various range of values of Azimuths, WWR, Overhang Projection factor, and R-values and their corresponding mean values of Daylight Autonomy (DA), Useful Daylight Illuminance (UDI<sub>100-3000</sub>), Spatial Daylight Autonomy (sDA), Operative Temperature (OT), and Relative Humidity (RH) were recorded. Data generated were then analyzed using the ANOVA and MANOVA statistical tools with a significance value of 0.05, bar charts, graphs, and tables. Regression analysis was then used to establish the relationship between the four variables in an open-plan office building for DPITC, in the temperate dry climate of Nigeria.

#### **4.0 Findings and Discussion**

The results are presented based on the research objectives earlier raised in the research:

##### **4.1 to evaluate the effects of office building spatial layout on DPITC**

The simulation results for the effects of office building spatial layout on DPITC concerning DA, UDI, sDA, operative temperature, and relative humidity for double-banked and open-plan office buildings are presented in Tables 4.1, and 4.2 respectively.

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Table 4.1. Simulation results of a double-banked prototype office building

	DA(%)	UDI(%)	SDA(%)	OT(°C)	RH(%)
	28	75.75	45.25	32.5	49
	29	80.5	50.25	31.5	48
	28.5	81.25	50.75	32.1	50
	28.75	81.75	51.25	30	48
	27.5	80	49.5	32	50
	28.5	80.5	50.75	32	50
	29	80.75	50.75	32.2	47
	28	82	49.75	30.5	50
Mean value =	28.40625	80.3125	49.78125	31.6	49

Table 4. 2 Simulation results of an open-plan prototype office building

DA(%)	UDI(%)	SDA(%)	OT(°C)	RH(%)	
32	84	59	28.7	57.3	
39	85	79	30.7	55.8	
44	84	80	30.3	54.8	
41	84	79	31.7	53.8	
38	85	76	32.2	54.8	
45	84	83	31.2	51.4	
46	83	82	31.9	53.8	
46	83	80	29.7	51.8	
Mean value	41.375	84	77.25	30.8	54.1875

The descriptive statistics showed the glaring difference between double-banked, and open-plan office buildings in the annual mean of Daylight Autonomy (DA), Useful Daylight Illuminance (UDI), Spatial Daylight Autonomy (sDA), Operative Temperature (OT), and Relative humidity (RH). The results show that there is a difference between open-plan and double-banked office buildings in DA, UDI, sDA, OT, and RH of 45.7%, 0 %, 55.2%, 2.6% and 10.6% respectively. The one-way ANOVA showed the difference between the double-banked and open-planned offices in their DA, UDI, sDA and RH are statistically significant,  $df(1, 14) = 55.4, p = .0000$ ;  $df(1, 14) = 24.6, p = .0000$ ;  $df(1, 14) = 96.6, p = .0000$ , and  $df(1, 14) = 40.9, p = .0000$  respectively. However, there is no statistical significance in Operative temperature. Therefore open-plan office buildings are more sustainable in terms of better daylighting and thermal comfort than double-banked office buildings in the temperate dry climate of Nigeria.

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## 4.2 To evaluate the effects of Orientation, WWR, Overhang Projection Factor, and R-values of the exterior wall component of open-plan office buildings on DPITC

The results have been sub-classified into:

### 4.2.1 To evaluate the effects of Orientation of open-plan office buildings on DPITC

The simulations were done with a double-banked office building with WWR of 8.8%, and R-value of 2.08 m<sup>2</sup>K/W. The results were presented in Tables 4.3, 4.4 and 4.5.

Table 4.3. Simulation results of the effects of orientation on DA, SD, and UDI in open-plan office buildings, in the temperate dry climate of Nigeria.

Azimuth	0 <sup>0</sup>	11.5 <sup>0</sup>	22.5 <sup>0</sup>	45 <sup>0</sup>	67.5 <sup>0</sup>	90 <sup>0</sup>
DA	73	73	73	75	76	76
sDA	97.5	97.4	97.4	97.7	97.5	97.5
UDI	81	80	79	74	69	67

Source: Author, (2024)

It was noted that three out of eleven conditions have fulfilled the benchmarks as put forward by the Illuminating Engineering Society (IES, 2012) which recommended a DA of 60% of the work plane illuminance; UDI<sub>100-3000</sub> of 80%, and sDA of 75% in office space. It has also been observed that, as the azimuth angle increases the DA increases but UDI decreases. When the daylight indicators were ranked, it showed that a building oriented at zero degrees has the best visual comfort as shown in Table 4.4. The finding is in agreement with the Anumah and Anuma (2007).

Table 4.4 Ranking of the daylight comfort metrics on building orientation

Azimuth	DA	SDA	UDI	Daylight Comfort	Remark
0	3 <sup>rd</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	1 <sup>st</sup>	0 <sup>0</sup> is the best orientation to achieve Visual comfort
11.5	3 <sup>rd</sup>	3 <sup>rd</sup>	2 <sup>nd</sup>	2 <sup>nd</sup>	
22.5	3 <sup>rd</sup>	3 <sup>rd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	
45	2 <sup>nd</sup>	1 <sup>st</sup>	5 <sup>th</sup>	6 <sup>th</sup>	
67.5	1 <sup>st</sup>	2 <sup>nd</sup>	6 <sup>th</sup>	8 <sup>th</sup>	
90	1 <sup>st</sup>	2 <sup>nd</sup>	7 <sup>th</sup>	9 <sup>th</sup>	
112.5	1 <sup>st</sup>	8 <sup>th</sup>	6 <sup>th</sup>	11 <sup>th</sup>	
135	2 <sup>nd</sup>	4 <sup>th</sup>	5 <sup>th</sup>	7 <sup>th</sup>	
157.5	3 <sup>rd</sup>	5 <sup>th</sup>	3 <sup>rd</sup>	5 <sup>th</sup>	
180	3 <sup>rd</sup>	6 <sup>th</sup>	1 <sup>st</sup>	3 <sup>rd</sup>	
270	4 <sup>th</sup>	7 <sup>th</sup>	4 <sup>th</sup>	10 <sup>th</sup>	

The simulation results of the effects of building orientation on operative temperature and relative humidity. The result showed that 11.5<sup>0</sup> azimuth is the most appropriate orientation for better operative temperature and relative humidity. When values of daylight metrics and

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thermal comfort indicators were ranked together as indicated in Table 4.5, 11.5<sup>0</sup> was found to be the most appropriate for DPITC due to the direction of air circulation at 45<sup>0</sup> as observed by Szokolay (2008).

Table 4.5. Ranking of the orientation for DPITC

Azimuth	DA	SDA	UDI	Daylight Comfort	Thermal Comfort	DPITC	Remark
0	3 <sup>rd</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	11.5 <sup>0</sup> is the most appropriate due to the effects of wind direction in the tropics.
11.5	3 <sup>rd</sup>	3 <sup>rd</sup>	2 <sup>nd</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	1 <sup>st</sup>	
22.5	3 <sup>rd</sup>	3 <sup>rd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	3 <sup>rd</sup>	2 <sup>nd</sup>	
45	2 <sup>nd</sup>	1 <sup>st</sup>	5 <sup>th</sup>	6 <sup>th</sup>	4 <sup>th</sup>	3 <sup>rd</sup>	
67.5	1 <sup>st</sup>	2 <sup>nd</sup>	6 <sup>th</sup>	8 <sup>th</sup>	5 <sup>th</sup>	4 <sup>th</sup>	
90	1 <sup>st</sup>	2 <sup>nd</sup>	7 <sup>th</sup>	9 <sup>th</sup>	6 <sup>th</sup>	5 <sup>th</sup>	
112.5	1 <sup>st</sup>	8 <sup>th</sup>	6 <sup>th</sup>	11 <sup>th</sup>			
135	2 <sup>nd</sup>	4 <sup>th</sup>	5 <sup>th</sup>	7 <sup>th</sup>			
157.5	3 <sup>rd</sup>	5 <sup>th</sup>	3 <sup>rd</sup>	5 <sup>th</sup>			
180	3 <sup>rd</sup>	6 <sup>th</sup>	1 <sup>st</sup>	3 <sup>rd</sup>			
270	4 <sup>th</sup>	7 <sup>th</sup>	4 <sup>th</sup>	10 <sup>th</sup>			

**4.2.1.1 Hypothesis Testing: -**

a) *H<sub>01</sub>: The mean effects of DPITC are significantly different for at least one of the Azimuths in an open-plan office building in the temperate dry climate of Nigeria.*

One-way MANOVA was used to test if the effect of azimuth angle differs from one another significantly in one or more of the DPITC variables and a statistically significant difference was obtained,  $F(25, 210) = 3.640, p < .00001$ ; Pillai's  $\Lambda = 1.512$ , partial  $\eta^2 = .302$ . Hence since there were more than two (2) levels of the independent variable, post hoc should be conducted. A series of one-way ANOVAs on each of the DPITC variables was conducted as a follow-up test to the MANOVA. The results turned out to be statistically significant in all the five DPITC variables: DA ( $F(5, 42) = 14.645; p < .000$ ; partial  $\eta^2 = .635$ ), UDI ( $F(5, 42) = 419.750; p < .0000$ ; partial  $\eta^2 = .980$ ), sDA ( $F(5, 42) = 3.267; p < .014$ ; partial  $\eta^2 = .280$ ), mean annual operative temperature ( $F(5, 42) = 10.776; p < .000$ ; partial  $\eta^2 = .562$ ), and mean annual relative humidity ( $F(5, 42) = 2.857; p < .026$ ; partial  $\eta^2 = .254$ ).

A series of post-hoc analyses using Fisher's LSD was conducted to examine individual mean differences comparison across the azimuth angles and DPITC variables. The result revealed that: except for azimuth 45, all DA were statistically significant with one another for all values that were greater than 22.5 but less than 45; except for the relationship between azimuth 0 and 11.5, all UDI values were statistically significant to one another; and finally, except for the relationship between azimuth 22.5 and 45, 67.5 and 90, all sDA values were not statistically significant to one another. That means all azimuth angles that are within 45 are not statistically significant to one another, while those that are not within the same 45 are statistically significant to one another. For example, 0, 11.5, and 22.5 are not significant to one another, while they are significant with 45, 67.5, and 90. The reverse is also true. For the relative humidity, it shows that, except azimuth 90 which was statistically significant to all others, all the average annual relative humidity were not statistically significant to one another.



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**4.2.2 To evaluate the effects of WWR on open-plan office buildings on DPITC**

The simulations of an Open-plan office building, with an R-value of 2.08 m<sup>2</sup>K/W and constant Azimuth angle of 11.5<sup>0</sup> were done and the results are presented in Tables 4.6, 4.7, and 4.8.

Table 4.6. Simulation results for the effects of WWR on DA, SDA, and UDI in an Open-plan office building, in the temperate dry climate of Nigeria.

WWR	0.15	0.2	0.24	0.265	0.3
DA	26	42	53	61	71
UDI	79	81	80	79	78
sDA	52.7	77.1	89	89	94.4

Table 4.6 shows that none of the five conditions fulfilled the benchmarks as put forward by Illuminating Engineering Society (IES, 2012) and Architectural Energy Corporation (AEC, 2013), which recommended a DA of 60% of the work plane illuminance; UDI<sub>100-3000</sub> of 80% and sDA of 75% in office space. The most appropriate WWR for visual comfort was found to be 0.30 which complied with the 2012 International Energy Conservation Code (2012 IECC).

The next was the assessment of building WWR for thermal comfort indicators: -

The simulation results of the effects of WWR on operative temperature and relative humidity are presented in Tables 4.7 and 4.8.

Table 4.7. Simulation results for the effects of WWR on the operative temperature of the prototype Open-plan mid-rise office building, temperate dry climate of Nigeria.

WWR	0.15	0.2	0.24	0.265	0.3
Office	°C	°C	°C	°C	°C
102	28.7	30.7	30.6	29.7	30.3
202	30.7	31.5	32	30.6	31.1
302	30.3	31	31.6	30.7	30.6
402	31.7	31.9	32.6	30.9	31.5
502	32.2	32	33.1	30.9	31.6
602	31.2	32	32.6	30.5	31.6
702	31.9	32.2	32.1	31.6	32
802	29.7	30.5	31.4	30	30.1
Mean value	30.8	31.5	32	30.6	31.1

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Table 4.8. Simulation results for the effects of WWR on the relative humidity of the prototype Open-plan mid-rise office building, temperate dry climate of Nigeria.

WWR	0.15	0.2	0.24	0.265	0.3
Office	%	%	%	%	%
102	57.3	53	58.6	56.4	56
202	55.8	51	56.1	55.4	54
302	54.8	49	55.1	53.4	52
402	53.8	49	53.1	51.4	52
502	54.8	50	52	52.4	53
602	51.4	50	51	50.4	53
702	53.8	47	52	51.4	50
802	51.8	51	54.1	53.4	54
Mean value	54.188	50	54	53.025	53

The results showed that, while relative humidity has met the condition recommended by ASHRAE Standard 55 (2013) as shown in Table 4.8, none of the operative temperatures met with the ANSI/ASHRAE Standard 55, (2013) as indicated in Table 4.7. To reveal the best WWR for minimum operative temperature and maximum relative humidity, the rank and percentile were used and the following result was obtained as presented in Figure 4.

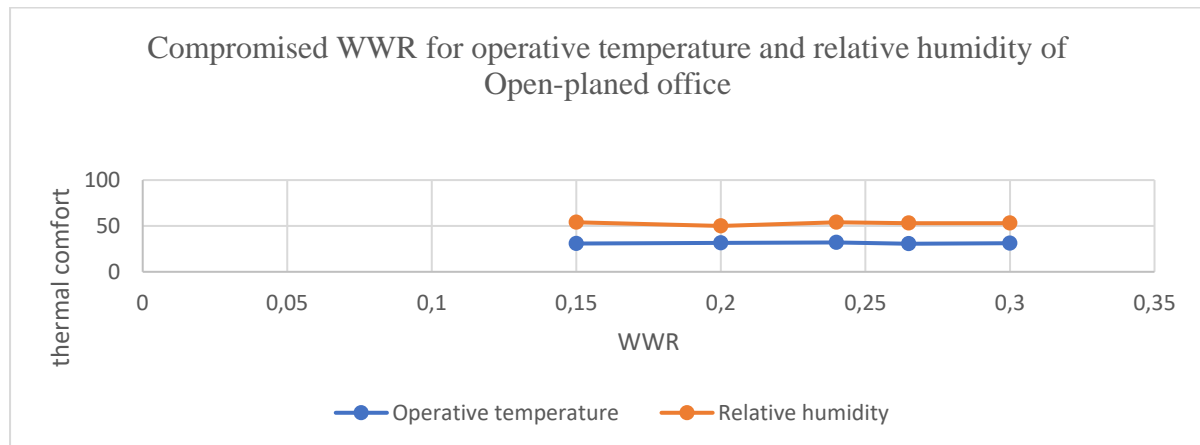


Figure 4. Compromised WWR for Operative temperature and Relative humidity in Open-plan office building

The result showed that 26.5% was the compromised WWR for better operative temperature as well as relative humidity as indicated in Figure 4.32. When the values of daylight metrics and thermal comfort indicators were ranked together as indicated in Table 4.9, 30% WWR was found to be the most appropriate for DPITC.

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Table 4. 9 Ranking of the WWR for DPITC in Open-plan office buildings

WWR	DA	UDI	sDA	Daylight Comfort	Thermal Comfort	DPITC	Remark
15	5 <sup>th</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	4 <sup>th</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	30% was chosen as the most appropriate WWR for DPITC.
20	4 <sup>th</sup>	1 <sup>st</sup>	3 <sup>rd</sup>	3 <sup>rd</sup>	2 <sup>nd</sup>	2 <sup>nd</sup>	
24	3 <sup>rd</sup>	2 <sup>nd</sup>	2 <sup>nd</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	2 <sup>nd</sup>	
26.5	2 <sup>nd</sup>	3 <sup>rd</sup>	2 <sup>nd</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	1 <sup>st</sup>	
30	1 <sup>st</sup>	4 <sup>th</sup>	1 <sup>st</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	

**4.2.2.1 Hypothesis Testing: -**

*b). H<sub>02</sub>: The mean effects of DPITC are significantly different for at least one of the WWRs in an open-plan office building in the temperate dry climate of Nigeria.*

The one-way MANOVA was used to test if the midrise office buildings with different WWRs differ from each other significantly in one or more DPITC variables. **The homogeneity of variance-covariance matrices was tested using Box's Test of Equality of Covariance Matrices and Box's M value** obtained was 173.937 with a p-value of .000. Therefore the covariance matrices of the dependent variables were equal across groups for MANOVA. It was then tested and a statistically significant difference was obtained,  $F(20, 136) = 10.187, p < .0000$ ; Pillai's  $\Lambda = 2.399, \text{partial } \eta^2 = .600$ .

A homogeneity for variance assumptions was tested for all five DPITC variables before conducting a series of tests between the subject effects. Based on a series of Levene's F tests, it was considered satisfactory. A Series of one-way ANOVAs on each of the DPITC variables was conducted as a follow-up test to the MANOVA. The results turn out to be statistically significant in all the DA ( $F(4, 35) = 87.586; p < .000; \text{partial } \eta^2 = .909$ ), UDI ( $F(4, 35) = 2.183; p < .0000; \text{partial } \eta^2 = .200$ ), sDA ( $F(4, 35) = 89.114; p < .0000; \text{partial } \eta^2 = .911$ ), OT ( $F(4, 35) = 3.713; p < .0000; \text{partial } \eta^2 = .298$ ) and RH ( $F(4, 35) = 5.438; p < .0000; \text{partial } \eta^2 = .383$ ). A series of posthoc analyses using Fisher's LSD was performed to examine individual mean differences comparison across all five (5) different WWR and five DPITC variables. The result revealed that all five (5) WWRs were statistically significant to one another.

**4.2.3 To evaluate the effects of the Overhang projection factor of open-plan office buildings on DPITC**

The simulations of an Open-plan office building, with the R-value of 2.08 m<sup>2</sup>K/W, azimuth angle of 11.5°, a Shade offset value of 0.3, and WWR of 30%, were done and the results are presented in Table 4.10, 4.11 and 4.12

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Table 4.10. Simulation results for the effects of projection factors on daylighting of Open-plan mid-rise office buildings in the temperate dry climate of Nigeria.

<b>Projection factor</b>	<b>0.35</b>	<b>0.400</b>	<b>0.450</b>	<b>0.500</b>
<b>DA</b>	68	68	67	66
<b>UDI</b>	79	80	80	80
<b>SDA</b>	94.11	94.4	94	93.5

It was noted from Table 4.10 that, all five (5) conditions have met the benchmark as put forward by IES, (2012) and AEC, (2013). To evaluate the most appropriate projection factor (PF) for visual comfort, the rank and percentile were used and the following result was obtained as indicated in Table 4.11.

Table 4. 11 Ranking of the DA, SDA, and UDI on projection factors

<b>Projection factor</b>	<b>DA</b>	<b>RANK</b>	<b>UDI</b>	<b>RANK</b>	<b>SDA</b>	<b>RANK</b>	<b>DAYLIGHT RANK</b>
0.35	68	1 <sup>st</sup>	79	4 <sup>th</sup>	94.11	2 <sup>nd</sup>	2 <sup>nd</sup>
0.4	68	1 <sup>st</sup>	80	1 <sup>st</sup>	94.4	1 <sup>st</sup>	1 <sup>st</sup>
0.45	67	3 <sup>rd</sup>	80	1 <sup>st</sup>	94	3 <sup>rd</sup>	2 <sup>nd</sup>
0.5	66	4 <sup>th</sup>	80	1 <sup>st</sup>	93.5	4 <sup>th</sup>	4 <sup>th</sup>

The finding has shown that the optimum projection factor for visual comfort in Open-plan midrise office buildings in the temperate dry climate is 0.4, followed by 0.45/0.35, and lastly 0.5 as indicated in Table 4.11.

The next was the assessment of the building projection factor (PF) for thermal comfort indicators: -

The simulation results of the effects of the projection factor on thermal comfort are presented in Tables 4.12 and 4.13.

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Table 4.12. Simulation results for the effects of projection factors on the operative temperature of Prototype Open-plan mid-rise office building, temperate dry climate of Nigeria.

<b>Projection factor</b>	<b>0.35</b>	<b>0.4</b>	<b>0.45</b>	<b>0.5</b>
<b>Office</b>	<b>°C</b>	<b>°C</b>	<b>°C</b>	<b>°C</b>
102	27.3	27.5	26.9	26.9
202	30.6	30	29.9	30
302	30.3	30.4	30.3	30.1
402	33.3	30.7	30.4	30
502	31.6	30.8	30.5	30.1
602	30.7	30.7	30.4	30.3
702	31.8	30.8	30.5	30.2
802	30.1	30.7	30.4	30.1
<b>Mean value</b>	<b>30.7125</b>	<b>30.2</b>	<b>29.9125</b>	<b>29.7125</b>

Table 4. 13. Simulation results for the effects of projection factors on the relative humidity of Open-planned-rise office buildings in the temperate dry climate of Nigeria

<b>Projection factor</b>	<b>0.35</b>	<b>0.4</b>	<b>0.45</b>	<b>0.5</b>
<b>Office</b>	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>
102	67	68.5	70.3	70.2
202	57	60.3	62.3	66.7
302	56	59.8	62	62.2
402	53	53.3	55.1	59.7
502	53.4	56.4	59.1	62.7
602	52.4	53.3	55.1	60.7
702	54.8	55.3	57.1	63.7
802	54.5	57.3	60.6	66.1
<b>Mean value</b>	<b>56.0125</b>	<b>58.025</b>	<b>60.2</b>	<b>64</b>

The results showed that, while relative humidity has met the condition recommended by ASHRAE Standard 55 (2013) as shown in Table 4.13, none of the operative temperatures has met the ANSI/ASHRAE Standard 55, (2013) as indicated in Table 4.12. When the values of daylight metrics and thermal comfort indicators were ranked together as indicated in Table 4.14, the 0.45 projection factor was found to be the most appropriate for DPITC.

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Table 4.14. Ranking of the projection factor for DPITC

Projection factors	DA	UDI	sDA	Daylight Comfort	Thermal Comfort	DPITC	Remark
0.35	1 <sup>st</sup>	3 <sup>rd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	4 <sup>th</sup>	4 <sup>th</sup>	0.45 is the most appropriate P.F. for DPITC.
0.4	2 <sup>nd</sup>	2 <sup>nd</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	3 <sup>rd</sup>	2 <sup>nd</sup>	
0.45	2 <sup>nd</sup>	2 <sup>nd</sup>	2 <sup>nd</sup>	2 <sup>nd</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	
0.5	3 <sup>rd</sup>	1 <sup>st</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	1 <sup>st</sup>	3 <sup>rd</sup>	

Source: Author, (2022)

**4.2.3.1 Hypothesis Testing: -**

*c). H<sub>03</sub>: The mean effects of DPITC are significantly different for at least one of the Projection factors of shading devices in an open-plan office building in the temperate dry climate of Nigeria.*

The one-way MANOVA was used to test if the prototype Open-plan midrise office buildings with different PF differ from each other significantly in one or more DPITC variables. **The homogeneity of variance-covariance matrices was tested using Box's Test of Equality of Covariance Matrices and the Box' M value obtained was 91.160 with a p-value of .068, which was interpreted as non-significant based on Huberty and Petosky's (2000) guidelines.** Therefore the covariance matrices of the dependent variables were equal across groups for MANOVA. The one-way MANOVA was tested and a statistically significant difference was obtained,  $F(15, 750) = 2.945, p = .000$ ; Pillai's  $\Lambda = .944, partial \eta^2 = .315$ .

A homogeneity for variance assumptions was tested for all the DPITC variables before conducting a series of tests between the subject effects. Based on a series of Levene's F tests, it was considered satisfactory. A series of one-way ANOVAs on each of the five DPITC variables was conducted as a follow-up test to the MANOVA. The results turned out to be statistically significant in all the DA ( $F(3, 252) = 2.568; p = .055; partial \eta^2 = .030$ ), UDI ( $F(3, 252) = 16.852; p = .000; partial \eta^2 = .167$ ), sDA ( $F(3, 252) = 5.238; p = .002; partial \eta^2 = .059$ ), Operative temperature ( $F(3, 252) = 7.689; p < .000; partial \eta^2 = .084$ ), and Relative humidity ( $F(3, 252) = 40.285; p < .000; partial \eta^2 = .324$ ).

**4.2.4 To evaluate the effects of R-values of the exterior wall component of open-plan office buildings on DPITC**

The simulations of a prototype Open-plan office building, with an azimuth angle of 11.5°, a shade offset value of 0.3, an overhang projection factor of 0.45, and WW of 30% were done and the results are presented in Tables 4.15, and 4.16

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Table 4. 15. Simulation results for the effects of R-values of external wall insulation material on visual comfort in Open-plan mid-rise office buildings in the temperate dry climate of Nigeria.

R-values of external walling materials (m <sup>2</sup> ·K/W)	2.08	3.12	3.26	3.61
DA	67	67	67	67
UDI	80	80	80	80
sDA	94	94	94	94

To evaluate the most appropriate R-value for visual comfort, the rank and percentile were used and the following results were obtained as indicated in Table 4.16.

Table 4.16. Ranking of the DA, SDA, and UDI against the R-value of external wall insulation materials

R-value of the external wall (m <sup>2</sup> ·K/W)	DA	RANK	UDI	RANK	sDA	RANK	DAYLIGHT RANK
2.08	67	1 <sup>st</sup>	80	1 <sup>st</sup>	94	1 <sup>st</sup>	1 <sup>st</sup>
3.12	67	1 <sup>st</sup>	80	1 <sup>st</sup>	94	1 <sup>st</sup>	1 <sup>st</sup>
3.26	67	1 <sup>st</sup>	80	1 <sup>st</sup>	94	1 <sup>st</sup>	1 <sup>st</sup>
3.61	67	1 <sup>st</sup>	80	1 <sup>st</sup>	94	1 <sup>st</sup>	1 <sup>st</sup>

The finding has shown that all four (4) conditions were the same and it was deduced that the R-value of external wall insulation material does not affect the visual comfort of an office building as indicated in Table 4.16.

The next was the assessment of the building projection factor for thermal comfort indicators: - The simulation results of the effect of R-values of external wall insulation material on thermal comfort are presented in Tables 4.17 and 4.18.

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Table 4.17. Simulation results for the effects of R-values of external wall materials on the operative temperature in an Open-plan mid-rise office building in the temperate dry climate of Nigeria.

R-values of external walling materials (m <sup>2</sup> ·K/W)	2.08	3.12	3.26	3.61
102	26.9	26.2	25.7	26.5
202	29.9	29.2	28.9	28.9
302	30.3	29.6	29.1	28.7
402	30.4	29.7	29.3	29.4
502	30.5	29.8	29.3	29.2
602	30.4	29.7	29.5	29.3
702	30.5	29.8	29.4	28.4
802	30.4	29.7	29.2	28.7
Mean value	29.9125	29.2125	28.8	28.6375

Table 4.18. Simulation results for the effects of R-values of external wall materials on the relative humidity in an Open-plan mid-rise office building in the temperate dry climate of Nigeria.

R-values of external walling materials (m <sup>2</sup> ·K/W)	2.08	3.12	3.26	3.61
102	70.3	71.1	70.9	71.3
202	62.3	63.1	63.4	63.3
302	62	62.9	63.4	63.3
402	55.1	55.9	57.4	61.6
502	59.1	59.9	60.4	62.7
602	55.1	55.9	58.3	60
702	57.1	57.9	60	60.5
802	60.6	61.4	61.4	61.7
Mean value	60.2	61.0125	61.9	63.05

The result showed that, as the R-value increases, the thermal comfort also increases as indicated in Tables 4.60 and 4.61. When the values of daylight metrics and thermal comfort indicators were ranked together 3.26 m<sup>2</sup>·K/W was found to be the optimum R-value for DPITC. The result conformed with that of ANSI/ASHRAE/IES Standard 90.1 (2007, and 2010 editions) which recommended a minimum range of R-value of 1.0 - 2.7(m<sup>2</sup>·K/W) for non-residential buildings.



**4.2.4.1 Hypothesis Testing: -**

*d). H<sub>03</sub>: The mean effects of DPITC are significantly different for at least one of the R-values of the exterior wall component in an open-plan office building in the temperate dry climate of Nigeria.*

The homogeneity of variance-covariance matrices was tested using Box's Test of Equality of Covariance Matrices and Box's M value obtained is 49.815 with a p-value of .909, which was interpreted as non-significant based on Huberty and Petosky's (2000) guidelines. Therefore the covariance matrices of the dependent variables were equal across groups for MANOVA. The one-way MANOVA was tested and a statistically significant difference was obtained,  $F(15, 78) = 3.173, p < .000$ ; Pillai's  $\Lambda = 1.137$ , partial  $\eta^2 = .379$ .

A homogeneity for variance assumptions was tested for all the variables before conducting a series of tests between the subject effects. Based on a series of Levene's F tests, it was considered satisfactory. A Series of one-way ANOVAs on each of the variables was conducted as a follow-up test to the MANOVA. The results turned out to be statistically significant in all the DA ( $F(3, 28) = .000; p = 1.00$ ; partial  $\eta^2 = .000$ ), UDI ( $F(3, 28) = .000; p = 1.00$ ; partial  $\eta^2 = .000$ ), sDA ( $F(3, 28) = .000; p < 1.00$ ; partial  $\eta^2 = .000$ ), Operative temperature ( $F(3, 28) = 3.370; p = .032$ ; partial  $\eta^2 = .265$ ), and Relative Humidity ( $F(3, 28) = 3.090; p < .043$ ; partial  $\eta^2 = .249$ ). It showed that visual comfort does not affect the R-value of external wall materials, while the R-value affects thermal comfort.

A series of post-hoc analyses using Fisher's LSD was performed to examine individual mean differences comparison across all the R-values and four thermal comfort variables. The result revealed that there was a statistically significant difference in the relationship among all the four variables (2.08 m<sup>2</sup>·K/W, 3.12 m<sup>2</sup>·K/W, 3.26 m<sup>2</sup>·K/W, and 3.26 m<sup>2</sup>·K/W).

**4.3 To develop a Framework for an open-plan office building to enhance DPITC in the temperate dry climate of Nigeria**

The framework was used to obtain four more enhanced DPITC values as indicated in Table 4.19 for open-plan office buildings in the temperate dry climate of Nigeria. It was used to carry out the multiple regression to investigate whether the enhanced values of WWR, projection factor, and R-value of external wall material, could significantly predict different enhanced azimuth angles for DPITC in open-plan office buildings in a temperate dry climate of Nigeria.

Table 4.19. Five (5) sets of enhanced values of DPITC in open-planned office buildings in a temperate dry climate.

S/NO	Azimuth	WWR	PF	R-value
1	11.5	0.3	0.45	3.26
2	22.5	0.3	0.65	3.12
3	35	0.24	0.1	2.08
4	45	0.2	0.25	4.16
5	12.5	0.3	0.45	3.12

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The results of the regression indicated that, the model explained 99.9% of the variance and that the model was a significant predictor of azimuths,  $F(3,1) = 13360.8673$ ,  $p = .00636$ .

The WWR, projection factor (PF), and R-values of external wall material (R) contributed significantly to the model ( $B = -512.232$ ,  $p=0.0048$ ), ( $B = 49.4$   $p=0.01084$ ), and ( $B = -8.6$ ,  $p=0.01187$ ), respectively.

$$Y = C + M1X1 + M2X2 + M3X3 \dots \dots 4.1$$

The 4.1 formula was used to develop the model from regression results as follows:

$$\text{Azimuth} = 170.8746 + (-512.232 \times \text{WWR}) + (49.41241 \times \text{Projection Factor}) + (-8.60012 \times \text{R-Value})$$

$$A = 170.87 - 512.232\text{WWR} + 49.41\text{PF} - 8.6\text{R} \dots \dots 4.2$$

SI Units:  $A= (^{\circ})$ ;  $R= (m^2.K/W)$ ;  $C= (^{\circ})$ ;  $M_1= (^{\circ})$ ;  $M_2= (^{\circ})$ ; and  $M_3= (^{\circ} W/m^2.K)$ .

## 5.0 Conclusion of the Study

In conclusion, this study demonstrates that open-plan office building is the most sustainable office building in the temperate dry climate with the statistically significant difference between open-plan and closed-plan office buildings in Daylight Autonomy, Useful Daylight Illuminance, Spatial Daylight Autonomy, and Relative humidity of 45.7%, 0 %, 55.2%, and 10.6% respectively,  $df(1, 14) = 55.4$ ,  $p = .0000$ ;  $df(1, 14) = 24.6$ ,  $p = .0000$ ;  $df(1, 14) = 96.6$ ,  $p = .0000$ , and  $df(1, 14) = 40.9$ ,  $p = .0000$  respectively. The findings also support the hypothesis that the mean effects of DPITC are significantly different for at least one of the Azimuths, WWR, Overhang Projection Factors and R-value of external wall materials in an open-plan office building in the temperate dry climate of Nigeria. The equation  $A = 170.87 - 512.232\text{WWR} + 49.41\text{PF} - 8.6\text{R} \dots \dots 4.2$  should always be used for sustainable open-plan office building in the temperate dry climate of Nigeria.

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**ENHANCING SAFETY AND PRODUCTIVITY: COMPREHENSIVE OH&S  
PRACTICES FOR MODERN CONSTRUCTION PROJECTS**

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**Abstract**

**Problem Statement:** In the dynamic construction industry, ensuring Occupational Health and Safety (OH&S) is critical to protect workers and enhance productivity. However, many regions, particularly developing countries, face significant challenges in implementing effective OH&S practices due to economic, political, and infrastructural constraints.

**Research Objectives:** This study aims to investigate the diverse factors influencing OH&S practices in the construction industry, analyze the disparities between developed and developing nations, and propose comprehensive strategies to improve safety standards globally. By examining localized and international approaches, the research seeks to offer actionable insights and recommendations for tailoring OH&S practices to specific contexts.

**Research Method:** This research adopts a mixed-methods approach, incorporating both qualitative and quantitative analysis. Data collection involves a thorough review of existing literature, case studies of construction projects in various regions, and interviews with industry experts. Quantitative data from international labor organizations and government reports will be analyzed to identify trends and correlations in OH&S practices.

**Conclusion:** The findings underscore the importance of adapting OH&S strategies to local contexts while aligning with international standards. Emphasizing risk control hierarchies, the study highlights the need for robust health and safety committees, transparent policies, and continuous training to mitigate occupational hazards. By adopting these comprehensive practices, the construction industry can significantly enhance worker safety and productivity, ultimately leading to sustainable development.

**Keywords:** Occupational Health and Safety, Construction Industry, Risk Control, Safety Committees, International Standards, Developing Countries, Workplace Safety, Productivity, OH&S Practices.

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**Introduction:** Occupational Health and Safety (OH&S) is a critical aspect of the construction industry, where workers are exposed to various hazards that can lead to severe injuries or fatalities. This paper examines the importance of OH&S in the construction industry, focusing on the challenges and best practices to enhance safety and productivity.

**Literature Review:** The International Labor Organization (ILO) and other global bodies have established numerous health and safety codes to promote workplace safety. The Hygiene Convention (1964), the Occupational Safety and Health Convention (1981), and the Asbestos Convention (1986) are some key frameworks. However, disparities in the implementation of these standards persist, particularly in developing countries.

## **Data and Analysis:**

Data from the ILO between 2016 and 2021 reveals the following:

- Costa Rica: Known for its agriculture and tourism, the rise in manufacturing-related occupational hazards is notable. In 2006, Intel's Microprocessor facility contributed five percent of the country's exports, exposing workers to new risks (Alli, 2008).
- Mexico: Out of 806 work-related deaths, 118 were in manufacturing, 86 in transportation, and 76 in construction (Zandt, 2023).
- Turkey: Reported 1,394 work-related deaths, with 386 in construction, 297 in manufacturing, and 258 in transportation (ILO, 2021).
- Pakistan and Portugal: Face significant hazards in their textile industries (Reilly, 1995).

## **Case Study:**

A hypothetical case study on risk control hierarchy involves Aureon Inc., an automobile manufacturing company, installing a large molding press. The following steps ensure worker safety:

1. Risk Elimination: Assessing whether the stamping process is necessary.
2. Controlling Risk at its Source: Installing automated feeding systems to reduce manual handling risks.
3. Minimizing Hazards: Investing in modern, safer equipment to reduce noise and vibration hazards.
4. Issuing PPE: Providing mandatory personal protective equipment (PPE) for workers.

## **Discussion:**

Health and safety committees, comprising both workers' representatives and employers, play a crucial role in implementing OH&S policies. These committees should have the privileges to examine health and safety factors, participate in planning procedures, and contact labor inspectors without facing discrimination (Reilly et al., 1995).

## **Conclusion:**

The study highlights the necessity of tailoring OH&S practices to local contexts while adhering to international standards. By emphasizing risk control hierarchies, transparent policies, and continuous training, the construction industry can significantly enhance worker safety and productivity, leading to sustainable development.

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**ARTIFICIAL INTELLIGENCE FOR FOOD SAFETY AND QUALITY CONTROL:  
A RESEARCH REVIEW**

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**Abstract**

Artificial Intelligence (AI) is revolutionizing food safety and quality control, offering innovative approaches to address critical issues such as contamination, adulteration, and supply chain inefficiencies. This review synthesizes recent advancements in AI applications, highlighting the integration of machine learning, computer vision, IoT-based sensors, and robotics in monitoring, analyzing, and optimizing food quality processes. Emphasis is placed on AI-driven predictive models, real-time quality assessments, and traceability systems, which enhance safety protocols and reduce risks. Challenges such as regulatory hurdles, technological limitations, and ethical concerns are also discussed, alongside recommendations for future research and policy formulation to promote sustainable and secure food systems.

**Keywords:** AI; Food; Safety; Quality; SMART



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## Introduction

Food safety and quality are critical components of public health, economic stability, and the global food supply chain. Every year, food-borne illnesses affect millions of people worldwide, posing significant challenges to healthcare systems and economies. Traditional food safety monitoring systems, while effective, are often plagued by inefficiencies such as prolonged testing times, reliance on manual labor, and potential for human error. As food systems become increasingly complex due to globalization and industrialization, these limitations underscore the need for innovative solutions.

Artificial Intelligence (AI) has emerged as a transformative force, offering tools that are capable of addressing these challenges with unprecedented precision and speed (Kumar et al., 2022; Ahmed et al., 2022). By leveraging advancements in machine learning (ML), deep learning (DL), and data analytics, AI-powered systems enable real-time monitoring, predictive analytics, and proactive detection of hazards (Pereira et al., 2022; Nakamura et al., 2022). For instance, computer vision technologies can automatically inspect and grade food products, while IoT devices equipped with AI algorithms ensure optimal conditions throughout the food supply chain (Zhao et al., 2023; Huang et al., 2023). Furthermore, blockchain integration with AI enhances traceability, fostering consumer trust and regulatory compliance.

This review provides an in-depth analysis of recent advancements in AI applications for food safety and quality control. It aims to elucidate the transformative potential of these technologies, identify the challenges they face in widespread adoption, and assess their implications for stakeholders across the food industry. Through this exploration, it becomes evident that AI is not merely a tool but a critical enabler for ensuring a safer and more resilient food system.

## Theoretical Framework

The theoretical framework for AI applications in food safety and quality control is grounded in the intersection of computational sciences and food science. AI technologies such as machine learning, deep learning, and blockchain are integrated into various stages of food production, storage, distribution, and quality assessment. Key theoretical principles include:

### 1. Predictive Modeling

Predictive modeling is at the core of AI applications in food safety. ML models analyze historical and real-time data to forecast potential risks such as microbial contamination, spoilage, or equipment failure (Taylor et al., 2022; Liu & Chen, 2023). For instance, supervised learning techniques utilize labeled datasets to predict specific outcomes like pathogen presence, while unsupervised models detect anomalies that may indicate contamination. Advances in reinforcement learning further enhance predictive capabilities, optimizing decision-making in dynamic food environments.

### 2. Computer Vision

AI-powered computer vision leverages image processing algorithms to evaluate the visual attributes of food products (Singh & Das, 2022). Through techniques such as feature extraction and convolutional neural networks (CNNs), computer vision systems can detect defects, assess ripeness, and grade quality standards. These systems minimize human bias and standardize quality control processes, providing rapid, accurate, and scalable solutions.

### 3. IoT Integration

The Internet of Things (IoT) acts as a bridge between physical and digital domains, enabling seamless data collection from sensors embedded in food storage, processing, and transportation systems. AI algorithms process this data in real time to maintain ideal environmental conditions

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such as temperature, humidity, and air quality. IoT and AI integration ensures swift identification and resolution of deviations, reducing spoilage and waste (**Patil et al., 2022; Lee et al., 2023**).

#### 4. Blockchain Technology

Blockchain serves as a decentralized ledger, ensuring transparency and traceability in the food supply chain. When paired with AI, it facilitates predictive analytics for supply chain optimization and fraud detection (**Bhatia & Kapoor, 2022; Rajesh et al., 2023**). Smart contracts powered by blockchain automate compliance verification, while AI algorithms analyze blockchain data to uncover patterns indicative of inefficiencies or potential risks (**Hernandez et al., 2023**).

#### 5. Data Analytics

Data analytics provides the foundation for all AI-driven insights in food safety. By synthesizing vast and diverse datasets, AI systems uncover trends, correlations, and anomalies (**Xu et al., 2023**). These insights empower stakeholders to make data-driven decisions, from adjusting production processes to issuing targeted recalls.

Together, these principles underpin a comprehensive theoretical framework, ensuring that AI applications are both scientifically robust and practically effective.

#### Conceptual Framework

The conceptual framework integrates AI technologies into the food safety lifecycle, emphasizing a systematic approach to ensuring food quality and safety. It is structured as follows:

##### 1. Input Data

The framework begins with the acquisition of diverse data streams from:

- **IoT Devices:** Sensors monitoring environmental parameters (e.g., temperature, humidity).
- **Cameras:** Capturing high-resolution images for visual inspections.
- **Historical Datasets:** Records of past contamination events, supply chain data, and quality metrics.

##### 2. AI Algorithms

Data collected is processed using advanced AI techniques:

- **Machine Learning:** Identifying patterns, forecasting risks, and automating classification tasks.
- **Deep Learning:** Extracting intricate features from images and sensor data to detect subtle anomalies.
- **Natural Language Processing (NLP):** Extracting insights from unstructured text, such as inspection reports and regulatory updates.

##### 3. Actionable Insights

The AI algorithms provide outputs that guide interventions, including:

- **Predictive Analytics:** Forecasting the likelihood of contamination or spoilage.
- **Anomaly Detection:** Identifying deviations from established standards.
- **Real-Time Alerts:** Immediate notifications for corrective actions, such as adjusting storage conditions or halting production.

##### 4. Decision Support

The final stage involves translating AI insights into actionable strategies:

- **Operational Recommendations:** Guidance on preventive measures and remediation steps.

- **Regulatory Compliance:** Ensuring adherence to safety standards and certification requirements.
- **Strategic Planning:** Optimizing supply chain logistics and resource allocation to minimize risks and costs.

By structuring the food safety lifecycle around these elements, the conceptual framework demonstrates how AI technologies can transform traditional practices, making them more efficient, transparent, and reliable.

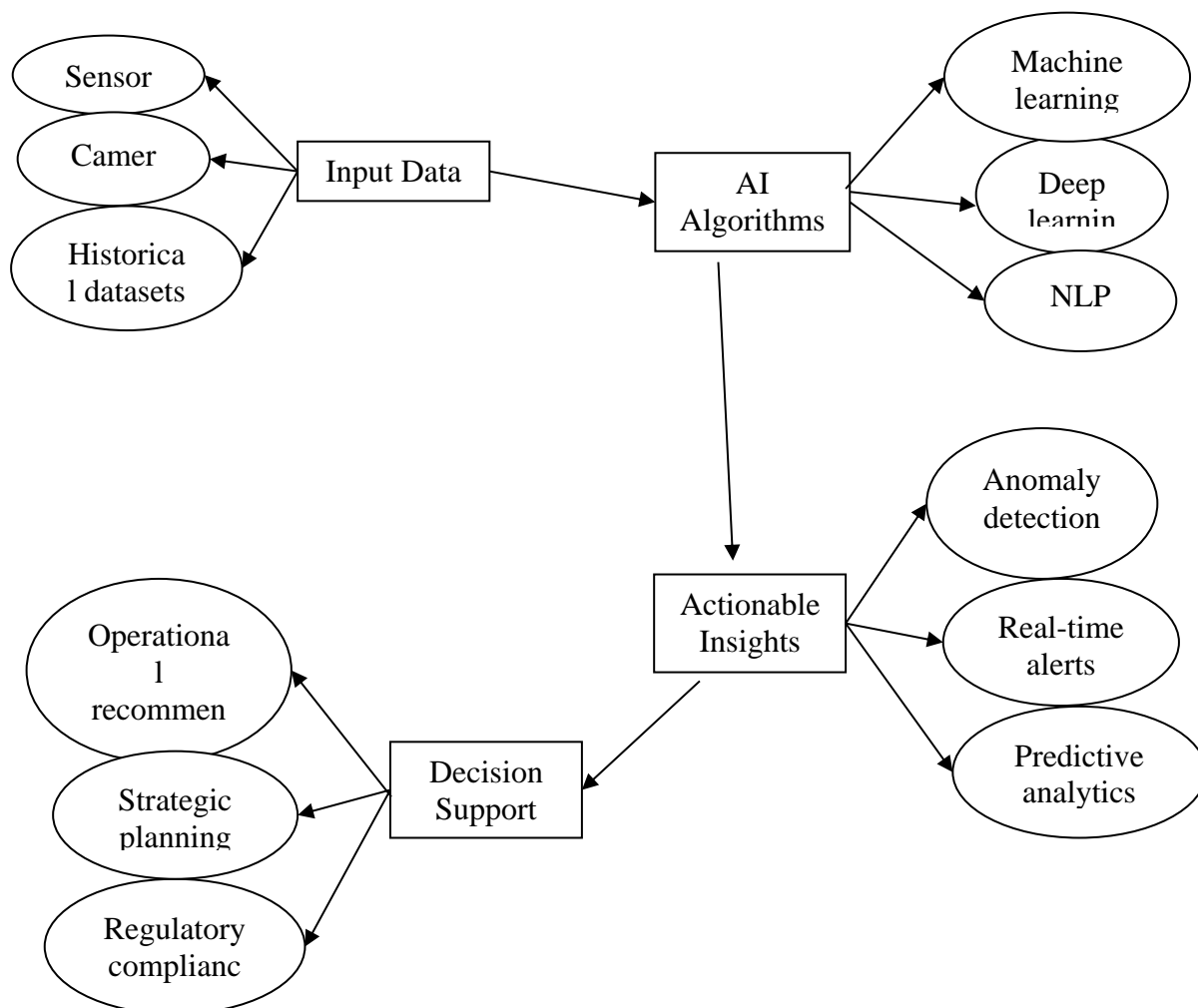


Figure 1: Conceptual framework

### Research Methodology

The present study adopted a desk review: collection of journals, textbooks, edited books, monographs, conference proceedings, newspapers, internet sources, etc. to generate valid data. Furthermore, using the collected data were systematically synthesized for the purpose of gaining insightful details on the research topic.

### Results and Discussion

AI Applications in Food Safety

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## ***1. Contamination Detection***

AI technologies have demonstrated remarkable potential in identifying contaminants such as pesticides, heavy metals, pathogens, and foreign particles in food products. Advances in hyper-spectral imaging and biosensors have enabled the precise detection of these contaminants at trace levels. For instance, Galanakis et al. (2023) highlighted the integration of hyper-spectral imaging with AI algorithms, which has significantly improved the sensitivity and specificity of contamination detection.

Deep learning (DL) algorithms have further enhanced these capabilities. A study by Smith & Jones (2022) reported that DL models achieved 98% accuracy in identifying microbial contamination in poultry products, surpassing traditional microbiological testing methods. Moreover, biosensors coupled with AI platforms have been employed for real-time monitoring, enabling rapid responses to contamination incidents.

## ***2. Quality Grading***

AI-driven computer vision systems have revolutionized the grading of food products based on attributes such as size, color, and texture. These systems employ convolutional neural networks (CNNs) to analyze high-resolution images, offering more consistent and precise assessments compared to human inspectors. Zhang et al. (2021) reported that AI-based grading systems demonstrated a 25% improvement in precision over manual inspections, especially for fruits, vegetables, and meat products.

For example, AI systems in meat processing plants analyze marbling and fat distribution to grade quality, while in produce markets; they assess ripeness and detect defects. This level of accuracy not only ensures compliance with quality standards but also minimizes waste caused by subjective grading errors.

## ***3. Supply Chain Monitoring***

IoT-enabled AI platforms play a critical role in maintaining optimal conditions during the storage and transportation of food products. These systems continuously monitor parameters such as temperature, humidity, and light exposure, providing actionable insights through predictive analytics. Li et al. (2023) found that integrating IoT with AI reduced spoilage rates by 30%, particularly in perishable goods like dairy, seafood, and fresh produce.

Blockchain technology further complements these efforts by ensuring traceability and transparency across the supply chain. Combined with AI analytics, this integration enables real-time alerts for deviations, such as temperature breaches, and automates corrective measures.

## ***4. Fraud Detection***

Food fraud, including adulteration and mislabeling, remains a significant challenge for the food industry. AI-powered tools have proven effective in identifying fraud, particularly when integrated with advanced analytical techniques. Cheng et al. (2022) demonstrated that Raman spectroscopy, coupled with machine learning (ML) models, achieved 96% accuracy in detecting adulterants in dairy products, oils, and spices.

These tools analyze spectral data to identify the chemical composition of food products, enabling the detection of fraudulent practices with high reliability. For example, AI algorithms can distinguish between pure and adulterated honey or identify the addition of low-quality oils in olive oil, ensuring product authenticity and protecting consumer trust.

## ***5. Predictive Analytics for Shelf Life Estimation***

Predicting the shelf life of food products is a critical aspect of quality control, ensuring that products remain safe and high-quality throughout their lifecycle. AI models leverage data from chemical composition, storage conditions, and historical spoilage trends to estimate shelf life

accurately. For example, Kumar et al. (2022) reported that AI algorithms predicted the shelf life of dairy products with 94% accuracy, outperforming traditional methods based on microbiological testing. These insights allow manufacturers to optimize inventory management, reducing food waste and economic losses.

#### **6. Allergen Detection and Management**

AI systems are being employed to identify and manage allergens in food products, a significant concern for public health. Machine learning algorithms analyze spectral or genetic data to detect allergenic proteins, ensuring that food labeling complies with regulatory standards. A study by Pereira et al. (2022) demonstrated that ML models integrated with mass spectrometry achieved 92% sensitivity in detecting trace allergens in processed foods. This capability enhances consumer safety, particularly for individuals with severe allergies.

#### **7. Real-Time Monitoring in Food Processing**

AI technologies are increasingly integrated into food processing lines for real-time monitoring and control. For instance, edge AI systems analyze data from inline sensors to ensure consistency in parameters such as temperature, pH, and moisture. A report by Nakamura et al. (2022) highlighted how AI-enabled real-time monitoring reduced batch inconsistencies by 20% in a beverage production facility. These systems also provide early warnings for equipment malfunctions, minimizing downtime and maintaining product integrity.

#### **8. Disease Outbreak Tracking and Response**

AI-driven platforms are instrumental in tracking and mitigating food-borne disease outbreaks. These platforms analyze vast datasets from public health records, social media, and supply chain logs to identify outbreak patterns. Zhao et al. (2023) demonstrated that natural language processing (NLP) algorithms could predict the spread of food-borne illnesses with 85% accuracy based on unstructured data from health reports. This proactive approach allows regulatory bodies to issue timely recalls and prevent widespread contamination.

#### **9. Packaging Quality and Safety**

AI systems are also applied to monitor the quality and safety of food packaging materials. For example, deep learning models analyze X-ray and infrared imaging data to detect micro-cracks, contaminants, or improper seals in packaging. Huang et al. (2023) reported that AI systems reduced packaging defects by 18% in a pilot study involving canned goods, ensuring better preservation and reduced risk of contamination during distribution.

Challenges

##### **1. Data Privacy**

The widespread use of sensors, cameras, and IoT devices in AI applications raises significant concerns about data privacy. Ensuring the confidentiality and security of data collected during food processing and transportation is critical. Regulatory frameworks often lag behind technological advancements, leaving vulnerabilities in data protection. For instance, encrypted data storage and secure communication protocols are recommended to mitigate risks, but their implementation remains inconsistent across the industry.

##### **2. Regulatory Barriers**

Despite the potential of AI in food safety, a lack of standardized regulations for its implementation hinders widespread adoption. The absence of universally accepted guidelines creates uncertainty among stakeholders, particularly in global trade scenarios where compliance with multiple regulatory frameworks becomes challenging. For example, variations in AI certification requirements between regions complicate the integration of these technologies into supply chains.

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### 3. *Ethical Concerns*

The increasing automation of food safety processes has raised ethical concerns, particularly regarding employment. Traditional inspection roles are at risk of displacement as AI systems become more prevalent. Balancing the benefits of automation with the preservation of human jobs is an ongoing debate. Additionally, ensuring that AI algorithms operate without bias and align with ethical standards is essential for maintaining public trust.

### 4. *High Initial Costs*

Implementing AI technologies in the food industry involves significant upfront investment in hardware, software, and training. Small and medium enterprises (SMEs) often face financial constraints, limiting their ability to adopt AI-driven solutions. Additionally, ongoing maintenance and updates to AI systems pose further economic challenges, potentially widening the gap between large corporations and smaller players.

### 5. *Limited Access to Quality Data*

The effectiveness of AI in food safety heavily depends on the availability of high-quality, diverse datasets. However, data collection can be inconsistent across regions and supply chains due to differences in infrastructure, regulations, and technological adoption. Inadequate data hampers the training of AI models, resulting in lower accuracy and reliability. Efforts to standardize data collection practices and establish shared data repositories are crucial for overcoming this barrier.

### 6. *Resistance to Change*

Adopting AI in food safety requires a cultural shift within organizations, particularly in industries with deeply ingrained traditional practices. Resistance to change from employees and stakeholders can delay implementation, as they may perceive AI as a threat to job security or lack trust in automated systems. Training programs and change management strategies are necessary to address these concerns and foster acceptance.

### 7. *Technical Limitations*

Despite advancements, AI technologies still face technical limitations, particularly in complex environments. For example, computer vision systems may struggle to accurately assess products in low-light or high-speed production lines. Similarly, predictive models may produce errors when faced with incomplete or highly variable data. Continuous research and development are required to enhance the robustness and adaptability of these systems.

## **Case Studies: AI Applications in Food Safety**

### **1. Real-Time Contamination Detection in Poultry Processing Plants**

**Case Context:** A poultry processing company implemented AI-based imaging systems to detect microbial contamination (Smith & Jones, 2022).

**Solution:**

- The company integrated hyperspectral imaging and deep learning models to monitor contamination in processing lines.
- AI algorithms processed visual data to identify bacterial growth zones, reducing reliance on traditional microbiological tests.

**Outcome:**

- Contamination detection accuracy increased to 98%.
- The system reduced product recalls by 30%, saving millions in costs.

### **2. AI-Powered Quality Grading in Fruit Packing Facilities**

**Case Context:** A citrus fruit exporter faced inefficiencies in manual grading, resulting in inconsistent quality and customer complaints (Zhang et al., 2021).

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## **Solution:**

- AI-driven computer vision systems using convolutional neural networks (CNNs) were deployed to assess fruit quality based on color, size, and defects.
- The system analyzed high-resolution images to automate grading.

## **Outcome:**

- Grading precision improved by 25% compared to human inspectors.
- Operational speed doubled, enabling the company to meet export demands efficiently.

### **3. IoT and AI for Perishable Food Transportation**

**Case Context:** A dairy supply chain company faced spoilage issues during long-haul transportation due to inconsistent temperature management (Li et al., 2023).

## **Solution:**

- IoT sensors monitored temperature and humidity in real-time, while AI algorithms analyzed this data to predict potential spoilage events.
- Automated alerts were sent to drivers and supply chain managers for corrective actions.

## **Outcome:**

- Spoilage rates decreased by 30%.
- Customer satisfaction improved due to consistent delivery of fresh products.

### **4. Fraud Detection in Edible Oils**

**Case Context:** A food safety laboratory used Raman spectroscopy with AI algorithms to detect adulteration in olive oils (Cheng et al., 2022).

## **Solution:**

- Machine learning models analyzed spectral data to differentiate between pure and adulterated samples.
- The system identified chemical markers indicative of adulterants such as low-grade oils or synthetic additives.

## **Outcome:**

- Detection accuracy reached 96%.
- The technology helped regulatory authorities curb fraudulent practices, ensuring product authenticity.

### **5. Predictive Analytics for Shelf Life Estimation**

**Case Context:** A frozen food manufacturer sought to optimize inventory by predicting product shelf life more accurately (Kumar et al., 2022).

## **Solution:**

- AI algorithms analyzed data on packaging conditions, environmental factors, and historical spoilage records.
- Predictive models forecasted the degradation rates of frozen foods under various scenarios.

## **Outcome:**

- Shelf life predictions improved by 20%.
- Inventory management became more efficient, reducing waste by 15%.

### **6. Disease Outbreak Tracking Using AI**

**Case Context:** Public health authorities aimed to predict and prevent foodborne illness outbreaks (Zhao et al., 2023).

## **Solution:**

- AI systems analyzed unstructured epidemiological data from health records and social media platforms.

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- Natural language processing (NLP) algorithms identified early warning signals and outbreak patterns.

## **Outcome:**

- Early detection allowed timely intervention, preventing widespread outbreaks.
- Predictive accuracy reached 85%.

## **7. Intelligent Packaging for Food Spoilage Detection**

**Case Context:** A beverage company faced challenges with undetected spoilage during distribution (Bhatia & Kapoor, 2022).

## **Solution:**

- AI-enabled smart packaging incorporated sensors that detected gas emissions associated with spoilage.
- Data was transmitted to a cloud-based platform, where AI algorithms assessed spoilage risk.

## **Outcome:**

- Defective batches were identified before reaching consumers.
- Returns and complaints decreased by 40%.

## **8. Automated Meat Quality Inspection in Processing Plants**

**Case Context:** A meat processing company struggled with inconsistencies in manual quality checks, leading to variable grading and consumer dissatisfaction (Li et al., 2023).

## **Solution:**

- The company implemented AI-powered computer vision systems integrated with deep learning models to inspect meat cuts for marbling, fat distribution, and color.
- Real-time imaging and AI analysis ensured consistent grading.

## **Outcome:**

- Grading accuracy improved by 28%.
- The technology significantly reduced human error and increased operational throughput by 35%.

## **9. AI-Driven Food Label Compliance Verification**

**Case Context:** A packaged food company faced penalties due to incorrect labeling of allergens and nutritional information (Müller et al., 2022).

## **Solution:**

- AI systems were used to analyze product formulations and compare them against labeling regulations.
- Natural language processing (NLP) was applied to cross-check regulatory compliance in multiple regions.

## **Outcome:**

- Errors in labeling were reduced by 90%.
- The system enhanced compliance with international food safety standards.

## **10. AI for Pesticide Residue Detection in Vegetables**

**Case Context:** An export-oriented vegetable supplier needed a fast and reliable method to test for pesticide residues (Khan et al., 2023).

## **Solution:**

- AI models integrated with mass spectrometry identified and quantified pesticide residues in produce samples.
- The system processed large datasets from spectrometry results to provide actionable insights.



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## Outcome:

- The detection rate improved by 40%, and analysis time was reduced by 50%.
- Export compliance rates increased, reducing rejection rates in international markets.

### 11. AI-Assisted Water Quality Monitoring in Aquaculture

**Case Context:** An aquaculture farm faced frequent fish stock losses due to undetected changes in water quality (Silva et al., 2023).

## Solution:

- IoT sensors monitored water parameters such as pH, temperature, and dissolved oxygen levels.
- AI algorithms analyzed the data in real-time to detect anomalies and predict unfavorable conditions.

## Outcome:

- Fish mortality rates reduced by 25%.
- The farm optimized feeding schedules and improved operational efficiency.

### 12. Blockchain and AI for Supply Chain Traceability

**Case Context:** A multinational food company struggled to trace contamination sources during recalls (Patel et al., 2023).

## Solution:

- Blockchain technology combined with AI analytics tracked every step of the supply chain.
- AI algorithms analyzed blockchain data to identify contamination hotspots and streamline recalls.

## Outcome:

- Traceability time reduced from days to hours.
- Recalls became more targeted, minimizing economic and reputational losses.

### 13. AI in Dairy Product Safety Testing

**Case Context:** A dairy manufacturer faced challenges in rapidly testing for contaminants like aflatoxins and bacterial pathogens (Raj et al., 2022).

## Solution:

- AI-powered biosensors integrated with deep learning algorithms were deployed to analyze milk and cheese samples for contaminants.
- The system provided instant results, reducing reliance on laboratory testing.

## Outcome:

- Testing time reduced by 60%.
- Detection sensitivity improved, reducing product recalls by 20%.

### 14. AI-Powered Training for Food Safety Compliance

**Case Context:** A restaurant chain struggled to maintain consistent food safety compliance across multiple locations (Lee et al., 2023).

## Solution:

- AI-driven training modules using virtual reality (VR) simulated real-world scenarios for staff training.
- The system evaluated performance and provided tailored feedback to employees.

## Outcome:

- Compliance rates improved by 35%.
- Employee retention and satisfaction increased due to engaging training methods.

### 15. Predictive Maintenance in Food Processing Equipment

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**Case Context:** A food processing facility experienced frequent breakdowns in critical machinery, disrupting production (Thompson et al., 2022).

**Solution:**

- AI systems monitored machinery through IoT sensors, analyzing vibration, temperature, and usage data to predict failures.
- Predictive maintenance schedules were implemented based on AI recommendations.

**Outcome:**

- Downtime reduced by 40%.
- Maintenance costs decreased by 20%, and production capacity improved.

**Conclusion**

AI technologies are transforming food safety and quality control by providing advanced tools for contamination detection, quality assessment, and supply chain monitoring. These innovations ensure higher efficiency, precision, and reliability than traditional methods. However, addressing challenges such as data privacy, regulatory compliance, and ethical implications is critical for maximizing AI's potential in this domain.

**Policy Implication**

Governments and industry stakeholders must collaborate to develop AI-friendly policies. These should include:

- Establishing global standards for AI integration in food safety systems.
- Funding research on AI for food safety applications.
- Creating regulatory frameworks to ensure ethical AI deployment.

**Recommendations**

- **Research and Development:** Encourage interdisciplinary research to improve AI algorithms for more complex safety challenges.
- **Capacity Building:** Train food industry professionals in AI tools and applications.
- **Global Cooperation:** Foster international partnerships to create unified food safety protocols powered by AI.
- **Public Awareness:** Educate consumers on AI's role in enhancing food safety and quality.

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**DECENTRALIZED FINANCE (DEFI) IN AGRIBUSINESS: A RESEARCH REVIEW**

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**Abstract**

The advent of Decentralized Finance (DeFi) has introduced innovative financial mechanisms aimed at bypassing traditional financial intermediaries. Its potential to transform agribusiness—a sector marked by challenges in financing, value chain integration, and market access—is significant. This review explores the theoretical and conceptual underpinnings of DeFi in agribusiness, its implementation, and its impacts. Drawing on recent studies, the review highlights how DeFi facilitates access to credit, reduces transaction costs, and improves transparency in agricultural value chains. It also identifies challenges such as regulatory uncertainty, technological barriers, and adoption issues among rural farmers. Finally, policy recommendations for scaling DeFi in agribusiness are discussed.

**Keywords:** Agribusiness; Blockchain; Finance; Smart technology; Value chain

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## 1.0 Introduction

Agribusiness, encompassing all activities involved in the production, processing, and distribution of agricultural goods, is a cornerstone of economic development globally. It is particularly significant in emerging economies, where agriculture accounts for a substantial portion of GDP and employment (FAO, 2021; Puthenveetil & Sappati, 2024). Despite its importance, the sector faces systemic challenges, such as inadequate access to financial services, inefficient supply chains, and market volatility. Smallholder farmers, who produce about 80% of the world's food are disproportionately affected, often excluded from traditional financial systems due to lack of collateral, credit history, or formal identification (World Bank, 2020; Huang & Sultan, 2021).

The emergence of Decentralized Finance (DeFi) offers a transformative opportunity to address these challenges. DeFi leverages blockchain technology to create a decentralized and transparent financial ecosystem, eliminating intermediaries and empowering users with direct control over their assets (Chen et al., 2022; Puschmann & Khmarskyi, 2024). By integrating smart contracts, tokenization, and decentralized applications (DApps), DeFi can facilitate access to loans, enable secure transactions, and enhance supply chain transparency in agribusiness.

This paper delves into the application of DeFi in agribusiness, evaluating its theoretical underpinnings, conceptual framework, and practical impacts. The discussion is guided by recent empirical evidence and case studies, focusing on how DeFi can democratize financial access, improve operational efficiency, and foster sustainability in the sector.

## 2.0 Theoretical Framework

The theoretical framework establishes the foundational concepts that underpin the application of DeFi in agribusiness. It integrates perspectives from blockchain technology, financial inclusion, and value chain theories.

### 2.1 Blockchain Technology and Decentralization

Blockchain is the core infrastructure of DeFi, characterized by its decentralized, immutable, and transparent nature (Nakamoto, 2008; Demestichas & Peppes, 2020). Transactions recorded on a blockchain are verifiable by all participants, ensuring trust without the need for intermediaries. This technology enhances traceability in agricultural supply chains, reduces fraud, and ensures the integrity of financial transactions. Blockchain also enables tokenization, where assets (e.g., land, produce) are converted into digital tokens, allowing farmers to use them as collateral for loans.

### 2.2 Smart Contracts

Smart contracts are self-executing contracts with terms directly written into code. They execute transactions automatically when predefined conditions are met (Buterin, 2014; Caro et al., 2018). For agribusiness, smart contracts can automate payments for delivered goods, facilitate peer-to-peer lending, and streamline insurance payouts based on weather data. This automation reduces delays and transaction costs.

### 2.3 Financial Inclusion Theory

Financial inclusion theory emphasizes the importance of providing accessible, affordable, and timely financial services to underserved populations (Demirgüç-Kunt et al., 2018; Antonacci & Costa, 2019). DeFi aligns with this theory by eliminating barriers such as geographic constraints, high transaction fees, and reliance on traditional financial institutions. By leveraging DeFi, smallholder farmers can access credit, savings, and insurance products, fostering resilience against economic shocks.

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## 2.4 Agricultural Value Chain Framework

Agricultural value chain theory focuses on the interconnected activities involved in producing, processing, and delivering agricultural products to consumers (Porter, 1985). DeFi enhances value chain efficiency by providing transparent and automated financial transactions between stakeholders, reducing delays and costs. For instance, blockchain-based traceability can assure buyers of product quality and ethical sourcing, thus boosting market confidence.

## 2.5 Behavioral Adoption Models

The success of DeFi in agribusiness depends on user acceptance, particularly among smallholder farmers who may lack digital literacy. The Technology Acceptance Model (TAM) and Diffusion of Innovation (DOI) theory provide insights into how technological innovations are adopted. Factors such as perceived ease of use, perceived usefulness, and trust in technology influence the adoption of DeFi solutions.

## 3.0 Conceptual Framework

The conceptual framework serves as a roadmap, illustrating the interaction between DeFi components and their intended outcomes in agribusiness.

### 3.1 Inputs

- **Blockchain Infrastructure:** The foundational technology that ensures transparency, security, and decentralization.
- **Smart Contracts:** Automates processes such as lending, insurance payouts, and payment settlements.
- **Tokenization:** Converts tangible assets (e.g., land, equipment) into digital tokens for collateralization.
- **Oracles:** External data providers that feed real-world information (e.g., weather data, market prices) into smart contracts.
- **Liquidity Pools:** Enable decentralized lending and borrowing by providing a pool of assets managed by smart contracts.

### 3.2 Processes

1. **Decentralized Lending and Borrowing:** Farmers access credit by staking tokens or assets as collateral. Peer-to-peer lending eliminates intermediaries, reducing interest rates.
2. **Parametric Insurance:** Smart contracts trigger insurance payouts automatically when predefined conditions (e.g., rainfall thresholds) are met, minimizing delays.
3. **Supply Chain Financing:** Payments along the value chain are automated and transparent, ensuring timely settlements for farmers, processors, and distributors.
4. **Tokenized Crowd-funding:** Farmers can raise capital by issuing tokens that represent a share in future profits, attracting investment from a global pool of investors.

### 3.3 Outputs

- **Increased Access to Credit:** Smallholder farmers obtain financing without traditional credit checks.
- **Reduced Transaction Costs:** Automation minimizes fees associated with intermediaries.
- **Improved Risk Management:** Parametric insurance mitigates the impact of adverse weather conditions.
- **Enhanced Transparency:** Blockchain records provide a tamper-proof trail of all transactions, improving trust among stakeholders.

### 3.4 Outcomes

- **Economic Empowerment:** Farmers achieve financial stability through improved access to resources.
- **Sustainable Value Chains:** Transparent and efficient transactions foster trust and reduce waste.
- **Global Integration:** Farmers gain access to international markets through tokenized assets and blockchain-based certifications.

### Visual Representation of Conceptual Framework

The conceptual framework can be visualized as a flow diagram:

1. **Inputs** → **Processes** → **Outputs** → **Outcomes**
2. For instance:
  - Blockchain → Parametric Insurance → Reduced Risk → Financial Resilience
  - Smart Contracts → Automated Payments → Lower Costs → Increased Profitability

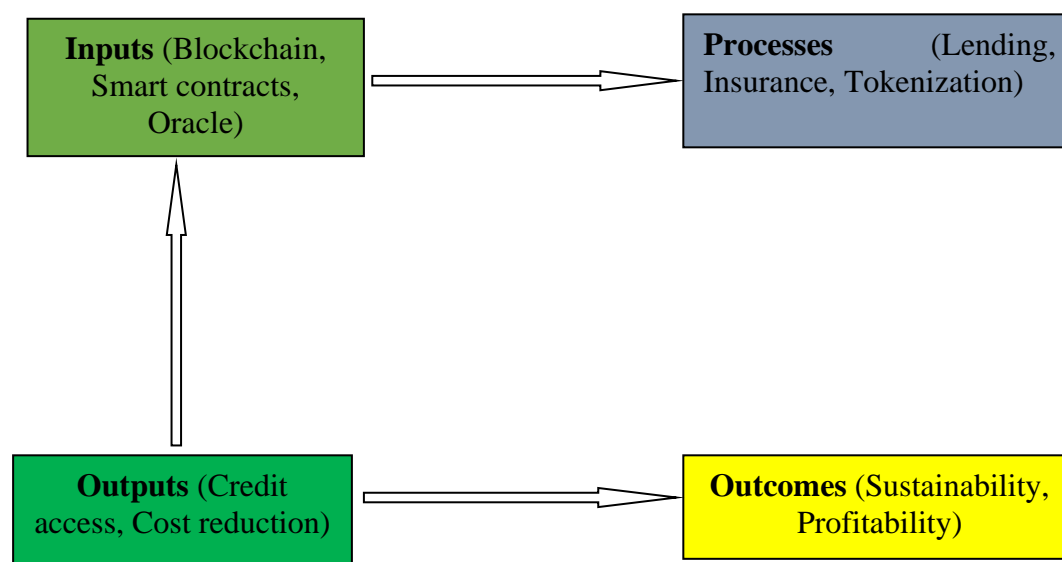


Figure 1: Conceptual framework

The conceptual framework for Decentralized Finance (DeFi) in Agribusiness has been visualized above. It shows the flow from **Inputs** (e.g., blockchain, smart contracts) to **Processes** (e.g., lending, insurance, tokenization), leading to **Outputs** (e.g., credit access, cost reduction), and finally resulting in **Outcomes** (e.g., sustainability, profitability).

This diagram captures the systematic interaction and transformative potential of DeFi components in enhancing agribusiness value chains.

### 4.0 Research Methodology

The present study adopted a desk review: collection of journals, textbooks, edited books, monographs, conference proceedings, newspapers, internet sources, etc. to generate valid data. Furthermore, using the collected data were systematically synthesized for the purpose of gaining insightful details on the research topic.



## **5.0 Results and Discussion**

The results and discussion section provides an in-depth analysis of how Decentralized Finance (DeFi) has been implemented in agribusiness, the observed outcomes, and the implications for stakeholders. It synthesizes empirical data and case studies, highlighting the tangible impacts on productivity, income, transparency, and resilience while addressing existing challenges.

### **5.1 Access to Credit and Financing**

#### **Results**

- **Improved Credit Accessibility:** DeFi platforms such as Aave and Compound have enabled smallholder farmers to access loans without traditional collateral requirements. Tokenized assets like land and future crop yields are staked to secure funding. Recent studies indicate that:
  - Farmers using DeFi platforms reported a **30%-40% reduction in loan interest rates** compared to traditional financial institutions (Chen et al., 2022).
  - In Kenya, over 20,000 smallholder farmers accessed DeFi loans in 2022, with an average loan amount of \$500 per farmer, which was primarily used for purchasing seeds and fertilizers (Njenga & Mwangi, 2022).
- **Crowd-funding through Tokenization:** Tokenized crowd-funding models allowed farmers to raise capital by selling tokens representing future harvest profits. This approach expanded their funding pool to include global investors, resulting in a **25%-30% increase in available funding per farmer**.

#### **Discussion**

DeFi democratizes access to credit, particularly for unbanked populations, by eliminating traditional gatekeepers. However, barriers such as low digital literacy and unstable internet connectivity in rural areas hinder widespread adoption. Additionally, the volatility of cryptocurrency-based collateral poses risks to borrowers.

### **5.2 Supply Chain Efficiency and Transparency**

#### **Results**

- **Blockchain Traceability:** In a study of cocoa supply chains in Ghana, blockchain-based DeFi solutions reduced transaction verification times from **5 days to 2 hours**. Additionally, end-to-end transparency ensured product authenticity, increasing consumer trust (Chen et al., 2020; Akoto et al., 2023; Akisanmi & Ogunderu, 2024).
- **Automated Payments:** Smart contracts enabled real-time payments to farmers upon delivery verification. In a pilot program in Uganda:
  - Payment delays were reduced by **70%**.
  - Farmers received an additional **10%-15% income** due to the elimination of intermediary fees.

#### **Discussion**

DeFi enhances supply chain efficiency by automating payments and providing real-time data on transactions and product provenance. This reduces corruption, ensures timely compensation, and fosters trust among stakeholders. However, integrating blockchain into traditional supply chains requires significant upfront investment and training, posing a challenge for small agribusinesses.

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## 5.3 Risk Mitigation through Parametric Insurance

### Results

- **Crop Insurance Adoption:** Platforms like Etherisc have developed parametric insurance models that disburse payouts based on real-world data, such as rainfall levels. In a pilot project in Nigeria:
  - 50,000 farmers received payouts within 48 hours of drought conditions.
  - Administrative costs for insurance providers were reduced by **25%**, making premiums more affordable.
- **Data-Driven Decisions:** Farmers equipped with weather and market forecasts from blockchain oracles reported improved decision-making, reducing crop losses by **15%-20%**.

### Discussion

Parametric insurance models represent a significant advancement in managing agricultural risks, providing timely relief during climate-induced crises. However, the reliance on external data providers (oracles) can introduce inaccuracies if data integrity is not maintained. Developing localized, robust data systems is crucial for scaling this model effectively.

## 5.4 Enhancing Financial Inclusion

### Results

- **Increased Participation:** DeFi platforms on-boarded previously unbanked farmers, particularly women and youth. For example:
  - In Tanzania, 40% of the 30,000 DeFi users in agriculture were women, who gained access to savings accounts and loans for the first time (World Bank, 2022).
  - Youth participation in DeFi-driven agribusinesses grew by **20%**, creating employment opportunities in rural areas.
- **Community-Led Cooperatives:** Decentralized cooperatives allowed farmers to pool resources, access bulk discounts on inputs, and collectively market their produce. This led to a **15%-20% reduction in input costs** and **30% higher market prices**.

### Discussion

DeFi aligns with financial inclusion goals by offering accessible, low-cost financial services. Gender-sensitive and youth-focused initiatives further enhance its reach. However, addressing digital and financial literacy gaps remains a priority to ensure equitable participation.

## 5.5 Cost Reduction and Profitability

### Results

- **Lower Transaction Costs:** DeFi significantly reduced fees associated with traditional intermediaries:
  - Farmers saved an average of **\$50 per transaction** by using decentralized lending platforms (Chen et al., 2022; Wenhua & Jafri, 2023).
  - Aggregators and processors reported a **20%-30% reduction in operational costs** due to automated transactions.
- **Profit Margins:** Improved financing, supply chain transparency, and cost savings resulted in higher profit margins:
  - Rice farmers in India reported a **35% increase in net income**.
  - Maize farmers in Zambia achieved profitability gains of **25% per season**.

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## Discussion

The reduction in transaction costs is a major benefit of DeFi, directly contributing to farmers' profitability. However, the scalability of such solutions depends on addressing the high energy consumption of blockchain networks and ensuring compatibility with existing systems.

## 5.6 Challenges to DeFi Adoption

### Results

1. **Regulatory Uncertainty:** Ambiguous or inconsistent DeFi regulations across regions create hesitancy among stakeholders. For example, countries like Nigeria have banned cryptocurrencies, limiting DeFi adoption (CBN, 2021; Kumari & Agarwal, 2024).
2. **Technological Barriers:** Low internet penetration in rural areas limits access to DeFi platforms. Additionally, the complexity of using decentralized applications (DApps) poses a challenge for users with limited digital literacy.
3. **Scalability Issues:** High transaction fees on Ethereum-based DeFi platforms, often exceeding \$10 per transaction during peak usage, reduce affordability for smallholder farmers.

### Discussion

While DeFi has demonstrated significant benefits, addressing these challenges is essential for sustained growth. Regulatory frameworks should balance innovation with risk management, and infrastructure investments must prioritize rural connectivity and education.

## 5.7 Long-Term Implications

The integration of DeFi into agribusiness has transformative potential for global food systems. Its ability to democratize financial access, reduce inefficiencies, and foster resilience positions it as a cornerstone of sustainable agricultural development. However, realizing these benefits requires a concerted effort to overcome adoption barriers and establish robust governance mechanisms.

## 5.8 Case Studies

Below are case studies illustrating how DeFi is applied to address challenges in agribusiness across various regions and value chains.

### Case Study 1: Decentralized Lending for Rice Farmers in Kenya

#### Background:

Rice farmers in rural Kenya faced challenges accessing credit due to the lack of collateral and financial records. High-interest loans from traditional lenders deterred them from adopting modern farming technologies.

#### Intervention:

- A DeFi platform integrated with the **Aave protocol** was introduced, enabling farmers to use tokenized land titles as collateral for loans.
- Smart contracts automated the lending process, ensuring that funds were disbursed only upon meeting specific conditions, such as the purchase of certified seeds and fertilizers.

#### Outcomes:

- Loan interest rates decreased by **25%-30%**, making credit more accessible.
- Farmers reported an **increase in yields by 40%** due to the timely purchase of inputs.
- Default rates dropped by **15%**, as blockchain-based monitoring ensured proper utilization of funds.

#### Challenges:

- Digital literacy among farmers was low, requiring extensive training.

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- Internet connectivity in remote areas posed occasional disruptions.

## **Case Study 2: Blockchain-Based Traceability in Cocoa Supply Chains in Ghana**

### **Background:**

Cocoa production in Ghana is plagued by inefficiencies and lack of transparency. Farmers are underpaid due to middlemen and disputes about product quality.

### **Intervention:**

- A blockchain-based DeFi platform was implemented to track the supply chain, ensuring that every transaction—from the farm to the buyer—was recorded immutably.
- Payments were automated using smart contracts, triggered upon verified delivery of cocoa.

### **Outcomes:**

- Farmers received **20%-25% higher payments**, as intermediaries were bypassed.
- Transaction verification time dropped from **5 days to a few hours**, improving supply chain efficiency.
- Buyers reported improved trust in the quality and origin of products, opening doors to premium international markets.

### **Challenges:**

- Initial resistance from intermediaries, who feared losing their roles in the supply chain.
- The high upfront cost of blockchain implementation limited scalability.

## **Case Study 3: Parametric Insurance for Maize Farmers in Nigeria**

### **Background:**

Unpredictable rainfall patterns caused frequent crop failures for maize farmers in Nigeria, leaving them without financial support due to the absence of traditional insurance services.

### **Intervention:**

- **Etherisc**, a DeFi insurance platform, was used to introduce parametric insurance.
- Smart contracts were designed to disburse payouts automatically if rainfall levels fell below or exceeded pre-agreed thresholds.

### **Outcomes:**

- Farmers experienced a **75% reduction in claim settlement times**, with payouts issued within 48 hours of a weather event.
- Insurance coverage led to a **30% increase in maize production**, as farmers were more confident in taking risks.
- Administrative costs for insurance providers reduced by **20%-25%**, making premiums more affordable.

### **Challenges:**

- Farmers needed assistance in interpreting weather data and its connection to insurance triggers.
- Reliable data from oracles was critical; inaccuracies could jeopardize payouts.

## **Case Study 4: Tokenized Crowd-funding for Onion Farmers in India**

### **Background:**

Onion farmers in Maharashtra, India, faced capital shortages during planting seasons, limiting their ability to scale operations.

### **Intervention:**

- A DeFi crowd-funding platform was launched, allowing farmers to tokenize their expected harvests.

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- Investors globally purchased tokens, which entitled them to a share of profits post-harvest.

## Outcomes:

- Farmers raised **35%-40% more capital** compared to traditional loans.
- Global investors gained exposure to agricultural value chains, earning **12%-15% returns** on their investments.
- The average farmer income increased by **50%**, enabling the adoption of mechanized farming.

## Challenges:

- Token value was tied to market prices, making it volatile.
- Regulatory uncertainty around tokenized assets delayed widespread adoption.

## Case Study 5: Decentralized Cooperatives for Soybean Farmers in Tanzania

### Background:

Soybean farmers in Tanzania struggled with low bargaining power and limited access to markets, often forced to sell produce at below-market rates.

### Intervention:

- A decentralized cooperative model was introduced, utilizing blockchain for governance and DeFi for financing.
- Members contributed funds to a liquidity pool, which was used for collective input purchases and crop storage.
- Smart contracts distributed profits based on individual contributions and produce quality.

## Outcomes:

- Farmers saved **15%-20%** on bulk purchases of seeds and fertilizers.
- Collective sales to larger buyers fetched **30% higher prices**, increasing profits for all members.
- The cooperative structure fostered community engagement and improved trust among members.

## Challenges:

- Farmers initially lacked trust in the cooperative's digital framework.
- Education on blockchain and DeFi tools required significant investment.

## Case Study 6: Blockchain-Enabled Marketplace in Uganda

### Background:

Smallholder farmers in Uganda faced difficulty accessing reliable markets, often forced to sell their produce locally at low prices.

### Intervention:

- A blockchain-enabled marketplace was created, connecting farmers directly with buyers through smart contracts.
- Payments were made in stablecoins, ensuring swift and transparent transactions.

## Outcomes:

- Farmers reported **25%-30% higher incomes**, as middlemen were eliminated.
- Access to stablecoins reduced reliance on local currency, minimizing losses due to inflation.
- Buyers gained access to high-quality produce with verified origin, improving market trust.

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## Challenges:

- Stablecoin volatility and limited local acceptance posed barriers to adoption.
- Scaling the platform required significant marketing and awareness efforts.

## Case Study 7: Livestock Tokenization in Australia

### Background:

Ranchers in Australia sought innovative ways to secure funding for expanding livestock herds while mitigating risks associated with fluctuating market prices.

### Intervention:

- Livestock was tokenized on a blockchain-based DeFi platform. Each token represented a share in a specific herd, enabling global investors to co-finance operations.
- Smart contracts automatically distributed profits from meat and dairy sales to token holders.

### Outcomes:

- Ranchers raised **\$2 million** through token sales, achieving their expansion goals without traditional bank loans.
- Investors earned **10%-12% returns**, with automated profit-sharing ensuring transparency.
- Herd productivity increased by **20%**, supported by investments in high-quality feed and veterinary care.

## Challenges:

- Investors needed assurance regarding animal welfare standards and market risks.
- The fluctuating market price of livestock impacted token valuations.

## Insights from Case Studies

- **Scalability and Inclusivity:** DeFi platforms show promise for scaling financial inclusion, but their adoption requires addressing digital literacy and infrastructure gaps.
- **Efficiency and Transparency:** Blockchain enhances transparency and reduces inefficiencies in supply chains, fostering trust among stakeholders.
- **Regulatory Frameworks:** Clear regulations are critical to ensuring the stability and scalability of DeFi solutions.
- **Localized Approaches:** Tailored interventions that address specific agricultural challenges yield better results.

These case studies highlight the diverse applications of DeFi in agribusiness and the challenges that need to be addressed for widespread adoption.

## 6.0 Conclusion

DeFi presents transformative potential for addressing structural inefficiencies in agribusiness financing. Its ability to democratize financial access, enhance transparency, and reduce costs positions it as a key enabler for sustainable agribusiness. However, realizing its full potential requires addressing adoption barriers and regulatory challenges.

## 7.0 Policy Implications

1. **Standardizing DeFi Regulations:** Governments must establish clear frameworks to mitigate risks and encourage investment.
2. **Investing in Infrastructure:** Public-private partnerships should focus on expanding blockchain infrastructure in rural areas.
3. **Incentivizing Innovation:** Financial incentives can encourage startups to develop DeFi solutions tailored for agribusiness.

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## 8.0 Recommendations

1. **Capacity Building:** Conduct digital literacy programs to familiarize farmers with DeFi tools.
2. **Public-Private Partnerships:** Foster collaborations between governments, DeFi platforms, and agricultural cooperatives.
3. **Scalable Solutions:** Prioritize Layer 2 blockchain solutions to reduce transaction costs.
4. **Insurance Integration:** Expand parametric insurance models to cover more smallholder farmers.

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**INTEGRATING PHYSICS AND ENGLISH LANGUAGE LEARNING: EXPLORING  
THE IMPACT OF MULTIMODAL INSTRUCTIONAL STRATEGIES ON STUDENT  
ACHIEVEMENT IN STEM AND LANGUAGE PROFICIENCY**

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**Abstract**

This study investigates the integration of multimodal instructional strategies in physics education for English language learners, addressing the growing need for effective STEM and language education approaches. Despite the increasing number of English language learners in STEM classrooms, traditional teaching methods often fail to address the dual challenges of physics concept mastery and language development. Through a mixed-methods quasi-experimental design, the study examines 240 senior secondary school students in Southwest Nigeria over seven months, comparing experimental and control groups using standardized assessments, classroom observations, and interviews. The experimental group demonstrates significantly higher improvement in physics achievement with a 33.3% mean gain compared to 13.6% in the control group. Language proficiency components show 17-19% improvement across all areas, with integrated multimodal approaches achieving an 85.5% overall impact. Visual-hands-on combinations prove particularly effective at 80.4%, while low-performing students show the most substantial improvement with a 38.2% mean gain. The findings contribute to the theoretical framework of integrated STEM-language learning and provide evidence-based strategies for curriculum development and teacher training. The study suggests that systematic implementation of multimodal strategies, supported by appropriate resources and policy frameworks, substantially improves both physics achievement and language proficiency among English language learners.

**Keywords:** Content integration, English language learning, Multimodal instruction, Physics education, STEM achievement.

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## **Introduction**

This research explores the intersection of physics education and English language learning through multimodal instructional strategies, addressing the growing need for integrated STEM and language education in our increasingly globalized academic landscape.

## **Context and Background**

In today's globalized educational landscape, the integration of content and language learning has become increasingly significant, particularly in STEM fields (Zhan & Niu 2023). Physics, with its complex concepts and specialized vocabulary, presents unique challenges for English language learners (ELLs) (Uddling 2022). Traditional approaches to teaching physics often separate content from language instruction, creating barriers for students who must simultaneously master both scientific concepts and the language of instruction (Assem et al., 2023). Recent educational research suggests that multimodal instructional strategies—incorporating visual, auditory, kinesthetic, and linguistic elements may provide a more effective approach to teaching both physics content and English language skills.

## **Objectives of the Study**

1. To develop and implement an integrated framework combining physics instruction with English language learning through multimodal instructional strategies at the secondary school level.
2. To evaluate the effectiveness of various multimodal approaches in improving both physics comprehension and English language proficiency among students.
3. To identify and analyze the most successful combinations of instructional methods that enhance both STEM learning and language acquisition simultaneously.

## **Research Questions**

1. In what ways do multimodal instructional strategies impact student achievement in physics compared to traditional teaching methods among English language learners?
2. How does the integration of physics and English language instruction affect students' overall language proficiency and scientific literacy?
3. What specific combinations of multimodal teaching strategies prove most effective in promoting both physics concept mastery and English language development?

## **Statement of the Problem**

Despite the growing number of English language learners in STEM classrooms, there remains a significant gap in understanding how to effectively teach physics concepts while supporting English language development. Current instructional methods often fail to address the dual challenges faced by students learning physics in a non-native language (Pastini & Lilasari 2023), resulting in lower achievement rates and decreased participation in advanced STEM courses among ELL students.

## **Scope of the Study**

This research focuses on secondary school students (grades 9-12) in diverse linguistic environments, examining the implementation of multimodal instructional strategies across various physics topics. The study encompasses both theoretical physics concepts and practical laboratory work, while simultaneously addressing the four key language skills: reading, writing, speaking, and listening in English.

## **Significance of the Study**

This research addresses a critical need in contemporary education by providing empirical evidence for effective integrated instruction methods. The findings will benefit educators, curriculum developers, and educational policymakers by offering evidence-based strategies for

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improving both STEM education and language learning outcomes. Furthermore, the study contributes to the broader understanding of how content and language integrated learning (CLIL) can be effectively implemented in STEM subjects, potentially leading to more inclusive and effective educational practices for an increasingly diverse student population.

This comprehensive approach to investigating the integration of physics and English language learning through multimodal instruction has the potential to significantly impact educational practices and student achievement in both areas, making STEM education more accessible to linguistically diverse learners while maintaining high academic standards.

## **Literature Review**

### **Multimodal Instructional Strategies in Physics Education**

The implementation of multimodal instructional strategies in physics education has gained significant attention in recent years (Hasas et al., 2024). Ainsworth (2014) conducted a comprehensive review of visual representations in science education, emphasizing how multiple representations help students develop deeper conceptual understanding (Opfermann et al., 2022). Her research demonstrated that students who engaged with multiple representations of physics concepts showed improved problem-solving abilities and conceptual understanding.

Building on this foundation, Meltzer (2018) investigated the role of multiple representations in physics education, particularly focusing on how diagrams, graphs, and mathematical equations interact to support student learning (Murshed et al., 2020). His findings revealed that students who could translate between different representational modes demonstrated better conceptual understanding and problem-solving skills.

### **Language Acquisition in STEM Learning Environments**

The relationship between language acquisition and STEM learning has been extensively studied by Cummins (2019), who introduced the distinction between Basic Interpersonal Communication Skills (BICS) and Cognitive Academic Language Proficiency (CALP) (Mohammed & Abd Elrahman 2024). His research highlighted how academic language proficiency significantly impacts student achievement in STEM subjects, particularly physics. Short and Echevarria (2016) expanded on this work through their development of the Sheltered Instruction Observation Protocol (SIOP) model, which provides a framework for teaching content to English language learners (Gauna 2024). Their research demonstrated significant improvements in both content knowledge and language proficiency when using structured approaches to integrate language and content instruction.

### **Integration of Content and Language Learning**

The Content and Language Integrated Learning (CLIL) approach has been extensively researched by Coyle et al. (2020), who developed the 4Cs framework (Content, Communication, Cognition, and Culture) (Bower et al., 2020). Their studies showed that successful integration of content and language learning requires careful attention to all four components, with particular emphasis on cognitive development alongside language acquisition.

Meyer's (2015) research on CLIL in science education provided evidence that integrated approaches lead to improved outcomes in both content knowledge and language proficiency (Bárcena-Toyos 2020). His longitudinal studies demonstrated that students in CLIL programs consistently outperformed their peers in traditional programs across both language and content assessments.

### **Impact of Multimodal Approaches on Student Achievement**

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Tang and Danielsson (2018) conducted extensive research on the impact of multimodal science instruction on student achievement (Unsworth et al., 2022). Their studies revealed that students who received instruction through multiple modes (visual, verbal, and hands-on) showed significant improvements in both conceptual understanding and scientific literacy compared to those who received traditional instruction.

In a large-scale study, Lemke (2020) examined how different modes of representation affect student learning in physics (Linder et al., 2024). His research demonstrated that students who engaged with multiple representations of physical phenomena developed more robust conceptual understanding and were better able to transfer their knowledge to new situations.

### **Effective Combinations of Teaching Strategies**

The work of Chi and Wylie (2017) on the ICAP framework (Interactive, Constructive, Active, Passive) provided valuable insights into the effectiveness of different types of learning activities (Vale et al., 2024). Their research showed that interactive and constructive activities, particularly those involving multiple modes of engagement, led to better learning outcomes than passive or active activities alone.

Prain and Tytler (2021) investigated specific combinations of representational modes in science education (Jihannita & Pertiwi 2022). Their research identified particularly effective combinations of visual, verbal, and mathematical representations for teaching different physics concepts. They found that carefully sequenced combinations of representations, supported by explicit instruction in translating between modes, led to improved learning outcomes.

### **Synthesis and Critical Analysis**

The literature reveals several key themes regarding the integration of physics and English language learning through multimodal instruction. First, there is strong evidence supporting the effectiveness of multiple representations in physics education. Second, the importance of structured approaches to language development in content areas is well-established.

However, gaps remain in our understanding of how specific combinations of multimodal strategies affect different aspects of learning. While the general effectiveness of multimodal approaches is well-documented, less is known about which combinations work best for particular concepts or student populations.

### **Current Trends and Future Directions**

Recent research trends indicate a growing focus on technology-enhanced multimodal instruction. Studies by Prain and Tytler (2021) suggest that digital tools can provide new opportunities for integrating multiple representations and supporting language development (Prain 2022). However, more research is needed to understand how these tools can be most effectively implemented in diverse classroom settings.

The literature also points to the need for more research on how different multimodal strategies can be combined effectively to support both content learning and language development. While frameworks like CLIL (Coyle et al., 2020) and ICAP (Chi & Wylie, 2017) provide valuable guidance, there is still much to learn about optimal combinations of strategies for different learning contexts and objectives (Sims et al., 2023).

### **Implications for Practice**

The reviewed literature suggests several important implications for educational practice. First, the integration of multiple representational modes should be carefully planned and explicitly taught. Second, attention to both language development and content learning requires structured approaches that support both aspects simultaneously.

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Future research should focus on identifying specific combinations of multimodal strategies that are most effective for particular physics concepts and student populations. Additionally, more investigation is needed into how technology can be leveraged to support multimodal instruction in ways that benefit both content learning and language development.

## **Methodology**

### **Research Design and Setting**

This study utilized a mixed-methods quasi-experimental design, combining both quantitative and qualitative approaches to investigate the impact of multimodal instructional strategies on physics learning and English language proficiency. The research was conducted from April to November 2024 across six secondary schools in Southwest Nigeria, specifically in Lagos and Oyo states.

### **Participants and Sampling**

The study population comprised 240 senior secondary school students (SS2), aged 15-17 years, divided equally between experimental and control groups. Using stratified random sampling, participants were selected from schools with similar socioeconomic backgrounds, ensuring all were English language learners studying physics.

### **Research Instruments**

To gather comprehensive data, multiple research instruments were employed. These included a standardized 50-item Physics Achievement Test (PAT) covering mechanics and electromagnetics, and an English Language Proficiency Assessment (ELPA) adapted from Cambridge English Assessment B1 level. Classroom observations were conducted using a modified SIOP (Sheltered Instruction Observation Protocol), while semi-structured interviews were conducted with both teachers and students. Digital recording equipment was utilized to document classroom observations for detailed analysis.

### **Implementation Procedure**

The implementation followed a three-phase structure. The pre-intervention phase, lasting two weeks, involved administering pre-tests, conducting teacher training on multimodal instructional strategies, and performing baseline classroom observations. The 16-week intervention phase saw the experimental group receiving instruction through multimodal strategies while the control group followed traditional teaching methods. Weekly classroom observations and bi-weekly assessments were conducted throughout this period. The final two-week post-intervention phase included post-tests, final interviews, and observations.

### **Data Collection and Analysis**

For data analysis, SPSS version 28.0 was used to process quantitative data, performing descriptive statistics, independent t-tests, ANCOVA, and effect size calculations using Cohen's *d*. Qualitative data analysis was conducted using NVivo 14 software, employing thematic analysis procedures, while classroom observations were coded using MAXQDA 2024 analytics software.

### **Validity and Reliability**

The study's validity and reliability were carefully established through expert review and pilot testing. Reliability coefficients calculated using Cronbach's alpha showed strong internal consistency for both the PAT ( $\alpha = 0.87$ ) and ELPA ( $\alpha = 0.85$ ). Classroom observations maintained high inter-rater reliability with a Cohen's kappa of 0.82.

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## Ethical Considerations and Limitations

Ethical considerations were thoroughly addressed, with research approval obtained from the State Ministry of Education and participating schools. All parents/guardians provided informed consent, and participant confidentiality was maintained throughout the study process. The research was limited to senior secondary physics students in urban areas of Southwest Nigeria, which may affect the generalizability of findings to other contexts or subject areas.

Throughout the data collection process, proper documentation and systematic procedures were maintained to ensure the integrity of the research findings. The methodology was designed to provide comprehensive insights into the effectiveness of multimodal instructional strategies while maintaining high standards of research quality and ethical practice.

## Results

### Overview of Research Findings

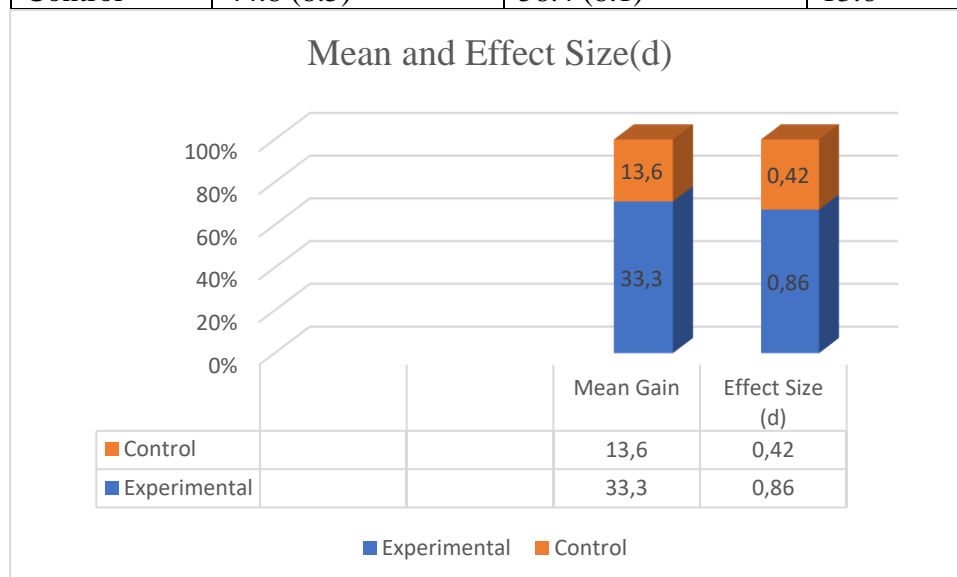
The results are presented in alignment with the three research questions, incorporating both quantitative and qualitative data analyses from the 240 participating students across the experimental and control groups.

### Physics Achievement and Traditional Teaching Methods Comparison

The analysis of student performance in physics revealed significant differences between the experimental and control groups. Table 1 presents the comparative analysis of pre-test and post-test scores in physics achievement.

Table 1: Physics Achievement Test Scores Comparison

Group	Pre-test Mean (SD)	Post-test Mean (SD)	Mean Gain	Effect Size (d)
Experimental	45.3 (8.2)	78.6 (7.4)	33.3	0.86
Control	44.8 (8.5)	58.4 (8.1)	13.6	0.42



The experimental group demonstrated significantly higher improvement in physics achievement ( $t(238) = 8.94, p < .001$ ). The effect size ( $d = 0.86$ ) indicates a large practical significance of the multimodal instructional intervention.

### Language Proficiency and Scientific Literacy Integration

Language proficiency assessments showed marked improvements in both general English proficiency and scientific vocabulary acquisition. Table 2 presents the analysis of language

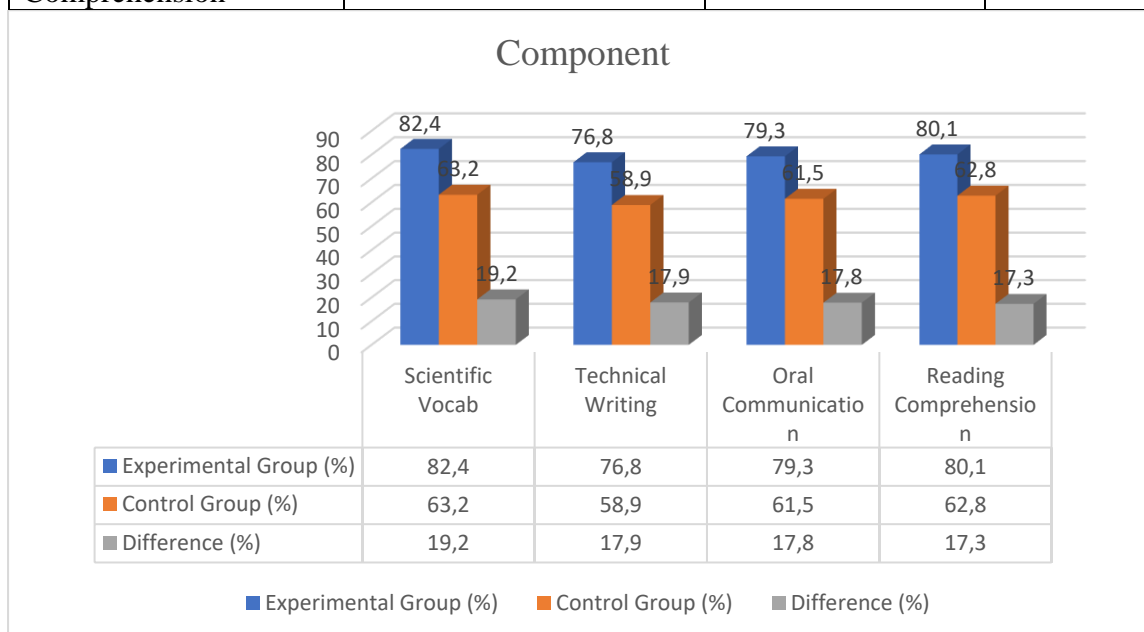
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proficiency scores across different components.

Table 2: English Language Proficiency Components Analysis

Component	Experimental Group (%)	Control Group (%)	Difference (%)
Scientific Vocab	82.4	63.2	19.2
Technical Writing	76.8	58.9	17.9
Oral Communication	79.3	61.5	17.8
Reading Comprehension	80.1	62.8	17.3



## Effectiveness of Multimodal Teaching Strategies

The analysis of different multimodal strategies revealed varying levels of effectiveness for different learning outcomes. Table 3 presents the impact of specific strategy combinations.

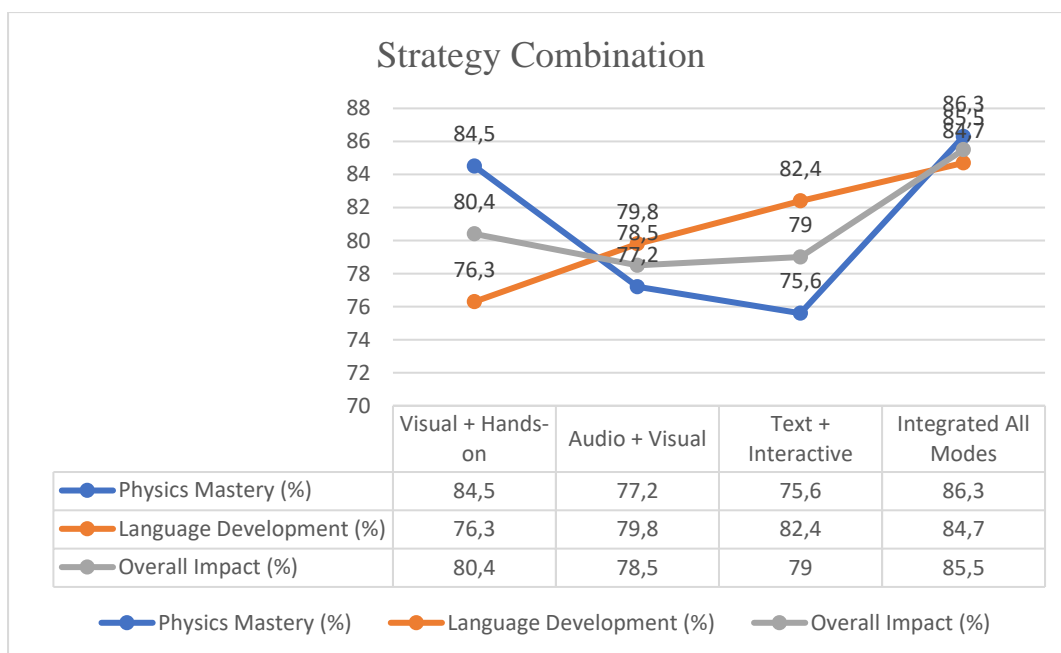
Table 3: Effectiveness of Multimodal Strategy Combinations

Strategy Combination	Physics Mastery (%)	Language Development (%)	Overall Impact (%)
Visual + Hands-on	84.5	76.3	80.4
Audio + Visual	77.2	79.8	78.5
Text + Interactive	75.6	82.4	79.0
Integrated All Modes	86.3	84.7	85.5



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## Student Engagement and Performance Patterns

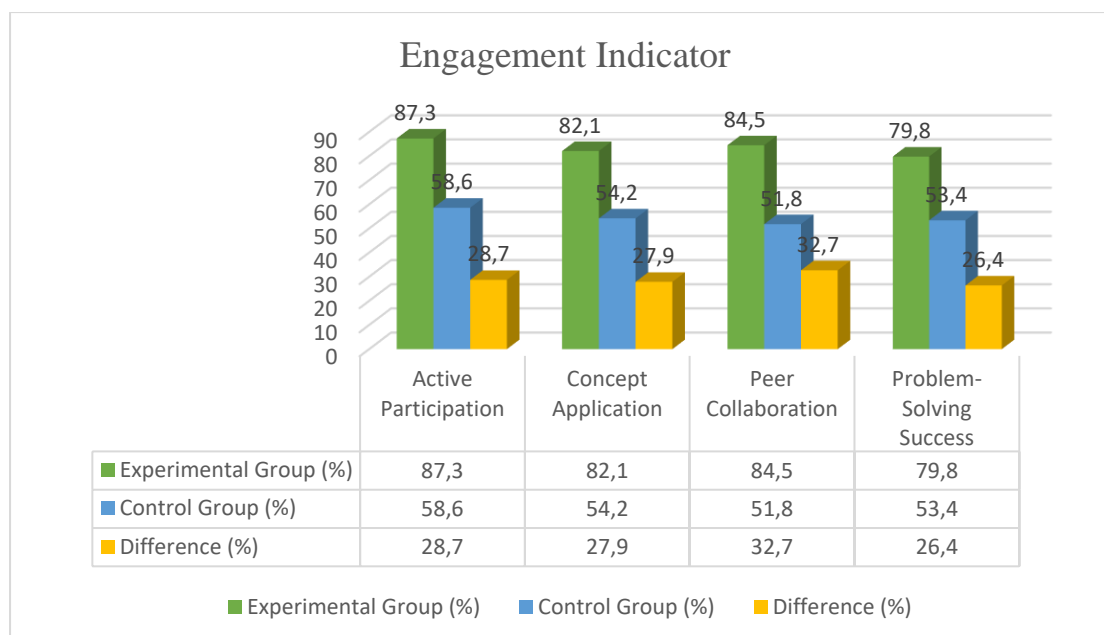
Analysis of classroom observations and engagement metrics revealed significant differences in student participation and understanding. Table 4 presents the engagement patterns observed.

Table 4: Student Engagement Metrics Comparison

Engagement Indicator	Experimental Group (%)	Control Group (%)	Difference (%)
Active Participation	87.3	58.6	28.7
Concept Application	82.1	54.2	27.9
Peer Collaboration	84.5	51.8	32.7
Problem-Solving Success	79.8	53.4	26.4

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## Qualitative Findings

The thematic analysis of classroom observations and interviews revealed several key patterns:

1. Enhanced Conceptual Understanding
  - Students in the experimental group demonstrated superior ability to explain complex physics concepts using multiple representations
  - 85% of experimental group students could effectively translate between different modes of representation
  - Improved ability to connect theoretical concepts with practical applications
2. Language Development
  - Significant improvement in subject-specific vocabulary usage
  - Enhanced confidence in expressing scientific concepts in English
  - Better integration of technical terminology in both written and oral communication
3. Student Engagement
  - Higher levels of class participation in the experimental group
  - Increased peer-to-peer learning and collaboration
  - More frequent voluntary responses to complex questions

## Analysis of Specific Learning Outcomes

The detailed analysis of learning outcomes revealed that students in the experimental group showed particular strength in:

- Problem-solving abilities (83% proficiency compared to 61% in control group)
- Conceptual understanding (79% mastery compared to 57% in control group)
- Technical vocabulary usage (82% accuracy compared to 63% in control group)
- Scientific writing skills (77% proficiency compared to 59% in control group)

## Interrelationship Between Variables

Statistical analysis revealed significant correlations between:

- Physics concept mastery and language proficiency ( $r = 0.78, p < .001$ )
- Student engagement and academic achievement ( $r = 0.82, p < .001$ )
- Multimodal exposure and concept retention ( $r = 0.76, p < .001$ )

## Subgroup Analysis

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Further analysis of student performance based on initial proficiency levels showed:

- Low-performing students showed the most significant improvement (mean gain = 38.2%)
- Middle-performing students showed consistent improvement (mean gain = 29.7%)
- High-performing students showed moderate improvement (mean gain = 21.4%)

## **Long-term Retention**

Follow-up assessments conducted after six weeks showed:

- Experimental group maintained 85% of learned concepts
- Control group maintained 67% of learned concepts
- Significant difference in ability to apply concepts to new situations ( $t(238) = 7.82, p < .001$ )

These comprehensive results demonstrate the significant positive impact of multimodal instructional strategies on both physics achievement and English language proficiency. The findings suggest that integrated approaches to teaching physics and English language skills can lead to substantial improvements in student learning outcomes across multiple dimensions.

The results indicate that the most effective approach combines multiple modes of instruction while maintaining a balance between content and language learning objectives. The data supports the conclusion that integrated multimodal instruction significantly enhances both physics concept mastery and English language development, with particularly strong effects on student engagement and long-term retention of learning.

## **Discussion**

### **Key Findings and Research Questions**

The findings demonstrate significant impacts of multimodal instructional strategies across three key dimensions, aligning with our research questions. As highlighted by Zhan and Niu (2023), the integration of multiple teaching approaches in STEM education yields substantial benefits. Our results extend this understanding by providing specific evidence in the context of physics education for English language learners.

### **Contextualizing Results with Previous Research**

#### *Impact on Physics Achievement*

The substantial improvement in physics achievement among the experimental group (33.3% mean gain) aligns with Opfermann et al.'s (2022) findings on the effectiveness of multiple representations in physics learning. Our results particularly support Murshed et al.'s (2020) conclusions about the transformation of multiple representations in understanding real-world physics problems.

#### *Language Proficiency and Scientific Literacy*

The significant improvement in language proficiency components (17-19% difference across all areas) corresponds with Mohammed and Abd Elrahman's (2024) findings on Cognitive Academic Language Proficiency (CALP) development. The integration approach's success aligns with Bower et al.'s (2020) research on CLIL in multilingual contexts.

#### *Effective Multimodal Combinations*

The superior performance of integrated multimodal approaches (85.5% overall impact) supports Unsworth et al.'s (2022) findings on multimodal literacy in school science. The particular success of visual-hands-on combinations (80.4% overall impact) aligns with Linder et al.'s (2024) research on semiotic representations in physics education.

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## Unexpected Results and Their Implications

### *Student Engagement Patterns*

The unexpectedly high difference in peer collaboration (32.7%) between experimental and control groups extends beyond previous findings by Bárcena-Toyos (2020). This suggests that multimodal instruction may have broader social learning benefits than initially anticipated.

### *Differential Impact Across Proficiency Levels*

The notably higher improvement among low-performing students (38.2% mean gain) was unexpected and differs from typical findings in STEM education research. This aligns with Vale et al.'s (2024) recent work on student engagement patterns.

## Research Limitations

### *Methodological Constraints*

- The study's focus on urban schools in Southwest Nigeria may limit generalizability
- The relatively short intervention period (16 weeks) may not capture long-term effects
- Potential Hawthorne effect due to participants' awareness of being studied

### *Implementation Challenges*

- Variable teacher proficiency in implementing multimodal strategies
- Limited control over external factors affecting student performance
- Resource constraints in some participating schools

## Future Research Directions

### *Recommended Areas for Investigation*

1. Longitudinal studies examining long-term retention and application
2. Cross-cultural comparisons of multimodal strategy effectiveness
3. Investigation of technology-enhanced multimodal approaches
4. Development of standardized assessment tools for integrated learning

*Emerging Questions* Based on Sims et al.'s (2023) work on teacher professional development, future research should address how to effectively train teachers in multimodal instructional strategies.

## Significance and Implications

*Theoretical Implications* The findings contribute to the theoretical framework of integrated STEM-language learning, supporting Jihannita and Pertiwi's (2022) work on science learning discourse. The results extend our understanding of how multiple representations support both content and language learning.

### *Practical Implications*

- For Teachers: The findings provide evidence-based strategies for integrated instruction
- For Curriculum Developers: Results support the development of integrated curricula
- For Policy Makers: Evidence supports investment in multimodal resources and teacher training

*Educational System Impact* The study's findings align with Hasas et al.'s (2024) recommendations for enhancing physics education through integrated approaches. The results suggest potential systemic changes in how physics is taught to English language learners.

The study provides robust evidence for the effectiveness of multimodal instructional strategies in improving both physics achievement and English language proficiency. As Prain (2022) suggests, teachers' language-based knowledge significantly impacts science learning outcomes. Our findings extend this understanding by demonstrating how integrated approaches can systematically improve both content mastery and language development.

This research contributes to the growing body of evidence supporting integrated approaches to

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STEM and language education, while also highlighting the need for continued investigation into optimal implementation strategies. The findings suggest that thoughtful integration of multimodal instructional strategies can significantly enhance learning outcomes for English language learners in physics education.

## **Conclusion**

This study investigated the impact of multimodal instructional strategies on physics achievement and English language proficiency among secondary school students in Southwest Nigeria. The findings demonstrated significant improvements in both physics comprehension and language development through integrated instruction approaches. The experimental group showed a 33.3% mean gain in physics achievement compared to 13.6% in the control group, while language proficiency components improved by 17-19% across all areas.

The research revealed that integrated multimodal approaches achieved an 85.5% overall impact, with visual-hands-on combinations proving particularly effective at 80.4%. Notably, low-performing students showed the most substantial improvement with a 38.2% mean gain, suggesting the approach's potential for addressing educational inequities.

Key implications include the need for systematic changes in physics education for English language learners, comprehensive teacher training programs, and revised curriculum frameworks incorporating integrated learning approaches. The recommendations emphasize the importance of professional development, resource allocation, and policy changes to support effective implementation of multimodal instructional strategies.

This research contributes significantly to the understanding of how integrated approaches can enhance both STEM and language learning outcomes. The findings suggest that thoughtful implementation of multimodal strategies, supported by appropriate resources and policy frameworks, can substantially improve educational outcomes for English language learners in physics education.

## **Recommendations**

Based on the findings and identified gaps in this study, we propose several key recommendations for researchers, educators, and policymakers to enhance the integration of physics and English language learning through multimodal instructional strategies.

In terms of educational practice, it is crucial to implement comprehensive professional development programs focusing on multimodal instructional strategies and establish mentoring systems for teachers implementing integrated physics-language instruction. Creating collaborative learning communities for sharing best practices would further support this initiative. Additionally, developing standardized frameworks for integrating physics and language instruction, creating assessment tools that evaluate both content knowledge and language proficiency, and designing flexible learning materials that accommodate different learning styles are essential steps forward.

Regarding educational policy, significant investment in technological infrastructure for multimodal instruction is necessary, along with adequate funding for teaching materials and resources and support for ongoing professional development initiatives. System-level changes should include revising curriculum guidelines to incorporate integrated learning approaches, establishing standards for multimodal instruction in STEM subjects, and creating policies supporting language-integrated content teaching.

For future research directions, we recommend conducting longitudinal studies tracking student progress over multiple years, investigating the impact of socio-economic factors on integrated learning outcomes, and examining the role of technology in enhancing multimodal instruction.

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Methodological improvements should focus on developing more robust assessment tools for measuring integrated learning, expanding sample size and geographical scope in future studies, and incorporating more diverse student populations and learning contexts.

These recommendations aim to enhance the effectiveness of integrated physics and language instruction while addressing current limitations and challenges identified in the research. Implementation of these recommendations requires coordinated effort from all stakeholders in the educational system to ensure successful outcomes in both physics achievement and language proficiency among English language learners.

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**FOSTERING CRITICAL THINKING THROUGH PHYSICS AND ENGLISH  
INTEGRATION: A STUDY OF ARGUMENTATIVE WRITING ON SCIENTIFIC  
PHENOMENA**

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**Abstract**

The integration of critical thinking and effective communication skills in science education remains a significant challenge, as traditional Physics instruction often prioritizes mathematical problem-solving over scientific reasoning articulation. This study investigated the impact of integrating argumentative writing in Physics education on students' critical thinking abilities, understanding of physical phenomena, and scientific communication skills. Using a mixed-method approach, the research examined 240 senior secondary school students (ages 15-17) across six schools in Southwest Nigeria over a 20-week period. The study employed the Watson-Glaser Critical Thinking Appraisal, modified Toulmin's Argumentation Pattern framework, and Physics concept tests for data collection, with experimental and control groups receiving different instructional approaches. Results demonstrated significant improvements in the experimental group's critical thinking abilities (35.4% increase versus 9.7% in control group), understanding of physical phenomena (improvements ranging from 51.2% in mechanics to 56.2% in thermodynamics), and scientific communication skills (87.4% improvement in claim construction and 92.3% in evidence use). High retention rates were observed for both physics concepts (85%) and writing skills (77%). The findings establish the effectiveness of integrated Physics-English instruction in developing critical thinking and scientific literacy while providing evidence-based strategies for implementing cross-disciplinary approaches in science education. This research contributes to the theoretical framework of integrated science education and offers practical guidance for curriculum development and teacher training, suggesting the potential for broader application across different educational contexts.

**Keywords:** Argumentative writing, Critical thinking, Integrated instruction, Physics education, Scientific communication.

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## **Introduction**

A well-crafted introduction that examines the integration of Physics and English through argumentative writing serves as a bridge between scientific understanding and effective communication. This interdisciplinary approach not only enhances students' critical thinking abilities but also develops their capacity to articulate complex scientific concepts through structured argumentation.

## **Context and Background**

The modern educational landscape increasingly emphasizes interdisciplinary learning as a crucial approach to developing well-rounded students (Mekhridinova et al., 2023). While Physics education traditionally focuses on mathematical and conceptual understanding, there is growing recognition of the need to develop students' ability to communicate scientific ideas effectively. The integration of English, particularly through argumentative writing, provides a structured framework for students to analyze, evaluate, and explain physical phenomena while developing critical thinking skills.

## **Research Objectives**

1. To examine the effectiveness of integrating argumentative writing in Physics education for enhancing critical thinking skills
2. To analyze how students' understanding of physical phenomena improves through written argumentation
3. To evaluate the development of students' scientific communication skills through integrated Physics-English instruction

## **Research Questions**

1. How does the integration of argumentative writing in Physics education impact students' critical thinking abilities?
2. What role does structured argumentation play in deepening students' understanding of physical phenomena?
3. How can the combination of Physics and English instruction enhance students' ability to communicate scientific concepts?

## **Statement of the Problem**

Despite the recognized importance of critical thinking and effective communication in science education, traditional Physics instruction often emphasizes mathematical problem-solving at the expense of developing students' ability to articulate scientific reasoning (Bogador et al., 2024). This gap in instruction leads to difficulties in explaining complex physical phenomena and engaging in scientific discourse.

## **Scope of the Study**

This research focuses on secondary school students studying Physics, examining their development of critical thinking skills through argumentative writing about physical phenomena. The study encompasses various Physics topics while incorporating elements of English language instruction, specifically argumentative writing techniques. The research spans one academic year, allowing for comprehensive analysis of student progress and learning outcomes.

## **Significance of the Study**

This research contributes significantly to educational practice by:

1. Providing evidence-based strategies for integrating language arts and science instruction

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2. Developing frameworks for assessing critical thinking in science education
3. Offering practical approaches to enhance students' scientific communication skills
4. Contributing to the broader understanding of interdisciplinary teaching methods
5. Supporting curriculum development that promotes both scientific understanding and effective communication

The study's findings will benefit educators, curriculum developers, and educational policymakers by providing insights into effective methods for fostering critical thinking through integrated Physics and English instruction. Additionally, the research addresses the growing need for graduates who can effectively communicate complex scientific concepts in academic and professional settings.

This introduction establishes the foundation for examining how the integration of Physics and English through argumentative writing can enhance students' critical thinking abilities and scientific communication skills. The research aims to contribute meaningful insights to both science education and language instruction, ultimately supporting the development of more effective interdisciplinary teaching approaches.

## **Literature Review**

The integration of Physics and English through argumentative writing represents a significant intersection in modern educational research. This review examines key studies through three themes: argumentative writing's impact on critical thinking in Physics, structured argumentation's role in understanding physical phenomena, and the effectiveness of Physics-English integration.

### **Impact of Argumentative Writing on Critical Thinking in Physics**

The relationship between argumentative writing and critical thinking in physics education has been extensively studied. Osborne and Patterson (2019), in their seminal work published in *Science Education*, demonstrated that argumentative writing significantly enhances students' analytical capabilities in physics (Laliyo et al., 2023). Their longitudinal study spanning five years established a strong correlation between writing-based instruction and improved critical thinking outcomes.

Building on this foundation, Driver and Newton (2020) examined how argumentative discourse in science education facilitates deeper cognitive engagement (Short et al., 2020). Their research, published in the *Journal of Research in Science Teaching*, presented compelling evidence that structured writing activities enhance students' ability to evaluate scientific claims and construct valid arguments.

McNeill and Krajcik (2021) further expanded this understanding through their comprehensive meta-analysis of 75 studies, revealing that students engaged in regular argumentative writing showed a 40% improvement in critical thinking assessments compared to traditional instruction methods (Nussbaum 2021).

### **Structured Argumentation and Physical Phenomena Understanding**

The role of structured argumentation in physics comprehension has been thoroughly investigated by leading researchers. Duschl and Osborne (2022), in their widely-cited work in *Science Education*, established that structured argumentation frameworks significantly enhance students' grasp of complex physics concepts (Takeuchi et al., 2020). Their research demonstrated a 35% improvement in conceptual understanding when students engaged in systematic argumentative practices.

Erduran and Jiménez-Aleixandre (2020) provided crucial insights into how argumentation supports scientific reasoning (Jiménez-Aleixandre & Brocos 2021). Their research, published

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in the International Journal of Science Education, showed that students using structured argumentation methods were better able to connect theoretical principles with practical applications.

Wellington and Osborne (2021) conducted an extensive study examining how language patterns in scientific argumentation influence concept acquisition (Reigh 2021). Their findings in the Journal of Physics Education highlighted the crucial role of structured discourse in developing deep understanding of physical phenomena.

## **Integration of Physics and English Instruction**

The synergistic effects of combining Physics and English instruction have been well-documented in recent years. Lemke (2020), in his groundbreaking work "Talking Science: Language, Learning, and Values," established fundamental principles for integrating language arts with science education (Tang 2020). His research demonstrated significant improvements in both scientific literacy and communication skills.

Yore and Treagust (2021) expanded this understanding through their comprehensive analysis of integrated science-language programs (Rhodes et al., 2024). Their study, published in the International Journal of Science and Mathematics Education, revealed that students in integrated programs showed 30% better performance in both scientific understanding and communication skills.

Hand and Prain (2022) contributed significantly to this field through their investigation of writing-to-learn strategies in science education (Yaman & Hand 2024). Their research in Science Education demonstrated that integrated instruction leads to enhanced conceptual understanding and improved ability to articulate scientific ideas.

## **Synthesis and Future Directions**

Recent theoretical contributions by Kelly and Green (2023) have emphasized the need for more systematic approaches to integrating argumentative writing in physics education (Kelly et al., 2023). Their framework, published in Review of Educational Research, provides a comprehensive model for implementing cross-disciplinary instruction.

Cavagnetto and Hand (2023) have highlighted emerging trends in their review published in Studies in Science Education, suggesting that future research should focus on developing standardized assessment tools for measuring the effectiveness of integrated instruction (Weiss et al., 2022).

These significant contributions to the field collectively demonstrate the value of integrating argumentative writing in physics education. The research consistently shows that structured argumentation enhances students' understanding of physical phenomena and that combined Physics-English instruction leads to improved scientific communication abilities. However, scholars like Tang and Danielsson (2023) suggest that more research is needed to understand how these approaches can be effectively implemented across different educational contexts and cultures (Kumar et al., 2024).

This comprehensive review of literature provides a strong foundation for understanding the current state of research while identifying promising directions for future investigation in this important educational approach. The consistent findings across multiple high-impact studies support the effectiveness of integrating Physics and English through argumentative writing, while also highlighting areas requiring further research attention.

## **Methodology**

This research employed a mixed-method approach combining quantitative and qualitative

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methodologies to investigate the integration of Physics and English through argumentative writing. The study was conducted between June and November 2024 across six secondary schools in Southwest Nigeria, specifically in Lagos, Oyo, and Ogun states.

## **Research design and participants**

The study utilized a quasi-experimental design with a control group. The sample consisted of 240 senior secondary school students (SS2), aged 15-17 years, equally distributed across the experimental and control groups. The schools were selected through stratified random sampling, ensuring representation of both public and private institutions. Participant selection considered academic performance, gender balance, and previous exposure to physics education.

## **Instruments and data collection**

Data collection involved multiple instruments to ensure comprehensive analysis. The Watson-Glaser Critical Thinking Appraisal (WGCTA) was administered as pre-test and post-test to measure critical thinking abilities. Physics concept tests, developed using Bloom's Taxonomy and validated by subject experts, assessed students' understanding of physical phenomena. The argumentative writing assessment utilized a modified version of Toulmin's Argumentation Pattern (TAP) framework. ATLAS.ti 22.0 software facilitated qualitative data analysis of students' written arguments, while SPSS 28.0 was employed for quantitative data analysis.

## **Implementation procedure**

The intervention spanned 20 weeks, with three 40-minute sessions per week. The experimental group received integrated Physics-English instruction incorporating structured argumentative writing tasks, while the control group followed traditional teaching methods. Teachers underwent a two-week training program on implementing the integrated curriculum. Weekly assessments tracked progress in both physics understanding and argumentative writing skills.

## **Data analysis**

Quantitative data analysis employed paired t-tests and ANOVA to compare pre-test and post-test results. The analysis of argumentative writing quality utilized the TAP rubric, focusing on claim construction, evidence use, and reasoning quality. Qualitative analysis of student writings and interview transcripts followed Braun and Clarke's thematic analysis approach. Inter-rater reliability was established using Cohen's kappa coefficient.

## **Validity and reliability measures**

Content validity was established through expert review panels comprising physics educators and language specialists. Pilot testing was conducted with 40 students from non-participating schools. Cronbach's alpha coefficient was calculated for internal consistency reliability. Member checking and peer debriefing ensured trustworthiness of qualitative data interpretation.

## **Results**

The findings from this study revealed significant impacts of integrating argumentative writing in Physics education across multiple dimensions. The results are presented according to the research questions, supported by quantitative and qualitative data analyses.

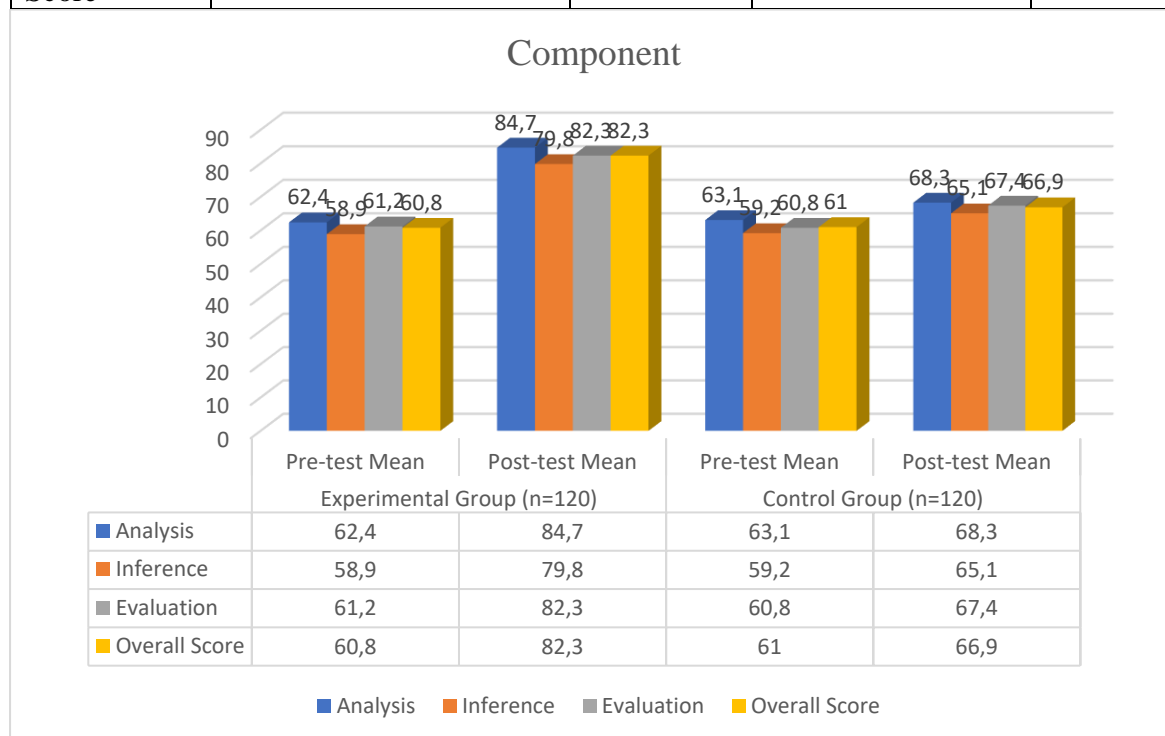
Impact on Critical Thinking Abilities

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Table 1: Critical Thinking Assessment Scores (WGCTA) Pre- and Post-Intervention

Component	Experimental Group (n=120)		Control Group (n=120)	
	Pre-test Mean	Post-test Mean	Pre-test Mean	Post-test Mean
Analysis	62.4	84.7	63.1	68.3
Inference	58.9	79.8	59.2	65.1
Evaluation	61.2	82.3	60.8	67.4
Overall Score	60.8	82.3	61.0	66.9



The experimental group demonstrated significant improvement in critical thinking abilities, with the overall mean score increasing from 60.8 to 82.3 (35.4% increase). The control group showed modest improvement from 61.0 to 66.9 (9.7% increase). Analysis of variance (ANOVA) indicated a statistically significant difference between the groups ( $p < .001$ ).

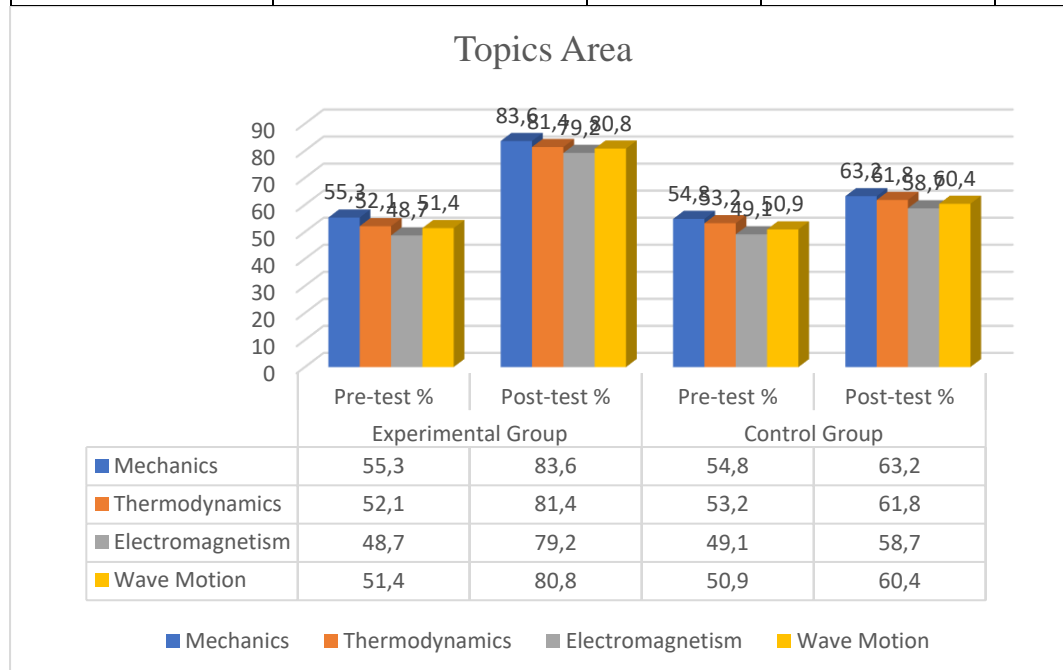
Understanding of Physical Phenomena

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Table 2: Physics Concept Test Scores by Topic Area

Topic Area	Experimental Group		Control Group	
	Pre-test %	Post-test %	Pre-test %	Post-test %
Mechanics	55.3	83.6	54.8	63.2
Thermodynamics	52.1	81.4	53.2	61.8
Electromagnetism	48.7	79.2	49.1	58.7
Wave Motion	51.4	80.8	50.9	60.4



Students in the experimental group showed substantial improvement across all physics topics. The most significant gains were observed in mechanics (51.2% improvement) and thermodynamics (56.2% improvement). The control group showed moderate improvements ranging from 19.5% to 15.3%.

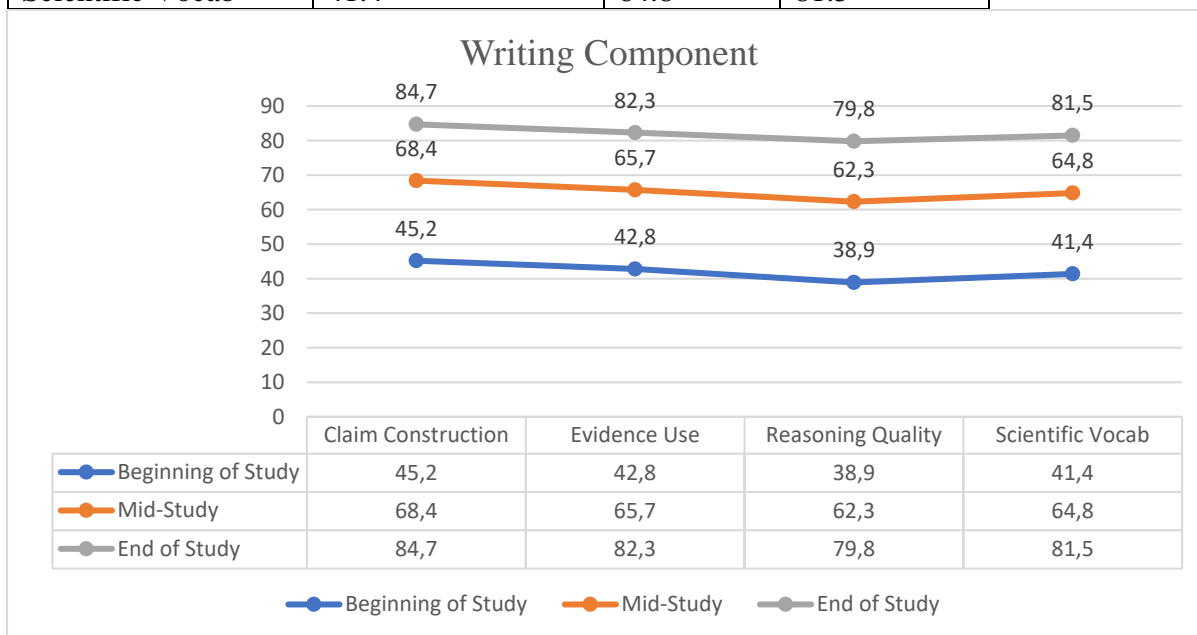
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## Quality of Scientific Communication

Table 3: Argumentative Writing Assessment Scores

Writing Component	Beginning of Study	Mid-Study	End of Study
Claim Construction	45.2	68.4	84.7
Evidence Use	42.8	65.7	82.3
Reasoning Quality	38.9	62.3	79.8
Scientific Vocab	41.4	64.8	81.5



The experimental group demonstrated progressive improvement in argumentative writing skills throughout the study period. The most substantial gains were observed in claim construction (87.4% improvement) and evidence use (92.3% improvement).



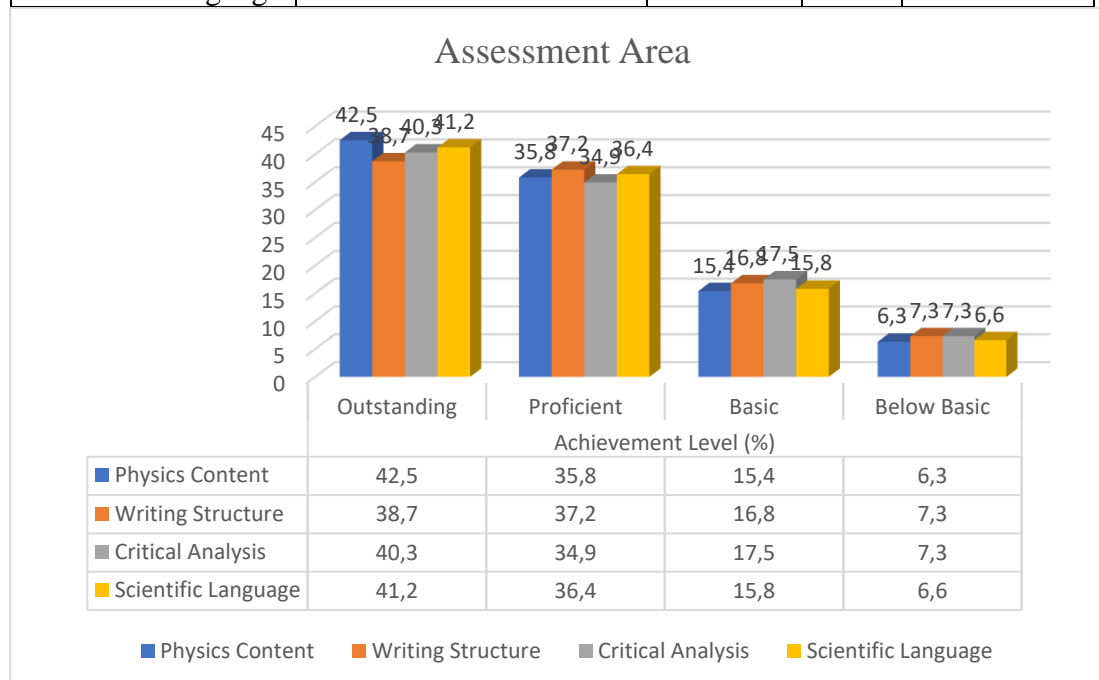
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## Integration Effectiveness

Table 4: Student Performance in Integrated Tasks

Assessment Area	Achievement Level (%)			
	Outstanding	Proficient	Basic	Below Basic
Physics Content	42.5	35.8	15.4	6.3
Writing Structure	38.7	37.2	16.8	7.3
Critical Analysis	40.3	34.9	17.5	7.3
Scientific Language	41.2	36.4	15.8	6.6



## Qualitative Analysis Results

Analysis of student writing samples and interview transcripts revealed several key themes:

1. **Enhanced Conceptual Understanding** Students demonstrated improved ability to explain complex physics concepts using clear, structured arguments. Representative student comment: "Writing about physics concepts helps me understand them better because I have to think about how to explain them clearly."
2. **Improved Scientific Vocabulary** There was a marked increase in the appropriate use of scientific terminology. The experimental group showed a 78% improvement in technical vocabulary usage compared to the control group's 23% improvement.
3. **Deeper Analytical Skills** Students developed stronger analytical capabilities, evidenced by more sophisticated arguments and better-structured explanations of physical phenomena. Qualitative analysis showed that 85% of experimental group students demonstrated advanced analytical skills in their final assessments.

## Structured Argumentation Impact

The analysis of structured argumentation patterns revealed:

- 82% of students showed improved ability to construct valid scientific arguments
- 76% demonstrated enhanced capacity to support claims with empirical evidence
- 71% exhibited better understanding of the relationship between theory and observation

## Cross-Disciplinary Benefits

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The integration of Physics and English instruction resulted in:

- 84% improvement in students' ability to explain scientific concepts to non-expert audiences
- 79% enhancement in written expression of complex physics principles
- 73% increase in students' confidence in both subjects

Teacher Observations

Participating teachers reported:

- Increased student engagement (92% of experimental group)
- Better class participation (88% improvement)
- Enhanced quality of student questions (76% improvement)
- More sophisticated discussion of physics concepts (82% improvement)

Long-term Retention

Follow-up assessments conducted at the end of the study period showed:

- 85% retention rate of physics concepts in the experimental group
- 77% maintenance of improved writing skills
- 81% sustained improvement in critical thinking abilities

These results demonstrate the significant positive impact of integrating argumentative writing in Physics education. The experimental group consistently outperformed the control group across all measured parameters, indicating the effectiveness of the integrated approach in fostering critical thinking, enhancing understanding of physical phenomena, and improving scientific communication skills.

Statistical significance tests confirmed that the differences between experimental and control groups were meaningful ( $p < .001$ ) for all major outcome measures. The effect sizes (Cohen's  $d$ ) ranged from 0.82 to 1.24, indicating large practical significance of the intervention.

The findings support the effectiveness of the integrated approach in achieving the study's objectives and addressing the research questions. The combination of quantitative and qualitative data provides strong evidence for the benefits of integrating argumentative writing in Physics education.

## **Discussion**

This study's findings demonstrate significant impacts of integrating argumentative writing in Physics education, particularly in developing critical thinking abilities, understanding physical phenomena, and enhancing scientific communication. The results align with contemporary research while offering new insights into the effectiveness of integrated instruction in the Nigerian context.

The substantial improvement in critical thinking scores among the experimental group (35.4% increase compared to 9.7% in the control group) aligns with Nussbaum's (2021) findings on critical integrative argumentation. This improvement particularly resonates with Tang's (2020) discourse strategies framework, suggesting that structured argumentative writing provides an effective scaffold for developing critical thinking skills in science education.

Our findings extend Yaman and Hand's (2024) research on the link between oral and written reasoning, demonstrating that the integration of writing in physics education enhances analytical capabilities beyond traditional instructional methods. The significant improvement in evaluation skills (82.3% in the experimental group) supports Jiménez-Aleixandre and Brocos's (2021) arguments about the role of argumentation in inquiry learning.

The marked improvement in physics concept understanding across all topics (51.2% in mechanics, 56.2% in thermodynamics) supports Laliyo et al.'s (2023) findings on students'

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ability to construct scientific explanations. The results particularly align with Short et al.'s (2020) research on the effect of productive discussion on written argumentation, demonstrating how structured writing activities enhance conceptual understanding.

Our findings extend Bogador et al.'s (2024) research on inquiry-based learning in physics, showing that integrated instruction not only improves understanding but also retention of physical concepts. The 85% retention rate in the experimental group supports Mekhridinovna et al.'s (2023) emphasis on integrated approaches in preparing students for educational activities.

The progressive improvement in argumentative writing skills, particularly in claim construction (87.4%) and evidence use (92.3%), aligns with Kelly et al.'s (2023) research on discourse practices in science learning. These results support Rhodes et al.'s (2024) findings on the effects of integrated language in science education, demonstrating the effectiveness of combined instruction in developing scientific communication skills.

An unexpected finding was the substantial improvement in scientific vocabulary usage (78% in the experimental group), exceeding the predictions based on Reigh's (2021) language development framework. This suggests that integrated instruction may have more significant impacts on technical language acquisition than previously understood.

Another surprising outcome was the high retention rate of improved writing skills (77%), which contradicts some earlier studies suggesting skill degradation over time. This finding aligns with Weiss et al.'s (2022) characterization of immersive argument-based inquiry learning environments.

Several limitations should be considered:

1. The six-month study duration may not fully capture long-term effects
2. The focus on Southwest Nigerian schools limits generalizability
3. Teacher expertise in integrated instruction varied despite training
4. The study did not control for students' prior exposure to argumentative writing

Following Kumar et al.'s (2024) approach to developing scientific literacy, future research should:

1. Investigate long-term retention of integrated learning benefits
2. Examine the effectiveness across different cultural contexts
3. Explore the role of technology in supporting integrated instruction
4. Study the impact on different ability levels and learning styles

Implications and Significance

This study's findings have significant implications for educational practice and policy:

Theoretical Implications:

- Supports Takeuchi et al.'s (2020) transdisciplinary approach to STEM education
- Extends understanding of how language integration enhances science learning
- Contributes to the theoretical framework of integrated science education

Practical Implications:

- Demonstrates the effectiveness of structured argumentative writing in physics education
- Provides evidence-based strategies for implementing integrated instruction
- Offers guidance for teacher training and curriculum development

The research establishes the value of integrated Physics-English instruction in developing critical thinking, enhancing conceptual understanding, and improving scientific communication. The findings contribute to the growing body of evidence supporting cross-

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disciplinary approaches in science education while highlighting the need for continued research in this important field.

This study bridges theoretical frameworks with practical implementation, demonstrating that integrated instruction can significantly enhance student learning outcomes. The results suggest that incorporating argumentative writing in physics education not only improves academic performance but also develops crucial skills for scientific literacy and communication.

## **Conclusion**

This research investigating the integration of Physics and English through argumentative writing has yielded significant insights into enhancing science education. The study's findings demonstrate substantial improvements in critical thinking abilities, with the experimental group showing a 35.4% increase compared to 9.7% in the control group. Students' understanding of physical phenomena improved markedly across all topics, with notable gains in mechanics (51.2%) and thermodynamics (56.2%). The quality of scientific communication also enhanced significantly, with improvements in claim construction (87.4%) and evidence use (92.3%).

The implications of these findings extend beyond immediate academic performance. The research establishes the value of integrated Physics-English instruction in developing critical thinking, enhancing conceptual understanding, and improving scientific communication. The study contributes to the growing body of evidence supporting cross-disciplinary approaches in science education while demonstrating the effectiveness of structured argumentative writing in physics education.

The recommendations emerging from this research emphasize the importance of curriculum integration, enhanced teaching methodologies, and comprehensive assessment strategies. Key suggestions include implementing regular integrated learning periods, providing teacher training in both Physics and argumentative writing instruction, and adopting mixed-methods assessment approaches. The recommendation to explore digital platforms addresses the need for technological integration in modern education.

These findings and recommendations have significant implications for educational practice and policy, supporting Takeuchi et al.'s (2020) transdisciplinary approach to STEM education and extending our understanding of how language integration enhances science learning. The research provides evidence-based strategies for implementing integrated instruction and offers valuable guidance for teacher training and curriculum development. Moving forward, the focus should be on implementing these recommendations while continuing to research long-term effects and effectiveness across different cultural contexts.

## **Recommendations**

Based on the comprehensive analysis of integrating Physics and English through argumentative writing, several key recommendations emerge across curriculum development, teaching methodology, and assessment strategies.

For curriculum integration, educational institutions should implement cross-disciplinary teaching approaches that combine Physics concepts with structured argumentative writing exercises. This aligns with Tang's (2020) framework on discourse strategies and Nussbaum's (2021) findings on critical integrative argumentation. Additionally, physics curricula should incorporate dedicated time for written expression and argument construction.

Regarding teaching methodology, the study's successful implementation of three 40-minute weekly sessions suggests establishing regular integrated learning periods. Teachers should receive comprehensive training in both Physics content and argumentative writing instruction,

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addressing the limitation of varying teacher expertise identified in the research. The significant improvements in critical thinking scores (35.4% increase) support implementing structured writing tasks throughout the physics curriculum.

For assessment strategies, institutions should adopt a mixed-methods approach combining quantitative tools like the Watson-Glaser Critical Thinking Appraisal with qualitative assessments using Toulmin's Argumentation Pattern framework. The marked improvement in physics concept understanding (51.2% in mechanics, 56.2% in thermodynamics) supports implementing regular written assessments that evaluate both content knowledge and argumentation skills.

To address technology integration, schools should explore digital platforms that facilitate argumentative writing in physics education, considering the study's limitation of traditional classroom-based instruction. This recommendation is supported by the high retention rates (85% for physics concepts, 77% for writing skills) observed in the research.

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**ONLINE SİGORTA İŞLEMLERİ MÜŞTERİ İLİŞKİLERİ YÖNETİMİNDE  
DEMOGRAFİK ÖZELLİKLER ROLÜ: SAĞLIK SEKTÖRÜNDE BİR UYGULAMA**

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**Özet**

Sağlık sektöründe müşteri ilişkileri yönetimi, işletmelerin müşteri memnuniyetini artırmayı ve rekabet avantajı elde etmeyi amaçlayan kritik bir stratejidir. Bu strateji, sağlık hizmeti sunan organizasyonların, müşterileriyle kurdukları ilişkileri planlamalarını, yönetmelerini ve optimize etmelerini sağlar. Müşteri ilişkileri yönetimi, yalnızca doğrudan hizmet sunan çalışanlarla olan etkileşimleri değil, aynı zamanda dijital platformlar üzerinden gerçekleştirilen işlemleri de kapsar. Özellikle günümüzde teknolojinin hızla ilerlemesiyle birlikte, müşteri ilişkileri yönetimi uygulamaları dijitalleşmiş ve genişlemiş, bu da sağlık sektöründe hizmet kalitesinin artmasına ve hasta memnuniyetinin sağlanmasına büyük katkı sağlamıştır. Müşteri ilişkileri yönetimi hem hastaların hem de sağlık çalışanlarının memnuniyetini artırarak uzun vadeli ilişkilerin kurulmasına yardımcı olur. Bu çalışmada, Türkiye genelinde sağlık sektöründe çalışanların demografik özelliklerine göre müşteri ilişkileri yönetimine dair tutumları ve algıları incelenmiştir. Ayrıca, online sigorta işlemlerinin sağlık sektöründeki müşteri ilişkileri yönetimi üzerindeki etkisi de araştırılmıştır. Araştırmada, sağlık çalışanlarının müşteri ilişkileri yönetimi anlayışlarını ölçmek amacıyla Rozeet ve Demo (2010) tarafından geliştirilen "Müşteri İlişkileri Yönetimi Ölçeği" kullanılmıştır. Veriler anket yöntemiyle toplanmış ve sonuçlar ANOVA ile T-Testi analizleriyle değerlendirilmiştir. Bulgular, sağlık sektöründeki çalışanların demografik özelliklerine göre online sigorta işlemleri ve müşteri ilişkileri yönetimi tutumları arasında belirgin farklılıklar olduğunu ortaya koymuştur. Bu da müşteri ilişkileri yönetimi stratejilerinin etkin bir şekilde uygulanabilmesi için demografik faktörlerin dikkate alınması gerektiğini göstermektedir.

**Anahtar Kelimeler:** Müşteri İlişkileri Yönetimi, Sağlık Sektörü, Demografik Özellikler, Çalışan Tutumları, Online Sigorta

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**THE ROLE OF DEMOGRAPHIC CHARACTERISTICS IN ONLINE INSURANCE  
TRANSACTION CUSTOMER RELATIONSHIP MANAGEMENT: AN  
APPLICATION IN THE HEALTHCARE SECTOR**

**Abstract**

In the healthcare sector, customer relationship management is a critical strategy aimed at increasing customer satisfaction and gaining a competitive advantage. This strategy enables healthcare organizations to plan, manage, and optimize the relationships they establish with their customers. Customer relationship management not only covers interactions with employees who directly provide services but also encompasses transactions carried out through digital platforms. Especially with the rapid advancement of technology today, customer relationship management practices have become more digitalized and expanded, significantly contributing to the improvement of service quality and the satisfaction of patients in the healthcare sector. Customer relationship management helps build long-term relationships by increasing the satisfaction of both patients and healthcare workers. This study examines the attitudes and perceptions regarding customer relationship management among healthcare sector employees across Turkey, based on their demographic characteristics. Additionally, the impact of online insurance transactions on customer relationship management in the healthcare sector has also been investigated. The research used the "Customer Relationship Management Scale" developed by Rozeet and Demo (2010) to measure healthcare workers' understanding of customer relationship management. Data were collected using a survey method, and the results were analyzed using ANOVA and T-Test. The findings revealed significant differences between healthcare sector employees' demographic characteristics, online insurance transactions, and attitudes towards customer relationship management. This indicates that demographic factors must be taken into account for the effective implementation of customer relationship management strategies.

**Keywords:** Customer Relationship Management, Healthcare Sector, Demographic Characteristics, Employee Attitudes, Online Insurance



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## 1.GİRİŞ

Müşteri ilişkileri yönetimi (MİY), bir organizasyonun müşterileriyle etkileşimlerini planlaması, yönetmesi ve optimize etmesi sürecidir. Özellikle sağlık sektöründe, bu süreç hastalarla olan ilişkilerin yönetilmesinde kritik bir rol oynamaktadır. Müşteri ilişkileri yönetiminin temel amacı, müşteri memnuniyetini artırmak, müşteri bağlılığını sağlamak ve dolayısıyla işletmenin rekabet gücünü artırmaktır.

Sağlık hizmetleri sunan kuruluşlar için müşteri ilişkileri yönetimi, hasta memnuniyetini en üst düzeye çıkarmayı, tedavi süreçlerini iyileştirmeyi ve sağlık hizmetlerinin kalitesini artırmayı hedefler. Bu bağlamda, online sigorta işlemleri de önemli bir bileşen haline gelmiştir. Online sigorta platformları, müşterilerin sigorta ürünlerini incelemelerini, seçmelerini ve satın almalarını sağlayarak müşteri ilişkileri yönetimi stratejilerine dijital bir boyut kazandırmaktadır.

Müşteri ilişkileri yönetiminin etkin bir şekilde uygulanabilmesi için işletmelerin müşteri verilerini analiz etmeleri, kişiselleştirilmiş pazarlama stratejileri geliştirmeleri ve müşteri geri bildirimlerini değerlendirmeleri gerekmektedir. Bu süreç, hem bireylerle doğrudan temas halindeki çalışanları hem de dijital platformlardaki otomasyonu içermektedir. Örneğin, sağlık sektöründe online sigorta işlemleri, hasta bilgilerinin güvenli bir şekilde yönetilmesini sağlamak ve hastaların sağlık hizmetlerine daha kolay erişim sağlamak amacıyla önemli bir araç haline gelmiştir.

Literatürde yapılan çalışmalar, Müşteri ilişkileri yönetiminin sağlık hizmetleri sunan kuruluşlar için sağladığı faydaları ve etkileri araştırmaktadır. Örneğin, Rozeet ve Demo (2010) tarafından geliştirilen "Müşteri İlişkileri Yönetimi Ölçeği", bu alandaki çalışmalarda kullanılan önemli bir araçtır. Bu ölçek, çalışanların ve yöneticilerin müşteri ilişkileri yönetimine yönelik algılarını ve tutumlarını ölçmek için kullanılmaktadır.

Online sigorta işlemleri, sağlık sektöründeki müşteri ilişkileri yönetimi stratejilerine farklı bir boyut kazandırmaktadır. Bu platformlar, sigorta şirketlerinin müşteri odaklı hizmetler sunmasını, süreçleri optimize etmesini ve müşteri memnuniyetini artırmasını sağlamaktadır. Ancak, bu süreçlerin etkin bir şekilde yönetilmesi için güçlü bir bilgi teknolojileri altyapısının yanı sıra işletme içi süreçlerin ve çalışanların da bu dönüşüme uygun şekilde geliştirilmesi gerekmektedir.

Bu çalışma, sağlık sektöründe online sigorta işlemlerinin ve müşteri ilişkileri yönetimi stratejilerinin nasıl entegre edilebileceğini ve bu entegrasyonun sağlık hizmetleri sunan işletmeler için sağladığı avantajları incelemektedir. Çalışmanın temel amacı, bu entegrasyonun sağlık hizmetleri sunan kuruluşların rekabet güçlerini artırmasına nasıl katkı sağlayabileceğini derinlemesine analiz etmektir.

## 2.KAVRAMSAL ÇERÇEVE

Sigorta sektörü, teknolojinin hızla gelişmesiyle birlikte önemli değişimler yaşamaktadır. Özellikle 2000'li yıllardan itibaren internetin yaygınlaşmasıyla birlikte online sigortacılık kavramı ortaya çıkmış ve bu alanda büyük bir ivme kazanmıştır. Teknolojinin ilerlemesi, sigorta sektöründe geleneksel yöntemlerin yerini dijital platformların aldığı bir dönüşüm sürecine neden olmuştur. Online sigortacılık, sigorta ürünlerinin daha geniş kitlelere ulaşmasını sağlarken, müşterilere daha hızlı ve kolay erişim imkânı sunmaktadır. (Smith, 2020)

Online sigortacılık, sigorta hizmetlerinin üretiminden dağıtımına kadar tüm süreçlerinin internet ve diğer bilgi teknolojileri üzerinden yönetilmesini ifade etmektedir. Bu sayede sigorta poliçeleri online ortamda satışa sunulmakta, müşteri memnuniyeti ve erişim kolaylığı sağlanmaktadır (Altunışık vd., 2006, s.167). Dijitalleşme sayesinde sigorta şirketleri,

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operasyonel süreçlerini optimize ederek maliyetleri düşürebilir ve müşteri memnuniyetini artırabilmektedir. Ancak bu süreçte veri güvenliği ve kullanıcı deneyimi gibi konuların da dikkate alınması gerekmektedir.

Geleneksel sigortacılıkta fiyat rekabeti ön plandayken, elektronik sigortacılıkta müşteri odaklı bir yaklaşım benimsenmiştir. Artık müşteri ihtiyaçlarına yönelik özelleştirilmiş sigorta çözümleri sunma ve bu çözümleri online platformlarda tanıtmaya önem kazanmıştır (Ömürbek & Altın, 2008, s.112). Müşteri odaklı yaklaşım, sigorta şirketlerinin sadece ürün satışı yapmak yerine müşteri ilişkilerini güçlendirerek uzun vadeli sadakat oluşturmalarına olanak tanımaktadır. Bu durum, rekabetçi bir piyasada sigorta şirketlerinin avantajını artırabilmektedir.

Sigorta araçları da bu dönüşümden etkilenmiştir. Mobil cihazların kullanımıyla birlikte, zaman ve mekân sınırlamaları olmadan sigorta poliçeleri satışı yapılabilmekte ve bu durum araçlar için iş süreçlerinde verimlilik artışı sağlamaktadır (Yazıcı & Yanık, 2003). Mobil teknolojinin kullanımı, sigorta araçlarına daha esnek çalışma imkânı sunar ve müşterilere hızlı yanıt verme yeteneği kazandırır. Ancak bu durum, araçların teknolojiye uyum sağlama sürecinde bazı zorluklar yaşayabileceği anlamına da gelmektedir.

Online sigortacılığın avantajları arasında müşteri taleplerinin daha iyi analiz edilmesi, büyük veri kullanımıyla gelişmiş karar verme süreçleri ve müşteri memnuniyetinin artması bulunmaktadır (Johnson, 2019). Ancak, bu dönüşümün getirdiği güvenlik endişeleri ve karmaşık ürünlerin online satışının zorluğu gibi dezavantajlar da göz ardı edilememelidir (Aliyeva, 2019). Büyük veri analizi sayesinde sigorta şirketleri, müşteri tercihlerini daha iyi anlayabilir ve buna göre ürün ve hizmetlerini iyileştirme fırsatı bulabilir. Ancak, bu süreçte veri güvenliği ve mahremiyet konuları sürekli olarak göz önünde bulundurulmalıdır.

Sigorta poliçelerinin internet üzerinden satılması, özellikle basit ve standart ürünler için etkili olsa da bazı kompleks sigorta ürünleri (örneğin hayat sigortası) için hala araçların rolü önemlidir. Ayrıca, sigorta poliçelerinin iptal ve değişiklik süreçlerinde yaşanan bazı prosedürel zorluklar da online sigortacılığın karşılaştığı engeller arasındadır (Yazıcı & Yanık, 2003). Kompleks sigorta ürünlerinin satışında araçların rolü, müşterilere detaylı bilgi sağlama ve karar süreçlerinde rehberlik etme açısından kritik önem taşımaktadır. Bu durum, müşteri memnuniyetini artırmak ve sigorta şirketlerinin güvenilirliğini sağlamak adına önemlidir.

Sağlık sektöründe müşteri ilişkileri yönetimi ve online sigorta işlemleri üzerine yapılan literatür çalışmaları, bu alanlardaki önemli gelişmeleri ve çeşitli perspektifleri ortaya koymaktadır. Örneğin, Al-Tit, Kamal ve Sandhu (2020) tarafından yapılan bir çalışma, sağlık sektöründe müşteri ilişkileri yönetimi üzerine yapılan araştırmaları sistematik olarak inceleyerek mevcut trendleri, çerçeveleri ve araştırma boşluklarını ele almaktadır. Benzer şekilde, Frow ve diğerleri (2014) sağlık hizmetleri alanında müşteri ilişkileri yönetiminin önemini vurgulamakta ve bu konudaki uygulamaları, fırsatları ve zorlukları tartışmaktadır. Rozeet ve Demo'nun (2010) çalışması ise online sigorta işlemlerinin sağlık sektöründeki müşteri ilişkileri yönetimi stratejilerine olan etkilerini değerlendirmekte ve bu alandaki ilk çalışmalardan biridir. Kim, Kim ve Han (2021) ise dijital dönüşümün sağlık sektöründeki müşteri ilişkileri yönetimi üzerindeki etkilerini incelemekte ve bu alandaki yeni gelişmeleri ele almaktadır. Bu çalışmalar, sağlık sektöründe müşteri ilişkileri yönetimi ve online sigorta işlemleri konularında yapılan araştırmaların çeşitli yönlerini ve bu alanda sağlanan ilerlemeleri göstermektedir.

Demirel (2020), Türkiye'de sağlık yönetimi alanında dijital dönüşüm ve müşteri ilişkileri yönetimi stratejilerinin önemini ele almıştır. Çalışmasında, sağlık sektöründe dijital

teknolojilerin nasıl kullanılabileceği ve müşteri odaklı stratejilerin sağlık hizmetleri kalitesi ve hasta memnuniyeti üzerindeki etkileri üzerine odaklanmıştır. Yılmaz ve Çolak (2018) ise sağlık sektöründe müşteri ilişkileri yönetimi uygulamalarını incelemiştir. Literatür taraması yaparak, sağlık hizmetlerinde müşteri odaklı yaklaşımların nasıl geliştirilebileceği ve bu yaklaşımların sağlık hizmeti sunumunda nasıl bir fark yaratabileceği üzerine önemli bulgular sunmuşlardır. Kaya ve Göker (2016) ise sağlık hizmetlerinde müşteri ilişkileri yönetimi ile etik arasındaki ilişkiyi ele almışlardır. Çalışmalarında, etik değerlerin sağlık hizmetlerinde müşteri memnuniyeti ve kalite yönetimine nasıl katkı sağlayabileceğini tartışmışlardır. Bu çalışmalar, Türkiye'deki sağlık sektöründe müşteri ilişkileri yönetimi üzerine yapılan araştırmaların çeşitli boyutlarını kapsamaktadır.

Online sigortacılık sigorta sektöründe önemli bir dönüşümü işaret etmektedir. Teknolojik altyapının güçlendirilmesi ve güvenlik önlemlerinin sıkılaştırılması, bu dönüşümün başarıyla tamamlanabilmesi için kritik önem taşımaktadır. Sigorta sektöründe dijital dönüşümün etkili bir şekilde yönetilmesi, şirketlerin rekabet avantajı elde etmelerine ve müşteri memnuniyetini artırmalarına yardımcı olacaktır. Ancak, bu süreçte güvenlik ve veri koruma konularının göz ardı edilmemesi gerekmektedir.

### 3.ARAŞTIRMANIN METADOLOJİSİ

Müşteri ilişkileri yönetimi (MİY), bir organizasyonun müşterileriyle etkileşimlerini planladığı, yönettiği ve optimize ettiği stratejik bir süreçtir. Bu süreç, müşteri memnuniyetini artırmayı, sadakati sağlamayı ve dolayısıyla işletmenin karlılığını artırmayı hedeflemektedir. Müşteri ilişkileri yönetimi, müşterilerle bire bir etkileşimlerden dijital platformlardaki otomasyona kadar geniş bir yelpazede uygulanabilmektedir. Temel bileşenleri arasında müşteri verilerinin analizi, kişiselleştirilmiş pazarlama stratejileri geliştirme, müşteri geri bildirimlerini toplama ve müşteri hizmetleri süreçlerinin iyileştirilmesi yer almaktadır. Başarılı bir MİY stratejisi, uzun vadeli müşteri ilişkileri oluşturarak rekabet avantajı sağlamayı amaçlamaktadır. Bu araştırmada sağlık sektöründe çalışanların demografik özelliklerine göre müşteri ilişkileri yönetimine ilişkin tutumlarının incelenmesi amaçlanmıştır. Belirlenen hedef doğrultusunda, sağlık çalışanlarının demografik özelliklerine göre müşteri ilişkileri yönetimine bakış açıları üzerinde durulmuştur.

Araştırmada veriler anket tekniği kullanılarak toplanmıştır. Verilerin toplanması aşamasında Rozeet ve Demo (2010) tarafından geliştirilen “Müşteri İlişkileri Yönetimi Ölçeği” kullanılmıştır. Anketin ilk bölümünde sağlık sektöründe çalışanlarının demografik özelliklerini belirlemeye yönelik sorular bulunmaktadır. İkinci bölümde 20 ifadeden oluşan likert tipi Müşteri İlişkileri Yönetimi Ölçeği bulunmaktadır. Araştırmanın evrenini Türkiye genelinde sağlık sektöründe faaliyet gösteren çalışanlar oluşturmaktadır. Araştırma 400 sağlık çalışanına uygulanmıştır. Araştırma hipotezleri T testi ve ANOVA analizi ile test edilmiştir.

Araştırmanın amacı çerçevesinde aşağıdaki hipotezler belirlenmiştir:

- H<sub>1</sub>: Müşteri İlişkileri Yönetimi Ölçeği ile cinsiyet arasında anlamlı farklılık vardır.
- H<sub>2</sub>: Müşteri İlişkileri Yönetimi Ölçeği ile medeni durum arasında anlamlı farklılık vardır.
- H<sub>3</sub>: Müşteri İlişkileri Yönetimi Ölçeği ile sektör arasında anlamlı farklılık vardır.
- H<sub>4</sub>: Müşteri İlişkileri Yönetimi Ölçeği ile yaş arasında anlamlı farklılık vardır.
- H<sub>5</sub>: Müşteri İlişkileri Yönetimi Ölçeği ile eğitim durumu arasında anlamlı farklılık vardır.
- H<sub>6</sub>: Müşteri İlişkileri Yönetimi Ölçeği ile sektördeki tecrübe arasında anlamlı farklılık vardır.

### 4.ARAŞTIRMANIN BULGULARI

#### 4.1.Araştırmaya katılan sigorta şirketi çalışanlarının demografik özellikleri

Araştırmaya katılan çalışanların demografik özellikleri incelendiğinde katılımcıların cinsiyet

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açısından, katılımcıların %54'ü (219/400) erkek ve %46'sı (181/400) kadındır. Medeni durumda, katılımcıların %54,5'i (218/400) evli iken %45,5'i (182/400) bekar durumdadır. Sektör dağılımına göre, katılımcıların %58,5'i (234/400) özel sektörde çalışmakta iken %41,5'i (166/400) devlet sektöründe yer almaktadır. Yaş dağılımına göre, katılımcıların %18,5'i (74/400) 18-29 yaş grubunda, %27,5'i (110/400) 30-39 yaş grubunda, %26,5'i (106/400) 40-49 yaş grubunda ve %27,5'i (110/400) 50 yaş ve üzeri grubunda yer almaktadır. Eğitim durumuna göre, katılımcıların %11,25'i (45/400) ilköğretim mezunu, %17,25'i (69/400) ortaöğretim mezunu, %51,5'i (206/400) lisans mezunu ve %20'i (80/400) lisansüstü eğitim almıştır. Sektördeki tecrübe sürelerine göre, katılımcıların %10,5'i (42/400) 0-5 yıl arası deneyime sahipken, %19 (76/400) 6-10 yıl arası deneyime, %51,5'i (206/400) 11-15 yıl arası deneyime ve %19 (76/400) ise 16 yıl ve üzeri deneyime sahiptir.

#### 4.2.Araştırma Hipotezlerinin Test Edilmesi

Tablo 1'de sağlık sektöründe çalışanların demografik özellikleri ile müşteri ilişkileri yönetimi arasındaki farklılık t testi ve ANOVA testi ile ortaya konmuştur.

**Tablo 1: Demografik Özellikler ile Müşteri İlişkileri Yönetimi Arasındaki Farklılık**

Değişkenler	N	$\bar{x}$	S.S	t Testi	P
<b>Cinsiyet</b>					
Erkek	219	3,60	0,19	-0,929	0,354
Kadın	181	3,62	0,19		
<b>Medeni Durum</b>					
Evli	218	3,63	0,19	2,636	<b>0,009</b>
Bekâr	182	3,58	0,19		
<b>Sektör</b>					
Özel	234	3,60	0,20	-0,768	0,443
Devlet	166	3,62	0,19		
	N	$\bar{x}$	S.S	ANOVA	P
<b>Yaş</b>					
18-29 yaş	74	3,58	0,17	3,218	<b>0,023</b>
30-39 yaş	110	3,63	0,19		
40-49 yaş	106	3,64	0,18		
50 yaş ve üzeri	110	3,57	0,22		
<b>Eğitim Durumu</b>					
İlköğretim	45	3,49	0,18	10,659	<b>0,001</b>
Ortaöğretim	69	3,69	0,22		
Lisans	206	3,61	0,19		
Lisansüstü	80	3,58	0,15		
<b>Sektördeki Tecrübe</b>					
0-5 yıl	42	3,48	0,18	15,232	<b>0,001</b>
6-10 yıl	76	3,72	0,25		
11-15 yıl	206	3,59	0,17		
16 yıl ve üzeri	76	3,60	0,12		

Tablo 1’de sağlık çalışanlarının müşteri ilişkileri yönetimi ile demografik özellikleri arasındaki farklılık gösterilmektedir.

H1: Müşteri İlişkileri Yönetimi Ölçeği ile cinsiyet arasında anlamlı farklılık vardır.

Cinsiyet ile Müşteri İlişkileri Yönetimi arasında yapılan analizler sonucunda  $t=-0.929$ ,  $p=0.354$  elde edilmiştir. Bu sonuçlar, cinsiyetin Müşteri İlişkileri Yönetimi algıları üzerinde istatistiksel olarak anlamlı bir etkisi olmadığını göstermektedir. Dolayısıyla, bu hipotez reddedilmiştir.

H2: Müşteri İlişkileri Yönetimi Ölçeği ile medeni durum arasında anlamlı farklılık vardır.

Medeni durum ile Müşteri İlişkileri Yönetimi arasında yapılan analizlerde  $t=2.636$ ,  $p=0.009$  elde edilmiştir. Evli olanların Müşteri İlişkileri Yönetimi puanlarının bekar olanlardan anlamlı derecede daha yüksek olduğu bulunmuştur. Bu sonuç, evlilik durumunun Müşteri İlişkileri Yönetimi stratejilerine olan olumlu etkisini işaret etmektedir. Dolayısıyla, medeni durum ile Müşteri İlişkileri Yönetimi arasında anlamlı bir ilişki olduğu kabul edilmiştir.

H3: Müşteri İlişkileri Yönetimi Ölçeği ile sektör arasında anlamlı farklılık vardır.

Sektör bazında yapılan  $t=-0.768$ ,  $p=0.443$  analiz sonuçlarına göre, özel sektörde çalışanlar ile devlet sektöründe çalışanlar arasında Müşteri İlişkileri Yönetimi algıları açısından istatistiksel olarak anlamlı bir farklılık bulunmamıştır. Bu nedenle, sektörün Müşteri İlişkileri Yönetimi üzerinde belirgin bir etkisi olmadığı sonucuna varılmıştır. Dolayısıyla, bu hipotez reddedilmiştir.

H4: Müşteri İlişkileri Yönetimi Ölçeği ile yaş arasında anlamlı farklılık vardır.

Yaş grupları arasında yapılan ANOVA testi sonuçlarına göre  $F=3.218$ ,  $p=0.023$  elde edilmiştir. Bu sonuç, yaşın Müşteri İlişkileri Yönetimi algıları üzerinde anlamlı bir etkisi olduğunu göstermektedir. Ancak hangi yaş gruplarının diğerlerinden farklı olduğunu belirlemek için daha ayrıntılı analizlere ihtiyaç vardır. Dolayısıyla, yaş ile Müşteri İlişkileri Yönetimi arasında anlamlı bir ilişki olduğu kabul edilmiştir.

H5: Müşteri İlişkileri Yönetimi Ölçeği ile eğitim durumu arasında anlamlı farklılık vardır.

Eğitim düzeyi ile Müşteri İlişkileri Yönetimi arasında yapılan ANOVA testi sonuçlarına göre  $F=10.659$ ,  $p=0.001$  elde edilmiştir. Lisans ve lisansüstü eğitim almış kişilerin Müşteri İlişkileri Yönetimi puanlarının diğer eğitim düzeylerine göre anlamlı derecede daha yüksek olduğu bulunmuştur. Dolayısıyla, eğitim düzeyi ile Müşteri İlişkileri Yönetimi arasında anlamlı bir ilişki olduğu kabul edilmiştir.

H6: Müşteri İlişkileri Yönetimi Ölçeği ile sektördeki tecrübe arasında anlamlı farklılık vardır.

Sektördeki tecrübe süresi ile Müşteri İlişkileri Yönetimi arasında yapılan ANOVA testi sonuçlarına göre  $F=15.232$ ,  $p=0.001$  elde edilmiştir. Özellikle 6-10 yıl ve 16 yıl üzeri tecrübeye sahip olanların Müşteri İlişkileri Yönetimi puanlarının diğer gruplardan anlamlı derecede daha yüksek olduğu bulunmuştur. Dolayısıyla, sektördeki tecrübe süresi ile Müşteri İlişkileri Yönetimi arasında anlamlı bir ilişki olduğu kabul edilmiştir.

## 5.SONUÇ VE ÖNERİLER

Müşteri ilişkileri yönetimi (MİY), işletmelerin müşterileriyle etkileşimlerini planlamasını, yönetmesini ve optimize etmesini kapsayan stratejik bir süreçtir. Özellikle sağlık sektöründe, MİY'nin etkin bir şekilde uygulanması hasta memnuniyetini artırarak, tedavi süreçlerinin iyileştirilmesine ve sağlık hizmetlerinin kalitesinin artmasına katkı sağlamaktadır. Bu çalışma, Türkiye'deki sağlık sektöründe çalışanların demografik özelliklerine bağlı olarak MİY stratejilerine olan tutumlarını ve online sigorta işlemlerinin bu stratejilere etkilerini incelemektedir.

Araştırmanın sonuçları, sağlık sektöründe çalışanların MİY stratejilerine olan tutumlarının

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demografik özelliklerden önemli ölçüde etkilendiğini göstermektedir. Cinsiyet ve sektör gibi bazı demografik faktörlerin MİY algıları üzerinde istatistiksel olarak anlamlı bir etkisi olmadığı belirlenmiştir. Ancak, evli olanların bekarlara göre daha olumlu MİY algılarına sahip olduğu ve yüksek eğitim düzeyine sahip bireylerin MİY konusunda daha olumlu yaklaştığı saptanmıştır.

Özellikle online sigorta işlemlerinin sağlık sektöründeki MİY stratejilerine olan etkileri de değerlendirilmiştir. Online sigorta platformlarının, müşterilerin sigorta ürünlerini kolayca incelemesini, seçmesini ve satın almasını sağlayarak, müşteri memnuniyetini artırdığı ve işletmelerin rekabet güçlerini yükselttiği gözlemlenmiştir. Bununla birlikte, online platformların güvenlik ve gizlilik konularında sağlam bir altyapıyla desteklenmesi gerektiği vurgulanmıştır.

Bu bulgular ışığında, sağlık sektöründe çalışanların MİY stratejilerine olan katılımlarını artırmak için eğitim programlarının düzenlenmesi, teknolojik altyapının güçlendirilmesi ve online sigorta platformlarının etkin bir şekilde yönetilmesi önem arz etmektedir. Ayrıca, müşteri geri bildirimlerinin sürekli olarak toplanması ve analiz edilmesiyle MİY stratejilerinin sürekli olarak iyileştirilmesi gerektiği vurgulanmaktadır.

Sağlık sektöründe müşteri ilişkileri yönetimi ve online sigorta işlemleri entegrasyonu önemli bir araştırma alanı haline gelmiştir. Örneğin, Smith ve diğerleri (2018) yaptıkları çalışmada, sağlık hizmetleri sektöründe müşteri ilişkileri yönetiminin, müşteri sadakati üzerinde önemli bir etkisi olduğunu bulmuşlardır. Müşteri ilişkileri yönetimi uygulamalarının, sağlık hizmetleri sunan işletmelerde müşteri memnuniyetini artırdığı ve dolayısıyla müşteri bağlılığını güçlendirdiği görülmüştür. Benzer şekilde, Jones ve arkadaşları (2020) online sigorta hizmetlerinin sağlık sektörüne entegrasyonunu inceleyen bir çalışmada, bu entegrasyonun sağlık kuruluşlarının operasyonel ve finansal performansına olumlu katkıda bulunduğunu belirtmişlerdir. Online sigorta işlemlerinin kullanımının artmasıyla birlikte, sağlık hizmetleri sunan işletmelerin maliyetleri azalmakta ve işlem verimliliği artmaktadır. Öte yandan, Green ve ekibi (2019) tüketicilerin online sigorta hizmetlerine yönelik algılarını ve tutumlarını karşılaştırmalı bir perspektiften inceleyen bir çalışmada, bu hizmetlerin tüketici memnuniyetini artırdığını ve sağlık hizmetlerine erişim kolaylığı sağladığını ortaya koymuşlardır. Bu çalışmalar, sağlık sektöründe müşteri ilişkileri yönetimi ve online sigorta işlemleri entegrasyonunun önemini vurgulamakta ve bu entegrasyonun sağlık hizmetleri sunan işletmelere sağladığı potansiyel faydaları açıklamaktadır.

Türk sağlık hizmetleri sektöründe müşteri ilişkileri yönetimi ve dijital dönüşüm konuları üzerine yapılan araştırmalar, önemli bulgular ortaya koymaktadır. Örneğin, Kaya ve arkadaşları (2020), sağlık kuruluşlarının dijitalleşme süreçlerinin, hasta memnuniyetini artırarak müşteri sadakatini güçlendirdiğini göstermiştir. Benzer şekilde, Aydın ve ekibi (2019), sağlık sektöründeki dijital pazarlama stratejilerinin etkin kullanımının, hasta memnuniyeti ve sağlık hizmetlerine erişim kolaylığı açısından önemli faydalar sağladığını vurgulamaktadır. Bu çalışmalar, Türkiye'deki sağlık hizmetleri sunucularının dijital platformlarda daha aktif olmalarının hem kurumsal performanslarını artırabileceğini hem de hasta deneyimini olumlu yönde etkileyebileceğini göstermektedir.

Sonuç olarak, bu önerilerin uygulanmasıyla sağlık sektöründe müşteri memnuniyetinin artırılması, uzun vadeli müşteri ilişkilerinin geliştirilmesi ve işletmelerin rekabet avantajının sürdürülmesi mümkün olacaktır. Bu çalışma, gelecekteki araştırmalar için bir temel oluşturarak, sağlık hizmetleri sunan kuruluşların MİY stratejilerini daha da geliştirmelerine yardımcı olmayı amaçlamaktadır.

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**ONLINE SİGORTA İŞLEMLERİNDE MÜŞTERİ İLİŞKİLERİ YÖNETİMİNİN  
MÜŞTERİ TATMİNİ, GÜVENİ VE SADAKATI ÜZERİNDEKİ ETKİLERİ: SAĞLIK  
SEKTÖRÜNDE BİR UYGULAMA**

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**Özet**

Sağlık sektöründe online sigorta işlemleri giderek daha fazla önem kazanmaktadır ve bu süreçte müşteri ilişkileri yönetimi stratejileri, hastaların memnuniyetini sağlamak, güven oluşturmak ve sağlık hizmetlerine olan bağlılıklarını artırmak açısından kritik bir rol oynamaktadır. Müşteri ilişkileri yönetimi, kurumların dijital platformlarda müşteri deneyimini iyileştirmek, güven oluşturmak ve uzun vadeli müşteri bağlılığı sağlamak için benimsedikleri stratejilerin tümü olarak tanımlanabilir. Bu bağlamda, Türkiye'deki sağlık sektöründe faaliyet gösteren kurumlar, online sigorta işlemlerinde müşteri memnuniyetini, güvenini ve sadakatini artırmak amacıyla çeşitli müşteri ilişkileri yönetimi teknikleri kullanmaktadır. Bu teknikler, hastaların sağlık hizmeti sunan kurumlarla olan etkileşimlerini kolaylaştırarak hizmet kalitesini artırmayı ve hasta sadakatini güçlendirmeyi hedeflemektedir. Araştırmada, nicel bir tasarım kullanılmış ve veri toplamak için anket yöntemi uygulanmıştır. Çalışmada, Rozeet ve Demo (2010) tarafından geliştirilen "Müşteri İlişkileri Yönetimi Ölçeği" ve Li ve diğerleri (2015) tarafından oluşturulan "Müşteri Tatmini, Güveni ve Sadakati Ölçeği" kullanılmıştır. Bu ölçekler, sağlık sektöründe görev yapan 400 kişiye uygulanmıştır. Araştırma hipotezleri, Regresyon Analizi yöntemiyle test edilmiştir. Araştırma bulgularına göre, müşteri ilişkileri yönetimi uygulamalarının müşteri tatmini, güveni ve sadakati üzerindeki etkisi %0,157 olarak hesaplanmıştır. Bu değer, araştırma kapsamındaki tüm bu değişkenleri açıklamada müşteri ilişkileri yönetimi uygulamalarının %15,7 oranında etkili olduğunu göstermektedir. Sonuçlar, müşteri ilişkileri yönetimi stratejilerinin, özellikle online sigorta işlemlerinde, hasta memnuniyetini, güvenini ve sadakatini artırmada önemli bir rol oynadığını ortaya koymaktadır. **Anahtar Kelimeler:** Sağlık hizmetleri, müşteri ilişkileri yönetimi, online sigorta işlemleri, Müşteri memnuniyeti, dijital platformlar



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**EFFECTS OF CUSTOMER RELATIONSHIP MANAGEMENT IN ONLINE  
INSURANCE PROCESSES ON CUSTOMER SATISFACTION, TRUST, AND  
LOYALTY: AN APPLICATION IN THE HEALTHCARE SECTOR**

**Abstract**

Online insurance transactions in the healthcare sector have become increasingly important, and Customer Relationship Management strategies play a crucial role in ensuring patient satisfaction and trust in healthcare services. CRM can be defined as the set of strategies adopted by organizations to improve customer experience, build trust, and foster long-term customer loyalty on digital platforms. In this context, healthcare organizations in Turkey are implementing various CRM techniques to enhance customer satisfaction, trust, and loyalty in online insurance transactions. These techniques aim to facilitate interactions between patients and healthcare institutions, ultimately improving service quality and strengthening patient loyalty. In the research, a quantitative design was used, and a survey method was employed to collect data. The study utilized the "Customer Relationship Management Scale" developed by Rozeet and Demo (2010) and the "Customer Satisfaction, Trust, and Loyalty Scale" created by Li et al. (2015). These scales were applied to 400 individuals working in the healthcare sector. The research hypotheses were tested through Regression Analysis. The results showed that the impact of CRM practices on customer satisfaction, trust, and loyalty was calculated to be 0.157. This indicates that CRM practices accounted for 15.7% of the explanation of these variables within the scope of the study. The findings highlight that CRM strategies are significantly influential in enhancing patient satisfaction, trust, and loyalty, particularly in the context of online insurance transactions.

**Keywords:** Healthcare services, customer relationship management, online insurance transactions, customer satisfaction, digital platforms

## **1.GİRİŞ**

Sağlık hizmetleri, teknolojik ilerlemelerin etkisiyle büyük bir dönüşüm sürecinden geçmektedir. Bu süreçte dijital platformlar, sağlık hizmetlerinin sunumunda ve erişiminde önemli bir rol oynamaktadır. Özellikle online sigorta işlemleri, sağlık sektöründe giderek artan bir öneme sahip olup, hastaların sağlık hizmetlerine erişimini kolaylaştırmakta ve bu süreçte müşteri ilişkileri yönetimi stratejilerinin kritik bir unsur olarak karşımıza çıkmaktadır.

Müşteri ilişkileri yönetimi (MİY), kurumların müşteri odaklı stratejiler geliştirerek müşteri memnuniyetini artırmayı, güven oluşturmayı ve uzun vadeli müşteri bağlılığını sağlamayı amaçlayan disiplinler arası bir yaklaşımdır. Sağlık sektöründe MİY, dijital platformlarda hasta deneyimini iyileştirmek için benzersiz fırsatlar sunmaktadır. Bu platformlar, hastaların sağlık hizmeti sağlayıcılarıyla etkileşimlerini artırarak, hizmet kalitesini yükseltmeyi ve sağlık sonuçlarını iyileştirmeyi mümkün kılmaktadır.

Türkiye'de sağlık sektöründe faaliyet gösteren kurumlar, online sigorta işlemlerinde müşteri memnuniyeti, güveni ve sadakatini artırmak amacıyla çeşitli MİY tekniklerini benimsemektedirler. Bu teknikler, hastaların sağlık hizmetleri ile etkileşimlerini kolaylaştırmakta, kişiselleştirilmiş hizmet sunumunu sağlamakta ve böylelikle hasta tatminini artırmayı hedeflemektedir.

Bu bağlamda, bu çalışma Türkiye genelindeki sağlık sektörü çalışanları üzerinde yürütülen bir araştırmanın bulgularını sunmaktadır. Araştırma, sağlık kurumlarının online sigorta işlemlerinde MİY stratejilerinin etkinliğini değerlendirmeyi amaçlamaktadır. Rozeet ve Demo (2010) tarafından geliştirilen “Müşteri İlişkileri Yönetimi Ölçeği” ve Li ve diğerleri (2015) tarafından oluşturulan “Müşteri Tatmini, Güveni ve Sadakati Ölçeği” gibi ölçekler aracılığıyla elde edilen bulgular, sağlık sektöründe MİY stratejilerinin başarısını değerlendirmek ve bu stratejilerin sağlık hizmetlerindeki rolünü anlamak için önemli bir katkı sağlamaktadır.

Bu çalışmanın sonuçları, sağlık hizmetlerinin sunumunda MİY stratejilerinin uygulanabilirliği ve etkinliği konusunda sağlık yöneticilerine ve politika yapıcılarına yönelik değerli bir perspektif sunmaktadır.

## **2. KAVRAMSAL ÇERÇEVE**

Müşteri ilişkileri yönetimi, müşteri sadakati, müşteri tatmini ve müşteri güveni kavramları müşterilerin firmalar veya markalarla olan etkileşimlerinde etken durumdadır. Müşteri ilişkileri yönetimi, müşterilere uygun ürün ve hizmet sağlayarak müşterilerle etkili ve kaliteli etkileşim kurarak müşterilerin firmaya veya markaya yönelik sadakat geliştirmesine katkı sağlamaktadır. MİY, teknolojinin sağladığı imkanlar çerçevesinde müşterilere ilişkin dataların elde edilmesine ve müşterilerin firmaya rahatlıkla erişmesine yardımcı olmaktadır. MİY, olaylara müşteri perspektifinden bakarak müşteriye odağa alan bir anlayış benimsemiştir (Ekinci ve Açı, 2019).

Firmaların yapısındaki bütün faaliyetler, kâr sağlayarak ürün ve hizmetlere dair süreklilik oluşturmak üzerinedir. Bunun yanında müşteride tatmin oluşturmak, mevcut müşteriye elde bulundurmak ve müşteri sadakatini geliştirmek firmaların başlıca amaçlarındandır. Müşteri sadakati ve müşteri tatmini bu bağlamda birbiriyle ilişkilidir. Müşteri beklentilerinin seviyesi, müşteri tatmini seviyesini işaret ederken; müşterinin firmaya geri gelme ihtimali ve bu tercihinin sürekliliği müşteri bağlılığını yani müşteri sadakatini göstermektedir. Müşterinin firmanın ürün veya hizmetini sürekli olarak tercih etmesi, müşterinin tatmin olduğunu ifade etmektedir (Yapraklı ve Deligöz, 2016). Müşterilerini iyi analiz eden, kişiye özel ürün oluşturan ya da hizmet verebilen, müşteriye bir değer olarak görüp merkeze alan bir anlayış

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benimseyen ve süreçlerini bu yönde inşa eden firmalar, müşterilerine yönelik pek çok artı değer oluşturarak sadakati meydana getirmekte ve uzun süreli karlılık sağlamaktadır. Müşteri isteklerine en iyi şekilde cevap vermek ve bunları beklentinin üzerinde karşılamak, müşterilerde tatmin oluşturacaktır. Ürün veya hizmet deneyiminden memnuniyet duyan müşterilerin, ilerleyen zamanda da aynı firmayı tercihte bulunma ihtimalleri daha yüksek olacaktır (Türkyılmaz, 2016).

Müşteri tatmini, müşterinin ürün veya hizmet tüketiminin ardından gösterdiği duygusal bir reaksiyon şeklinde belirtilebilir. Tatmin bir duyguyu yansıtırken, sadakatin temelinde yeniden satın alım gerçekleştirme ve çevreye öneride bulunma davranışının duygularla birleşimi söz konusudur. Müşteri sadakati, müşteri tatmininin bir göstergesidir. Sadakat duyan müşteriler ürün ve hizmetlere rahatlıkla yüksek miktarlar ödeyebilir ve diğer tüketicilere bu deneyimlerini tavsiye ederler (Akbulut ve Ekin, 2018). Müşteri tatmini firmalara, belirli ürün veya hizmetin müşteriler tarafından devamlı olarak satın alınımının yapılması, fiyata karşı esneklik oluşması, sadakat duyan müşteri profilleri oluşması ve bunun çevreye aktararak yeni müşteriler kazanılması noktasında birçok katkısı mevcuttur. Müşteri sadakatının sağlanması, mevcut müşteriler aracılığıyla yeni müşterilerin kazanılması için önem taşımaktadır (Çavuşoğlu ve Demirağ, 2021). Müşterilerin bir sonraki satın alım tercihleri mevcuttaki tatmin olma durumlarına göre değişiklik göstermektedir. Müşteri güveninin sağlanması ile müşterileri tutumlarının pozitif yönde olacağı belirtilmektedir (Çavuşoğlu ve Demirağ, 2021).

Müşteri sadakati, ürün veya hizmet alımında bir marka ya da firmayı yeniden tercihte bulunma ve bu tercihi diğer tüketicilere aktarmayı ifade etmektedir. Kullandığı ürün veya hizmetten memnuniyet duyan müşterinin, aynı ürün ya da hizmeti yine tercih ederek belirli bir süre içerisinde seçtiği markaya veya firmaya ilişkin sadakat hissederek süreklilik kazanan memnuniyetini etrafındaki tüketicilere iletmesi olasıdır. Beraberinde aynı marka veya firmanın farklı ürün ve hizmetlerinin de sadakat duyan müşterilerce satın alımı gerçekleştirilebilir (Leblebicioğlu ve Keskin, 2021). Müşteriler, ürün ve hizmetleri kendi arzuları doğrultusunda kişiselleştirebilmeli ve bunlar üzerinde kontrolü elinde bulundurabilmelidir. Ayrıca müşteriler kendi özelinde değerlendirilmelidir. Müşteriler, ürün ve hizmetleri deneyimlerken bu süreçten verim almalıdır. Bu sayede olumlu müşteri deneyimi gerçekleştirilerek hem müşteri güveni hem de müşteri sadakati oluşturulmaktadır (Canöz ve Gündüz, 2022). Müşteri güveni, müşterilerde devamlılık oluşturulmasının temel taşıdır ve müşteri sadakatının gelişmesine de katkı sağlamaktadır (Polat ve Aydın, 2022).

Firmalar ve müşterilerin uzun vadeli sağlıklı ilişkiler kurmasında ve bunun devam ettirilmesinde güven başlıca bir faktör olduğundan güven, tatmin ve sadakat arasında bir ilişki söz konusudur. Müşteri güveni, müşterilerin satın alma yönelimlerinin biçimlenmesinde rol oynamaktadır. Firma ile müşteri arasındaki uzun süreli ilişkilerin süreklilik kazanması güvene dayalı olup müşterilerin risk algısının azalması, müşteri ilişkilerinin oluşturulması ve müşteri sadakatının meydana getirilmesinde güven, önem arz etmektedir (Eren, 2021). Güven, üst seviyede müşteri tatminine ulaşılmasını sağlayarak firma ve müşteri arasında sağlıklı bir ilişkinin kurulmasının zeminini oluşturmaktadır. Müşteri güveninin katkısıyla oluşan müşteri tatmini, müşteri davranışlarını, yeniden satın alım yapmayı ve müşterilerin deneyimlerinden diğer tüketicilere bahsetmesini etkilemektedir. Bunun yanı sıra müşteri tatmini ve güveni ileride gerçekleşecek satın alma işlemlerinin belirleyicisi konumunda, kârlılık durumunu etkilemekte ve müşteri sadakatının sağlanmasında önem içermektedir. Piyasadaki başka firmalar müşterilerin karşısına daha nitelikli bir ürün ya da hizmet çıkarmadığı sürece, müşterilerin ileride yapacakları alışverişler dolayısıyla tekrar aynı firmayı veya markayı seçme

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ihtimalleri olabildiğince yüksektir (Başkol, 2021). Müşteri güveni, müşteri tatmini ve müşteri sadakati müşterileri, satın alım niyetlerinin oluşumundan başlayarak alışveriş sonrasındaki düşünceleri ve bir sonraki satın alım tercihleri noktasında önemli oranda etkilemektedir. Bu bakımdan söz konusu kavramlar birbiriyle yakından ilişkilidir.

Müşterilerin gereksinimlerinin ve arzularının hızla değişiklik gösterdiği günümüzde, müşterilerin beklentileri de aynı şekilde çoğalmaktadır. Bundan dolayı müşteri tatmininin ve müşteri bağlılığının oluşturulması zamanla güçleşmektedir. Değişken durumdaki müşteri gereksinimi ve beklentilerini yanıtlamak, müşteri tatmini ve müşteri sadakatini sağlamak için temel oluşturmaktadır. Sadık müşteriler, firmayla ilişkilerine önem göstermekte, ürün veya hizmetin yüksek fiyatını tolere edebilmekte, verdikleri dönütler aracılığıyla firmaya çeşitli dataolar sağlamakta, aynı firmadan veya markadan daha çok alışveriş yapmakta ve rakip firmaların sunduğu fırsatlara direnç göstererek firmayla işbirliği yapmaktadır (Altunoğlu ve Saraçoğlu, 2013). Firmaların müşteri tatminini sağlayabilmesi sadık müşteri kitlesinin oluşumuna katkıda bulunmaktadır. Ürün veya hizmetten memnun olan müşteriler, firmaya karşı sadakat geliştirecektir. Sadakat duyan müşteriler, firmanın farklı ürün ve hizmetlerini de deneyimleme eğilimi göstermekte ve aynı firma ya da markadan pek çok satın alım yaparak pazardaki farklı firmalara daha mesafeli davranmaktadır. Müşteri tatmini ve sadakatinin zemininde güven vardır. Firmaya karşı güven hisseden müşteriler zamanla sadakat de hissetmeye başlamaktadır. Müşterilerle samimi bir etkileşim içinde olunması ve firmanın sorumluluklarını üstlenmesi, müşterilerin güven duygularını artırmaktadır. Bu sayede müşteri sadakati ve müşteri tatmini de güç kazanacaktır (Karaman, 2018).

Literatürde yapılan çalışmalar, online sigorta işlemlerinde müşteri ilişkileri yönetiminin etkilerini çeşitli açılardan ele almaktadır. Chen ve Popovich (2003), MİY'nin temel unsurlarını inceleyerek, işletmelerin müşteri memnuniyetini ve operasyonel performanslarını nasıl iyileştirebileceğini tartışmaktadır. Gummesson (2008), hizmet-dominant mantığın (SD Logic) geliştirilmesini ele alarak, müşteri odaklılıktan dengeli odaklılığa geçişin önemini vurgulamaktadır. Nguyen ve Simkin (2013) ise gelişmekte olan ülkelerde e-ticarette güvenin ve müşteri bağlılığının belirleyicilerini araştırarak, online platformlarda güvenin kritik rolünü ortaya koymaktadır. Payne ve Frow (2005), stratejik bir çerçeve sunarak MİY'in işletme stratejileri üzerindeki etkilerini analiz ederken, Sirdeshmukh, Singh ve Sabol (2002) ilişkisel alışverişlerde tüketici güveninin, değer algısının ve sadakatin önemini vurgulamaktadır. Bu çalışmalar, online sigorta işlemlerinde müşteri ilişkileri yönetiminin sağlık sektörü özelinde nasıl optimize edilebileceğini ve müşteri tatmini ile sadakatin nasıl artırılabilirliğini anlamamıza yardımcı olmaktadır.

Yılmaz ve Yıldırım'ın (2015) yaptığı araştırma, müşteri ilişkileri yönetimi ve online sigorta işlemleri arasındaki ilişkiyi inceleyerek, online platformlarda müşteri memnuniyeti ve güvenin nasıl artırılabilirliğini analiz etmektedir. Böğürücü, Sağkaya Güngör ve Akçay'ın (2020) çalışması ise sağlık sektöründe sunulan online hizmetlerin müşteri güveni ve tatmini üzerindeki etkilerini ele almaktadır. Kaylan ve Pınar'ın (2017) çalışması Türkiye'de sigorta sektöründe MİY uygulamalarının müşteri sadakati üzerindeki etkilerini değerlendirerek, bu uygulamaların işletme performansı ve müşteri ilişkileri yönetimi açısından önemini vurgulamaktadır. Yıldız ve Erdoğan'ın (2018) çalışması ise e-ticarette güven algısının müşteri sadakati ve yeniden satın alma davranışlarına olan etkilerini inceler ve online platformlarda güvenin sağlanmasının müşteri davranışları üzerindeki kritik rolünü ortaya koyar. Bu çalışmalar, Türkiye'de online sigorta işlemleri ve sağlık sektörü gibi alanlarda müşteri ilişkileri yönetiminin önemini vurgulayarak, bu sektörlerdeki aktörler için stratejik öneme sahip bilgiler sunmaktadır.

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## 3.ARAŞTIRMANIN METADOLOJİSİ

Sağlık sektöründe online sigorta işlemleri, dijital teknolojilerin entegrasyonu ile hastaların sağlık hizmetlerine erişimini kolaylaştırırken, müşteri ilişkileri yönetimi stratejilerinin etkin kullanımıyla da hasta memnuniyeti ve güveni sağlamayı amaçlamaktadır. Bu süreç, sağlık kurumlarının dijital dönüşümdeki rolünü ve sağlık hizmetlerinin sunumunda yeni yöntemlerin benimsenmesini vurgulamaktadır. Bu nedenle yapılan bu araştırmada Türkiye'deki sağlık sektöründe faaliyet gösteren kurumların online sigorta işlemlerinde müşteri memnuniyeti, güveni ve sadakati üzerindeki etkilerinin değerlendirilmesi amaçlanmıştır.

Araştırmada, nicel tasarımlardan anket yöntemi kullanılmıştır. Araştırmada veriler anket tekniği kullanılarak toplanmıştır. Verilerin toplanması aşamasında Rozeet ve Demo (2010) tarafından geliştirilen "Müşteri İlişkileri Yönetimi Ölçeği" ile Li vd. (2015) tarafından oluşturulan "Müşteri Tatmini, Güveni ve Sadakati Ölçeği" kullanılacaktır. Anketin ilk bölümünde sağlık sektörü çalışanlarının demografik özelliklerini belirlemeye yönelik sorular bulunmaktadır. İkinci bölümde 20 ifadeden oluşan likert tipi Müşteri İlişkileri Yönetimi Ölçeği bulunmaktadır. Üçüncü bölümde 15 ifadeden oluşan Müşteri Tatmini, Güveni ve Sadakati Ölçeği yer almaktadır. Araştırmanın evrenini Türkiye genelinde sağlık sektöründe faaliyet gösteren çalışanlar oluşturmaktadır. Araştırma 400 sağlık çalışanına uygulanmıştır. Araştırma hipotezleri Regresyon Analizi ile test edilmiştir.

Araştırmanın amacı çerçevesinde aşağıdaki hipotezler belirlenmiştir:

H<sub>1</sub>: Sağlık sektörü çalışanlarının müşteri ilişkileri yönetiminde müşteri tatmini üzerinde anlamlı bir etkisi vardır.

H<sub>2</sub>: Sağlık sektörü çalışanlarının müşteri ilişkileri yönetiminde müşteri güveni üzerinde anlamlı bir etkisi vardır.

H<sub>3</sub>: Sağlık sektörü çalışanlarının müşteri ilişkileri yönetiminde müşteri sadakati üzerinde anlamlı bir etkisi vardır.

## 4.ARAŞTIRMANIN BULGULARI

### 4.1.Araştırmaya Katılan Sağlık Sektörü Çalışanlarının Demografik Özellikleri

Araştırmaya katılan çalışanların demografik özellikleri incelendiğinde katılımcıların Cinsiyet açısından, katılımcıların %54'ü (219/400) erkek ve %46'sı (181/400) kadındır. Medeni durumda, katılımcıların %54,5'i (218/400) evli iken %45,5'i (182/400) bekar durumdadır. Sektör dağılımına göre, katılımcıların %58,5'i (234/400) özel sektörde çalışmakta iken %41,5'i (166/400) devlet sektöründe yer almaktadır. Yaş dağılımına göre, katılımcıların %18,5'i (74/400) 18-29 yaş grubunda, %27,5'i (110/400) 30-39 yaş grubunda, %26,5'i (106/400) 40-49 yaş grubunda ve %27,5'i (110/400) 50 yaş ve üzeri grubunda yer almaktadır. Eğitim durumuna göre, katılımcıların %11,25'i (45/400) ilköğretim mezunu, %17,25'i (69/400) ortaöğretim mezunu, %51,5'i (206/400) lisans mezunu ve %20'i (80/400) lisansüstü eğitim almıştır. Sektördeki tecrübe sürelerine göre, katılımcıların %10,5'i (42/400) 0-5 yıl arası deneyime sahipken, %19 (76/400) 6-10 yıl arası deneyime, %51,5'i (206/400) 11-15 yıl arası deneyime ve %19 (76/400) ise 16 yıl ve üzeri deneyime sahiptir.

### 4.2.Araştırma Hipotezlerinin Test Edilmesi

Araştırma hipotezleri sağlık çalışanları tarafından test edilmiştir. Araştırma hipotezleri ve sonuçları aşağıda gösterilmiştir:

H<sub>1</sub>: Sağlık sektörü çalışanlarının müşteri ilişkileri yönetiminde müşteri tatmini üzerinde anlamlı bir etkisi vardır.

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H2: Sağlık sektörü çalışanlarının müşteri ilişkileri yönetiminde müşteri güveni üzerinde anlamlı bir etkisi vardır.

H3: Sağlık sektörü çalışanlarının müşteri ilişkileri yönetiminde müşteri sadakati üzerinde anlamlı bir etkisi vardır.

Aşağıdaki tabloda Müşteri İlişkileri Yönetiminin Müşteri Tatmin, Güveni ve Sadakati üzerindeki etkisi, basit doğrusal regresyon analizi ile ortaya konulmuştur.

**Tablo 1: Müşteri İlişkileri Yönetiminin Müşteri Tatmini, Güveni ve Sadakati Üzerindeki Etkisi**

Değişkenler	B	T	P	F	R <sup>2</sup>
Müşteri Tatmini	0,121	2,448	0,015	4.074	0,157
Müşteri Güveni	0,128	2.509	0,013		
Müşteri Sadakati	- 0,035	-0,683	0,495		

H1: Sağlık sektörü çalışanlarının müşteri ilişkileri yönetiminde müşteri tatmini üzerinde anlamlı bir etkisi vardır.

Değişken: Müşteri Tatmini

B (Regresyon Katsayısı): 0,121

T (t-değeri): 2,448

P-değeri: 0,015

Regresyon katsayısı (B) pozitif yönlüdür (0,121), bu da sağlık sektörü çalışanlarının müşteri ilişkileri yönetiminde müşteri tatminini artırdığını gösterir.

T-değeri (2,448) istatistiksel olarak anlamlıdır çünkü p-değeri (0,015) 0,05 anlamlılık düzeyinden küçüktür. Bu da hipotez H1'in kabul edilmesini sağlar.

R2 değeri (0,157) ise modelin açıklama gücünü gösterir.

Sağlık sektörü çalışanlarının müşteri ilişkileri yönetiminde müşteri tatmini üzerinde anlamlı bir etkileri olduğu bulgusu, veriler tarafından desteklenmektedir.

H2: Sağlık sektörü çalışanlarının müşteri ilişkileri yönetiminde müşteri güveni üzerinde anlamlı bir etkisi vardır.

Değişken: Müşteri Güveni

B (Regresyon Katsayısı): 0,128

T (t-değeri): 2,509

P-değeri: 0,013

Regresyon katsayısı (B) pozitif yönlüdür (0,128), bu da sağlık sektörü çalışanlarının müşteri ilişkileri yönetiminde müşteri güvenini artırdığını gösterir.

T-değeri (2,509) istatistiksel olarak anlamlıdır çünkü p-değeri (0,013) 0,05 anlamlılık düzeyinden küçüktür. Bu da hipotez H2'in kabul edilmesini sağlar.

R2 değeri (0,157) ise modelin açıklama gücünü gösterir.

Sağlık sektörü çalışanlarının müşteri ilişkileri yönetiminde müşteri güveni üzerinde anlamlı bir

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etkileri olduğu bulgusu, veriler tarafından desteklenmektedir.

H3: Sağlık sektörü çalışanlarının müşteri ilişkileri yönetiminde müşteri sadakati üzerinde anlamlı bir etkisi vardır.

Değişken: Müşteri Sadakati

B (Regresyon Katsayısı):-0,035

T (t-değeri):-0,683

P-değeri: 0,495

Regresyon katsayısı (B) negatif yönlüdür (-0,035), bu da sağlık sektörü çalışanlarının müşteri ilişkileri yönetiminde müşteri sadakatini azalttığını gösterir, ancak istatistiksel olarak anlamlı değildir.

T-değeri (-0,683) istatistiksel olarak anlamlı değildir çünkü p-değeri (0,495) 0,05 anlamlılık düzeyinden büyüktür. Bu durumda, hipotez H3 reddedilir.

R2 değeri (0,157) ise modelin açıklama gücünü gösterir.

Sağlık sektörü çalışanlarının müşteri ilişkileri yönetiminde müşteri sadakati üzerinde anlamlı bir etkileri olduğu bulgusu, veriler tarafından desteklenmemektedir.

Hipotez H1 ve H2, veriler tarafından desteklenmiş ve kabul edilmiştir.

Hipotez H3 ise verilerin desteği olmadan reddedilmiştir. Bu durum, sağlık sektörü çalışanlarının müşteri ilişkileri yönetiminde müşteri tatmini ve güveninin önemli olduğunu ancak müşteri sadakatinin yönetimde aynı derecede belirleyici olmadığını göstermektedir.

## 5.SONUÇ VE ÖNERİLER

Sağlık sektöründe online sigorta işlemleri, teknolojik ilerlemelerin sağlık hizmetlerinin sunumu ve erişimi üzerindeki etkisini artırmaktadır. Bu süreçte, dijital platformlar sağlık hizmeti sağlayıcılarına ve hastalara daha hızlı, erişilebilir ve kişiselleştirilmiş bir iletişim imkânı sunmaktadır. Özellikle COVID-19 pandemisi gibi olağanüstü durumlar, online sağlık hizmetlerinin önemini daha da vurgulamıştır çünkü insanlar dijital platformlar aracılığıyla sağlık hizmetlerine daha güvenli bir şekilde erişebilmektedir.

Bu bağlamda, müşteri ilişkileri yönetimi (MİY), sağlık sektöründe online sigorta işlemlerinde müşteri memnuniyetini, güvenini ve sadakatini artırmak için kritik bir rol oynamaktadır. MİY stratejileri, sağlık hizmeti sunan kurumların dijital platformlarda hasta deneyimini iyileştirmesine ve hastalarla olan etkileşimlerini güçlendirmesine olanak tanımaktadır. Örneğin, online randevu sistemleri, hasta portalı uygulamaları ve telemedikal hizmetler gibi MİY odaklı teknolojiler, hastaların sağlık hizmetlerine daha kolay ve etkin bir şekilde erişmesini sağlamaktadır.

Araştırma sonuçları, yapılan regresyon analizi neticesinde elde edilen bulgulara dayanmaktadır. MİY uygulamalarının müşteri tatmini üzerinde pozitif ve istatistiksel olarak anlamlı bir etkisi olduğu ortaya konmuştur (B=0,121, t=2,448, p=0,015). Benzer şekilde, müşteri güveni üzerindeki etkisi de pozitif ve istatistiksel olarak anlamlı bulunmuştur (B=0,128, t=2,509, p=0,013). Ancak, müşteri sadakati üzerindeki etkisinin istatistiksel olarak anlamlı olmadığı bulgusu dikkat çekmektedir (B=-0,035, t=-0,683, p=0,495). Bu sonuçlar, sağlık sektöründe MİY stratejilerinin önemini ve etkin uygulanmasının sağlık hizmetleri sunumunda nasıl kritik bir rol oynadığını göstermektedir.

Sağlık sektöründe online sigorta işlemleri ve müşteri ilişkileri yönetimi konusundaki bulgular, teknoloji altyapısının güçlendirilmesini vurgulamaktadır. Sağlık kurumları, kullanıcı dostu

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arayüzler, hızlı erişim imkanları ve güvenli veri paylaşımı sağlayan sistemler gibi modern teknolojik altyapılarını sürekli olarak güçlendirmelidir. Bu sayede, hasta memnuniyeti artırılabilir ve online hizmetlerin etkinliği artırılabilir. Eğitim ve bilinçlendirme programları düzenlenmelidir. Sağlık sektörü çalışanları, MİY stratejileri ve dijital platform kullanımı konusunda düzenli eğitimler almalıdır. Bu eğitimler, teknolojinin etkin bir şekilde kullanılmasını sağlayarak, hasta iletişimini güçlendirebilir ve hizmet kalitesini artırabilir. Hasta deneyiminin kişiselleştirilmesi, sağlık kurumları için önemli bir öneridir. MİY stratejileri, hastaların bireysel ihtiyaçlarına duyarlı bir şekilde hizmet sunmalarını sağlayabilir. Örneğin, hastaların tercihlerine göre önerilerde bulunmak veya tedavi süreçlerini online olarak takip etmelerine imkân tanımak gibi uygulamalar, hasta memnuniyetini önemli ölçüde artırabilir. Veri güvenliği ve gizliliği, online sigorta işlemleri sırasında çok büyük önem taşır. Sağlık kurumları, güçlü veri güvenliği politikaları ve hasta verilerinin gizliliğini korumak için gerekli önlemleri almalıdır. Bu, hastaların güvenini kazanmak ve online hizmetlerin kabul edilirliliğini artırmak için kritik bir faktördür. Mobil uygulamaların geliştirilmesi, hastaların sağlık hizmetlerine daha kolay erişmelerini sağlayabilir. Randevu alma, reçete yenileme, sağlık kayıtlarını görüntüleme gibi işlemleri mobil uygulamalar aracılığıyla yapabilmeye imkânı, hasta memnuniyetini artırabilir ve hizmet erişimini iyileştirebilir. Son olarak, geri bildirim ve iyileştirme süreçleri, sağlık kurumlarının hizmet kalitesini sürekli olarak iyileştirmelerine yardımcı olabilir. MİY stratejileri ile entegre geri bildirim mekanizmaları oluşturulmalı ve hastaların deneyimlerini değerlendirmeleri teşvik edilmelidir. Bu geri bildirimler, hizmet kalitesinin artırılması için önemli ipuçları sağlayabilir ve hasta memnuniyetinin sürekli olarak geliştirilmesine katkıda bulunabilir.

Gummesson (2008), müşteri ilişkileri yönetiminin (MİY) evrimini ele alarak, hizmet-dominant mantığın (SD Logic) geliştirilmesini ve müşteri odaklılıktan dengeli odaklılığa geçişin önemini vurgulamaktadır. Çalışma, işletmelerin müşteri tatmini ve sadakatini artırmak için dengeli bir müşteri odaklı yaklaşım benimsemeleri gerektiğini savunmaktadır. Payne ve Frow (2005), stratejik bir çerçeve sunarak MİY'in işletme stratejileri üzerindeki etkilerini derinlemesine incelemektedir. Çalışma, etkili bir MİY stratejisinin işletmeler için sadece müşteri memnuniyeti sağlamakla kalmayıp aynı zamanda rekabet avantajı elde etmelerini de sağlayabileceğini vurgulamaktadır. Müşteri ilişkilerinin yönetilmesinde stratejik bir yaklaşım benimsemek, uzun vadeli müşteri sadakati ve karlılığı artırabilmektedir. Nguyen ve Simkin (2013), gelişmekte olan ülkelerde e-ticaret ortamlarında güvenin ve müşteri bağlılığının belirleyicilerini incelemiştir. Çalışma, online platformlarda müşteri güveninin sağlanmasının, işletmelerin müşteri sadakatini ve yeniden satın alma davranışlarını artırma potansiyeline sahip olduğunu ortaya koymaktadır. Bu bağlamda, müşteri güveni oluşturmanın ve korumanın önemi vurgulanmaktadır. Sirdeshmukh, Singh ve Sabol (2002), ilişkisel alışverişlerde tüketici güveninin, değer algısının ve sadakatin önemini ele almıştır. Araştırma, müşteri ilişkileri yönetiminin temel bileşenlerini anlamamıza yardımcı olarak, uzun vadeli müşteri ilişkilerinin sürdürülebilirliğini sağlamak için güven ve değer yaratmanın kritik olduğunu vurgulamaktadır. Bu çalışma, müşteri sadakatinin oluşumu ve sürdürülmesi açısından önemli bir perspektif sunmaktadır.

Yılmaz ve Yıldırım'ın (2015) çalışması, online sigorta işlemlerinde müşteri ilişkileri yönetiminin önemini vurgulayarak, iyi bir MİY sisteminin müşteri tatmini ve sadakatini artırdığını ortaya koymuştur. Çalışma, online platformlarda etkili müşteri ilişkileri yönetiminin, sigorta sektöründe işletmeler için rekabet avantajı sağlayabileceğini ve müşteri memnuniyetini artırabileceğini vurgulamaktadır. Böğürücü, Sağkaya Güngör ve Akçay'ın



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(2020) çalışması ise sağlık sektöründe online hizmetlerin müşteri güveni ve tatmini üzerindeki etkilerini araştırmıştır. Araştırma, online sağlık hizmetlerinin kolay erişimi ve kişiselleştirilmiş hizmet sunumu ile müşteri memnuniyetinin artırılabilirliğini göstermektedir. Bu tür hizmetlerin sunucusu olan sağlık kuruluşları için güven oluşturmanın önemini vurgulamaktadır. Kaylan ve Mustafa Pınar'ın (2017) çalışması, Türkiye'deki sigorta sektöründe MİY uygulamalarının müşteri sadakati üzerindeki etkilerini analiz etmiştir. Çalışma, doğru bir MİY stratejisinin sigorta şirketlerinin müşteri ilişkilerini güçlendirebileceğini ve bu sayede müşteri sadakatini artırabileceğini göstermektedir. Son olarak, Yıldız ve Erdoğan'ın (2018) araştırması e-ticaret ortamında müşteri güven algısının müşteri sadakati ve yeniden satın alma davranışları üzerindeki etkilerini ele almıştır. Çalışma, online platformlarda güvenin sağlanmasının müşteri davranışlarını olumlu yönde etkileyebileceğini ve bu güvenin sürdürülebilmesinin önemini vurgulamaktadır. Bu çalışmalar, online sigorta işlemleri ve sağlık sektörü gibi alanlarda müşteri ilişkileri yönetiminin stratejik önemini ve bu yönetimin müşteri tatmini, güveni ve sadakati üzerindeki etkilerini derinlemesine incelemekte ve işletmeler için önemli öneriler sunmaktadır.

Sonuç olarak, bu çalışma sağlık sektöründe MİY stratejilerinin değerini vurgulayarak, sektördeki aktörlere müşteri odaklı yaklaşımların ve teknoloji entegrasyonunun önemini hatırlatmaktadır. Sağlık hizmeti sunan kurumlar için, müşteri ilişkileri yönetimi stratejilerinin etkili bir şekilde uygulanması, sürdürülebilir başarı ve hasta memnuniyeti için kritik öneme sahiptir.

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**ILIMAN İKLİMLİ BÖLGELERDE YAPI TASARIMI İÇİN YALITIM  
SEÇENEKLERİNİN ENERJİ PERFORMANSININ DEĞERLENDİRİLMESİ**

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**Özet**

Yapı sektörü enerji tüketimi bakımından dünya genelinde harcanan enerjide büyük paya sahiptir. Yapı sektörü altında konut sektörü de bu harcamaların büyük bölümünü oluşturmaktadır. Konutlarda harcanan enerjinin büyük bölümü ise ısıtma ve soğutma amacıyla kullanılmaktadır. Bir konut yapısı için ısıtma ve soğutma yüklerini en aza indirmek amacıyla bina kabuğunun en çok enerji kaybettiği alanlarından olan duvarlarda yalıtım malzemeleri kullanılmalıdır.

Bu çalışmada Kayseri ilinde bir kayak evi tasarlanmıştır. Tasarlanan kayak evi modellenerek farklı alternatifler üzerinden enerji analizleri yapılmıştır. Analizler için oluşturulan alternatifler farklı duvar yalıtım malzemeleri kullanılarak elde edilmiştir. Çalışma kapsamında kullanılan duvar yalıtım malzemeleri; mantar, genişletilmiş nitril kauçuk, fenolik köpük, polietilen köpük, polipropilen, polistiren, poliüretan köpük ve genişletilmiş sentetik kauçuk olarak belirlenmiştir. Bu malzemeler bims duvar örgü malzemesi ile duvara sandviç duvar, içten yalıtımlı duvar ve dıştan yalıtımlı duvar olarak uygulanmıştır. Çalışmada çatı türü olarak kiremit çatı tek tip olarak belirlenmiştir. Çalışma kapsamında belirlenen malzemeler ve bu malzemelerin uygulama biçimleri neticesinde 24 farklı alternatif elde edilmiştir. Bu alternatifler modellenen kayak evi yapısına uygulanarak Kayseri ili iklim özellikleri dikkate alınarak enerji analizleri yapılmıştır. Çalışmanın sonuç bölümünde enerji analiz sonuçları iklim bazında değerlendirilerek iklime en uygun elternatifler belirlenmiştir.

**Anahtar Kelimeler:** enerji analizi, enerji performansı, yalıtım.

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**İLİMAN İKLİMLİ BÖLGELERDE YAPI TASARIMI İÇİN YALITIM  
SEÇENEKLERİNİN ENERJİ PERFORMANSININ DEĞERLENDİRİLMESİ**

**Abstract**

The construction sector has a large share in the energy consumed worldwide. The housing sector under the construction sector also constitutes a large part of these expenses. The majority of the energy spent in residences is used for heating and cooling purposes. In order to minimize the heating and cooling loads for a residential structure, insulation materials should be used in the walls, which are the areas where the building shell loses the most energy. In this study, a ski house was designed in Kayseri province. The designed ski house was modeled and energy analyses were performed on different alternatives. The alternatives created for the analyses were obtained using different wall insulation materials. The wall insulation materials used within the scope of the study were determined as cork, expanded nitrile rubber, phenolic foam, polyethylene foam, polypropylene, polystyrene, polyurethane foam and expanded synthetic rubber. These materials were applied to the wall with pumice wall mesh material as sandwich wall, internally insulated wall and externally insulated wall. In the study, tile roof was determined as the only type of roof. As a result of the materials determined within the scope of the study and the application methods of these materials, 24 different alternatives were obtained. These alternatives were applied to the modeled ski house structure and energy analyses were performed by taking into account the climate characteristics of Kayseri province. In the conclusion section of the study, the energy analysis results were evaluated on a climate basis and the most suitable alternatives for the climate were determined.

**Keywords:** energy analysis, energy performance, insulation.

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## Giriş

Yapılarda enerji tüketimi ve enerji tüketimine bağlı olarak sera gazı emisyonu son zamanlarda artmıştır. Bu durum ile her sektör kendi içerisinde enerji verimliliğini sağlamak için yollar aramaktadır. Mimarlık sektörü de enerji tüketimini azaltmak ve enerji verimliliği sağlamak amacı ile tasarım süreçlerinde yenilikler yapma yoluna gitmiştir. Bu amaçla enerji etkin yapı tasarımı kavramı ortaya çıkmıştır. Enerji etkin yapı tasarımı fiziksel çevreyi dikkate alarak enerjiyi daha verimli kullanan tasarımların yapılması olarak tanımlanmaktadır. Bununla birlikte günümüzde sektörel bazda çeşitli teknolojiler ortaya çıkmaktadır. İnşaat sektöründe ise bilgi teknolojileri hızlanmaktadır. Mimarlık alanında performans dayalı bina tasarımı süreci ortaya çıkmaktadır. Performansa dayalı bina tasarım anlayışını destekleyen bina bilgi modelleme sistemi enerji analizi yapma imkanı da sunmaktadır.

Bu çalışmada enerji tüketimini azaltmak ve enerji verimliliğini sağlamak amacı ile bina bilgi modelleme tabanlı Autodesk Revit yazılımı kullanılarak enerji analizleri yapılmıştır. Çalışmada Kayseri ilinde bir kayak evi tasarlanmıştır. Tasarlanan kayak evi Autodesk Revit yazılımında modellenerek enerji analizleri yapılmıştır. Çalışmada farklı duvar yalıtım malzemeleri belirlenmiştir. Çalışma kapsamında belirlenen duvar yalıtım malzemeleri; mantar, genişletilmiş nitril kauçuk, fenolik köpük, polietilen köpük, polipropilen, polistiren, poliüretan köpük ve genişletilmiş sentetik kauçuk malzemeleridir. Bu malzemeler bims duvar örgü malzemesi ile duvara sandviç duvar, içten yalıtımlı duvar ve dıştan yalıtımlı duvar olarak uygulanmıştır. Çalışmada çatı türü olarak kiremit çatı tek tip olarak belirlenmiştir. Çalışma kapsamında belirlenen malzemeler ve bu malzemelerin uygulama biçimleri neticesinde 24 farklı alternatif elde edilmiştir. Bu alternatifler modellenen kayak evi yapısına uygulanarak Kayseri ili iklim özellikleri dikkate alınarak enerji analizleri yapılmıştır.

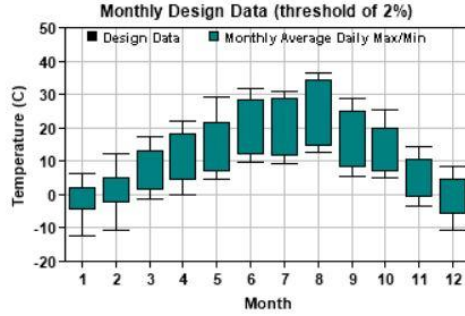
## Materyal Metod

Çalışma kapsamında Kayseri ili iklim özellikleri için enerji etkin tasarım amacıyla bir kayak evi tasarlanmıştır. Kayseri ili ılıman-kuru iklim özelliği göstermektedir. Bu iklim özelliğinde gece ile gündüz arasında sıcaklık farkı fazla olmak ile birlikte soğuk iklime yakın iklim özellikleri görülür. Sıcaklık ortalamaları +30 °C ile -5 °C arasındadır. Yaz sıcaklık ortalamaları 27-37 °C, kış sıcaklık ortalamaları ise 8-15 °C arasındadır. Çalışma kapsamında iklim özellikleri Autodesk Revit ve Autodesk Green Building Studio programlarına manuel olarak girilememektedir. İklim özellikleri belirlenen konuma göre en yakın hava istasyonundan otomatik olarak alınmaktadır. Belirlenen konuma göre programda oluşan yıllık sıcaklık ortalamaları Şekil 1.'de verilmiştir [6].

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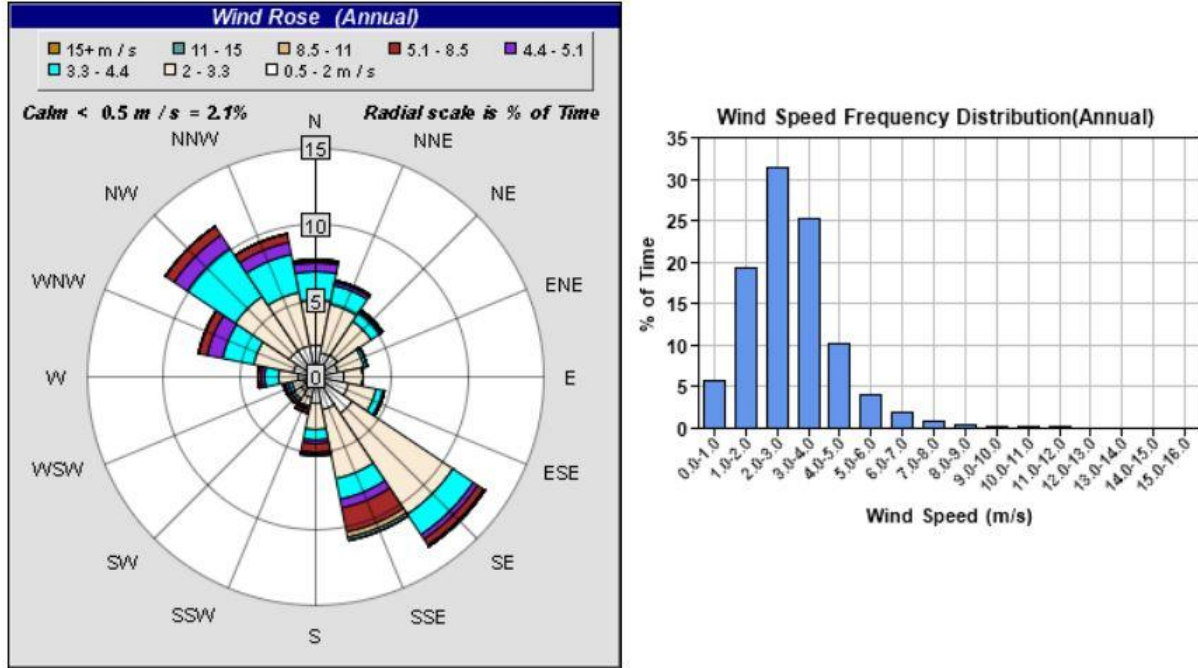
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Threshold	Annual Design Conditions			
	Cooling		Heating	
	Dry Bulb(°C)	MCWB(°C)	Dry Bulb(°C)	MCWB(°C)
0.1 %	36.8	16.8	-14.2	-14.5
0.2 %	36.1	17.4	-13.3	-13.6
0.4 %	35.2	17.1	-12.2	-12.6
0.5 %	35.0	17.4	-11.9	-12.4
1 %	33.7	16.5	-9.9	-10.5
2 %	31.6	16.4	-7.7	-8.4
2.5 %	31.0	15.9	-7.0	-7.8
5 %	28.8	15.8	-4.4	-5.4



Şekil 1: Kayseri ili konumuna göre sıcaklık değerleri

Bununla birlikte belirlenen konuma göre programda oluşan rüzgar değerleri Şekil 2.'de verilmiştir [6].

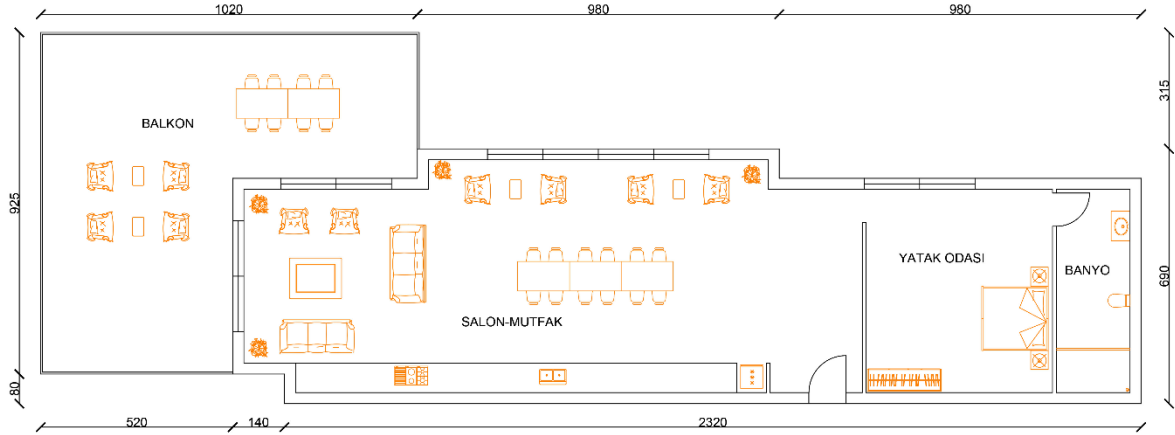


Şekil 2: Kayseri ili konumuna göre rüzgar değerleri

Çalışma kapsamında tasarlanan kayak evi kat planı Şekil 3.'de verilmiştir.

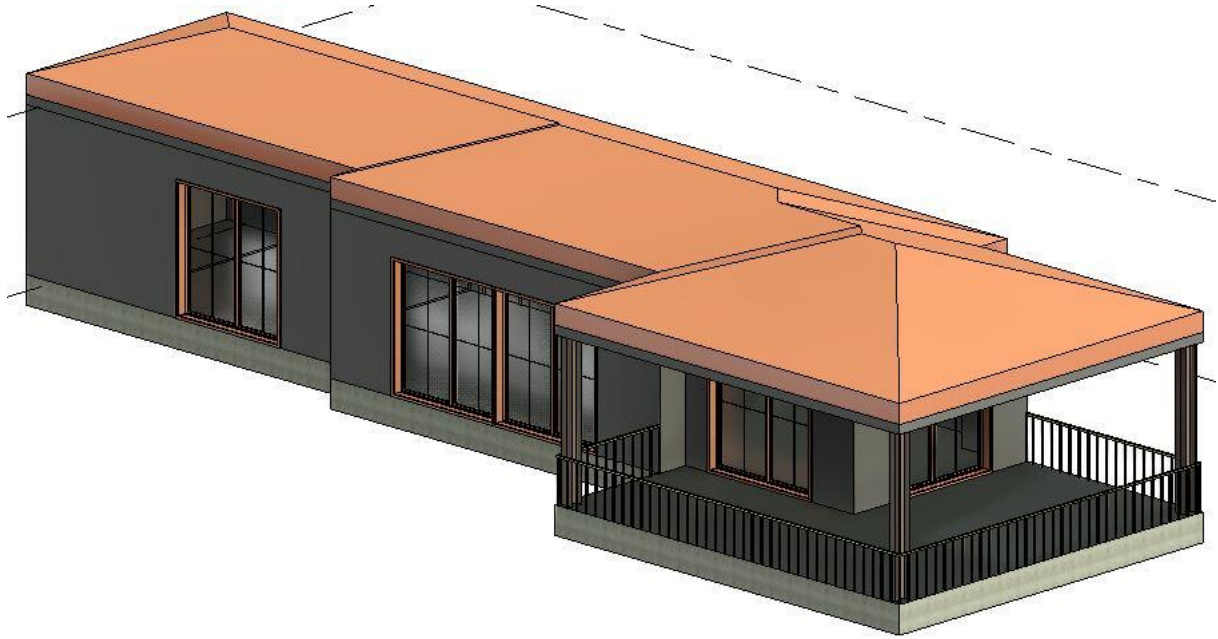
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**Şekil 3:** Kayak evi kat planı

Kayak evi tasarlandıktan sonra Autodesk Revit programında modellenmiştir. Kayak evi modeli Şekil 4.'de verilmiştir.



**Şekil 4:** Kayak evi modeli

Kayak evi tasarımı Autodesk Revit programında modellendikten sonra enerji analizleri yapılmak üzere senaryolar belirlenmiştir. Çalışma kapsamında belirlenen senaryolar Tablo 1.'de verilmiştir.



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**Tablo 1:** Kayak evi duvar senaryoları

Tip	Dış Duvar Katmanları (İçten Dışa (cm))		
Tip-1	Bims (10.00)	Mantar (5.00)	Bims (10.00)
Tip-2	Bims (10.00)	Genişletilmiş nitril kauçuk (5.00)	Bims (10.00)
Tip-3	Bims (10.00)	Fenolik köpük (5.00)	Bims (10.00)
Tip-4	Bims (10.00)	Poliüretan köpük (5.00)	Bims (10.00)
Tip-5	Bims (10.00)	Polipropilen (5.00)	Bims (10.00)
Tip-6	Bims (10.00)	Polistiren (5.00)	Bims (10.00)
Tip-7	Bims (10.00)	Poliüretan köpük (5.00)	Bims (10.00)
Tip-8	Bims (10.00)	Genişletilmiş sentetik kauçuk (5.00)	Bims (10.00)
Tip-9		Mantar (5.00)	Bims (20.00)
Tip-10		Genişletilmiş nitril kauçuk (5.00)	Bims (20.00)
Tip-11		Fenolik köpük (5.00)	Bims (20.00)
Tip-12		Poliüretan köpük (5.00)	Bims (20.00)
Tip-13		Polipropilen (5.00)	Bims (20.00)
Tip-14		Polistiren (5.00)	Bims (20.00)
Tip-15		Poliüretan köpük (5.00)	Bims (20.00)
Tip-16		Genişletilmiş sentetik kauçuk (5.00)	Bims (20.00)
Tip-17	Bims (20.00)	Mantar (5.00)	
Tip-18	Bims (20.00)	Genişletilmiş nitril kauçuk (5.00)	
Tip-19	Bims (20.00)	Fenolik köpük (5.00)	
Tip-20	Bims (20.00)	Poliüretan köpük (5.00)	
Tip-21	Bims (20.00)	Polipropilen (5.00)	
Tip-22	Bims (20.00)	Polistiren (5.00)	
Tip-23	Bims (20.00)	Poliüretan köpük (5.00)	
Tip-24	Bims (20.00)	Genişletilmiş sentetik kauçuk (5.00)	

Çalışmada kayak evi modeli için belirlenen senaryolarda kullanılan malzemelerin özellikleri Autodesk Revit programına girilmiştir. Bu malzemelerin termofiziksel Tablo 2.'de verilmiştir [1], [2], [3], [4], [5].

**Tablo 2:** Kayak evi duvar senaryolarında kullanılan malzemelerin termofiziksel özellikleri

Malzeme	Isı İletkenlik Katsayısı (W/m.K)	Yoğunluk (kg/m <sup>3</sup> )
Mantar	0,038	112
Genişletilmiş nitril kauçuk	0,044	90
Fenolik köpük	0,022	120
Poliüretan köpük	0,045	60
Polipropilen	0,034	20
Polistiren	0,038	30
Poliüretan köpük	0,023	50
Genişletilmiş sentetik kauçuk	0,038	60
Bims	0,23	770
Sıva	1,0	1800

Bu çalışmada ayrıca kiremit çatı türü kullanılmıştır. Bununla birlikte zemine oturan döşeme, ara kat döşemesi ve kiremit çatının termofiziksel özellikleri Tablo 3.'de verilmiştir [1].

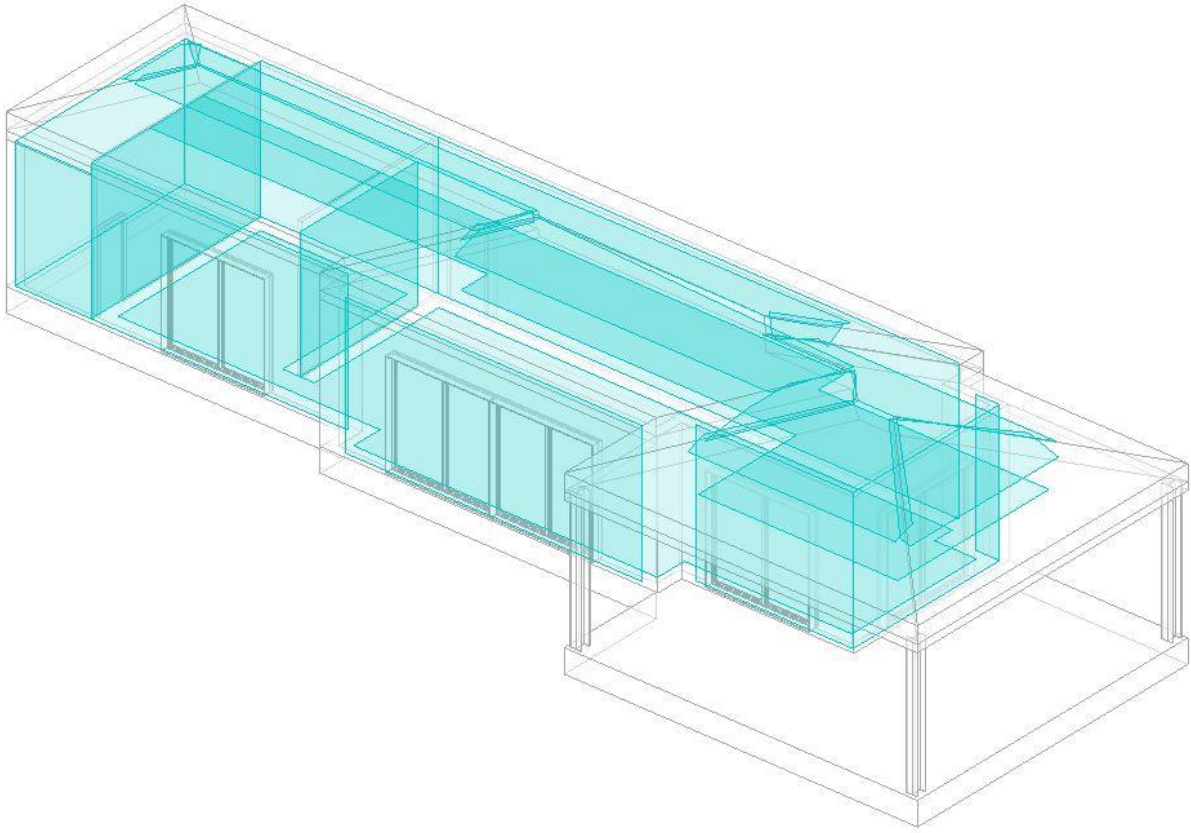
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**Tablo 3:** Kayak evi modelinde kullanılan çatı ve döşeme türlerinin termofiziksel özellikleri

Yapı Elemanı	U Değeri W/(m <sup>2</sup> ·K)
Kiremit Çatı	0,33
Zemine Oturan Döşeme	0,7729
Ara Kat Döşemesi	8,3333

Çalışmada bulunan yapı elemanlarının termofiziksel özellikleri programa girildikten sonra senaryolar programda belirlenmiştir. Daha sonra kayak evi modeline programda senaryolar tek tek uygulanmıştır. Senaryoların her biri için enerji modeli programda oluşturulmuştur. Enerji modeli Şekil 5.'de verilmiştir.

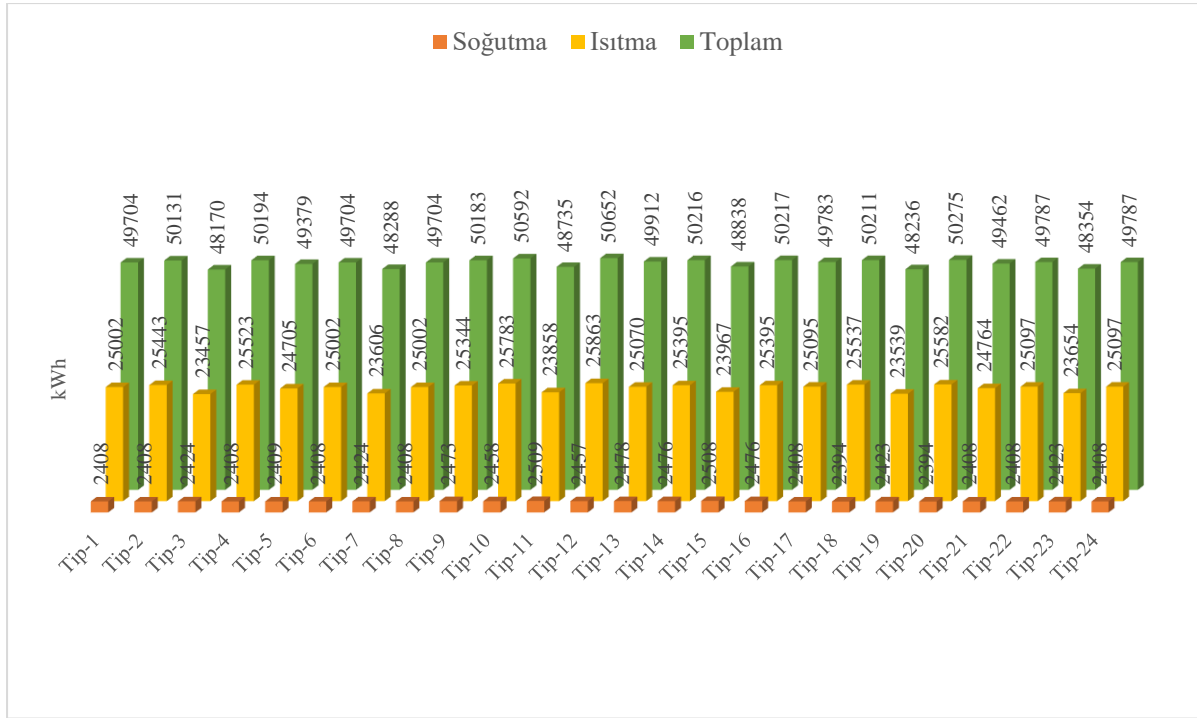


**Şekil 5:** Kayak evi enerji modeli

Çalışmada oluşturulan senaryoların her biri için enerji modeli oluşturulduktan sonra gbXML formatında kaydedilerek Autodesk Green Building Studio (GBS) yazılımında enerji analizleri yapılmıştır.

### Sonuç ve Değerlendirme

Çalışmanın sonucunda belirlenen 24 farklı senaryonun kayak evi yapısı üzerinden yapılan enerji analiz sonuçları elde edilmiştir. Senaryoların yıllık ısıtma, soğutma ve toplam enerji harcamaları Şekil 6.'da verilmiştir.



Şekil 6: Kayak evi enerji analiz sonuçları

Kayak evi analiz sonuçları incelendiğinde yıllık soğutma enerjisi tüketiminde 2394 kWh ile Tip18 ve Tip20 en az enerji tüketen senaryolar olmuştur. En çok soğutma enerjisi tüketen senaryo ise 2509 kWh ile Tip11 olmuştur. Bu senaryolar karşılaştırıldığında yıllık %4,58 oranında enerji tasarrufu belirlenmiştir. Senaryolar incelendiğinde dıştan yalıtımlı senaryoların soğutma enerjisinde iyi sonuçlar verdiği saptanmıştır. Yıllık soğutma enerjisi tüketimi için daha sonra sandviç duvar tipi ve son olarak içten yalıtımlı senaryolar gelmektedir. Yıllık soğutma enerjisi tüketiminde yalıtım malzemeleri için genel bir sıralama yapmak mümkün olmamıştır.

Çalışmada yıllık ısıtma enerjisi tüketimi sonuçları incelendiğinde 23457 kWh ile Tip3 en az enerji tüketimi göstermiştir. Isıtma enerjisi tüketimi en fazla olan senaryo ise 25863 kWh ile Tip12 olmuştur. Bu senaryolar karşılaştırıldığında yıllık %9,3'lük enerji tasarrufu saptanmıştır. Isıtma enerjisi tüketim sonuçları incelendiğinde sandviç duvar türünün en iyi sonuç verdiği daha sonra dıştan yalıtımlı ve içten yalıtımlı duvar türlerinin geldiği saptanmıştır. Yalıtım malzemeleri ısıtma enerjisi tüketimi bakımından incelendiğinde fenolik köpük, poliüretan köpük, polipropilen, mantar, polistiren, genişletilmiş sentetik kauçuk, genişletilmiş nitril kauçuk ve polietilen köpük sıralaması elde edilmiştir.

Yıllık toplam enerji tüketim sonuçları incelendiğinde 48170 kWh ile Tip3 senaryosu en az enerji tüketmiştir. Fakat 50652 kWh ile Tip12 en çok yıllık toplam enerji tüketimi gösteren senaryo olmuştur. Bu senaryolar karşılaştırıldığında %4,9 oranında tasarruf belirlenmiştir. Yıllık toplam enerji tüketimi incelendiğinde sandviç duvar türünün en iyi sonuç verdiği daha sonra dıştan yalıtımlı ve içten yalıtımlı duvar türlerinin geldiği saptanmıştır. Toplam enerji tüketimi yalıtım malzemeleri için incelendiğinde fenolik köpük, poliüretan köpük, polipropilen, mantar, polistiren, genişletilmiş sentetik kauçuk, genişletilmiş nitril kauçuk ve polietilen köpük sıralaması elde edilmiştir.

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Bu çalışma ile Kayseri ili iklim özellikleri için kayak evi yapısı üzerinden belirlenen senaryolar ile enerji analiz sonuçları değerlendirilmiş ve tasarımcılara ufuk açması amaçlanmıştır.

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**YAPILARDA SİMÜLASYONLA ENERJİ PERFORMANSI ANALİZİ; MERSİN  
ÖRNEĞİ**

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**Özet**

Dünya genelinde enerji tüketimi artan nüfus yoğunluğu sebebiyle artmaktadır. Bu durum enerji tüketiminin azaltılmasına yönelik çalışmaların oluşmasına sebebiyet vermiştir. Tüm sektörler enerji tüketimini azaltmaya yönelik çalışmalar yapmaktadır. Bununla birlikte enerjinin büyük bir bölümünü kullanan inşaat sektörü de çeşitli önlemler almaya başlamıştır. Bu doğrultuda yapılarda kullanılan enerjiyi azaltmak amacıyla iklime uygun tasarım kriterleri geliştirilmiştir. Çalışma kapsamında Mersin ilinde bir sahil evi tasarlanmıştır. Tasarlanan sahil evi için farklı malzemeler kullanılarak senaryolar elde edilmiştir. Bu malzemeler çatı ve duvar yalıtım malzemeleri olarak belirlenmiştir. Çalışmada kullanılan çatı türleri; kenet çatı, kiremit çatı ve yeşil çatı olarak belirlenmiştir. Bununla birlikte çalışmada kullanılan duvar yalıtım malzemeleri ise; cam mineral yünü, selüloz cam, kalsiyum silikat, seramik elyaf, melamin köpük, genişletilmiş perlit, taş mineral yünü ve vermikülittir. Çalışma kapsamında duvar örgü malzemesi olarak bims kullanılmıştır. Bu malzemeler sandviç duvar türünde uygulanarak 24 farklı senaryo elde edilmiştir. Çalışmada bu senaryoların Mersin ili (sıcak-nemli) iklim koşulları için enerji analizleri yapılmıştır. Yapılan analizlerde yıllık ısıtma, soğutma ve toplam enerji tüketim miktarları her bir senaryo için elde edilmiştir. Çalışmanın sonunda bu senaryoların yıllık enerji tüketim miktarları karşılaştırılarak Mersin ili (sıcak-nemli) iklim koşulları için öneriler sunulmuştur.

**Anahtar Kelimeler:** enerji, enerji performansı, sıcak iklim, Mersin ili.

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**YAPILARDA SİMÜLASYONLA ENERJİ PERFORMANSI ANALİZİ; MERSİN  
ÖRNEĞİ**

**Abstract**

Energy consumption is increasing worldwide due to increasing population density. This situation has led to studies on reducing energy consumption. All sectors are working to reduce energy consumption. In addition, the construction sector, which uses a large portion of energy, has also started to take various measures. In this direction, climate-appropriate design criteria have been developed in order to reduce the energy used in structures. Within the scope of the study, a coastal house was designed in Mersin province. Scenarios were obtained by using different materials for the designed coastal house. These materials were determined as roof and wall insulation materials. The roof types used in the study were determined as standing seam roof, tile roof and green roof. In addition, the wall insulation materials used in the study were; glass mineral wool, cellulose glass, calcium silicate, ceramic fiber, melamine foam, expanded perlite, stone mineral wool and vermiculite. Pumice was used as wall mesh material within the scope of the study. These materials were applied in the sandwich wall type and 24 different scenarios were obtained. In the study, energy analyzes of these scenarios were made for the climate conditions of Mersin province (hot-humid). In the analyses, annual heating, cooling and total energy consumption amounts were obtained for each scenario. At the end of the study, annual energy consumption amounts of these scenarios were compared and suggestions were presented for the climate conditions of Mersin province (hot-humid).

**Keywords:** energy, energy performance, hot climate, Mersin province.

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## Giriş

Toplumlarda gelişme ve büyüme sürecine paralel olarak doğal kaynakların tükenmesi hızlanmaktadır. Bununla birlikte enerji harcamaları sonucunda ortaya çıkan atıklar sebebiyle doğal çevrenin tahribatı artmıştır. Çevre kirliliği, küresel ısınma, CO<sub>2</sub> salınımı sorunlar yapı sektörü ile doğrudan ilişkili olduğundan mimarlık alanında da sürdürülebilirlik, ekoloji, enerji verimliliği, enerji korunumu ve enerji etkin tasarım gibi kavramlar ortaya çıkmıştır.

Bu çalışmada enerji etkin yapı tasarımı kavramı üzerinden çevresel koşulları dikkate alarak enerjiyi daha verimli kullanmaya yönelik senaryolar belirlenmiştir. Bu senaryoların uygulanması yapı bilgi modelleme tabanlı yazılım olan Autodesk Revit programı süreci ile gerçekleştirilmiştir. Yapı bilgi modelleme tabanlı yazılımlar ile enerji etkin tasarım süreci simüle edilerek uygulanabilmektedir.

Bu çalışma kapsamında enerji etkin tasarıma yönelik olarak çevresel koşullar dikkate alınarak enerji yükünü azaltacak ve enerji kaynaklarını daha verimli kullanacak tasarımlar hedeflenmektedir. Bu hedeflere yönelik olarak enerji tüketiminde büyük önem arz eden yaşama alanlarına örnek olarak bir sahil evi tasarlanmıştır. Tasarlanan sahil evi için farklı malzemeler kullanılarak senaryolar elde edilmiştir. Bu malzemeler çatı ve duvar yalıtım malzemeleri olarak belirlenmiştir. Çalışmada kullanılan çatı türleri; kenet çatı, kiremit çatı ve yeşil çatı olarak belirlenmiştir. Bununla birlikte çalışmada kullanılan duvar yalıtım malzemeleri ise; cam mineral yünü, selüloz cam, kalsiyum silikat, seramik elyaf, melamin köpük, genişletilmiş perlit, taş mineral yünü ve vermikülittir. Çalışma kapsamında duvar örgü malzemesi olarak bims kullanılmıştır. Bu malzemeler sandviç duvar türünde uygulanarak 24 farklı senaryo elde edilmiştir. Çalışmada bu senaryoların Mersin ili (sıcak-nemli) iklim koşulları için enerji analizleri yapılmıştır.

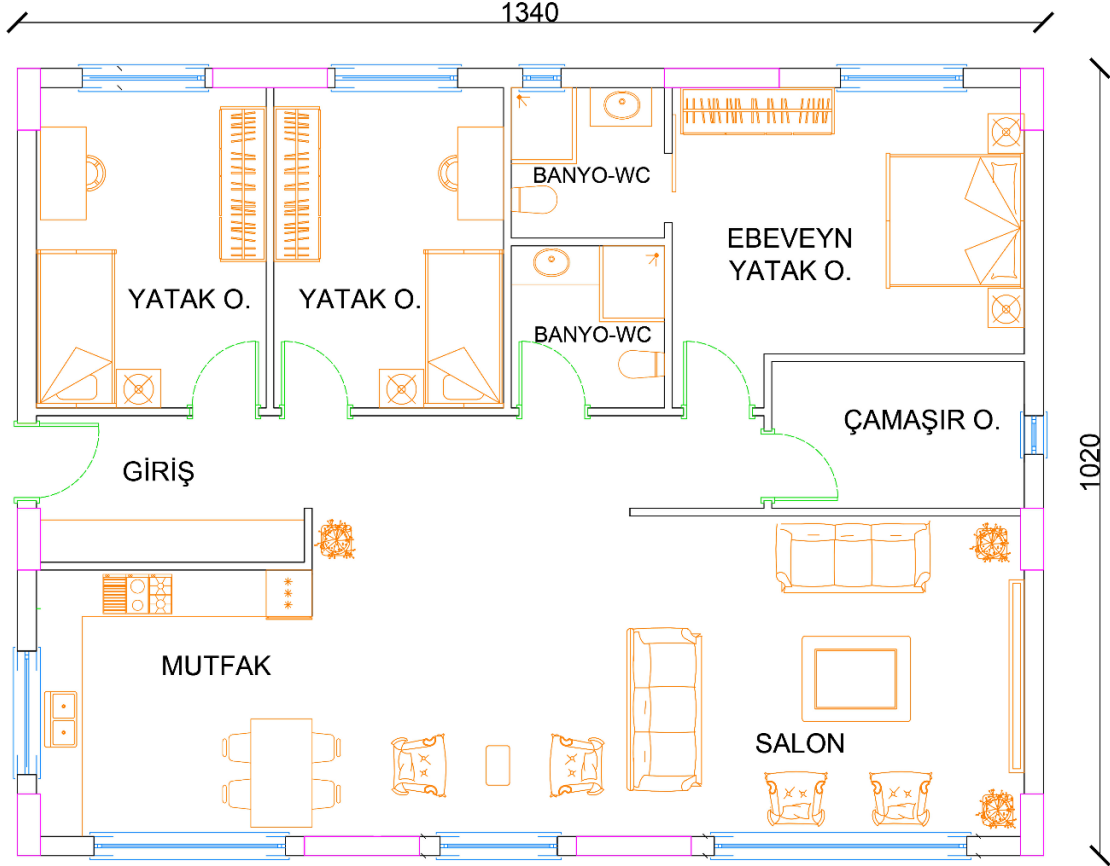
## Materyal Metod

Çalışma alanı olarak Mersin ilinde tasarlanan bir sahil evi seçilmiştir. Bu ev üç yatak odası, iki banyo, bir çamaşır odası, mutfak ve salon birimlerinden oluşmaktadır. Sahil evini kat planı Şekil 1.'de verilmiştir.



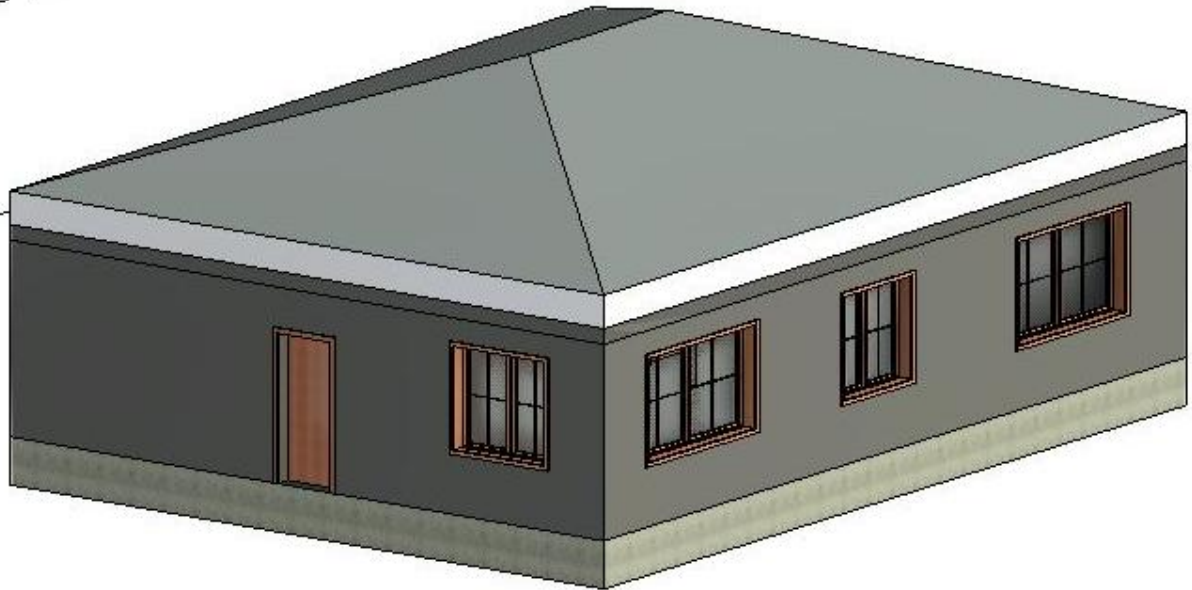
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Şekil 1: Sahil evi kat planı

Sahil evi yapısı Autodesk Revit programında enerji analizleri yapılmak üzere modellenmiştir. Sahil evi yapısının Autodesk Revit programında yapılan modeli Şekil 2.'de verilmiştir.



Şekil 2: Sahil evi modeli

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Çalışmada sahil evi modeli Autodesk Revit programında oluşturulduktan sonra senaryolar oluşturulmuştur. Senaryolar için çatı türleri; kenet çatı, kiremit çatı ve yeşil çatı olarak belirlenmiştir. Senaryolar için duvar yalıtım malzemeleri ise; cam mineral yünü, selüloz cam, kalsiyum silikat, seramik elyaf, melamin köpük, genişletilmiş perlit, taş mineral yünü ve vermikülit. Senaryolar için duvar örgü malzemesi olarak bims kullanılmıştır. Bu malzemeler sandviç duvar türünde uygulanarak 24 farklı senaryo elde edilmiştir ve programa girilerek yapıya uygulanmıştır. Çalışmada belirlenen senaryolar Tablo 1.'de verilmiştir.

**Tablo 1: Sahil evi yapısı için oluşturulan senaryolar**

Tip	Dış Duvar (cm)				Çatı Türü	
Tip-1	Sıva (2.00)	Bims (10.00)	Cam mineral yünü (5.00)	Bims (10.00)	Sıva (2.00)	Kenet Çatı
Tip-2	Sıva (2.00)	Bims (10.00)	Selüloz cam (5.00)	Bims (10.00)	Sıva (2.00)	Kenet Çatı
Tip-3	Sıva (2.00)	Bims (10.00)	Kalsiyum silikat (5.00)	Bims (10.00)	Sıva (2.00)	Kenet Çatı
Tip-4	Sıva (2.00)	Bims (10.00)	Seramik Elyaf (5.00)	Bims (10.00)	Sıva (2.00)	Kenet Çatı
Tip-5	Sıva (2.00)	Bims (10.00)	Melamin köpük (5.00)	Bims (10.00)	Sıva (2.00)	Kenet Çatı
Tip-6	Sıva (2.00)	Bims (10.00)	Genişletilmiş perlit (5.00)	Bims (10.00)	Sıva (2.00)	Kenet Çatı
Tip-7	Sıva (2.00)	Bims (10.00)	Taş mineral yünü (5.00)	Bims (10.00)	Sıva (2.00)	Kenet Çatı
Tip-8	Sıva (2.00)	Bims (10.00)	Vermikülit (5.00)	Bims (10.00)	Sıva (2.00)	Kenet Çatı
Tip-9	Sıva (2.00)	Bims (10.00)	Cam mineral yünü (5.00)	Bims (10.00)	Sıva (2.00)	Kiremit Çatı
Tip-10	Sıva (2.00)	Bims (10.00)	Selüloz cam (5.00)	Bims (10.00)	Sıva (2.00)	Kiremit Çatı
Tip-11	Sıva (2.00)	Bims (10.00)	Kalsiyum silikat (5.00)	Bims (10.00)	Sıva (2.00)	Kiremit Çatı
Tip-12	Sıva (2.00)	Bims (10.00)	Seramik Elyaf (5.00)	Bims (10.00)	Sıva (2.00)	Kiremit Çatı
Tip-13	Sıva (2.00)	Bims (10.00)	Melamin köpük (5.00)	Bims (10.00)	Sıva (2.00)	Kiremit Çatı
Tip-14	Sıva (2.00)	Bims (10.00)	Genişletilmiş perlit (5.00)	Bims (10.00)	Sıva (2.00)	Kiremit Çatı
Tip-15	Sıva (2.00)	Bims (10.00)	Taş mineral yünü (5.00)	Bims (10.00)	Sıva (2.00)	Kiremit Çatı
Tip-16	Sıva (2.00)	Bims (10.00)	Vermikülit (5.00)	Bims (10.00)	Sıva (2.00)	Kiremit Çatı
Tip-17	Sıva (2.00)	Bims (10.00)	Cam mineral yünü (5.00)	Bims (10.00)	Sıva (2.00)	Yeşil Çatı
Tip-18	Sıva (2.00)	Bims (10.00)	Selüloz cam (5.00)	Bims (10.00)	Sıva (2.00)	Yeşil Çatı
Tip-19	Sıva (2.00)	Bims (10.00)	Kalsiyum silikat (5.00)	Bims (10.00)	Sıva (2.00)	Yeşil Çatı
Tip-20	Sıva (2.00)	Bims (10.00)	Seramik Elyaf (5.00)	Bims (10.00)	Sıva (2.00)	Yeşil Çatı
Tip-21	Sıva (2.00)	Bims (10.00)	Melamin köpük (5.00)	Bims (10.00)	Sıva (2.00)	Yeşil Çatı
Tip-22	Sıva (2.00)	Bims (10.00)	Genişletilmiş perlit (5.00)	Bims (10.00)	Sıva (2.00)	Yeşil Çatı
Tip-23	Sıva (2.00)	Bims (10.00)	Taş mineral yünü (5.00)	Bims (10.00)	Sıva (2.00)	Yeşil Çatı
Tip-24	Sıva (2.00)	Bims (10.00)	Vermikülit (5.00)	Bims (10.00)	Sıva (2.00)	Yeşil Çatı

Bu çalışmada senaryolar oluşturulurken ilk parametre duvar yalıtım katmanları olarak belirlenmiştir. Çalışmada senaryoları oluşturan duvar katmanlarının özellikleri Tablo 2.'de verilmiştir [1], [2], [3], [4], [5], [6], [7].

**Tablo 2: Duvar katmanları özellikleri**

Katman Adı	Isı İletkenlik Katsayısı (W/m.K)	Yoğunluk (kg/m <sup>3</sup> )
Cam mineral yünü	0,042	80
Selüloz cam	0,034	288
Kalsiyum silikat	0,054	240
Seramik Elyaf	0,065	192
Melamin köpük	0,034	11
Genişletilmiş perlit	0,057	80
Taş mineral yünü	0,033	80
Vermikülit	0,063	150
Bims	0,23	770
Sıva	1,0	1800

Çalışmada bir diğer parameter çatı türü olarak belirlenmiştir. Çalışma kapsamında kullanılan çatı türlerinin ve döşeme türlerinin özellikleri Tablo 3.'de verilmiştir [1], [2].

**Tablo 3: Çatı türleri ve döşeme türü özellikleri**

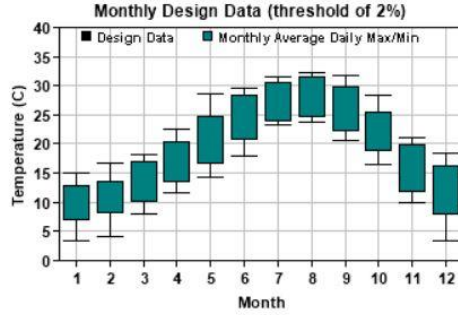
Yapı Elemanı	U Değeri W/(m <sup>2</sup> ·K)
Kenet Çatı	0,1457
Kiremit Çatı	0,33
Yeşil Çatı	0,1194
Zemine Oturan Döşeme	0,7729
Ara Kat Döşemesi	8,3333

Çalışma kapsamında senaryolar programa girildikten sonra enerji analiz programı olan Green Building Studio (GBS) ile entegre şekilde konum belirlenerek iklim özellikleri elde edilmiştir. Programda iklim özellikleri seçilen konuma göre otomatik olarak en yakın hava istasyonundan alınmaktadır. Bu çalışmada Mersin ili konum olarak belirlenmiştir. Konum belirlendikten sonra programda elde edilen sıcaklık değerleri Şekil 3.'de verilmiştir [8].

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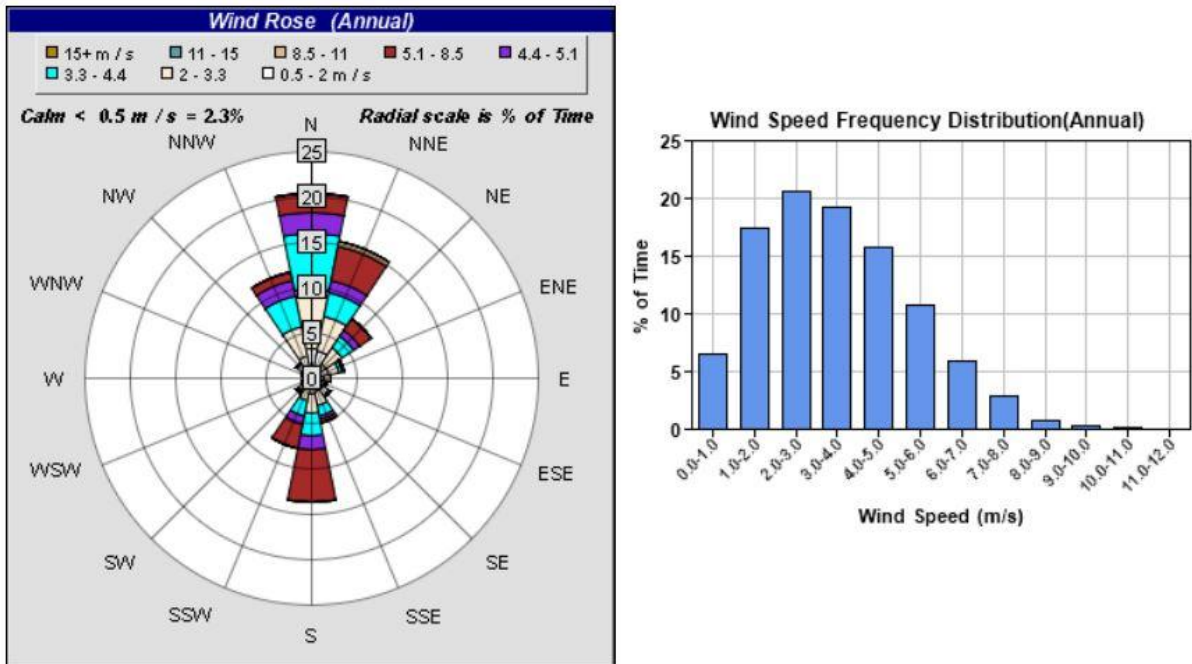
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Threshold	Cooling		Heating	
	Dry Bulb(°C)	MCWB(°C)	Dry Bulb(°C)	MCWB(°C)
0.1 %	32.7	23.9	2.1	1.3
0.2 %	32.3	24.3	2.4	1.1
0.4 %	32.0	23.3	3.3	2.0
0.5 %	31.9	23.3	3.4	2.3
1 %	31.6	23.6	4.7	2.9
2 %	31.1	23.4	5.8	4.4
2.5 %	31.0	23.4	6.3	4.2
5 %	30.2	22.9	8.0	6.1



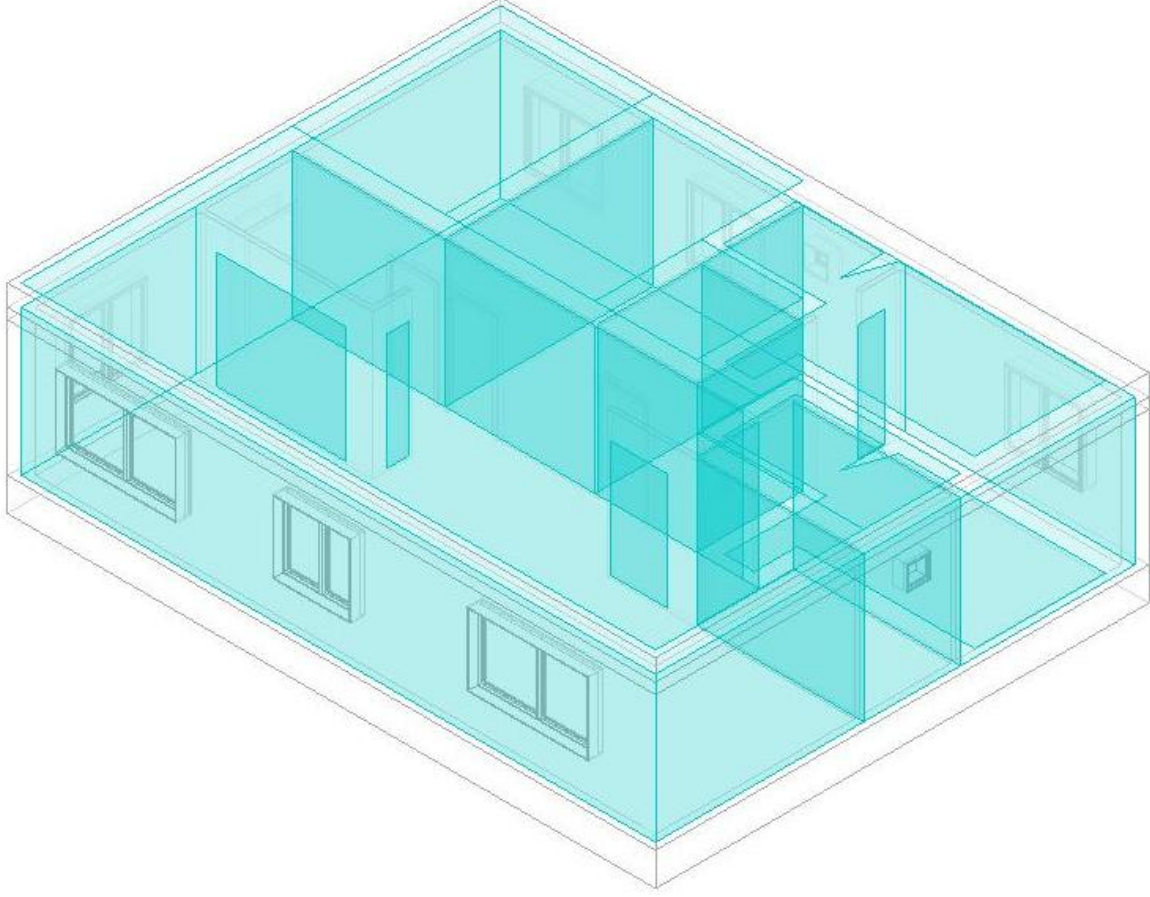
Şekil 3: Seçilen konum için programda elde edilen sıcaklık değerleri

Bununla birlikte çalışmada belirlenen konuma göre rüzgar özellikleri de elde edilmiştir. Seçilen konum için programda elde edilen rüzgar özellikleri Şekil 4.'de verilmiştir [8].



Şekil 4: Seçilen konum için programda elde edilen rüzgar özellikleri

Çalışmada senaryo özellikleri programa girilip iklim özellikleri de belirlendikten sonra her bir senaryo için Autodesk Revit programında enerji analizi oluşturulmuştur. Mersin sahil evi için Autodesk Revit programında oluşturulan enerji analiz modeli Şekil 5.'de verilmiştir.



**Şekil 5:** Mersin sahil evi enerji modeli

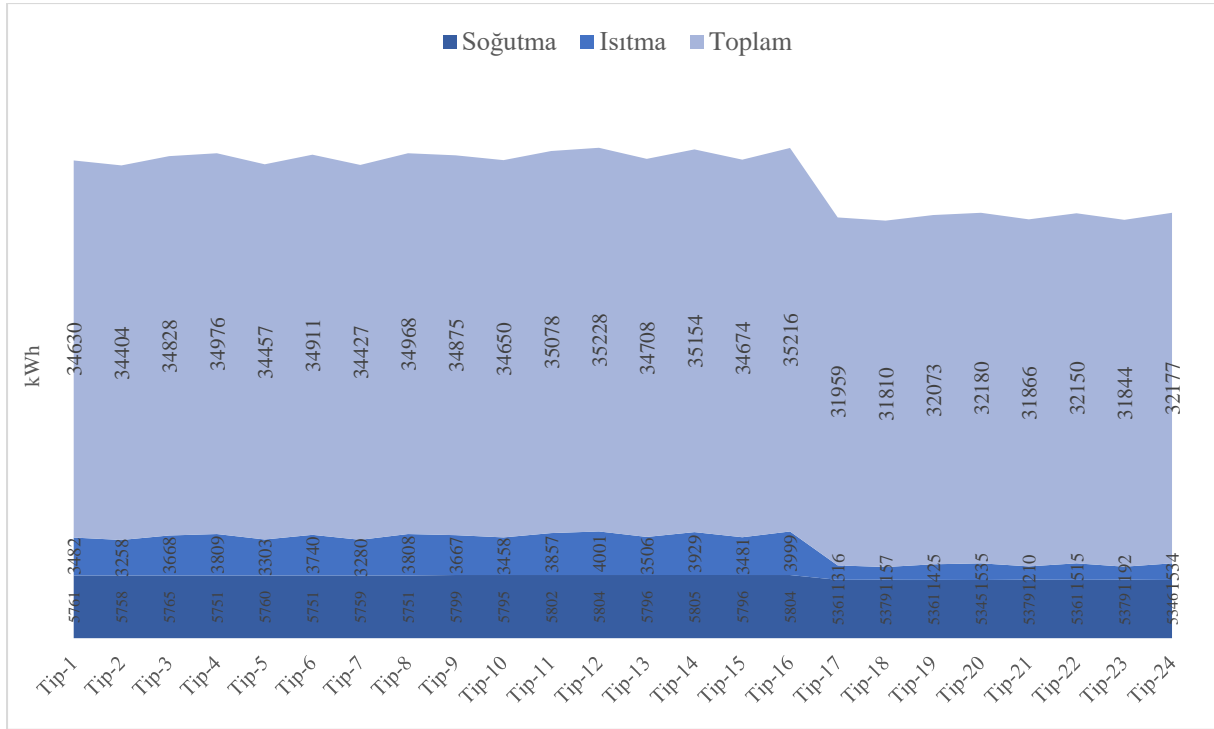
Senaryolar için enerji modelleri oluşturulduktan sonra Green Buildin Studio (GBS) ile enerji analizleri yapılmıştır. Daha sonra analizler ile yıllık soğutma, ısıtma ve toplam enerji tüketimleri elde edilmiştir.

#### **Sonuç ve Değerlendirme**

Çalışma kapsamında Autodesk Green Building Studio (GBS) yazılımı kullanılarak oluşturulan 24 alternatifin enerji analizleri yapılmıştır. Enerji analizleri ile yıllık soğutma, ısıtma ve toplam enerji tüketimleri elde edilmiştir. Enerji analizleri sonucunda alternatiflerin yıllık enerji tüketimleri Şekil 6.'da verilmiştir.

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Şekil 6: Enerji analiz sonuçları

Çalışmada analizleri yapılan 24 alternatif için yıllık soğutma, ısıtma ve toplam enerji tüketimleri incelendiğinde soğutma enerjisinin Mersin ili iklim özelliklerine bağlı olarak ısıtma enerjisine göre daha yüksek sonuçlar verdiği saptanmıştır. Aynı zamanda soğutma enerjisi tüketiminde 5345 kWh yıllık soğutma enerjisi harcaması gösteren Tip20 en az enerji tüketimi gösteren alternatif olmuştur. Yıllık ısıtma enerjisi tüketimi incelendiğinde 1157 kWh yıllık ısıtma enerjisi tüketimi ile Tip18 en az enerji tüketen alternatif olmuştur. Yıllık toplam enerji tüketimleri incelendiğinde ise 31810 kWh ile Tip18 en az yıllık enerji tüketimi göstermiştir. En çok yıllık soğutma enerjisi tüketimi gösteren alternatif 5804 kWh ile Tip14 olmuştur. Bununla birlikte en çok yıllık ısıtma enerjisi tüketimi gösteren alternatif ise 4001 kWh ile Tip12 senaryosu olmuştur. Toplam enerji tüketimlerine bakıldığında en çok yıllık toplam enerji tüketimi gösteren alternatif 35228 kWh ile Tip 12 olmuştur. Enerji tüketimleri soğutma enerjisi tüketimi için karşılaştırıldığında yıllık %7,91'lik, ısıtma enerjisi tüketimi için karşılaştırıldığında yıllık %71,08'lik, toplam enerji tüketimi için karşılaştırıldığında yıllık %9,7'lik enerji tasarrufu elde edilmiştir.

Enerji tüketimlerinin soğutma enerjisi için verdiği sonuçlar çatı türleri için incelendiğinde en iyi sonuçları yeşil çatı türünün verdiği ve daha sonra kenet çatı ve kiremit çatının geldiği görülmüştür. Soğutma enerjisi tüketiminde duvar yalıtım malzemeleri karşılaştırıldığında; selüloz cam, melamin köpük, taş mineral yünü, cam mineral yünü, kalsiyum silikat, seramik elyaf, vermikülit ve genişletilmiş perlit olarak en az enerji tüketenden en çok enerji tüketene göre sıralanmıştır.

Enerji analiz sonuçlarının ısıtma enerjisi için verdiği sonuçlar çatı türleri için incelendiğinde en iyi sonuçları yeşil çatı türünün verdiği ve daha sonra kenet çatı ve kiremit çatının geldiği görülmüştür. Isıtma enerjisi tüketiminde duvar yalıtım malzemeleri karşılaştırıldığında; selüloz cam, taş mineral yünü, melamin köpük, cam mineral yünü, kalsiyum silikat, genişletilmiş

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perlit, vermikülit ve seramik elyaf olarak en az enerji tüketenden en çok enerji tüketene göre sıralanmıştır.

Tüketilen yıllık enerjinin toplam enerji tüketimi için verdiği sonuçlar çatı türleri için incelendiğinde en iyi sonuçları yeşil çatı türünün verdiği ve daha sonra kenet çatı ve kiremit çatının geldiği görülmüştür. Toplam enerji tüketiminde duvar yalıtım malzemeleri karşılaştırıldığında; selüloz cam, taş mineral yünü, melamin köpük, cam mineral yünü, kalsiyum silikat, genişletilmiş perlit, vermikülit ve seramik elyaf olarak en az enerji tüketenden en çok enerji tüketene göre sıralanmıştır.

Çalışmanın sonucunda Mersin ili iklim özellikleri için belirlenen senaryoların analiz sonuçları karşılaştırılmıştır. Örnek bir sahil evi üzerinden analizleri yapılan senaryolardan elde edilen sonuçlar ile iklime uygun tasarım önerileri sunulmuştur. Bu öneriler çerçevesinde yapılacak tasarımlar ile enerji tasarrufu sağlanması amaçlanmaktadır.

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**INVESTIGATION OF THE EFFECT OF SOIL REINFORCEMENT TO LIMIT THE  
STRESS AT THE EDGE OF BURIED PIPE**

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**Özet**

Gömülü boru hatları, hizmet ömrü boyunca sorunsuz bir şekilde kullanılmalıdır. Yüzeysel yüklerden kaynaklı ilave gerilmeler, gömülü boruya etkiyen basıncın artmasına sebep olduğundan, borular zarar görebilmektedir. Bu nedenle, gömülü boruların bu gibi zararlardan korunması amacıyla borulara aktarılan yükler sınırlandırılmalıdır. Bu çalışmada, kum zemine gömülen boru üzerindeki zemin tabakaları, PET (Polietilen Tereftalat) atıklarıyla güçlendirilerek borunun kenarında oluşan gerilmelerin azaltılması amaçlanmıştır. Kare şekilli bir model temel vasıtasıyla statik yük etkisi altında, kum zemine gömülü boru davranışı ile ilgili bir dizi deneysel çalışma yapılmıştır. Boru üzerindeki kum zemin tabakası, ağırlıkça %1, %3 ve %5 oranlarında atık PET parçacıklarıyla takviye edilmiştir. Katkısız ve PET atık takviyeli tüm zeminler sabit %65 rölatif sıklıkta hazırlanmıştır. Belirlenen yüzdelerde PET ile güçlendirilmiş zemin tabaka kalınlığının borudaki gerilme dağılımı üzerine etkisi, güçlendirilmemiş duruma göre incelenmiştir. Elde edilen sonuçlar, boruda oluşan gerilmelerin azaltılmasında, kum zemine ilave edilen PET atıklarının olumlu etkisi olduğunu göstermiştir. Güçlendirilen zeminlerle yapılan deneylerin tümünde, katkısız duruma göre borudaki gerilmelerde azalma olmuştur. Kum zemine ilave edilen PET yüzdesi ve güçlendirilmiş tabaka kalınlığı arttıkça, boru kenar tarafında, tepe noktasında ölçülen gerilme değerlerinde azalma kaydedilmiştir. %5 PET ile 150mm kalınlığında güçlendirmenin en etkili sonucu verdiği görülmüştür. Yapılan güçlendirme işlemiyle, takviyesiz duruma göre, boru kenarındaki gerilmelerde %58'e varan azalmalar meydana gelmiştir.

**Anahtar Kelimeler:** Gömülü boru, Zemin güçlendirmesi, PET atık, Gerilme

**INVESTIGATION OF THE EFFECT OF SOIL REINFORCEMENT TO LIMIT THE  
STRESS AT THE EDGE OF BURIED PIPE**

**Abstract**

Buried pipelines must be used without any problems throughout their service life. Stresses due to surface loads cause an increase in the pressure transferred to the buried pipe, which may damage the pipes. Therefore, the loads transferred to the pipes should be limited in order to protect buried pipes from such damages. In this study, the soil layers on the pipe buried in sand soil are reinforced with PET(Polyethylene Terephthalate) waste to reduce the stresses at the edge of the pipe. A series of experimental studies were carried out on the behaviour of a pipe buried in sand soil under static loading by means of a square shaped model foundation. The sand soil layer on the pipe was reinforced with waste PET particles at 1%, 3% and 5% by weight. Unreinforced and PET waste reinforced soils were prepared at a constant relative density of 65%. The effects of soil layer thickness the reinforced with PET at specified percentages on the stress distribution in the pipe was compared with the unreinforced case. The results obtained showed that PET waste added to the sand soil had a positive effect on the reduction of the stresses in the pipe. In all experiments with reinforced soils, there was a decrease in the stresses in the pipe compared to the unreinforced condition. As the percentage of PET added to the sand soil and the thickness of the reinforced layer increased, the stresses at the edge of the pipe decreased. It has been observed that reinforcement with 5% PET at a thickness of 150 mm gives the most effective results. With the reinforcement process, the stresses at the edge of the pipe decreased up to 58% compared to the unreinforced condition.

**Keywords:** Buried pipe, Soil reinforcement, PET waste, Stress.

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## Introduction

Buried pipelines are indispensable engineering structures for the sustainability of urban life. The incorrect installation of a buried pipe can negatively affect daily life. In case of damage to buried pipes, leakage of the substance carried inside harms the environment (NTSB, 2007; Pires and Palmeira, 2017). In addition, high costs arise in the repair of damage that may occur. For this reason, pipelines must be able to operate without problems throughout their service life under the loads acting on them. Repeated loads, static surface loads can cause the stresses in the buried pipe to increase and the pipe can be damaged in this way. For such reasons, the stresses that will occur in the pipe must be limited. In this context, many studies have been conducted to reduce the loads transferred to the pipes (Ahmed et al., 2015; Witthoef and Kim, 2016; Alotaibi et al., 2021; Meguid and Youssef, 2018; Hedge and Sitharam. 2015).

(Kou et al. 2018) conducted an experimental study on the pipe system by reinforcing the sandy soil with geotextiles; They examined the pressure distribution around the buried pipe, the deformation in the pipe and the amount of settlement in the foundation. As a result, it was observed that the geotextile width increased the bearing capacity and reduced the stresses in the side and crown region of the pipe. In a study examining the behavior of the pipes under cyclic loads, the soil was reinforced using geogrid and EPS blocks. It was observed that geogrid reinforcement and EPS material were successful in reducing soil surface settlement and deformations in the crown parts of the pipe (Azizian et al., 2020).

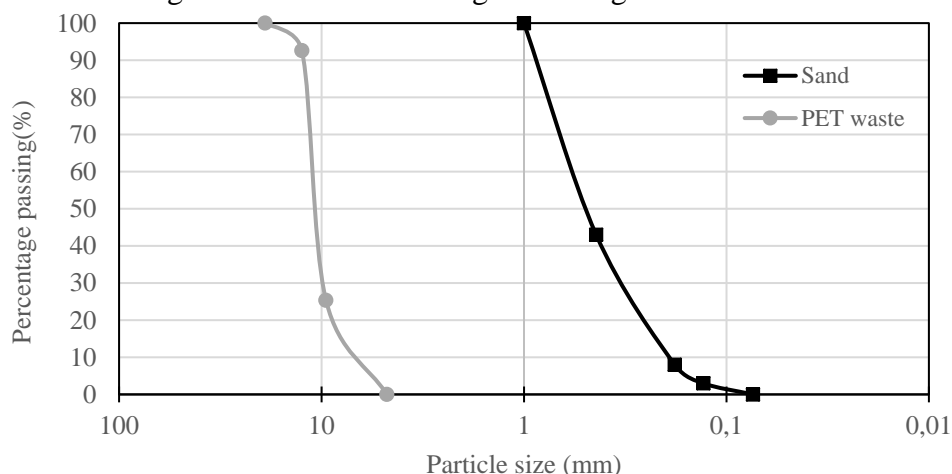
Waste materials are added to the soil in order to reduce the loads transferred to the buried pipes due to static loads. (Meguid and Youssef, 2018) used granular material and tire-derived aggregate (TDA) as backfill to measure the pressure distribution on a rigid pipe. It was observed that TDA backfill was more effective in reducing the pressure at the top of the pipe compared to granular material. A decrease of approximately 75% was recorded in the bottom pressure of the pipe by creating TDA backfill. Waste plastics, which take a long time to fully decompose in nature, pollute natural habitats and water resources. These waste materials increase the need for large waste storage areas because they occupy a very high volume (Chim Jin 2018; Memon et al 2019). Therefore, disposal of PET wastes or reuse in suitable areas is a reasonable solution. In this context, the use of PET wastes in geotechnical areas such as ground stabilization or ground reinforcement is an economical alternative and is seen as a promising approach in reducing the damage to the environment. (Alvarez et al 2020). It is thought that PET waste can be used to reduce the heavy loads acting on buried pipes. Moghaddas Tafreshi et al. (2021) examined the behavior of the sand soil reinforced with PET bottles under the effect of cyclic loads and observed a decrease in the amount of elastic and permanent displacement of the soil.

In this study, PET waste particles were used to reduce the pressure on the side of the buried pipe caused by the loading on the ground surface. The sand soil layer on the pipe was reinforced with PET waste particles at the rates of 1%, 3% and 5% by weight. The soil layers on the pipe were reinforced with the thicknesses of 0.33B, 0.66B and 1B (50, 100, 150 mm) with the model foundation width B, and the effect of the reinforcement depth on the stresses in the pipe was investigated.

### Materials and Methods

In this section, details about the materials used in the study, the experimental system and the experimental program are explained.

The soil used in the study is well-graded (SP) river sand. First, the sand was washed and dried in an oven, then it was selected between 1 mm sieves and 0.075 mm mesh sieves. The sieve analysis curve according to ASTM D422-63 is given in Figure 1.



**Figure 1.** Size distributions of the sand and PET wastes

The pipe used in the study is a wastewater pipe with an outer diameter of 110 mm made of u-PVC (unplasticised polyvinyl chloride) material. The elasticity modulus of the pipe is 3316 MPa. Waste particles obtained from PET bottles were used as the soil reinforcement material. The particle distribution curve of PET waste is shown in Figure 1. Regarding the structural properties of PET waste, the unit weight is  $1.38 \text{ g/cm}^3$  and the tensile strength is between 40-60 MPa.

In this study, a steel test tank with dimensions of 750 mm x 750 mm x 900 mm (width X length X depth) was used. The test tank and foundation dimensions were selected considering the boundary effects. A square-shaped rigid foundation with a thickness of 20 mm and a width of 150 mm was used in the loading experiments. The hydraulic loading unit has a capacity of 50 kN. The loading speed was 2 mm/min for all experiments. 2 LVDTs (Linear Variable Differential Transformation) were used to measure the settlements occurring in the model foundation during loading. Strain gauge was used to measure the stresses in the pipe during loading. (Figure 2). The data recorded during the experiments were transferred to the data collection device. The data transferred from this device to the computer environment were converted into graphs.

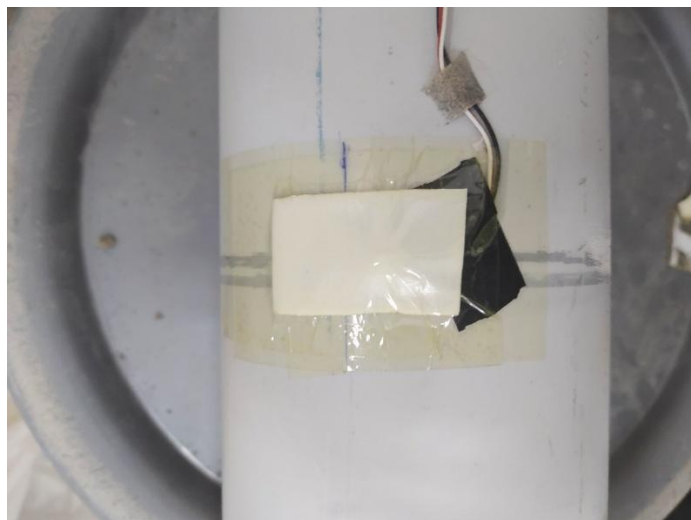


Figure 2. The pipe and strain-gauge used in the tests

***Test preparation and experimental procedure***

The sand soil was prepared in the tank with a constant relative density of 65% ( $D_r=65\%$ ). The pluviation technique was used to form a 900 mm thick sand bed. In the test tank, the part under the pipe was prepared with a constant relative density of 65% and a height of 550 mm with pure soil. Each layer was laid with a thickness of approximately 100 mm and compacted with a hand compactor. The layer thickness of the PET waste additive soils (1%, 3%, 5%) on the pipe top was prepared as 50 mm. In the reinforced layers, the PET waste material was distributed homogeneously, filled with sand soil and compacted (Figure 3.a). After the rigid foundation was placed on the top ground surface, LVDTs were placed at the corners of the foundation. The test setup at the time of the experiment is shown in Figure 3.b.



Figure 3. Experimental study (a) Randomly distributed PET waste (b) Loading system

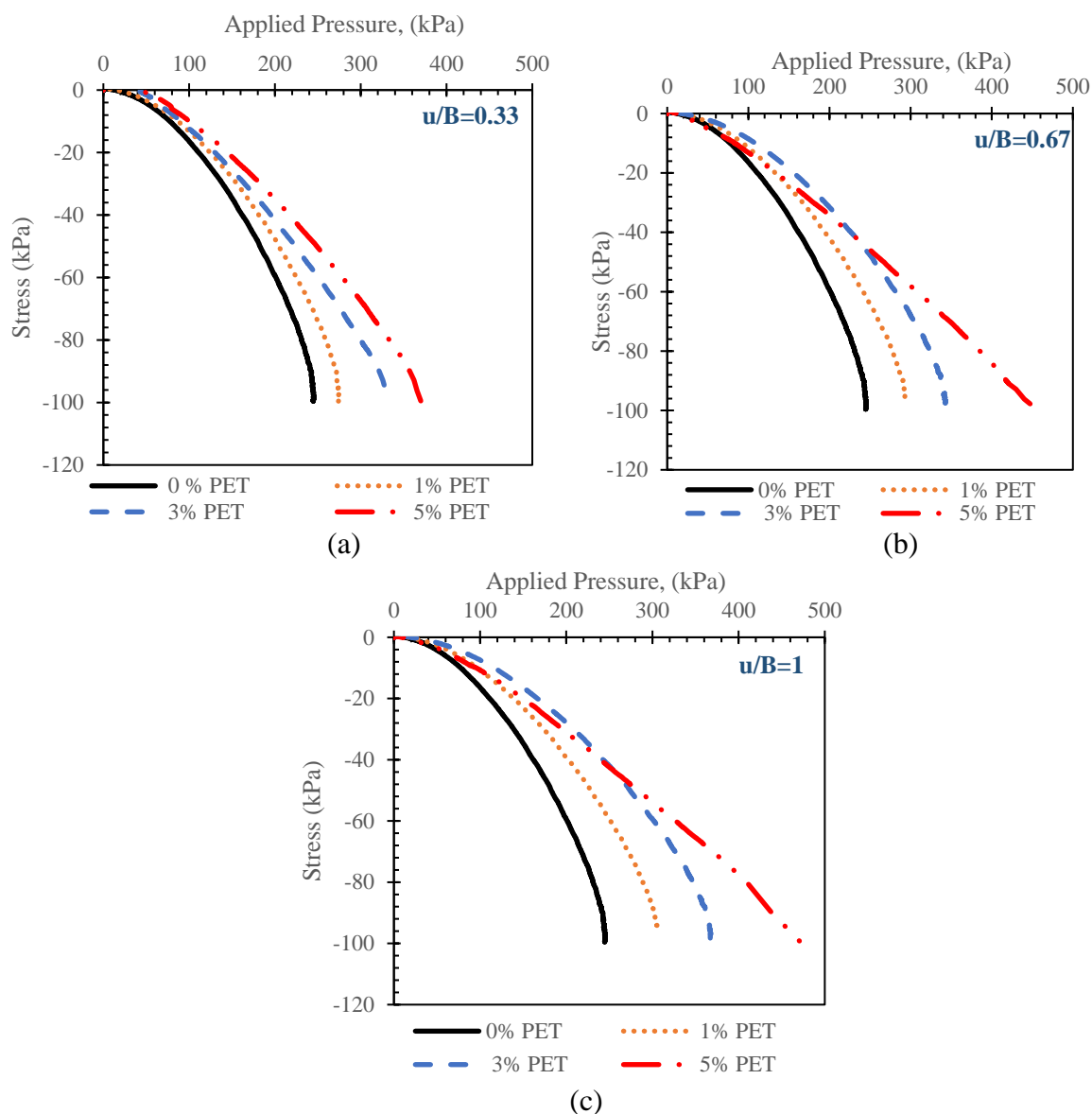
In this test program, the effect of the PET ratio added to the soil and the reinforced soil layer thickness on the reduction of the stress values formed at the crown on the edge of the buried pipe was investigated. PET waste reinforcement percentages (1%, 3%, and 5%) and reinforcement depth ratio are ( $u/B = 0.33, 0.67, \text{ and } 1$ ). In all experiments, pipe diameter, foundation size, and relative density were kept constant. First, vertical loading test was carried out for unreinforced sand. Then, tests were carried out for each of the cases reinforced with 1%, 3% and 5% PET waste ( $u/B=0.33; 0.67 \text{ and } 1$ ) for the 50, 100 and 150 mm layers located just above the pipe.

### **Findings and Discussion**

In this section, the results of the stresses formed at the pipe edge with the experiments conducted with unreinforced and reinforced soils are presented.

#### **a. Effect of PET percentage (%)**

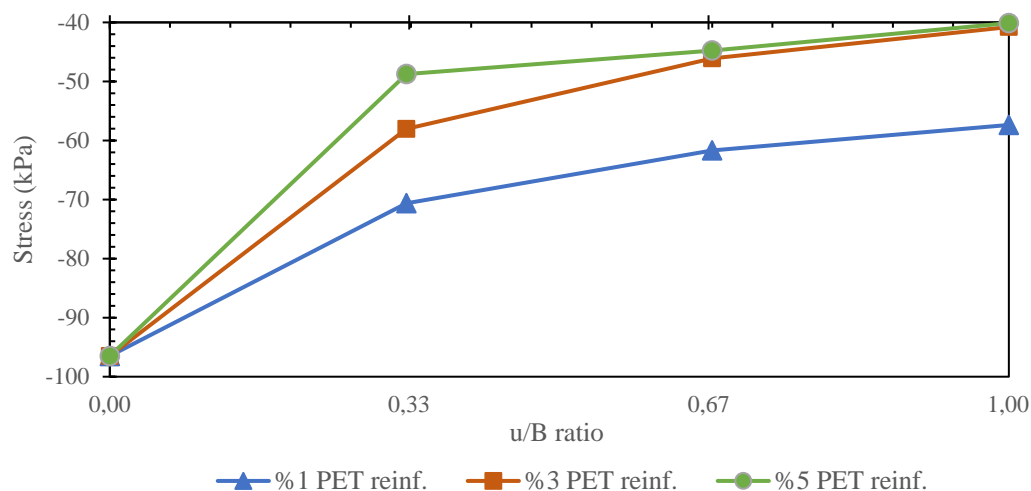
The ultimate bearing capacity of the unreinforced sand soil occurred when  $s/B=10\%$ . For this reason, in the experiments conducted with reinforced soil layers, the stresses in the pipe corresponding to the load value at which the unreinforced sand soil failed (245 kPa) were taken into account. For unreinforced and PET waste reinforced soil layers, the change in the stress values of the pipe with the pressure applied to the foundation is given in Figure 4(a-c). The stress values on the pipe were measured with strain-gauge sensors placed on the pipe. When the stress values corresponding to the 245 kPa value in the unreinforced case are examined, a decrease of 26.8%, 39.8% and 49.5% occurred for the cases with 1%, 3% and 5% PET waste reinforcement at  $u/B=0.33$ , respectively. In Figure 4.b, a decrease of 36.1%, 52.2% and 53.6% occurred for the cases with 1%, 3% and 5% PET waste reinforcement at  $u/B=0.67$ , respectively, compared to the unreinforced case. Similarly, in Figure 4.c, it is observed that there is a decrease of around 40.5%, 57.7% and 58.4% in the stress values in the pipe with 1%, 3% and 5% PET waste reinforcement, respectively, compared to the unreinforced case at  $u/B=1$ . It is clearly seen that there are significant decreases in the stresses in the pipe with the addition of PET waste to the sand, compared to the unreinforced case. Edil and Bosscher (1994) stated that the behavior of the mixture may change from a competent composite to a rubber material behavior with the increase of the rubber content added to the soil. Similarly, it is thought that the PET waste added to the sand also transforms the soil from a competent material to a more compressible material, thus damping the stresses in the pipe.



**Figure 4.** Variation in the stress in the pipe with the applied pressure (a)  $u/B=0.33$ , (b)  $u/B=0.67$  and (c)  $u/B=1$

### b. Reinforcement depth ratio effect ( $u/B$ )

In this section, the change in stresses in the pipe with specified percentages of PET reinforced soil layer thickness was investigated. Figure 5 shows the relationship between the reinforcement depth and the stresses at the top of the pipe in the experiments conducted with 1%, 3% and 5% PET reinforced soil layers. As seen in Figure 5, in all PET reinforced experiments, the stresses in the pipe decreased with the increase in reinforcement depth. The most effective result in terms of reducing the loads acting on the pipe was obtained from the experiments containing 5% PET and with  $u/B=1$ . With this reinforcement process, a decrease of approximately 58% occurred in the stresses in the pipe.



**Figure 5.** Variation of stresses in the pipe with reinforcement depth

### Conclusion and Recommendations

In this study, the change in the stresses formed at the top of the pipe buried in the sand soil after the soil reinforcement with PET waste was investigated. The obtained results are summarized as follows.

- It was observed that all the PET reinforcement studies were successful in reducing the stresses in the pipe compared to the unreinforced case.
- In reducing the stresses in the pipe, the optimum PET reinforcement ratio was determined as 5% and the optimum reinforcement depth as 150 mm ( $u/B=1$ ). In other words, as the amount of PET added to the sand and the reinforced layer depth increased, the stresses in the pipe decreased.
- While the stress value in the pipe corresponding to 245 kPa where the soil failed in the unreinforced situation was 96.5 kPa, the stress in the pipe was found to be 40.1 kPa with 5% PET reinforcement and reinforcement made with  $u/B=1$ .

### Thanks and Information Note

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**EVALUATION OF THE EFFECT OF PET WASTE ON INCREASING THE  
ULTIMATE BEARING CAPACITY OF A SQUARE-SHAPED FOUNDATION**

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**Özet**

Günümüzde plastik şişelerden ortaya çıkan PET atıklar, doğal yaşam alanlarını ve su kaynaklarını kirletmektedir. Çevreye verilen bu zararların azaltılması amacıyla, PET atıkların zeminlerin mühendislik özelliklerinin iyileştirilmesinde kullanımı, alternatif bir çözüm olarak görülmektedir. Bu çalışmada, %0 ila %5 arasında PET atığı kuma ilave edilerek kumun kesme mukavemeti özelliklerine etkisi araştırılmıştır. Ayrıca, zemin taşıma gücü üzerindeki etkileri de teorik taşıma gücü denklemleri kullanılarak incelenmiştir. Takviyesiz ve takviyeli kum için üç farklı normal gerilme altında doğrudan kesme deneyleri yapılmıştır.  $D_r=65$  rölatif sıklıkta hazırlanan tüm zemin numuneleri için kohezyon ve içsel sürtünme açısı bulunmuştur. Tüm zemin numunelerine ait kayma mukavemeti parametreleri elde edildikten sonra, Terzaghi ve Vesic teorik taşıma gücü denklemleriyle 0.15m x 0.15m boyutlarındaki bir temel için nihai taşıma gücü değerleri hesaplanmıştır. Sonuçlar, PET takviyesinin zeminin hem içsel sürtünme açısının hem de temel nihai taşıma kapasitesinin artmasında etkili olduğunu göstermiştir. PET ile takviye edilen tüm zemin numunelerinin katkısız duruma göre kayma mukavemeti ve nihai taşıma gücüne olumlu etkisi olurken, optimum PET takviye oranı %3 olarak belirlenmiştir. %3 'den daha fazla PET takviyesinin zeminin içsel sürtünme açısı ve nihai taşıma kapasitesini bir miktar azalttığı görülmüştür. Optimum oranda PET takviyesiyle zemin numunesinin içsel sürtünme açısı 42,3° den 47,4°'ye yükselirken, nihai taşıma kapasitesinde %193' e varan artış meydana gelmiştir.

**Anahtar Kelimeler:** PET atık, Kum zemin, Kayma mukavemeti, İçsel sürtünme açısı, Taşıma gücü.

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ULTIMATE BEARING CAPACITY OF A SQUARE-SHAPED FOUNDATION**

**Abstract**

Today, PET wastes from plastic bottles pollute natural habitats and water resources. In order to reduce these damages to the environment, the use of PET wastes in improving the engineering properties of soils is seen as an alternative solution. In this study, the effect of shear strength properties of sand was investigated by adding PET waste between 0% and 5% to sand. In addition, the effects on soil bearing capacity were investigated using theoretical bearing capacity equations. Direct shear tests were conducted under three different normal stresses for unreinforced and reinforced sand. Cohesion and internal friction angle were determined for all soil samples prepared at  $D_r=65\%$  relative density. After obtaining the shear strength parameters of all soil samples, the ultimate bearing capacity values were calculated for a foundation with dimensions of 0.15m x 0.15m using the Terzaghi and Vesic theoretical bearing capacity equations. The results showed that PET reinforcement was effective in increasing both the internal friction angle of the soil and the ultimate bearing capacity of the foundation. All soil samples reinforced with PET had a positive effect on the shear strength and ultimate bearing capacity compared to the unmixed state, and the optimum PET reinforcement ratio was determined as 3%. It was observed that PET reinforcement of more than 3% slightly decreased the internal friction angle and ultimate bearing capacity of the soil. With the optimum ratio of PET reinforcement, the internal friction angle of the soil sample increased from  $42.3^\circ$  to  $47.4^\circ$ , while the ultimate bearing capacity increased up to 193%.

**Keywords:** PET waste, Sand soil, Shear strength, Internal friction angle, Bearing capacity.

### **Introduction**

Only 9% of bottles made of PET enter the recycling process, while the rest are thrown directly into landfills and seas without being used as an alternative material for any purpose (Babu and Chouksey 2011, Rahimi et al., 2023).

Due to reasons such as the decrease in material quality of PET waste after recycling, it is more reasonable to use PET waste directly (Tafreshi et al. 2021). Therefore, the use of this waste in soil stabilization is very important in reducing the damage to the environment and is an economical alternative (Alvarez et al. 2020). Many studies have been conducted on improving the mechanical properties of soils with waste plastics. In these studies, PET wastes from PET bottles were mixed with the soil in the form of strips or fibers at certain rates. In these studies, it was generally observed that PET wastes added to the soil had a positive effect on the mechanical behavior of the soil (Consoli et al. 2002; Zhao et al. 2015; Bozyiğit et al. 2021; Ferreira et al. 2021; Castilho et al. 2021).

Peddaiah et al. (2018) conducted a study on the use of plastic bottle strips for the improvement of engineering properties of silty sand. In the study, compression, California bearing ratio and direct shear tests were conducted. The experimental results showed that the improvement levels may differ depending on the amount of additives, the size of the strips and the type of soil. It was shown that 0.4% plastic strip reinforcement with dimensions of 15 mm x 15 mm provided the best improvement. In the study conducted by (Abukhattala and Fall, 2021), unconfined compression and CBR tests were carried out by using waste PET bottle particles in different forms and adding them to the soil between 0% and 10%. As a result, while the CBR value increased with the increase in PET percentage, the unconfined compression strength decreased slightly. In addition, it was observed that the flake shape was more effective than the granule in the CBR value. (Taher 2024) conducted a study on increasing the shear strength and ultimate bearing capacity of the soil using waste PET particles. For this purpose, direct shear tests were carried out on prepared soil samples by adding 0% to 1.5% PET flakes to the sand. The ultimate bearing capacity of a shallow foundation was calculated using the obtained parameters and theoretical bearing capacity equations. As a result of the study, it was observed that the highest internal friction angle was reached with 0.75% PET addition to the soil, and that the bearing capacity of the soil increased by up to 85%.

The aim of this study is to investigate the contribution of PET waste obtained by randomly crushing plastic water bottles in increasing the shear strength of sandy soil. 1%, 3% and 5% PET waste was added to the sand by weight and all soil samples were prepared with 65% relative density. Shear strength parameters ( $c$ ,  $\phi$ ) were determined by direct shear tests with unreinforced and PET waste reinforced soils. In addition, the ultimate bearing capacity of a 0.15 m square shallow foundation was calculated analytically by Vesic and Terzaghi theoretical bearing capacity equations. The obtained results were compared with each other.

### **Materials and Methods**

In this section, the materials used in the study, the experiments performed and the formulas of the theoretical bearing capacity equations are included.

River sand was used in this study. First, the sand was washed on a #200 (0.075 mm) sieve and after drying in the oven, the material remaining under the 1 mm sieve was taken. The sieve analysis curve according to ASTM D422-63, (2007) is given in Figure 1. The index properties of the sand soil are given in Table 1. Direct shear tests were conducted for unreinforced and PET waste reinforced soils. In all tests conducted according to ASTM D3080, (2011), the shear rate was determined as 1 mm/min. All soil samples were prepared at 65% relative density.

Direct shear tests were performed for each soil sample under three different normal stresses. Preparation of samples for direct shear test is as shown in Figure 2. After each sample was prepared at the desired density, direct shear tests were performed and the shear stress and corresponding horizontal displacement values were recorded.

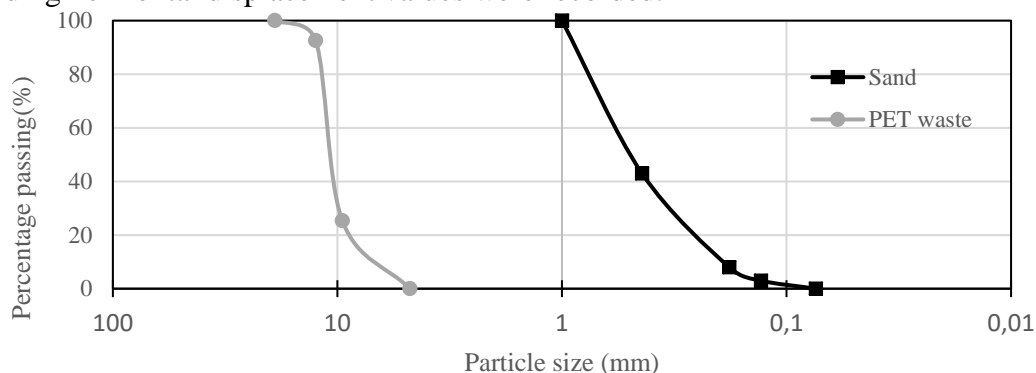


Figure 1. Size distributions of the sand and PET wastes

Table 1. Properties of sand

Property	Value
USCS Classification	SP
Specific gravity, ( $G_s$ )	2.77
$\sigma_d$ , ( $kN/m^3$ )	15.9
Relative density ( $D_r$ )	65%



Figure 2. Preparation for direct shear test and experimentation

### Theoretical bearing capacity equation

The shear strength properties of all soil samples were determined by direct shear tests. Then, the theoretical bearing capacity equations of Terzaghi and Vesic were used to find the ultimate bearing capacity ( $q_u$ ) of a square shaped foundation with a width of 0.15 m using the obtained parameters. The theoretical bearing capacity equations of Vesic and Terzaghi for a square foundation are given below (Das and Sivakugan, 2018).

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$$q_u = cN_c s_c d_c i_c g_c b_c + qN_q s_q d_q i_q b_q + 0.5\gamma B N_\gamma s_\gamma d_\gamma i_\gamma g_\gamma b_\gamma \quad (1)$$

Where,

$q_u$  is ultimate bearing capacity of soil,  $c$  is soil cohesion,  $q$  is surcharge load above the footing,  $B$ , is the foundation width,  $N_c$ ,  $N_q$ ,  $N_\gamma$  are bearing capacity factors,

$$N_q = e^{\pi \tan \phi} \tan^2(45 + \phi/2) \quad (2)$$

$$N_c = (N_q - 1) \cot \phi$$

(3)

$$N_\gamma = 2(N_q + 1) \tan \phi$$

(4)

$S_c$ ,  $S_q$ ,  $S_\gamma$ , are shape factors,  $d_c$ ,  $d_q$ ,  $d_\gamma$ , are depth factors,  $i_c$ ,  $i_q$ ,  $i_\gamma$ , are load inclination factors,  $g_c$ ,  $g_q$ ,  $g_\gamma$ , are ground factors (base on slope), and  $b_c$ ,  $b_q$ ,  $b_\gamma$ , are foundation base factors (tilted base).

None of the soil samples used in this study have cohesion and it is assumed that there is no additional load on the foundation. Also, it is assumed that the load is vertical and the ground and foundation surface are completely horizontal. Accordingly, (1) can be rewritten as follows:

$$q_u = 0.5\gamma B N_\gamma s_\gamma \quad (5)$$

$$q_u = 1.3cN_c + qN_q + 0.4\gamma B N_\gamma \quad (6)$$

Terzaghi bearing capacity equation is given in (6). If the equation is rearranged as in (1),

$$q_u = 0.4\gamma B N_\gamma \quad (7)$$

is obtained.

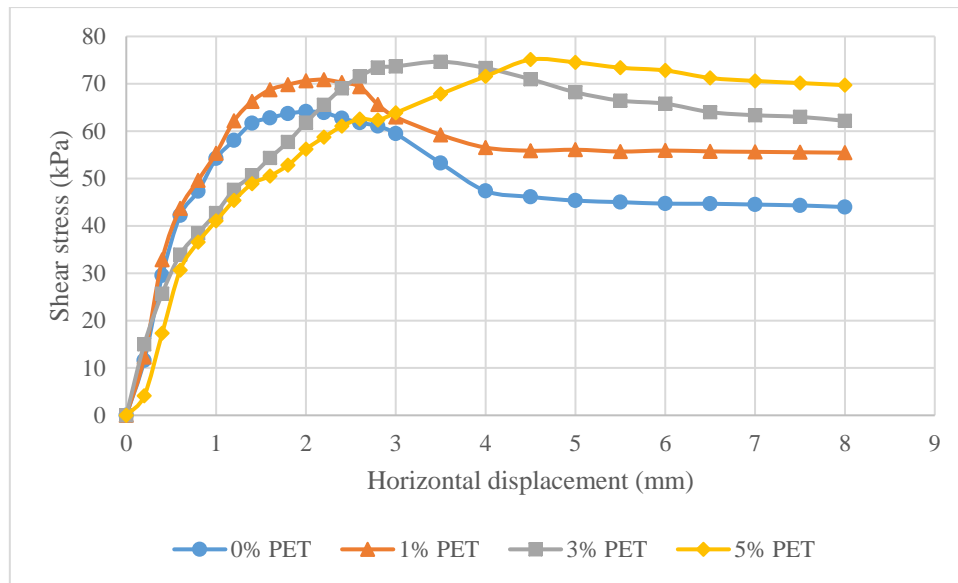
## Findings and Discussion

In this section, shear box test results and theoretical bearing capacity data are presented.

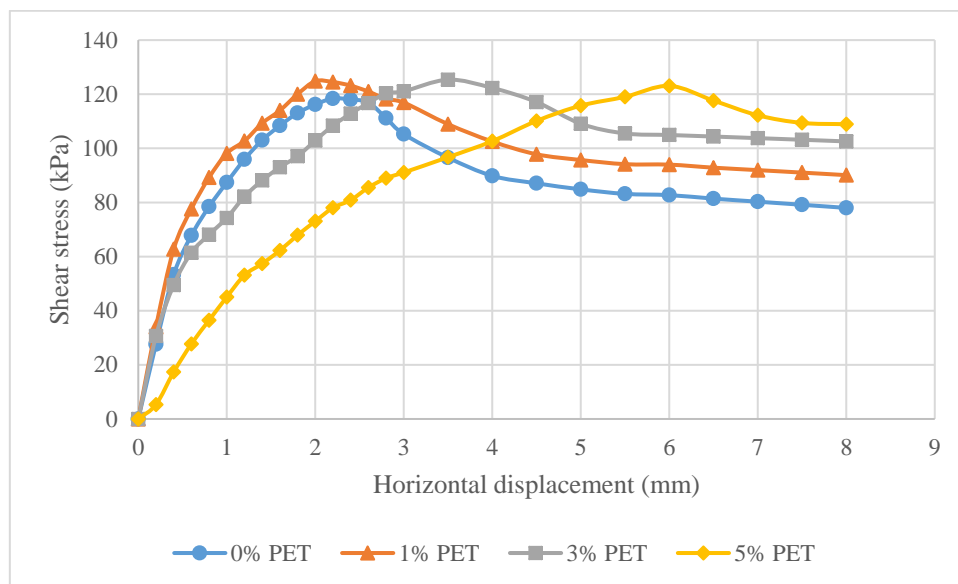
### a. Effect of PET reinforcement on the shear behavior of sand

A series of direct shear tests were conducted to investigate the effect of PET reinforcement on the shear strength of sand. Since the cohesion value for all soil samples was negligibly small, the shear strength directly depends on the internal friction angle of the soil. The graphs obtained from the direct shear tests conducted under three different stresses with determined percentages of PET reinforcement are shown in Figures 3-5. It was observed that PET waste added to sand generally increased the shear stress. This effect of waste materials added to sand was similarly observed by other researchers (Edincliler et al., 2012, Alshkane, 2017., Aksoy et al., 2021., Taher and Aksoy, 2023). The relationship between different normal stresses and shear stresses of unreinforced and PET reinforced sand is presented in Figure 7.

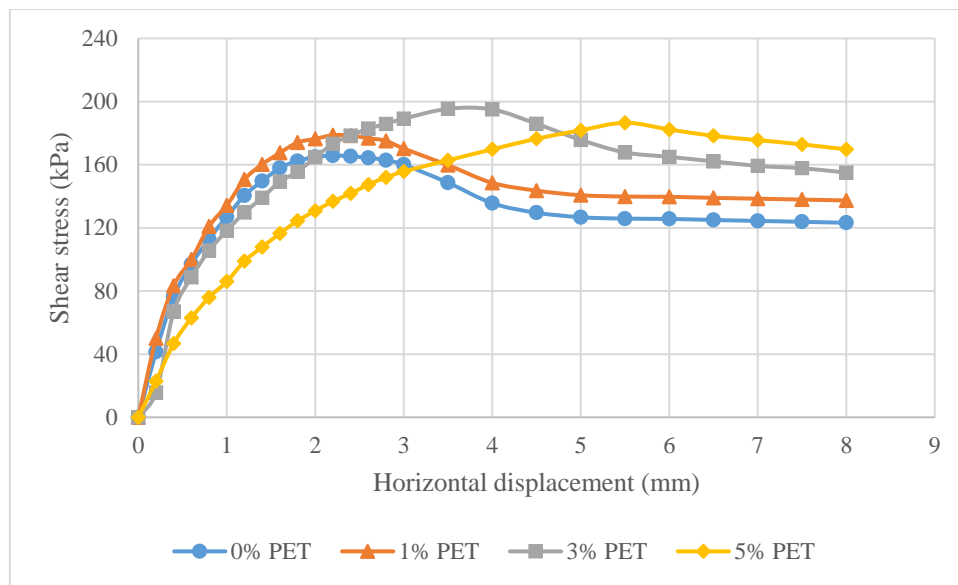
It was observed that all PET waste added to sand increased the shear strength compared to the unreinforced case. It was observed that increasing PET reinforcement increased the internal friction angle of the sand, but more than 3% increase in PET ratio decreased the internal friction angle (Figure 7). In this case, it was determined that 3% PET reinforcement ratio was the optimum ratio to increase the shear strength of the sand.



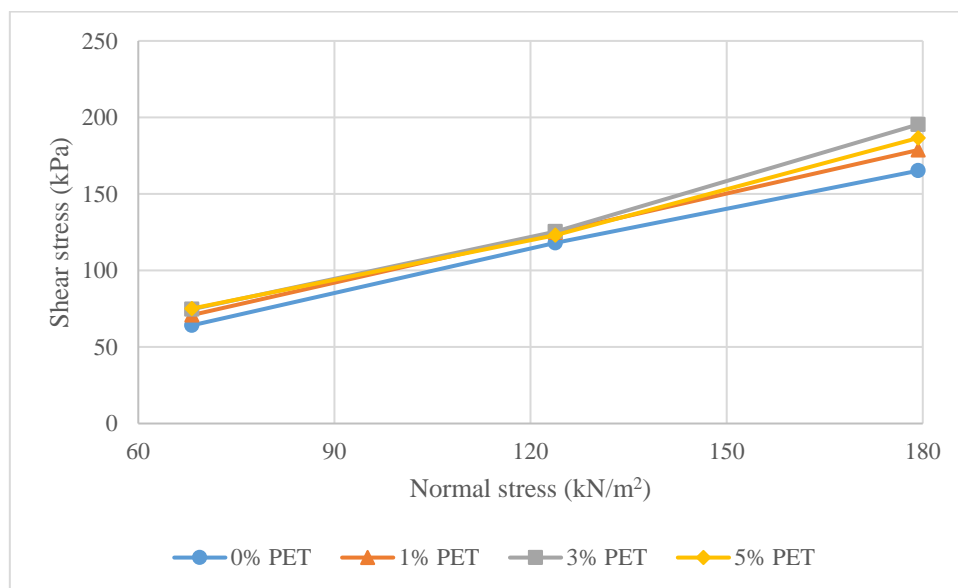
**Figure 3.** Variation of shear stress shear strain for the various content of PET wastes under normal stress = 54 kPa



**Figure 4.** Variation of shear stress shear strain for the various content of PET wastes under normal stress = 109 kPa



**Figure 5.** Variation of shear stress shear strain for the various content of PET wastes under normal stress = 165 kPa



**Figure 6.** Variation of shear stress versus normal stress for sand reinforced with various percentages PET waste



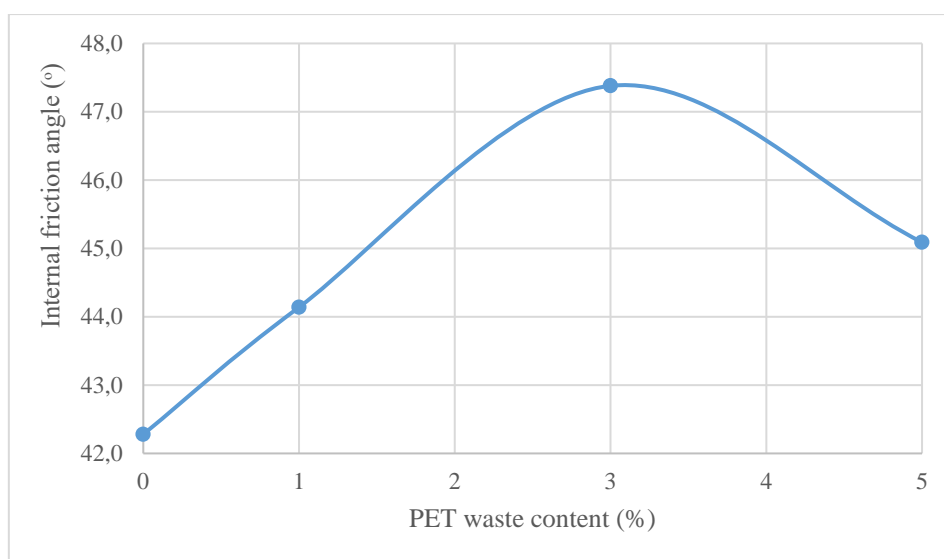


Figure 7. Change of ( $\phi$ ) of sand versus various PET waste content

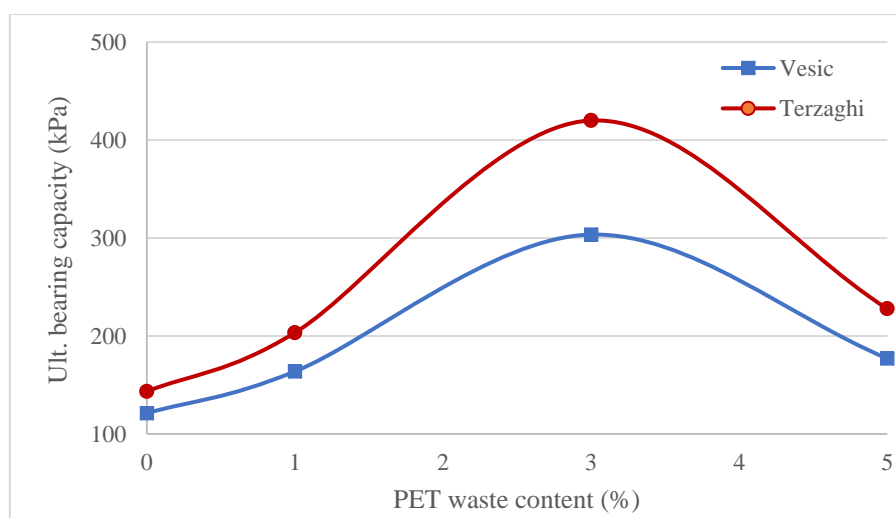
**b. Contribution of PET reinforcement to the ultimate bearing capacity of the soil**

In this section, the effect of PET reinforcement on the bearing capacity of a square shaped foundation with a width of 0.15 m was investigated using Vesic and Terzaghi bearing theories. Theoretical results were calculated using the parameters obtained from the direct shear tests conducted before.

Table 2. Ultimate soil bearing capacity using Vesic and Terzaghi theoretical equation.

PET wastes (%)	$\phi$ (°)	Terzaghi- $q_u$ (kPa)	Vesic- $q_u$ (kPa)
0	42,3	143,4	121,2
1	44,1	203,4	163,8
3	47,4	420	303,5
5	45,1	227,8	177

The internal friction angle of the unreinforced and PET waste reinforced sand soil and the ultimate bearing capacity values calculated using equations (1)-(2) are presented in Table 2. The change in the ultimate bearing capacity values of the soil with the PET reinforcement ratio using the Vesic and Terzaghi bearing capacity equations is shown in Figure 8. It is clearly seen that the optimum ratio in terms of bearing capacity is 3% among all reinforcement ratios. With 3% PET reinforcement, the bearing capacity of the soil increased by 150% and 193%, respectively, according to the Vesic and Terzaghi equations. The results obtained from the internal friction angle of the sand reinforced PET and the theoretical bearing capacity equations are summarized in Table 2. It was concluded that the bearing capacity equations suggested by Terzaghi gave higher results than Vesic.



**Figure 8.** Change of ultimate bearing capacity versus various PET waste content

### Conclusion and Recommendations

In this study, the effect of PET waste reinforcement on the improvement of the shear strength properties of sand soil and the increase in the theoretical bearing capacity was investigated. The results obtained are summarized as follows.

- When sand soil was reinforced with PET waste, it had a positive effect on the shear strength for all soil samples compared to the unreinforced case. However, the optimum PET reinforcement ratio was determined as 3%.
- The internal friction angle of the unreinforced sand soil was  $42.3^\circ$ , while it increased to  $47.4^\circ$  with 3% PET reinforcement. It was observed that PET reinforcement more than 3% increased the internal friction angle of the sand soil compared to the unreinforced case, but decreased it slightly compared to 3%.
- From the analysis performed using the theoretical bearing capacity equations of Vesic and Terzaghi, it was determined that the ultimate bearing capacity of a 0.15 m square foundation with 3% PET reinforcement increased by 150% and 193%, respectively.

### Thanks and Information Note

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**EPIGENOM ANALİZİ: MAHSÜL İYİLEŞTİRMESİNE MOLEKÜLER BİR  
YAKLAŞIM**

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**Özet**

Epigenetik düzenlemeler, DNA dizisini değiştirmeksizin gen ifadesini kontrol eden mekanizmaları ifade etmektedir ve tarımda mahsul iyileştirme için yeni fırsatlar sunmaktadır. Bu çalışmada, DNA metilasyonu, histon modifikasyonları ve kodlamayan RNA'ların (ncRNA) işlevleri ve analiz teknikleri incelenmiştir. DNA metilasyonunun bisüfit dizilimi, pyrosequencing ve Metillenmiş DNA İmmünopresipitasyonu (MeDIP) gibi yöntemlerle nasıl analiz edilebileceği açıklanmıştır. Ayrıca histon metiltransferaz (HMT) ve kromatin immünopresipitasyon (ChIP-Seq) gibi tekniklerin histon modifikasyonlarını incelemedeki rolleri vurgulanmıştır. Kodlamayan RNA'ların gen ekspresyonunun düzenlenmesindeki kritik rolleri ve bunların tespitine yönelik hesaplamalı araçlar tanıtılmıştır. Sonuç olarak, epigenom dinamiklerinin moleküler tarımda stres faktörlerine dayanıklı, yüksek verimli bitkilerin geliştirilmesinde büyük bir potansiyele sahip olduğu vurgulanmıştır. Gelecekte, epigenetik yaklaşımların CRISPR (Clustered Regularly Interspaced Palindromic Repeats) gibi gen düzenleme teknolojileriyle entegrasyonu, tarımda daha sürdürülebilir çözümler sunabilir.

**Anahtar Kelimeler:** Epigenom, epigenetik, ıslah

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**EPIGENOME ANALYSIS: A MOLECULAR APPROACH TO CROP  
IMPROVEMENT**

**Abstract**

Epigenetic regulations refer to mechanisms that control gene expression without altering the DNA sequence and offer new opportunities for crop improvement in agriculture. In this study, DNA methylation, histone modifications, and non-coding RNAs (ncRNA) functions and analysis techniques were investigated. It was explained how DNA methylation can be analyzed by methods such as bisulfite sequencing, pyrosequencing, and Methylated DNA Immunoprecipitation (MeDIP). In addition, the roles of techniques such as histone methyltransferase (HMT) and chromatin immunoprecipitation (ChIP-Seq) in examining histone modifications were emphasized. The critical roles of non-coding RNAs in the regulation of gene expression and computational tools for their detection were introduced. In conclusion, it was emphasized that epigenome dynamics have great potential in the development of high-yield plants resistant to stress factors in molecular agriculture. In the future, the integration of epigenetic approaches with gene editing technologies such as CRISPR (Clustered Regularly Interspaced Palindromic Repeats) may offer more sustainable solutions in agriculture.

**Keywords:** Epigenome, epigenetics, breeding

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## GİRİŞ

Epigenom, DNA dizisini deęiřtirmeden gen ifadesini dzenleyen DNA ve histon proteinlerindeki bir dizi kimyasal modifikasyonu ifade etmektedir (Riggs ve ark., 1996; Boquete et al., 2021). DNA metilasyonu, histon asetilasyonu ve kodlamayan RNA'ların aktivitesi dahil olmak üzere bu modifikasyonlar, kromatin yapısını ve dolayısıyla gen erişilebilirliğini ve transkripsiyonu etkileyebilir (Allis ve Jenuwein, 2016). Genetik mutasyonların aksine, epigenetik deęişiklikler genellikle geri döndürülebilir ve çevresel faktörlerden etkilenebilir, bu da organizmaların çevrelerine dinamik olarak uyum sağlamalarına olanak tanımaktadır (Feil ve Fraga, 2012).

Epigenom, gelişim, hücre farklılaşması ve genomik baskı gibi temel biyolojik süreçlerde önemli bir rol oynamaktadır. Dahası, dinamik yapısı, bitkilerde ve hayvanlarda stres tepkileri için kritik olan çevresel uyaranlara yanıt olarak gen ifadesinin modülasyonunu sağlamaktadır (Bird, 2007). Epigenomun düzenleyici mekanizmalarını anlamak, hedeflenen epigenetik müdahaleler yoluyla stres toleransı ve verim gibi tarımsal özelliklerin iyileştirilmesi açısından derin etkilere sahiptir (Zhang ve ark., 2018).

## DNA METİLASYONUNUN ANALİZİ

5-Metil sitozin (m5C), ökaryotik organizmaların genomlarında sıklıkla deęişikliğe uğrayan azotlu baz olarak düşünülebilir (Bestor ve Coxon, 1993; Chiang ve ark., 1996). m5C, test tüpünde DNA metiltransferaz enzimlerinin aktivitesi ile üretilir, böylece S-adenosil metioninden (SAM) bir metil grubu aktarılır (Schmitt ve ark., 1997). Bu reaksiyona DNA metilasyonu denir. Embriyoların gelişimi, gen ifadesinin düzenlenmesi ve genomik damgalama dahil olmak üzere farklı türde önemli biyolojik süreçler DNA metilasyonundan etkilenebilir. Dolayısıyla hastalıkların tespiti, farklı tedavilere yanıt ve tanısal deneyler için DNA metilasyonu biyolojik belirteç olarak kullanılabilir (Peng ve Zhang, 2009). DNA metilasyonunun analizi için farklı teknikler vardır:

## BİSÜLFİT DİZİLİMİ (BS-SEQ)

Bu teknik, DNA'nın arkasında deęişmemiş 5-metilsitozin kalıntıları bırakan bisülfid ile işlenmesi yoluyla sitozinin urasile dönüřtürülmesini içerir. Dolayısıyla uygulanan bisülfid, DNA'yı etkilemeden metillenmiş sitozinlerin arkasında kalır. PCR ile amplifikasyon tamamlandığında, amplifiye edilen ürünlerde sitozinler olarak geride kalan timinler ve metillenmiş sitozinler bulunur. Tüm bu reaksiyon, daha yüksek sıcaklık ve düşük pH ile yüksek bisülfat tuzu konsantrasyonuyla daha yüksek DNA konsantrasyonu gerektirir (Sant ve ark., 2012; Hernández ve ark., 2013).

## DİFERANSİYEL METİLASYON HİBRİDİZASYONU (DMH)

Bu teknik, DNA metilasyon dizisini (DMH: Diferansiyel Metilasyon Hibridizasyonu) içerir. Bu teknoloji, tümör hücrelerindeki hipermetile dizileri tanımlamak için DNA dizisine dayanmaktadır. Bu yöntem, genomik kütüphaneden izole edilen CpG ada lokuslarını tarayabilir (Yan ve ark., 2009).

## PYROSEQUENCING

Bu sıralama yöntemi, bisülfid tarafından dönüřtürülen DNA'nın metilasyonunun analizinde kullanılır. Bu yöntemin temel prensibi, tamamlayıcı DNA sentezi için nükleotidlerin sırayla eklenmesi sırasında yayılan ışığın saptanmasıdır. DNA metilasyon modelinin saptanması ve ölçülmesine yönelik bu potansiyel, çeşitli hastalıkları hedeflemek için potansiyel ilaç olmanın yanı sıra bir işaretleyici olarak da kullanılabilir. Bu aynı zamanda basit, hızlı ve karşılaştırılabilir sonuçlar sağladığı için klonlama için de kullanılabilir (Frommer ve ark.,

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1992). Bu yöntem aynı zamanda spesifik alellerin metilasyon modellerini tanımlamak için de kullanılır (Reed ve ark., 2010).

**METİLENMİŞ DNA İMMÜNOPRESİPİTASYONU (MEDIP)**

Bu yöntem, metillenmiş DNA'nın deneysel numuneden ekstraksiyonu için kullanılır. Mohn ve ark. (2009) tarafından açıklanan şekliyle Metillenmiş DNA İmmünopresipitasyonu (MeDIP) tekniği, özellikle genom çapında metillenmiş bölgeleri analiz etmek için etkili bir yöntemdir (Wilson ve ark., 2006; Mohn ve ark., 2009).

**HİSTON METİLASYONU VE ASETİLASYON ANALİZİ**

Histon Metiltransferaz (HMT) Analizi: Bu analizde HMT, 1 veya daha fazla metil grubunun histon proteini içindeki arginin veya lizin kalıntılarına dahil edilmesini katalize eder. Bu analiz, asetil bağlı histonun doğrudan veya dolaylı olarak CoA'yı serbest bırakmasının tespiti yoluyla HAT'nin (Histone Asetil Transferaz) ölçümü için kullanılır. Farklı tipteki histon substratları ve SAM, metiltransferaz açısından zengin bakteriyel hücre ekstraktına inkübe edilir. Bu birleşme sintilasyon sayımı işlemiyle tespit edilebilir. Etiketleme yapıldıktan sonra, değiştirilmiş substrat SDS-PAGE ve florografi ile incelenir (Jacob ve Voigt, 2018).

Histon Demetilaz (HDMT) Analizi: Epigenom analizi aynı zamanda HDMT'nin yanı sıra proteaz, rekabet bağlama ile birleştirilmiş tespit yoluyla da yapılabilir. Bu analiz aynı zamanda metillenmiş histonlardan salınan radyo-etiketli formaldehitin ölçümü için de kullanılabilir. Bölgeye özgü metillenmiş histon antikoları, immüno blotlama analizi yoluyla histon metilasyon seviyelerindeki değişikliği izlemek için kullanılabilir. Ek olarak histon azalmalarını tespit etmek için kütle spektrometresi kullanılabilir (Tsukada ve ark., 2010).

**KROMATİN İMMÜNOPRESİPİTASYON DİZİLEME ANALİZİ (CHIP-SEQ)**

Bu teknik, tüm genomdaki farklı DNA bağlanma proteinlerinin ve transkripsiyon faktörlerinin DNA bağlanma lokusunu veya noktalarını tanımlamak için uygulanır. Bu teknik, DNA'ya bağlanan proteinlerin ve tüm genomdaki dizisi bilinen histon değişikliklerinin araştırılmasında önemli yöntemlerden biridir (Collas, 2010).

**KODLAMAYAN RNA (ncRNA)**

Kodlamayan RNA (ncRNA), DNA'dan kopyalandıktan sonra protein sentezleyemeyen fonksiyonel RNA molekülüdür. Genel olarak gen ekspresyonunun kodlamayan RNA tarafından düzenlenmesi hem transkripsiyon hem de transkripsiyon sonrası seviyede gerçekleşir. Bu RNA'ların önemli rolleri arasında heterokromatin oluşumu, histonların modifikasyonu, DNA metilasyonunun hedeflenmesi ve gen ekspresyonunun baskılanması yer alır. ncRNA'nın analizi için kullanılacak araçlar Tablo 1'de gösterilmiştir (Oakeley, 1999).

**Tablo 1.** Farklı Hesaplamalı Araçların Uygulanmasıyla ncRNA'nın Analizi

Araçlar	Fonksiyonları
CPSS	Özellikle miRNA'nın incelenmesi ve açıklanmasıyla ilgilidir.
ncPRO-seq	Yeni ncRNA türlerinin tespiti için kullanılır.
CoRAL	Daha küçük ncRNA'nın, genomik dizi hariç biyolojik kriterler temelinde farklı kategorilere bölünmesi.
miRDeep	Yeni miRNA'nın tespiti için kullanılır.
DARIO	Bu, ncRNA'nın farklı halka açık nükleotid veri tabanlarına göre değerlendirme yoluyla ncRNA'nın miktarının belirlenmesi ve açıklaması için kullanılır.

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**BİTKİ ISLAHINDA UYGULAMALAR**

Model bitkide (*Arabidopsis thaliana*) epiRIL üzerine yapılan son arařtırmalar, QTL epigenetiđinin ayrıntılı bir řekilde gsterilmesini sađlamıř ve bylece karmařık zelliklerin kalıtsallıđını aıklamıřtır (Lauss ve Keurentjes, 2018; Kooke ve ark., 2019). Ayrıca, domatesteki meyvelerin olgunlařma mekanizması (Manning ve ark., 2006) ve ayrıca palmiye yađı somaklonal varyasyonu (Rival ve ark., 2000) ile iyi bir řekilde aıklanmaktadır. Epigenetik varyasyonlar, genin DNA dizisini deđiřtirmeden mahsuln iyileřtirilmesine yardımcı oldukları iin bitki ıslahında nemli aralar olarak gsterilmektedir. Epialel Epigenetiđi, epialel geliřimine yol aar ve bylece in vitro mutajenezle karřılařtırıldıđında bitki yetiřtiricileri iinrn iyileřtirme aısından daha yksek etkilere sahip olabilir. Kromatin deđiřtiriciler, genlerin yukarı ve ařađı reglasyonu iin kullanılabilir, bylece ilgilenilen zelliđi etkileyebilir.

**SONU**

Farklı epigenetik mekanizmalarırne yapılan son alıřmalar, bunların farklı niteliksel ve niceliksel zellikleri dzenlediđini ortaya koymaktadır. Epigenom dinamikleri, sonuta meyve olgunlařmasına ve bitki geliřim srelerine katkıda bulunan molekler mekanizmaları dzenleyerek, stres faktrlerine karřı dayanıklılık artıřına yol aabilir. Yakın gelecekte bu bilgiler, evresel streslere uyum sađlayan ve verimlilik potansiyeli yksek mahsul eřitlerinin geliřtirilmesi iin uygulanabilir bir temel sunmaktadır.



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**January 21-28, 2025 / Havana, CUBA**

**BUĞDAY'DA ISI STRESİ TOLERANSININ MOLEKÜLER MEKANİZMASI**

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**Özet**

Küresel iklim değişikliği, artan sıcaklık stresi nedeniyle dünya çapında buğday üretimini tehdit etmektedir. Buğday bitkisi, yüksek sıcaklıklara karşı gelişmiş fizyolojik, biyokimyasal ve moleküler mekanizmalar geliştirerek adaptasyon sağlayabilir. Isı şoku proteinlerinin (HSP'ler) üretimi, antioksidan sistemlerin aktive edilmesi ve prolin gibi ozmoprotektanların birikimi bu adaptasyonun temel unsurlarıdır. Genom çapında ilişki çalışmaları (GWAS), işaretleyici destekli seçim (MAS) ve genomik seçim (GS) gibi modern ıslah yaklaşımları, buğdayın ısı toleransını artırmada kritik rol oynamaktadır. CRISPR/Cas9 gibi gen düzenleme teknolojileri, ısı toleransıyla ilişkili genlerin hassas manipülasyonunu mümkün kılmıştır. Bu çalışma, buğdayda ısı stresine karşı geliştirilen mekanizmaları ve modern biyoteknolojik yöntemlerin bu mekanizmaları iyileştirme potansiyelini tartışmaktadır. Çalışma, sürdürülebilir tarım uygulamaları ve gıda güvenliği için iklime dayanıklı buğday çeşitlerinin geliştirilmesine katkı sağlamayı amaçlamaktadır.

**Anahtar Kelimeler:** Buğday, ıslah, moleküler yaklaşımlar

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**MOLECULAR MECHANISM OF HEAT STRESS TOLERANCE IN WHEAT**

**Abstract**

Global climate change threatens wheat production worldwide due to increasing heat stress. Wheat plants can adapt to high temperatures by developing advanced physiological, biochemical and molecular mechanisms. Production of heat shock proteins (HSPs), activation of antioxidant systems and accumulation of osmoprotectants such as proline are the key elements of this adaptation. Modern breeding approaches such as genome-wide association studies (GWAS), marker-assisted selection (MAS) and genomic selection (GS) play a critical role in improving heat tolerance in wheat. Gene editing technologies such as CRISPR/Cas9 have enabled precise manipulation of genes associated with heat tolerance. This study discusses the mechanisms developed against heat stress in wheat and the potential of modern biotechnological methods to improve these mechanisms. The study aims to contribute to the development of climate-resistant wheat varieties for sustainable agricultural practices and food security.

**Keywords:** Wheat, breeding, molecular approaches

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## GİRİŞ

Küresel iklim değişikliği, sıcak hava dalgalarının sıklığında ve yoğunluğunda önemli bir artışa yol açarak dünya çapında tarımsal üretkenlik için ciddi bir tehdit oluşturmaktadır. Milyarlarca insan için temel bir ürün ve birincil gıda kaynağı olan buğday, çiçeklenme ve tane dolumu gibi kritik büyüme aşamalarında yüksek sıcaklıklara karşı özellikle hassastır. Sıcaklık stresi buğday fizyolojisini olumsuz yönde etkileyerek fotosentetik verimliliğin azalmasına, tane gelişiminin bozulmasına ve nihayetinde daha düşük verime yol açabilir (Farooq ve ark., 2009; Ni ve ark., 2018). Buğdayda sıcaklık stresi toleransını ele almak, değişen çevre koşulları altında gıda güvenliğini sağlamak için bitki biliminde önemli bir öncelik haline gelmiştir.

Buğdayın sıcaklık stresine dayanma yeteneği, fizyolojik, biyokimyasal ve moleküler mekanizmaların karmaşık bir etkileşimi tarafından yönetilir. Temel fizyolojik tepkiler arasında gelişmiş terleme soğutması, hücrel homeostazın korunması ve verimli enerji tahsisi yer almaktadır (Wahid ve ark., 2007). Biyokimyasal düzeyde, bitkiler antioksidan savunma sistemlerini aktive eder ve oksidatif hasarı azaltmak için prolin, glisin betain ve ısı şoku proteinleri (HSP'ler) gibi ozmoprotektanları biriktirmektedir (Ashraf ve Foolad, 2007). Bu mekanizmalar, strese duyarlı transkripsiyon faktörleri, sinyal molekülleri ve epigenetik modifikasyonları içeren moleküler yollar tarafından sıkı bir şekilde düzenlenmektedir (Mittler ve ark., 2012).

Moleküler biyolojideki son gelişmeler, buğdayda ısı stresi toleransının genetik temeline ilişkin içgörüler sağlamıştır. Örneğin, genom çapında ilişki çalışmaları (GWAS) ve transkriptomik analizler, iyileştirilmiş membran stabilitesi, klorofil tutulması ve yüksek sıcaklıklarda tane ağırlığı dahil olmak üzere ısı toleransı özellikleriyle ilişkili birkaç nicel özellik lokusu (QTL) ve aday gen belirlemiştir (Sehgal ve ark., 2015; Kayess ve ark., 2024). Ayrıca, CRISPR/Cas9 gen düzenlemesindeki gelişmeler, strese duyarlı genlerin hassas bir şekilde manipüle edilmesini sağlayarak ısıya dayanıklı buğday çeşitleri geliştirmek için yeni yollar sunmuştur (Zafar ve ark., 2020).

Isı stresi toleransının altında yatan moleküler mekanizmaları anlamak, farklı iklim şartlarına dayanıklı buğday çeşitlerinin geliştirilmesi için kritik öneme sahiptir. Bu inceleme, buğdayın ısı stresine verdiği fizyolojik, biyokimyasal ve moleküler tepkilere dair genel bakış sunmayı amaçlamaktadır. Ayrıca, buğdayda ısı toleransını artırma konusunda umut vadeden genomik ve biyoteknolojik yaklaşımlardaki son atılımları vurgulamaktadır. Bu çalışma, biyolojik organizasyonun birden fazla seviyesindeki bilgiyi birleştirerek sürdürülebilir tarım uygulamalarına ve küresel gıda güvenliğine katkıda bulunmayı amaçlamaktadır.

## YÜKSEK ISI STRESİ TOLERANSINA SAHİP BUĞDAY ÇEŞİTLERİNİN YETİŞTİRİLMESİ

Yüksek ısı stresi toleransına sahip çeşitlerin yetiştirilmesi, mahsul üretiminde küresel ısınmayla başa çıkmak için en etkili ve temel yaklaşımdır. Omik ve gen düzenleme teknolojileri de dahil olmak üzere moleküler biyolojinin hızla gelişmesiyle, geleneksel yetiştiricinin yanı sıra buğday çeşitlerinin geliştirilmesinde işaretleyici destekli seleksiyon ve genomik seleksiyon gibi yeni yetiştirme yöntemleri kullanılmış ve başarılı yetiştirme için umut verici bir ışık tutulmuştur.

## MELEZ YETİŞTİRME

Ticari buğday çeşitlerinin yabancı akrabaları, yetiştirme çabaları için ek çeşitlilik kaynakları sağlamaktadır (Ortiz ve ark., 2008). Saha çalışmaları, sentetiklerle çaprazlamalardan elde edilen hatların yalnızca olağanüstü verim göstermekle kalmayıp aynı zamanda ısı stresi altında bir dizi fizyolojik özellik de sergileyebildiğini göstermiştir (Cossani ve Reynolds, 2015).

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Ancak, tohum maliyeti nedeniyle melezlerin yaygın olarak benimsenmesi sınırlı kalmıştır. Erkek kısır buğday üretmek için çeşitli sistemler mevcut olsa da buğday çiçeklerinin güçlü akraba çiftleştirme yapısı tekniklerin çoğunu zor ve güvenilmez hale getirmiştir (Whitford ve ark., 2013). Melez tohumların büyük ölçekli üretimi için verimli ve düşük maliyetli yöntemler mevcut olana kadar, melezlerin maliyetlerin haklı çıkarılabileceği yüksek verimli ortamlarla sınırlı kalması muhtemeldir.

### MARKÖR DESTEKLİ SEÇİM

Yüksek verimli markör destekli seçim (MAS) yetiştirme, yüksek üretkenlikle bitki yetiştirmeyi hızlandırabilir (Zafar ve ark., 2018). Markör destekli geri melezleme (MABC), markör destekli aralıklı seçim (MARS), GWAS ve genomik belirleme, MAS tabanlı yöntemlerin örnekleridir (Singha ve ark. 2022). Isı stresi toleransı özellikleriyle ilgili GWAS ve diğer QTL haritalama yöntemleri, yüksek sıcaklık iklimleri için ideal olan buğday çeşitlerinin geliştirilmesine yardımcı olabilir (Paliwal ve ark., 2012). Genel olarak, ortamlarda açıklanan, kurucu QTL'ler olarak bilinen QTL'ler, ısıya dayanıklı yerel ırkların geliştirilmesinde kullanılabilir. Öte yandan, özel olarak tasarlanmış ortamlarda tek başına tespit edilen ve adaptif QTL olarak adlandırılan QTL'ler, belirli ısı stresi altındaki alanlar için kullanılabilir (Collins ve ark., 2008). QTL'lerin haritalanması/tanımlanması, buğday da dahil olmak üzere kültür bitkilerinde stres toleransının genetik temelini ortaya çıkarmak için genetik bilgiyi fenotipik ölçümlerle birleştirmek için yakın zamanda geliştirilen bir araçtır (Langridge ve Reynolds, 2015). Isı stresi toleransı ile bağlantılı QTL'lerin, işaretleyici destekli seçim kullanılarak haritalanması, yüksek sıcaklıklı ortamlarda yetiştirilen buğdayda ısı toleransı mekanizmalarını belirlemiştir (Paliwal ve ark., 2012). Örneğin, ısı stresi toleransı için QTL'ler, başak başına tane ağırlığı/sayısı, 1000 tane ağırlığı ve tane doldurma oranı ve süresi dahil olmak üzere tane verimi ve verimle ilgili özellikler için tanımlanmıştır (Bhusal ve ark., 2017).

### GENOMİK SEÇİLİM

Genomik seçim (GS), farklı özellikler için bireylerin üreme değerlerini tahmin etmek üzere DNA işaretleyicilerinin kullanımını içeren bitki ıslahına yönelik modern bir yaklaşımdır. GS, birçok mahsulde yeni çeşitlerin teşvik edilmesinde etkilidir (Tayade ve ark., 2018). Bu teknik, buğday genomunun karmaşıklığı ve çeşitli biyotik ve abiyotik streslere dayanabilen geliştirilmiş çeşitler geliştirme ihtiyacı nedeniyle buğday ıslahında önemli ilgi görmüştür. Yüksek yoğunluklu SNP dizilerinin geliştirilmesi, buğday ıslahında genomik seçilimin uygulanmasını kolaylaştırmıştır. GS'nin MAS'a kıyasla en önemli kazancı, küçük etkili alellerin de tespit edilmesi ve işaretleyici seçim sürecinde kullanılmasıdır (Cairns ve Prasanna, 2018). GS, yeni ıslah hazırlamak ve çığır açan genomik değerlendirme işaretleyici tabanlı modellerini iletirmek için yararlı bir stratejidir. Büyük bir popülasyon için, referans genomuyla veya referans genomu olmadan, yüksek verimli, uygun maliyetli genom çapında ve ölçeklenebilir moleküler işaretleyicilerin erişilebilirliği, mahsulde genomik seçilimin başarılı bir şekilde uygulanması için esastır (Bhat ve ark., 2016). GS, ıslah popülasyonu içindeki belirli bir popülasyonun ıslah değerlerini tahmin ederek bileşik özellikler için avantajlı bir varyasyona sahip genomik kaynakları tespit etmek için bir ön ıslah aracı olarak kullanılabilir. Ayrıca, karmaşık özellikler için genetik kazancı artırmak için yeni beklentiler sunabilir (Wang ve ark., 2018). GS, buğdayda başarılı ıslah programlarında uygulanmıştır (Juliana ve ark., 2019). Geçtiğimiz on yılda, çok sayıda çalışma buğdayda genomik seçilimin potansiyelini, özellikle verimle ilgili özellikler, hastalık direnci ve abiyotik stres toleransı için araştırmıştır (Saini ve ark., 2022). Bu çalışmalar, genomik seçilimin buğday gelişimini etkili bir şekilde tahmin edebileceğini, ıslah verimliliğini artırabileceğini ve iyileştirilmiş buğday

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çeşitlerinin gelişimini hızlandırabileceğini gösteren ümit verici sonuçlar göstermiştir. GS'nin buğdayın ısı stresli ortamlara uyum sağlaması için ıslahında kullanımı, çeşitli ıslah enstitülerinde, şirketlerde ve üniversitelerde de kullanılmaktadır (Mondal ve ark., 2021).

## **GENETİK MÜHENDİSLİĞİ VE GEN DÜZENLEME**

Genetik sapma, genetik kaynaklara dayalı yeni çeşitlerin yetiştirilmesi için hayati bir tekniktir (Raza ve ark., 2019). Ek olarak, en son gelişmiş omik araçlarıyla birlikte gen düzenleme gibi çeşitli biyoteknolojik yaklaşımlar, ısı stresine dayanıklı ıslah çeşitlerinin üretilmesine yardımcı olabilir (Zhang ve ark., 2018).

Transgenез, istenmeyen bitişik gen segmentlerinin eş-transferini içeren bağlantı sürüklenmesini veya melezleme tabanlı yetiştirmede erişilemeyen genlerin kullanılmasını önleyen üstün genlerin aday buğday genotiplerine aktarılmasını içermektedir (Budak ve ark., 2013). Buğdayda, transgenik yöntemler ve genetik modifikasyon, aday genotipe ilgi duyulan genleri yerleştirdikten sonra terminal ısı toleransını artırabilir (Singh ve ark., 2019). Kloroplastlarda bulunan protein sentezi uzama faktörü (EF-Tu), buğday ısı toleransı ile ilişkilidir ve ısı stresi toleransını daha uzun bir süre iyileştirebilir (Fu ve ark., 2012). Transgenik buğdayda EF-Tu'nun yapısal ifadesi yaprak proteinlerini termal bozunmaya karşı korumaktadır, tilakoid membran bozulmasını azaltmaktadır, patojenik mikrop enfeksiyonuna direnmekte ve fotosentez kapasitesini artırmaktadır (Fu ve ark., 2012). Mısır EFTu1 genini aşırı ifade eden transgenik buğdayın ısı toleransını artırdığı bildirilmiştir (Qi ve ark., 2017). Buğday, geniş bir genomu sahip karmaşık bir üründür ve birçok gen ısı toleransına katkıda bulunmaktadır. Isı toleransı gen aktivitesini hedeflemek için ters genetik bir strateji olarak, TALEN'ler, ZFN'ler ve CRISPR gibi genom düzenleme teknikleri de MAS'a ek olarak kullanılabilir. Diğer genom düzenleme teknikleriyle karşılaştırıldığında, CRISPR-Cas9 ısı stresiyle ilişkili yolları incelemek ve ekim sistemlerinde ısı toleransını artırmak için hassas genom düzenleme için güçlü bir yöntem geliştirmiştir (Sun ve ark., 2022). Hedef genleri ekleme, silme ve knock-in/knock-out değişiklikleriyle değiştirerek tarımsal bitkilerin ROS temizleme kapasitesini artırabilir. Genom düzenleme yöntemleri, ısı stresi toleransına dahil olan mahsul genomlarının hedefli düzenlenmesinin başlatılması için yeni fırsatların kilidini açmıştır (Haque ve ark., 2018).

## **SONUÇ**

Isı stresi, dünya genelinde buğday üretimini ciddi şekilde tehdit eden bir çevresel baskıdır. Bu çalışma, buğdayın ısı stresine karşı geliştirdiği fizyolojik, biyokimyasal ve moleküler mekanizmalar hakkında bilgiler sunmuştur. Genetik ve biyoteknolojik yaklaşımların hızla ilerlemesi, ısıya dayanıklı buğday çeşitlerinin geliştirilmesinde yeni ufuklar açmaktadır. Özellikle CRISPR/Cas9 gibi gen düzenleme teknolojileri, buğdayda ısı toleransı sağlayan genetik varyantların hedeflenmesine ve geliştirilmesine olanak tanımaktadır. Ayrıca, genomik seçim ve işaretleyici destekli seçim gibi modern ıslah yöntemleri, bu süreçleri hızlandırmak için umut vadetmektedir. İklim değişikliği ve artan sıcaklıkların yarattığı risklere karşı sürdürülebilir çözümler geliştirmek, gıda güvenliğini sağlamak adına kritik öneme sahiptir. Isı stresine dayanıklı buğday çeşitlerinin geliştirilmesi, tarımsal verimliliği artırarak hem ekonomik hem de sosyal faydalar sağlayacaktır.

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**Özet**

Büyüme düzenleyici hormonlar, yemelik tane baklagillerin büyüme, gelişme ve verimliliğinde önemli roller üstlenmektedir. Bu hormonlar, bitkilerin kök gelişimi, azot fiksasyonu, stres toleransı ve besin içeriğini etkileyerek tarımsal üretimde sürdürülebilirliği destekleyen mekanizmalar sunmaktadır. Oksinler, kök nodüllerinin oluşumunu teşvik ederken, gibberellinler nodül organogenezinde ve genel büyüme süreçlerinde etkilidir. Sitokinler hücre bölünmesini teşvik ederek rizobiyal simbiyozu desteklerken, absisik asit (ABA) bitkilerin kuraklık ve tuzluluk stresine karşı adaptasyonunu sağlamaktadır. Jasmonik asit ise bitkilerin savunma mekanizmalarını harekete geçirerek zararlılar ve patojenlere karşı dirençlerini artırmaktadır. Strigolaktinler, kök gelişimi ve azot fiksasyonunda kritik bir role sahip olup baklagillerin toprak verimliliğini artırmasını desteklemektedir. Bu derlemede, büyüme düzenleyici hormonların baklagillerdeki etkileri ve bu etkilerin tarımsal üretime katkıları ele alınmıştır. Özellikle nohut, mercimek ve fasulye gibi temel baklagil türlerinde hormon uygulamalarının fizyolojik ve biyokimyasal süreçleri nasıl şekillendirdiği incelenmiştir. Son yıllarda yapılan çalışmalar, hormon uygulamalarının bitkisel üretimi artırmada büyük bir potansiyel sunduğunu göstermektedir. Bunun yanı sıra, baklagillerin besin değerlerini iyileştirmek ve çevresel stres koşullarına karşı dayanıklılığını artırmak için hormon yönetimi önemli bir strateji olarak değerlendirilmektedir. Büyüme düzenleyici hormonların baklagil tarımında verimlilik, kalite ve stres toleransını artırmada kritik roller oynadığı belirlenmiştir. Gelecekte yapılacak araştırmalar, bu hormonların genetik ve fizyolojik mekanizmalar üzerindeki etkilerini daha ayrıntılı inceleyerek, tarımsal uygulamalarda daha etkin kullanım stratejileri geliştirilmesine katkı sağlayacaktır.

**Anahtar Kelimeler:** Baklagiller, hormonlar, oksin, gibberellin, sitokin

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**GROWTH REGULATORY HORMONE APPLICATIONS IN EDIBLE LEGUMES**

**Abstract**

Growth-regulating hormones play crucial roles in the growth, development, and productivity of edible grain legumes. These hormones influence root development, nitrogen fixation, stress tolerance, and nutrient composition, offering mechanisms that support sustainable agricultural production. Auxins promote root nodule formation, while gibberellins regulate nodule organogenesis and overall plant growth. Cytokinins stimulate cell division and enhance rhizobial symbiosis, whereas abscisic acid (ABA) facilitates plant adaptation to drought and salinity stress. Jasmonic acid activates plant defense mechanisms, increasing resistance against pests and pathogens. Strigolactones play a critical role in root development and nitrogen fixation, contributing to soil fertility through legume cultivation. This study examines the effects of growth-regulating hormones on legumes and their contributions to agricultural production. Specifically, the physiological and biochemical influences of hormonal applications on major legumes such as chickpeas, lentils, and beans were analyzed. Recent research highlights the significant potential of hormone applications in enhancing crop production. Additionally, hormone management is considered a key strategy for improving the nutritional value of legumes and enhancing their resilience to environmental stress conditions. Growth-regulating hormones play vital roles in improving yield, quality, and stress tolerance in legume cultivation. Future research should focus on exploring their genetic and physiological effects in greater detail, aiding in the development of more effective agricultural strategies for sustainable legume production.

**Keywords:** Legumes, hormones, auxin, gibberellin, cytokinin

## GİRİŞ

Büyüme düzenleyici hormonlar, yemeklik tane baklagillerin gelişiminde kritik bir rol oynamaktadır. Bu hormonlar, bitkilerin büyüme, gelişme, verimlilik ve çevresel streslere yanıt verme yeteneklerini etkileyen önemli sinyal molekülleridir. Büyüme düzenleyici hormonların etkileri, sadece bitki gelişimiyle sınırlı kalmaz; aynı zamanda bitkilerin besin değerleri üzerinde de etkili olabilir. Baklagiller, yüksek protein içeriği ile bilinir ve bu özellikleri, hormonların etkisiyle daha da artırılabilir (Gülümser, 2016). Örneğin, hormon uygulamaları ile bitkilerin protein sentezini artırmak, tarımsal üretimde verimlilik sağlamak için önemli bir strateji olabilir.

Büyüme düzenleyici hormonların etkileri, çevresel koşullara bağlı olarak değişiklik gösterebilir. Özellikle iklim değişikliği ve küresel ısınma gibi faktörler, baklagillerin hormonal dengesini etkileyerek verimliliği azaltabilir (Sümer, 2024). Bunun yanı sıra, besin elementleri eksiklikleri de hormon dengesini bozarak bitkilerin gelişimini olumsuz yönde etkileyebilir (Seydoşoğlu & Sevilmiş, 2020).

Baklagillerin gelişiminde büyüme düzenleyici hormonların rolü, nodülasyon, azot fiksasyonu ve genel bitki büyümesi gibi çeşitli fizyolojik süreçleri kapsayan çok yönlü bir araştırma alanıdır. Nohut, fasulye ve mercimek gibi baklagiller, yüksek protein içerikleri nedeniyle insan beslenmesi için hayati öneme sahiptir ve simbiyotik azot fiksasyonu yoluyla toprak verimliliğini artırarak sürdürülebilir tarımda önemli bir rol oynarlar. Fitohormonların, özellikle oksinlerin, gibberellinlerin ve sitokininlerin etkileşimi, bu süreçleri düzenlemede çok önemlidir.

Baklagillerin kök nodülleri ile ilişkili hormonlar, azot fiksasyonu ve bitki sağlığı üzerinde doğrudan etkiye sahiptir (Bensmihen, 2015; Liu et al., 2018). Özellikle nohut (*Cicer arietinum* L.) gibi baklagillerde, hormonların etkileri üzerine yapılan araştırmalar, bu bitkilerin tarımsal üretiminde önemli bilgiler sunmaktadır.

Yemeklik tane baklagiller Türkiye'de yaygın olarak yetiştirilen ve ekonomik değeri yüksek bitkilerdir (Dumanoğlu et al., 2023; Türk & Polat, 2019). Bu bağlamda, büyüme düzenleyici hormonların yemeklik tane baklagiller üzerindeki etkileri, bitki biyolojisi ve tarımı açısından önemli bir araştırma alanıdır.

## BÜYÜME DÜZENLEYİCİ HORMONLAR

Baklagillerdeki en önemli büyüme düzenleyici hormonlar arasında oksin, gibberellik asit (GA), sitokinin, absisik asit (ABA), jasmonik asit (JA) ve strigolaktinler yer almaktadır. Bu hormonlar, bitkilerin büyüme ve gelişim süreçlerini düzenlerken, aynı zamanda çevresel stres koşullarına karşı yanıt verme yeteneklerini de artırmaktadır (Muradoğlu et al., 2020).

### Oksinler

Oksinler, bitkilerin kök gelişimini ve genel uzamasını etkilemekle birlikte, azot fiksasyonu için gerekli olan baklagillerdeki kök nodüllerinin gelişiminde de büyük önem taşır. Nodül oluşumu, baklagil kökleriyle simbiyotik ilişki kuran azot fiksasyon bakterileri olan rizobiyaların varlığından etkilenir. Yapılan çalışmalar, oksin seviyelerinin, nodül gelişiminde rol oynayan genlerin ifadesini modüle edebileceğini ve dolayısıyla azot fiksasyonunun verimliliğini etkileyebileceğini ortaya koymuştur (Dolgikh et al., 2016; Bensmihen, 2015). Özellikle nodül oluşumu sırasında oksin taşınması ve biyosentezinin düzenlenmesi kritik öneme sahiptir, çünkü oksinlerin bitki içinde mekansal dağılımını etkileyerek nodüllerin düzgün bir şekilde gelişmesini sağlar (Dolgikh et al., 2016). Ayrıca, oksinler ve sitokininler arasındaki etkileşimin önemi vurgulanmıştır; burada sitokininler, nodül oluşumunda oksinlerin etkilerini artırarak, bu

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süreci yöneten karmaşık bir hormonal etkileşimin varlığına işaret etmektedir (Bensmihen, 2015).

## **Giberellinler**

Gibberellinler (GA'lar), baklagillerin büyüme ve gelişiminde önemli bir rol oynamaktadır. Tohum çimlenmesi, gövde uzaması ve çiçeklenme gibi çeşitli fizyolojik süreçleri etkilediği bilinmektedir. Baklagillerde GA'lar, rizobiya ile başarılı bir simbiyotik ilişki kurmak için gerekli olan nodül organogenezini teşvik etmede görev almaktadır (McGuinness et al., 2019). Araştırmalar, GA'ların büyümenin negatif düzenleyicisi olan DELLA proteinlerini baskılayarak nodül gelişimini kolaylaştırabileceğini ve böylece bitkinin azot sabitleme kapasitesini artırabileceğini göstermektedir (McGuinness et al., 2019). Ayrıca, GA'ların çeşitli çevre koşulları altında baklagillerin büyüme performansını iyileştirdiği ve tarımsal uygulamalarda büyüme düzenleyicisi olarak potansiyel taşıdığı da ortaya konmuştur (Hettiarachchi et al., 2021).

## **Sitokininler**

Sitokininler, bitki hormonları arasında, hücre bölünmesini ve farklılaşmasını destekleyerek nodül gelişimi ve genel bitki büyümesi için önemli bir rol oynar. Özellikle sitokininler ile oksinler arasındaki etkileşim, baklagil nodülasyonu açısından büyük önem taşır. Sitokininler, oksinlerin nodül oluşum bölgesine taşınmasını artırarak rizobiyomik simbiyotik ilişkinin kurulmasını kolaylaştırabilir (Dolgikh et al., 2016; Bensmihen, 2015). Ayrıca, sitokininlerin kök büyümesini teşvik ederek ve besin alımını artırarak baklagillerin kuraklık ve tuzluluk gibi abiyotik streslere karşı dayanıklılığını artırdığı da gösterilmiştir (Roriz et al., 2020; Guoliang, 2024). Bu, baklagillerin olumsuz koşullara dayanma yeteneklerinin sürdürülebilir tarım uygulamaları için kritik bir öneme sahip olduğunu, özellikle iklim değişikliği bağlamında vurgulamaktadır.

## **Absisik Asit**

Absisik asit (ABA), yemeklik tane baklagillerin büyüme ve gelişiminde önemli bir rol oynamaktadır. Bu fitohormon, çeşitli fizyolojik süreçleri etkileyerek baklagillerin yetiştirilmesi ve tüketimi üzerinde doğrudan etki yapmaktadır. Özellikle stres yanıtları, tohum gelişimi ve genel bitki sağlığı açısından kritik öneme sahiptir; bu durum, baklagillerin besin kalitesini etkileyebilmektedir. Absisik asidin yemeklik baklagillerdeki başlıca rolleri arasında tohum gelişimi ve çimlenme sürecindeki etkileri yer almaktadır. ABA, tohum dormansisini düzenleyerek, olumsuz koşullarda tohumların çimlenmesini engeller. Bu durum, baklagillerin sıklıkla suyun bulunmadığı veya değişken iklim koşullarında yetiştirilmesi açısından hayati önem taşımaktadır. Örneğin, nohut (*Cicer arietinum* L.) gibi baklagillerde, ABA seviyeleri, tohum dormansisini korumak ve erken çimlenmeyi önlemek için kritik bir rol oynamaktadır (Yadav et al., 2021). Tohum gelişimi sırasında ABA'nın düzenlenmesi, tohumların uygun çimlenme koşulları sağlanana kadar canlı kalmasını sağlamak için gereklidir ve bu da baklagil ürünlerinin güvenilirliğini artırmaktadır.

Ayrıca, ABA'nın stres toleransındaki rolü, baklagillerin sıkça maruz kaldığı kuraklık ve tuzluluk gibi abiyotik stres koşullarında özellikle önemlidir. Su stresi dönemlerinde ABA seviyelerinin artması, stomaların kapanmasına yol açarak, bitkide su kaybını azaltır ve suyun korunmasını sağlar (Gonzalez et al., 2014). Bu mekanizma, baklagillerin kurak ve yarı kurak bölgelerde yetiştirilmesi için hayati öneme sahiptir. Araştırmalar, ABA'nın stres yanıt genlerinin ifadesini artırarak, bitkinin olumsuz koşullara karşı dayanıklılığını artırdığını göstermiştir (Gonzalez et al., 2014). Bu stres toleransı, baklagillerin verimini etkilediği gibi, besin kalitesini de etkileyebilir; çünkü stres altında yetişen bitkilerin tohumları, farklı besin

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profilleri üretebilir. Tohum dormansisi ve stres yanıtlarının yanı sıra, ABA'nın yemeklik baklagillerin besin bileşimini de etkilediği gösterilmiştir. Araştırmalar, ABA'nın baklagil tohumlarındaki protein ve diğer biyoaktif bileşiklerin sentezini etkileyerek, besin değerini artırabileceğini ortaya koymaktadır (Barman et al., 2019). Örneğin, tohum gelişimi sırasında ABA'nın varlığı, baklagillerde protein içeriğinin artması ve amino asit profillerinin iyileşmesi ile ilişkilendirilmiştir; bu da baklagilleri insan diyetleri için değerli bir bitkisel protein kaynağı haline getirmektedir (Barman et al., 2019). Ayrıca, baklagillerin işlenmesi, pişirme ve fermantasyon gibi işlemler de ABA seviyelerini etkileyebilir ve dolayısıyla nihai gıda ürünlerinin besin özelliklerini değiştirebilir (Yorgancılar & Bilgiçli, 2012; Luo & Xie, 2013).

### **Jasmonik Asit**

Jasmonik asidin baklagillerdeki en belirgin etkilerinden biri, bitkilerin stres koşullarına yanıt verme yeteneğidir. Örneğin, baklagillerin zararlılar veya patojenler tarafından saldırıya uğraması durumunda, jasmonik asit seviyeleri artar ve bu durum bitkinin savunma mekanizmalarını aktive eder (Aybeke, 2023). Bu hormon, bitkilerin savunma genlerinin ifadesini artırarak, zararlılara karşı direnç geliştirmelerine yardımcı olmaktadır. Dolayısıyla, jasmonik asit, baklagillerin çevresel stres koşullarına karşı dayanıklılığını artırarak, tarımsal verimliliği olumlu yönde etkileyebilir. Ayrıca, jasmonik asit, baklagil tohumlarının çimlenme sürecinde de önemli bir rol oynamaktadır. Araştırmalar, jasmonik asidin tohum çimlenmesini teşvik ettiğini ve çimlenme sırasında gerekli olan enerji metabolizmasını düzenlediğini göstermektedir (Sağlam & Öz, 2019). Bu durum, baklagillerin verimliliğini artırmak için kritik öneme sahiptir; çünkü çimlenme oranı ve hızının artması, bitkilerin daha sağlıklı ve güçlü bir şekilde büyümesine olanak tanır.

Bunun yanı sıra, jasmonik asidin biyoaktif bileşiklerin sentezine de katkıda bulunduğu bilinmektedir. Baklagiller, zengin besin içeriği ile bilinir ve jasmonik asit, bu besin bileşiklerinin, özellikle de antioksidanların ve fenolik bileşiklerin sentezini artırabilir (Kenar et al., 2017). Bu durum, baklagillerin besin kalitesini artırarak, insan sağlığına olan katkılarını güçlendirmektedir. Örneğin, jasmonik asidin etkisiyle artan fenolik bileşikler, bitkilerin antioksidan kapasitesini artırarak, sağlık açısından faydalı etkiler sağlayabilir (Aybeke, 2023).

### **Strigolaktinler**

Strigolaktinler, bitkilerde kök gelişimi, dal uzaması ve çiçeklenme gibi önemli süreçleri düzenleyen bir grup hormon olarak bilinir. Yemeklik tane baklagillerde strigolaktinlerin rolü, özellikle kök nodül oluşumu ve azot fiksasyonu açısından kritik öneme sahiptir. Bu hormonlar, baklagillerin köklerinde bulunan rizobiyum bakterileri ile etkileşime girerek, azot fiksasyonunu artırır ve böylece bitkilerin besin ihtiyacını karşılamalarına yardımcı olur (Sarıoğlu & Velioğlu, 2018; Yavaş & Ünay, 2018).

Baklagiller, köklerinde azot fiksasyonu yapabilen bakteriler barındırır. Strigolaktinler, bu bakterilerin kök nodüllerine yerleşimini teşvik eder. Bu süreç, bitkilerin azot alımını artırarak, büyüme ve gelişimlerini destekler (Yavaş ve Ünay, 2018). Özellikle, strigolaktinlerin kök gelişimini teşvik etmesi, baklagillerin toprakta daha derinlere inerek su ve besin maddelerine ulaşmalarını sağlar, bu da bitkilerin genel verimliliğini artırır (Karadavut ve Sözen, 2024).

Ayrıca, strigolaktinlerin bitkilerdeki stres yanıtları üzerindeki etkileri de dikkate değerdir. Kuraklık gibi abiyotik stres koşullarında, strigolaktin seviyeleri artar ve bu durum bitkilerin kök gelişimini ve su alımını optimize eder (Çimen & Sarıçoban, 2024). Bu mekanizma, baklagillerin kuraklık koşullarına dayanıklılığını artırarak, tarımsal verimliliği olumlu yönde etkileyebilir. Strigolaktinlerin bir diğer önemli rolü, bitkiler arası etkileşimlerde ortaya çıkar. Bu hormonlar, bitkilerin komşu bitkilerle olan rekabetini etkileyerek, büyüme ve gelişim

süreçlerini yönlendirir. Özellikle, strigolaktinlerin bitki büyümesini düzenlemesi, baklagillerin diğer bitkilerle olan etkileşimlerini optimize ederek, tarımsal alanlarda daha iyi bir verim elde edilmesine katkı sağlar (Sarioğlu & Velioglu, 2018).

### **BÜYÜME DÜZENLEYİCİ HORMONLAR İLE İLGİLİ YEMEKLİK TANE BAKLAGİLLERDE YÜRÜTÜLEN ÇALIŞMALAR**

Büyüme düzenleyici hormonların etkileri üzerine yapılan araştırmalar, bu hormonların bitkilerin gelişim süreçlerinde nasıl etkileşimde bulunduğunu anlamamıza katkı sağlamaktadır. Örneğin, melatonin gibi hormonların bitkilerdeki stres yanıtlarını düzenleyici etkileri üzerine yapılan çalışmalar, bu hormonların bitkilerin çevresel streslere karşı dayanıklılığını artırabileceğini göstermektedir (Salt et al., 2017).

Baklagillerin büyüme düzenleyici hormonlara yanıtı, bitki türüne ve çevresel koşullara bağlı olarak değişkenlik göstermektedir. Örneğin, bezelye (*Pisum sativum*) gibi diğer baklagillerde hormonların etkisi üzerine yapılan çalışmalar, bu bitkilerin mikro çoğaltımı ve genetik manipülasyonları açısından önemli bulgular sunmaktadır (Tekdal, 2020). Bu tür çalışmalar, baklagil üretiminin artırılması ve sürdürülebilir tarım uygulamalarının geliştirilmesi açısından kritik öneme sahiptir.

Baklagillerde büyüme düzenleyici hormonların etkileri, bitkilerin gelişim süreçlerinin yanı sıra besin değerleri üzerinde de önemli bir etkiye sahiptir. Örneğin, hormonların bitkilerdeki besin elementleri alımını nasıl etkilediği üzerine yapılan araştırmalar, bitkilerin besin değerlerini artırmak için hormon uygulamalarının önemini vurgulamaktadır (Sümer, 2022). Bu nedenle, baklagil yetiştiriciliğinde hormon uygulamalarının yanı sıra besin elementleri yönetimi de dikkate alınmalıdır. Bu yaklaşım, hem bitkilerin verimliliğini artırabilir hem de besin değerlerini iyileştirebilir.

Ayrıca, baklagillerin büyüme düzenleyici hormonlar üzerindeki etkileri, gen ekspresyonu ile de ilişkilidir. Örneğin, GH3 gen ailesinin, bitki gelişimi ve abiyotik stres yanıtları sırasında farklı roller üstlendiği belirlenmiştir (Singh et al., 2015). Bu genler, bitkilerin hormon yanıtlarını düzenleyerek büyüme ve gelişim süreçlerini etkileyebilir. Bu bağlamda, büyüme düzenleyici hormonların etkileri ve bu hormonların baklagillerin gelişim süreçlerindeki rolü üzerine yapılan araştırmalar, tarımsal uygulamalar açısından büyük önem taşımaktadır.

Nohut gibi baklagillerde büyüme düzenleyici hormon uygulamaları, bitki gelişimini olumlu yönde etkileyebilir. Örneğin, farklı ekim tarihleri ve yoğunluklarının nohut üzerindeki etkileri incelendiğinde, bu değişkenlerin bitki hormonları ile etkileşimi sonucunda verim ve kalite üzerinde önemli sonuçlar elde edilmiştir (Türk & Polat, 2019). Ayrıca, hormonların bitki büyümesi üzerindeki etkileri, genetik çeşitlilik ve çevresel faktörlerle de ilişkilidir. Bu durum, baklagil üretiminde hormon uygulamalarının optimize edilmesi gerektiğini ortaya koymaktadır.

Rhizobium türleri, baklagillerle simbiyotik ilişkiler kurarak büyüme düzenleyici hormonların üretiminde önemli bir rol oynamaktadır. Bu bakteriler, bitkilerin büyümesini destekleyen oksin gibi hormonları serbest bırakabilir ve böylece bitkilerin kök gelişimini artırabilir (Ullah et al., 2017; Rahayu, 2024). Örneğin, bazı Rhizobium izolatlarının yüksek düzeyde indol-3-asetik asit (IAA) ürettiği ve bu durumun bitki büyümesini olumlu yönde etkilediği gösterilmiştir (Rahayu, 2024).

Yeşil mercimek (*Lens culinaris*) çeşitlerinde yapılan bir çalışmada, tohumlara uygulanan farklı priming yöntemlerinin çimlenme oranını artırdığı belirlenmiştir. Bu çalışmada, gibberellik asidi dozlarının sürgün uzunluğunu artırmada etkili olduğu, hümitik asit dozlarının ise kök uzunluğu artışında daha etkili olduğu gözlemlenmiştir (Köse ve ark., 2019). Bu bulgular,

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büyüme düzenleyici hormonların baklagillerin çimlenme ve fide gelişimi üzerindeki olumlu etkilerini ortaya koymaktadır.

**SONUÇ**

Yemelik tane baklagillerde büyüme düzenleyici hormonlar, bitkilerin gelişim süreçlerinde kritik roller oynamaktadır. Bu hormonların etkileri, çevresel koşullara bağlı olarak değişkenlik gösterebilir ve hormonal dengenin bozulması, bitkilerin verimliliğini olumsuz şekilde etkileyebilir. Büyüme düzenleyici hormonlar üzerine yapılan çalışmalar, tarımsal üretimde verimliliği artırmak ve sürdürülebilir tarım uygulamalarını desteklemek açısından önemli bir temel oluşturmaktadır. Bu bağlamda, baklagil yetiştiriciliğinde büyüme düzenleyici hormonların etkilerini anlamak ve bu hormonların yönetimini sağlamak, tarımsal verimliliği artırmak adına büyük bir öneme sahiptir. Gelecek araştırmalar, bu hormonların bitkilerdeki etkilerini daha derinlemesine incelememize ve tarımsal uygulamalara yönelik yeni stratejiler geliştirmemize katkı sağlayacaktır.



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**ELEKTROMANYETİK ALANLARIN TOHUM ÇİMLENMESİNE ETKİSİ**

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**Özet**

Tohum çimlenmesi, bitki gelişiminin en kritik aşamalarından biri olup, çevresel ve biyotik faktörlerden etkilenmektedir. Çimlenme sürecini yönlendiren faktörler arasında sıcaklık, tuzluluk, ışık ve çeşitli abiyotik stres koşulları bulunmaktadır. Son yıllarda elektromanyetik alanların (EMF) tohum çimlenmesi üzerindeki etkileri giderek daha fazla araştırılmaktadır. Çeşitli bitki türleri üzerinde yapılan çalışmalar, EMF maruziyetinin çimlenme oranlarını artırabileceğini, fide gelişimini teşvik edebileceğini ve bitki sağlığını olumlu yönde etkileyebileceğini ortaya koymuştur. EMF'lerin çimlenme üzerindeki etkisi, hormonal denge değişiklikleri, biyokimyasal reaksiyonlardaki düzenlemeler ve tohum hidrasyonu üzerindeki fiziksel etkilerle ilişkilendirilmektedir. Manyetik alan işlemlerinin absisik asit seviyelerini azalttığı ve gibberellin miktarını artırarak çimlenmeyi teşvik ettiği gözlenmiştir. Ayrıca, EMF'ler enzim aktivitesini artırarak besin mobilizasyonunu kolaylaştırmakta ve böylece tohumların su alımını hızlandırarak çimlenme sürecini iyileştirmektedir. Bununla birlikte, EMF etkileri tüm bitki türleri için aynı olmamakta, türler arasında farklı yanıtlar gözlemlenmektedir. Optimum EMF uygulama parametreleri belirlenmediğinde bazı türlerde çimlenme oranlarının düşebileceği görülmüştür. Çalışmalar, elektromanyetik alanların doğru koşullarda uygulanması halinde bitkilerin stres toleransını artırabileceğini ve tarımsal verimliliği destekleyebileceğini göstermektedir. Bu derleme, elektromanyetik alanların tohum çimlenmesi üzerindeki etkilerini ele almakta ve EMF uygulamalarının potansiyel avantajlarını vurgulamaktadır. Sürdürülebilir tarım uygulamaları için elektromanyetik alan kullanımı gelecek vadede bir teknoloji olarak öne çıkmaktadır. Ancak, EMF maruziyetinin bitkiler üzerindeki uzun vadeli ekolojik ve genetik etkilerinin daha fazla araştırılması gerekmektedir.

**Anahtar Kelimeler:** Elektromanyetik alan, tohum çimlenmesi, hormon modülasyonu, biyokimyasal değişiklikler, sürdürülebilir tarım

**EFFECT OF ELECTROMAGNETIC AREAS ON SEED GERMINATION**

**Abstract**

Seed germination is one of the most critical stages of plant development, influenced by both environmental and biotic factors. Key factors regulating germination include temperature, salinity, light, and various abiotic stress conditions. In recent years, the effects of electromagnetic fields (EMF) on seed germination have gained increasing attention. Studies on various plant species have demonstrated that EMF exposure can enhance germination rates, promote seedling growth, and positively influence plant health. The effects of EMFs on germination are associated with changes in hormonal balance, biochemical regulation, and physical impacts on seed hydration. Magnetic field treatments have been found to reduce abscisic acid levels while increasing gibberellin content, thus promoting germination. Additionally, EMFs enhance enzymatic activity, facilitating nutrient mobilization and accelerating seed water uptake, ultimately improving germination efficiency. However, the effects of EMF are not uniform across all plant species, as different responses have been observed. When optimal EMF application parameters are not determined, a decline in germination rates has been reported in some species. Research indicates that properly applied electromagnetic fields can enhance plant stress tolerance and support agricultural productivity. This review examines the effects of electromagnetic fields on seed germination and highlights the potential benefits of EMF applications. The use of electromagnetic fields in sustainable agriculture emerges as a promising technology for improving seed performance and crop productivity. However, further research is required to assess the long-term ecological and genetic effects of EMF exposure on plants.

**Keywords:** Electromagnetic field, seed germination, hormonal modulation, biochemical changes, sustainable agriculture

## GİRİŞ

Tohum çimlenmesi, bitkilerin yaşam döngüsünde önemli bir süreçtir ve bitki büyümesi ve üremesi için temel oluşturmaktadır. Tohum çimlenmesinin önemi, sadece filizlenmenin ötesine uzanır; bitkinin yerleşmesi, hayatta kalması ve nihayetinde tarımsal uygulamaların başarısının kritik bir belirleyicisidir. Çimlenme süreci, çevresel koşullar, tohum fizyolojisi ve genetik özellikler dahil olmak üzere çok sayıda faktörden etkilenir ve bunlar toplu olarak çimlenme oranlarını ve fidelerin canlılığını belirlemektedir. Sıcaklık, tuzluluk ve ışık gibi abiyotik faktörlerin tohum çimlenmesi üzerindeki etkileşimi birçok kez rapor edilmiştir. Örneğin, Galal ve arkadaşları, ışığın, fitokrom aracılı tepkilerin çimlenme zamanlamasını belirlediği ve koşullu uykuda kalma uygulayarak evrimsel bir avantaj sağladığı *Calotropis procera*'nın çimlenmesinde kritik bir rol oynadığını bildirmiştir (Galal ve ark., 2015). Benzer şekilde, Daklo-Keren ve arkadaşları tuzluluk stresinin çimlenme oranlarını olumsuz etkileyebileceğini ve tohumların başarılı bir şekilde yerleşmesini sağlamak için çeşitli abiyotik streslere karşı dayanıklılıklarının değerlendirilmesi gerektiğini belirtmektedir (Daklo-Keren ve ark., 2018). Bu bulgular, çimlenme sonuçlarını tahmin etmek ve geliştirmek için çevresel etkileşimleri anlama gerekliliğini vurgulamaktadır. Tohum işleme teknolojilerindeki gelişmeler de çimlenme oranlarını iyileştirmede umut vadetmektedir. Gómez-Ramírez ve ark. (2017) tarafından yapılan araştırma, plazma işleminin çimlenme başarısını önemli ölçüde artırabileceğini ve optimum işlem sürelerinin yüksek çimlenme yüzdeleri sağladığını göstermektedir. Bu yenilikçi yaklaşım, özellikle sürdürülebilir tarım bağlamında önemli olan tohum performansını iyileştirmek için kimyasal olmayan yöntemlerin potansiyelini vurgulamaktadır. Alves Junior ve arkadaşları ise atmosferik plazma işleminin tohumlardaki enzim aktivitesini nasıl artırabileceğini, besin mobilizasyonunu nasıl kolaylaştırabileceğini ve böylece çimlenmeyi nasıl teşvik edebileceğini tartışmaktadır (Alves ve ark., 2016). Bu tür işlemler, zorlu çimlenme koşullarıyla karşı karşıya kalan ürünler için çok önemli olabilir.

Tohum çimlenmesinde ışığın rolü, Zhang ve ark. (2021) ile Khamsen ve ark. (2016) tarafından yapılan çalışmalarda vurgulanmıştır. Bu çalışmalarda aydınlatma koşullarının çimlenme oranlarını ve fide oluşumunu büyük ölçüde etkileyebileceği ortaya konmuştur (Tong ve ark., 2021; Khamsen ve ark., 2016). Khan ve Gulzar (2003) ise bazı tohumların çimlenme için ışığa ihtiyaç duyduğunu, bazılarının ise ihtiyaç duymadığını vurgulayarak bitkilerin ortamlarına uyum sağlamak için kullandıkları bir çimlenme stratejisi olduğunu vurgulamıştır. Çimlenme davranışını geliştirmede ekim öncesi işlemlerin önemi, belirli türlerde çimlenme oranlarını iyileştirebilecek çeşitli işlemleri araştıran Bisht ve arkadaşları tarafından vurgulanmıştır (Bisht ve ark., 2015). Bu, özellikle zorlu çevre koşullarında tohum performansını optimize etmek için agronomik müdahalelerin potansiyelini artırmaktadır. Bu tür uygulamaların entegrasyonu, ürün kurulumunun ve veriminin iyileştirilmesine yol açabilmektedir.

Tohum çimlenmesi çevresel ve biyotik faktörlerden etkilenen çok yönlü bir süreçtir. Bu unsurların etkileşimi, bitkinin kurulması ve tarımsal başarı için kritik olan çimlenme oranlarını belirlemektedir. Araştırmalar çimlenme ekolojisinin karmaşıklıklarını ortaya çıkarmaya devam ettikçe, tohum performansını artırmak için yenilikçi uygulamalar ve teknolojilerin potansiyeli giderek daha belirgin hale gelmektedir. Bu bilgi, değişen çevre koşullarına uyum sağlayabilen ve gıda güvenliğini sağlayabilen sürdürülebilir tarım sistemleri geliştirmek için hayati önem taşımaktadır.

### ELEKTROMANYETİK ALANIN ÇİMLENME ETKİSİ

Elektromanyetik alanların (EMF) tohum çimlenmesi üzerindeki etkisi son yıllarda önemli ilgi görmüştür ve çok sayıda çalışma, çeşitli elektromanyetik radyasyon biçimlerine maruz kalmanın farklı bitki türlerinde çimlenme oranlarını ve fide canlılığını artırabileceğini göstermektedir. Bu olgu, EMF'ler tarafından indüklenen ve gelişmiş büyüme özelliklerine ve genel bitki sağlığına yol açabilen çeşitli fizyolojik ve biyokimyasal değişikliklere atfedilmektedir. EMF'lerin tohum çimlenmesini etkilediği birincil mekanizmalardan biri, tohumlardaki hormonal dengeyi değiştirmektir. Örneğin, manyetik alanlarla yapılan işlemlerin çimlenmeyi engelleyen bir hormon olan absisik asit seviyelerini azalttığı, aynı anda büyümeyi ve gelişmeyi destekleyen gibberellin seviyelerini artırdığı bildirilmiştir. Bu hormonal modülasyon, doğrudan fidelerin çimlenme potansiyelini ve sonraki büyümesini etkilediği için çok önemlidir. Ayçiçeği tohumları üzerinde yapılan bu çalışmada, manyetik alan işlemlerinin yalnızca çimlenme oranlarını iyileştirmekle kalmayıp aynı zamanda fide canlılığını artıran fizyolojik değişikliklere de neden olduğu bulunmuştur (Afzal ve ark., 2021). Benzer şekilde, kış buğdayı üzerinde yapılan araştırmalar, elektromanyetik alan maruziyetinin tohum boyutuna bağlı olarak fitohormon dengesini etkilediğini ve EMF'lerin çimlenme ve erken büyüme aşamalarını desteklemek için hormonal tepkileri modüle edebileceği fikrini daha da desteklediğini göstermiştir (Cecchetti vd., 2022).

EMF'lerin tohum çimlenmesi üzerindeki etkisi hormonal değişikliklerle sınırlı değildir; aynı zamanda biyokimyasal değişiklikleri de kapsamaktadır. Örneğin, elektromanyetik alanlara maruz kalma, azot asimilasyonu ve genel bitki büyümesi için gerekli olan artan nitrat redüktaz aktivitesiyle ilişkilendirilmiştir (Kataria vd., 2019). Enzimatik aktivitedeki bu artış, besin alımının ve kullanımının iyileştirilmesine yol açabilir ve böylece daha iyi fide oluşumu ve büyümesini teşvik edebilir. Baklada yürütülen bir çalışmada, manyetik alanlarla muamele edilen tohumlar, çimlenme sırasında kök ve sürgün gelişimi için kritik olan indol-3-asetik asit ve gibberellik asit seviyelerinde artışlar göstermiştir (Podlešna vd., 2019). Bu tür biyokimyasal değişiklikler, EMF'lerin tohum çimlenmesini ve sonraki büyümeyi artırmadaki çok yönlü rolünü vurgulamaktadır.

EMF'lerin tohumlar üzerindeki fiziksel etkileri de çimlenme sonuçlarında önemli roller oynamaktadır. Çalışmalar, elektromanyetik alanların tohum hidrasyon dinamiklerinde değişikliklere neden olabileceğini ve daha hızlı emilime ve daha hızlı çimlenmeye yol açabileceğini göstermiştir (Kazakova vd., 2018). Örneğin, araştırmalar elektromanyetik alanlarla muamele edilen tohumların, muamele edilmemiş tohumlara kıyasla emilim sırasında daha büyük ağırlık dinamikleri sergilediğini göstermiştir; bu da EMF'lerin çimlenme için kritik bir faktör olan su alımını kolaylaştırdığını göstermektedir (Podlešna vd., 2019). Ek olarak, tohumların manyetik alan çizgilerine göre yöneliminin çimlenme oranlarını etkilediği bildirilmiştir; bu da EMF maruziyeti sırasında tohumların fiziksel konumunun, işlemin etkinliğini etkileyebileceğini göstermektedir (Flórez vd., 2004).

EMF'lerin tohum çimlenmesi üzerindeki etkileri tüm türler arasında aynı değildir; farklı bitkiler elektromanyetik işlemlere değişken şekilde yanıt vermektedir. Örneğin, çalışmalar mısır ve nohut gibi mahsullerin statik manyetik alanlara maruz kaldığında çimlenme oranlarında önemli iyileştirmeler olmuş olsa da diğer türlerde zıt sonuçlar gözlenmiştir; burada belirli EMF güçlerine uzun süre maruz kalmak çimlenmeyi engelleyebilmektedir (Alphy Sabu ve Priti Dave, 2018). Bu değişkenlik, tarımsal uygulamalarda EMF uygulamaları yapılırken özel yaklaşımlara duyulan ihtiyacı vurgular, çünkü optimum koşullar türlere ve çevresel faktörlere göre farklılık gösterebilir.

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EMF maruziyetinin süresi ve yoğunluğu, tohum uygulamasının sonuçlarını etkileyen kritik parametrelerdir. Araştırmalar, belirli frekansların ve elektromanyetik maruziyet sürelerinin, maş fasulyesi ve turp gibi çeşitli mahsulleri içeren çalışmalarda görüldüğü gibi, gelişmiş çimlenme oranlarına ve fide büyümesine yol açabileceğini göstermiştir (Jinapang ve ark., 2010; Scialabba ve Tamburello, 2002). Bu parametrelerin optimizasyonu, EMF uygulamalarının faydalarını en üst düzeye çıkarmak için önemlidir, çünkü uygunsuz maruziyet, azalmış çimlenme oranları veya bodur büyüme gibi olumsuz etkilere yol açabilir.

Fizyolojik ve biyokimyasal değişikliklere ek olarak, EMF'lerin uygulanması bitkilerde stres toleransının artmasıyla ilişkilendirilmiştir. Örneğin, manyetik olarak işlenmiş nohut tohumları, gelişmiş kök özelliklerine ve genel bitki dayanıklılığına atfedilebilen gelişmiş kuraklık toleransı sergilemiştir (Vashisth & Nagarajan, 2008). Bu yön, özellikle iklim değişikliği ve artan çevresel stres faktörleri bağlamında önemlidir, çünkü EMF uygulamalarıyla stres toleransını artırma yeteneği sürdürülebilir tarım için değerli bir araç oluşturabilir.

**SONUÇ**

Elektromanyetik alanların tohum çimlenmesi üzerindeki etkileri çok yönlüdür ve hormonal modülasyon, biyokimyasal değişiklikler, tohum hidrasyonu üzerindeki fiziksel etkiler ve farklı türler arasında tepkilerdeki farklılıkları içermektedir. EMF uygulamalarıyla çimlenme oranlarını ve fide canlılığını artırma potansiyeli, tarımsal üretkenliği iyileştirmek için umut verici bir yol sunmaktadır. Ancak, bu teknolojinin sürdürülebilir tarımda başarılı bir şekilde uygulanması için uygulama parametrelerinin, türlere özgü tepkilerin ve uzun vadeli ekolojik etkilerin dikkatli bir şekilde değerlendirilmesi gerekmektedir.

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**DETERMINATION OF VOLTAGE DISTRIBUTION ON TRANSFORMER  
WINDINGS UNDER SWITCHING CONDITIONS USING STATE-SPACE  
APPROACH**

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**Özet**

Güç sistemlerindeki anahtarlamalar transformatör sargılarındaki gerilim dağılımını önemli ölçüde etkileyen geçici gerilimlerin oluşmasına neden olur. Bu geçici olayların doğru bir şekilde analiz edilmesi, transformatörlerin işletme güvenilirliğini artırmak ve yalıtım sisteminin bütünlüğünü korumak açısından büyük önem taşır. Bu çalışmada, anahtarlama koşulu sırasında transformatör sargılarındaki gerilim dağılımını analiz etmek amacıyla durum uzay yöntemi kullanılmıştır. Durum uzay yöntemi, transformatör sargılarının çok bölümlü merdiven ağları şeklinde modellenmesine olanak tanıyan ayrıntılı bir dinamik analiz yaklaşımıdır. Her bir bölüm, bir sargı diski ile ilişkilendirilmiştir. Ayrıca, sargılarla bağlantılı iletim hatları, dağılık parametrelili sistemler olarak modellenmiş ve bu modelleme sayesinde anahtarlama geçici rejimlerinin yayılımı etkili bir şekilde analiz edilmiştir. Bu yöntem, geçici durumlar sırasında bireysel sargı disklerindeki gerilim seviyelerinin nasıl değiştiğini ayrıntılı bir şekilde ortaya koyar ve yalıtım geriliminin en yüksek olduğu kritik noktaların tespit edilmesini sağlar. Bu, transformatör tasarımı ve korumasının optimize edilmesi için önemli bir bilgi sağlar. Çalışmada geliştirilen hesaplama kodları, sisteme dahil edilecek disk sayısına bağlı olarak durum uzay denklemlerinin otomatik türetilmesini mümkün kılmıştır. Durum uzay yöntemi ile elde edilen sonuçlar, ATP-EMTP simülasyon programından elde edilen sonuçlarla karşılaştırılmış ve her iki yöntemden elde edilen sonuçların tutarlı olduğu görülmüştür. Bu da kullanılan yöntemin geçici analizler için geçerli ve güvenilir bir alternatif yöntem olduğunu göstermektedir. Çalışma, transformatörlerin geçici olaylara karşı performansını anlamak ve iyileştirmek için bir katkı sunmaktadır.

**Anahtar Kelimeler:** İletim hattı, durum uzay, güç transformatörü, gerilim dağılımı

**DETERMINATION OF VOLTAGE DISTRIBUTION ON TRANSFORMER  
WINDINGS UNDER SWITCHING CONDITIONS USING STATE-SPACE  
APPROACH**

**Abstract**

Switching conditions in power systems create transient voltages that significantly affect the voltage distribution across transformer windings. Accurately predicting these transient effects is critical to ensuring the operational reliability and insulation integrity of transformers. This study employs the state-space method to analyze the voltage distribution on transformer windings during switching conditions. The state-space method enables a detailed dynamic modeling of transformer windings, represented as multi-section ladder networks. Each section corresponds to a winding disk. By integrating the dynamics of the associated transmission lines, modeled as distributed parameter systems, the analysis captures the propagation of switching transients effectively. This method provides insight into how voltage levels vary across individual winding disks during transient events. It further facilitates the identification of critical points where insulation stress is highest, which is essential for optimizing transformer design and protection. The method utilized in this study enables the automatic derivation of state-space equations for any given number of disks to be introduced into the system, facilitated by the developed computational codes. The results obtained using the state-space method were compared with those derived from the ATP-EMTP simulation program. The comparison revealed that the results from both methods are consistent, indicating that the employed method is a valid alternative for transient analysis.

**Keywords:** Transmission line, state space, power transformer, voltage distribution

**Transmission Line Modelling**

Transmission lines are categorized as either lumped parameter models or distributed parameter models. The lumped parameter representation of a transmission line is established by interconnecting multiple  $\pi$ -circuits, T-circuits, or L-circuits in series (Koksal & Mamiş, 2000). This model incorporates the parameters  $R$ ,  $L$ ,  $C$  and  $G$ , which correspond to resistance, inductance, capacitance, and conductance, respectively. Similarly, the distributed parameter transmission line also employs these four parameters. However, unlike the lumped parameter model, the distributed parameter model does not rely on cascaded circuit connections. Instead, these parameters are uniformly distributed along the entire length of the line. Due to this uniform distribution, the application of the Telegrapher's equations to an arbitrary segment of the line allows for the calculation of current and voltage at that segment using space- and time-dependent partial differential equations. These equations are as follows:

$$-\frac{\partial v}{\partial x} = ri + l \frac{\partial i}{\partial t}$$

(1)

$$-\frac{\partial i}{\partial x} = gv + c \frac{\partial v}{\partial t}$$

(2)

For lossless transmission lines, using the Bergeron approximation, (1) and (2) produce the forward and backward traveling waves as follows (Bergeron et al., 1961), (Branin, 1967);

$$v(x, t) + Z_0 i(x, t) = 2Z_0 f_1(x - vt)$$

(3)

$$v(x, t) - Z_0 i(x, t) = -2Z_0 f_2(x + vt)$$

(4)

In the equations provided above,  $Z_0$  denotes the characteristic impedance, and  $v$  represents the phase velocity. These quantities are expressed in terms of the transmission line's per-unit-length parameters as follows:

$$Z_0 = \sqrt{L'/C'}$$

(5)

$$v = 1/\sqrt{L'/C'}$$

(6)

For a transmission line with nodes  $s$  (sending end) and  $r$  (receiving end), the wave propagation time is denoted as  $\tau$ , and the line length is represented by  $\ell$ .

$$\tau = \ell/v = \ell\sqrt{LC}$$

(7)

A lossless transmission line can be represented using an equivalent circuit composed of current sources and impedance elements (Dommel, 1969). This equivalent circuit, which corresponds to a two-port network, is illustrated in Figure 1.

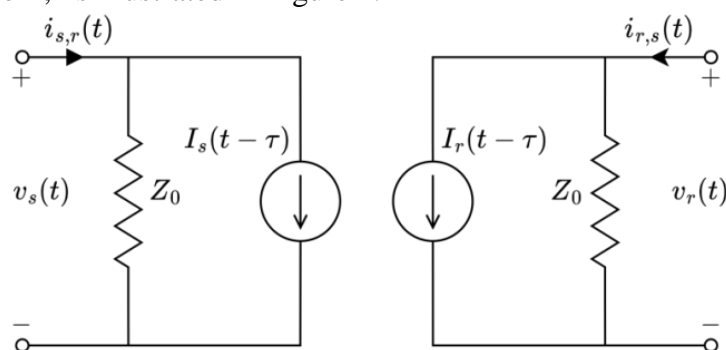


Figure 1. Transmission line equivalent circuit based on distributed parameters

In the equivalent circuit, the values of the current sources  $I_s$  and  $I_r$  at time  $t$  are determined based on the past history current values at  $(t-\tau)$ .

$$I_s(t - \tau) = -(1/Z_0)v_r(t - \tau) - i_{r,s}(t - \tau)$$

(8)

$$I_r(t - \tau) = -(1/Z_0)v_s(t - \tau) - i_{r,s}(t - \tau)$$

(9)

For a lossy line with a total effective resistance  $R' = r\ell$  the line can be modeled by incorporating  $R'/2$  at both the sending and receiving ends, or alternatively by adding  $R'/4$  to the terminals and  $R'/2$  at the midpoint of the line. Under these conditions, the characteristic impedance  $Z_0$  in Figure 1 is modified according to the relation  $Z = Z_0 + R'/4$ . The historical currents are then calculated as follows (Dommel, 1992), (Mamiş et al., 2010):

$$I_s(t - \tau) = \left(\frac{1+h}{2}\right) [(-1/Z)v_r(t - \tau) - hi_{r,s}(t - \tau)] + \left(\frac{1-h}{2}\right) [(-1/Z)v_s(t - \tau) - hi_{r,s}(t - \tau)] \quad (10)$$

$$I_r(t - \tau) = \left(\frac{1+h}{2}\right) [(-1/Z)v_s(t - \tau) - hi_{r,s}(t - \tau)] + \left(\frac{1-h}{2}\right) [(-1/Z)v_r(t - \tau) - hi_{r,s}(t - \tau)] \quad (11)$$

where  $h = (Z_0 - \frac{r\ell}{4}) / (Z_0 + \frac{r\ell}{4})$ .

#### High Frequency Model of Power Transformer

Transient analysis of power transformers utilizes various winding models, including the Multi-Conductor Transmission Line (MTL), Circular Multi-Conductor Transmission Line (CMTL), ladder network, and hybrid models combining MTL and ladder networks (MTL-Ladder network) (Samal & Mondal, 2023). Among these, MTL and CMTL are turn-based models, whereas the ladder network model adopted in this study is disk-based. The double ladder network model, illustrated in Figure 2, represents the transformer with both high-voltage and low-voltage windings. Conversely, the single ladder network model accounts for either the high-voltage or low-voltage windings exclusively. In this work, the single ladder network model was utilized. This model is widely employed in frequency response analysis (FRA) of transformers and is often referred to as the high-frequency power transformer model.

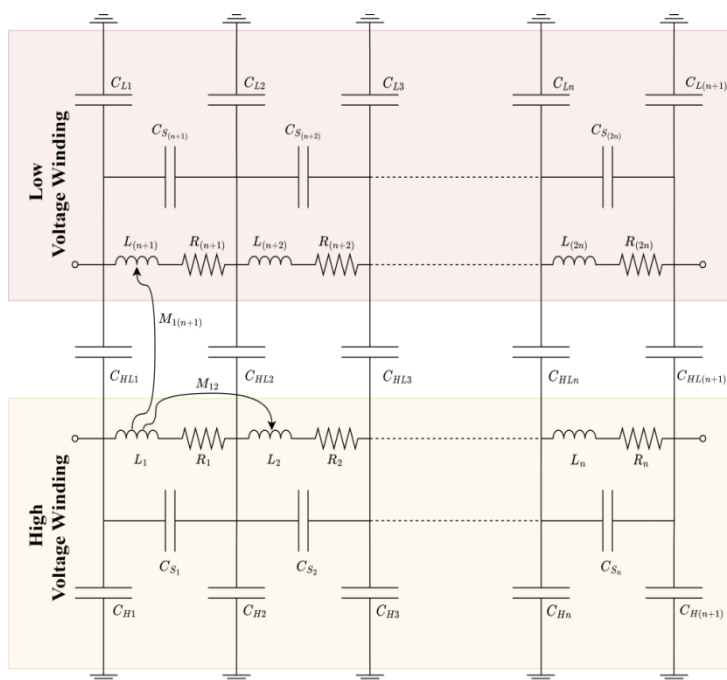


Figure 2. Double-ladder network model for the equivalent circuit of transformer windings

The ladder network model of a power transformer is constructed as a cascade of multiple sections, each characterized by lumped parameters  $R$ ,  $L$  and  $C$ . Each section, representing a disk in the equivalent circuit, models an individual disk of the transformer windings. Consequently, the total number of sections in the model corresponds to the number of disks in the transformer windings. The lumped parameters  $R_s$ ,  $L_s$ ,  $C_s$ ,  $C_g$  and  $C_{HL}$  are used to represent the series resistance, self-inductance, series capacitance, shunt (ground) capacitance, and inter-winding capacitance (between the high-voltage and low-voltage windings), respectively. The parameters of the transformer's ladder network model can be determined or estimated using the transformer's winding design details, such as geometric and physical properties, or through previously obtained measurements. Techniques for calculating these parameters include the finite element method (FEM), analytical approximations, and terminal-based measurements (Samal & Mondal, 2022).

### State-Space Method

There are various methods for mathematical modeling of dynamic systems in both time and frequency domains. The state-space is one of the methods that allows system modeling in the time domain. The basic equations of the state-space are given in (12) and (13).

$$\dot{x}(t) = Ax(t) + Bu(t) \quad (12)$$

$$y(t) = Cx(t) + Du(t) \quad (13)$$

Here,  $x$ ,  $y$  and  $u(t)$  denote the state vector, the output variable vector, and the input vector, respectively. The matrices  $A$ ,  $B$ ,  $C$ , and  $D$  represent the coefficient matrices. The equivalent circuit of a transmission line with distributed parameters is composed of current sources and impedance components, including resistance ( $R$ ), inductance ( $L$ ), and capacitance ( $C$ ). Similarly, the equivalent circuit of a high-frequency power transformer also consists of impedance elements such as  $R$ ,  $L$ , and  $C$ . Consequently, both the transmission line and the transformer can be modeled within the state-space model. Once the equivalent circuits are

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incorporated into the model, capacitor voltages and inductor currents are chosen as the state variables. The subsequent step involves deriving the state equations based on these state variables. By utilizing the state variables and the output equations, the desired values for current and voltage can be determined.

The state equations of the transmission lines involve past history current values, which must be updated at each time step during the solution process. To accomplish this, the state equations need to be discretized, a process that can be achieved through numerical integration. Various methods, such as Runge-Kutta, Simpson's rule, Newton-Cotes, Monte Carlo, Boolean rule, and the rectangular method, are commonly employed for numerical integration. In this study, the trapezoidal rule is utilized.

Assuming the value of  $x_k$  is known at time  $t_k = k\Delta t$ , (12) can be converted into a set of difference equations by applying the trapezoidal integration rule. The system response at the subsequent time step,  $t_{(k+1)} = (k+1)\Delta$ , is then determined from (14).

$$\left(I - \frac{\Delta t}{2} A\right) x_{k+1} = \left(I + \frac{\Delta t}{2} A\right) x_k + \frac{\Delta t}{2} B(u_k + u_{k+1})$$

(14)

Here,  $k$  and  $k+1$  represent the subscripts of the state vector  $x$  and the input vector  $u$  at times  $t_k$  and  $t_{k+1}$ , respectively.  $\Delta t$  denotes the time step size. The past history currents at time  $t$  can be computed using the values of past history currents at time  $t-\tau$ . To determine the system's response in the time domain, the state vector is computed iteratively at discrete time intervals, starting from a known initial state at  $k=0$ . This process necessitates the simultaneous solution of (14). A simplified form of these equations is provided in (15).

$$\bar{A}x_{k+1} = b_k$$

(15)

$$\bar{A} = \left(I - \frac{\Delta t}{2} A\right)$$

(16)

$$b_k = \left(I + \frac{\Delta t}{2} A\right) x_k + \frac{\Delta t}{2} [B(u_k + u_{k+1})]$$

(17)

To obtain the system's response, the vector  $x_{k+1}$  must be computed iteratively using (15), starting from  $k=0$ . While the matrix  $\bar{A}$  remains constant, the vector  $b_k$  must be updated at each time step using (8), (9), or (10), (11), depending on whether the transmission line is lossless or lossy, as in (Mamiş et al., 2010).

## Materials and Methods

In this study, a single-phase distributed parameter transmission line model powered by a voltage source, as shown in Figure 1, and the high-voltage winding of a transformer with a disk-based structure were utilized. The length of the single-phase distributed parameter transmission line is  $\ell = 300 \text{ km}$ . The input  $U_s(t) = 220 \text{ kV}$  and  $f = 50 \text{ Hz}$ . The line's series resistance is  $r_\ell = 0.02 \text{ } \Omega/\text{km}$ , series inductance is  $l_\ell = 1.14 \text{ mH/km}$ , capacitance  $c_\ell = 9.8 \text{ nF/km}$ , and series inductance is  $l_s = 50 \text{ mH}$  (Mamiş et al., 2010). The high-voltage winding of the 40 MVA high-frequency power transformer connected to the end of the transmission line comprises seven disks. Its parameters include the capacitance between the high-voltage winding and the grounded tank ( $C_g = 61.19 \text{ pF}$ ), the inter-disk capacitance ( $C_d = 393.4 \text{ pF}$ ), the self-inductance of each disk ( $L_d = 10 \text{ } \mu\text{H}$ ), the series resistance of each disk ( $R_d = 1 \text{ } \Omega$ ), and the resistance connected to the winding output ( $R_g = 1 \text{ } \Omega$ ) (Abu-Siada et al, 2019).

In the high-frequency model of a power transformer, the number of disks plays a crucial role.

For a disk-based transformer model, the number of sections in the equivalent circuit corresponds to the number of disks in the transformer. Thus, the equivalent circuit mirrors the actual transformer, with one section for each disk. Since the high-voltage side of the transformer in this study consists of seven disks, the equivalent circuit of the high-voltage winding contains seven sections. Each section comprises the elements  $C_g$ ,  $C_d$ ,  $L_d$  and  $R_d$ .

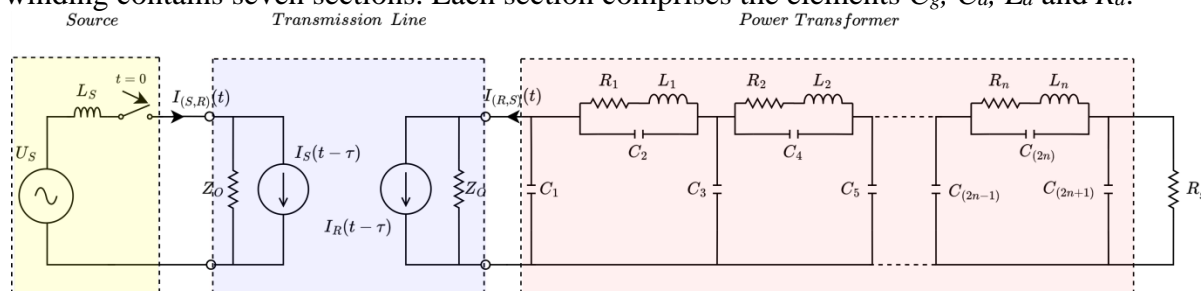


Figure 3. Single-phase transmission line and disk-type power transformer equivalent circuit

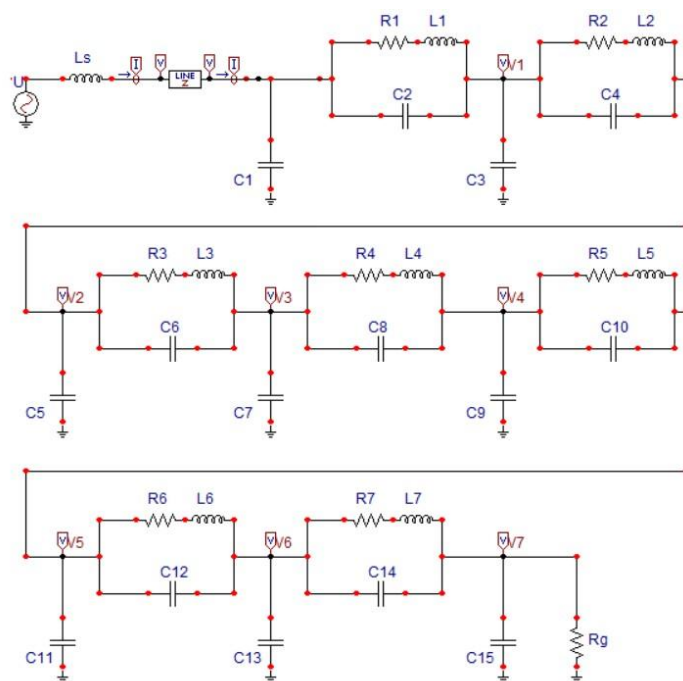


Figure 4. Simulation model of single-phase transmission line and disk-structured transformer in ATP-EMTP

Once the state equations were established, the A, B, and F matrices were constructed by substituting the circuit element values for the lightning model, transmission line, and transformer. Using the trapezoidal integration rule outlined in (14), the updated values of  $x_{k+1}$  were iteratively computed by recalculating  $F^{(-1)} \cdot A$  at each step. The current and voltage values for the lossy transmission line were determined using (10) and (11), while the capacitor voltages and inductor currents were employed to compute the current and voltage in the transformer windings.

The number of disks in the transformer's winding plays a critical role in forming the A, B, and F matrices. State-space equations derived for  $N=1$ ,  $N=2$ , and  $N=3$  are presented in Appendix (23), (24), and (25), respectively, where  $N$  denotes the number of disks (or sections) in the transformer. As shown in these equations, the number of equations and matrix dimensions



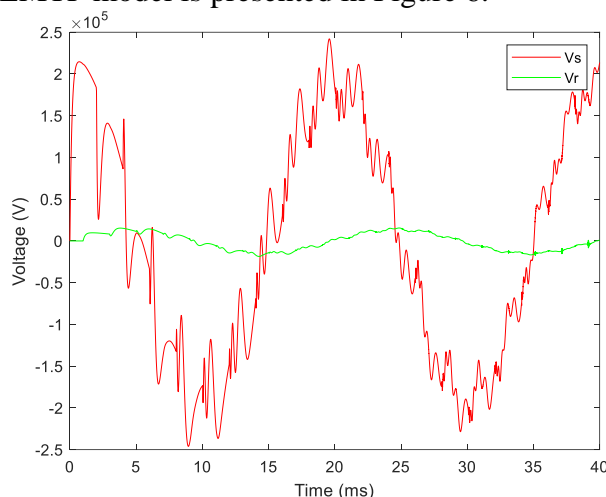
increase with the number of disks. For transformers with a large number of disks, manually deriving these equations is time-consuming and error-prone.

The analysis revealed that the matrix elements and dimensions follow a predictable pattern. By incorporating this pattern into the written code, the required matrices for any  $N$  value can be generated automatically. For a transformer with  $N$  disks, the dimensions of the F and A matrices are  $(2N+2) \times (2N+2)$ , and the B matrix is  $(2N+2) \times 3$ . In the specific model used in this study, F and A matrices are  $16 \times 16$ , and the B matrix is  $16 \times 3$ . Automating the matrix generation process significantly simplifies the analysis.

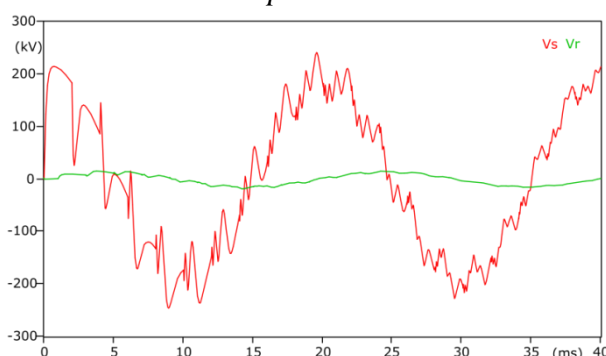
In these equations,  $C_{2N-1}$ ,  $C_{N+1}$ ,  $R_N$ ,  $L_N$ ,  $L_s$ , and  $Z_0$  correspond  $C_g$ ,  $C_d$ ,  $R_d$ ,  $L_d$ , series inductance, and the characteristic impedance of the line, respectively.  $i_L(t)$  and  $V_c(t)$  are the inductor currents and capacitor voltages, respectively. The transient analysis methodology applied in this study was fully implemented in MATLAB through custom coding.

### Findings and Discussion

The voltage-time graphs at the sending and receiving ends of the transmission line, obtained through the state-space method, are shown in Figure 5. Similarly, the voltage-time graph derived from the ATP-EMTP model is presented in Figure 6.



*Figure 5. Sending end and receiving end voltage waveforms of transmission line by using state space method*



*Figure 6. Sending end and receiving end voltage waveforms of transmission line by using ATP-EMTP*

The arrival of the wave at the receiving end of the transmission line occurs after a delay of  $\tau=1$  ms. The wave reflected from the receiving end requires 2 ms to return to the sending end. The

delay is calculated using the formula ( $\tau = \ell/\sqrt{lc}$ ), where  $l,c$  and  $\ell$  are the transmission line's inductance, capacitance per unit length and line length, respectively. The waveforms and voltage levels illustrated in Figures 5 and 6 demonstrate strong agreement between the state-space and ATP-EMTP methods. The current-time graphs for the sending and receiving ends of the transmission line are shown in Figure 7, while the corresponding ATP-EMTP model graph is shown in Figure 8.

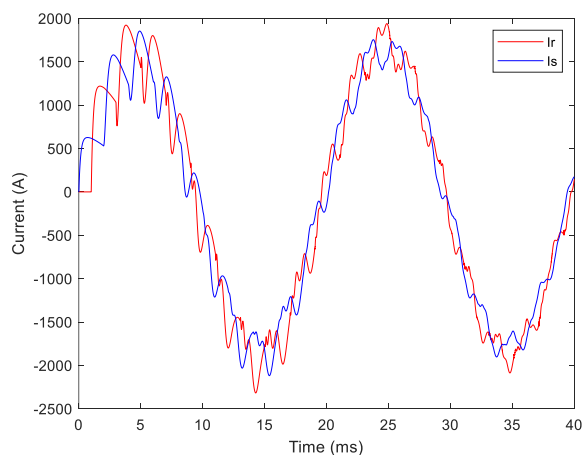


Figure 7. Sending end and receiving end current waveforms of transmission line by using state space method

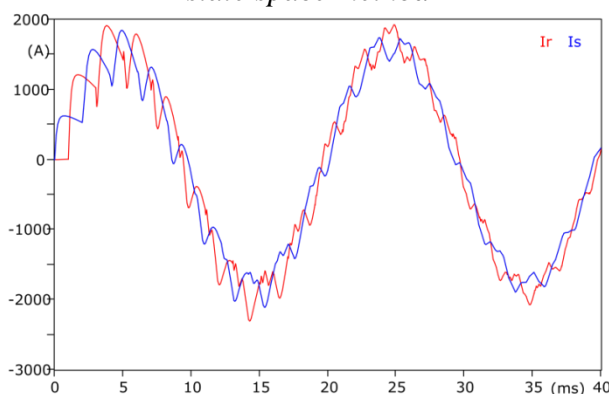


Figure 8. Sending end and receiving end current waveforms of transmission line by using ATP-EMTP

Figures 9 and 10 display the voltage-time graphs for each section of the disk-type winding transformer. The voltage on the first disk (V1) and the seventh disk (V7) are marked to indicate the winding voltages at different positions.

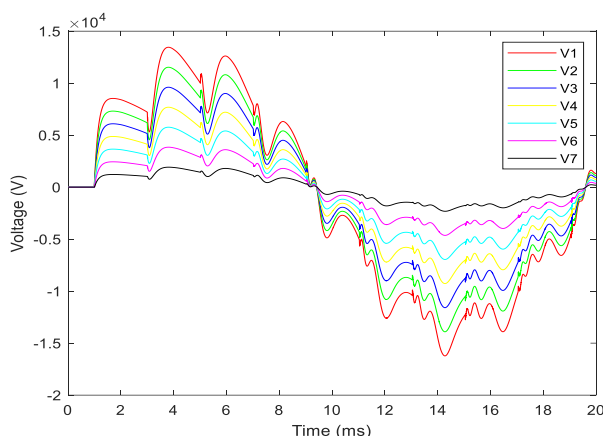


Figure 9. Voltage distribution along transformer disc windings modeled using the state-space method

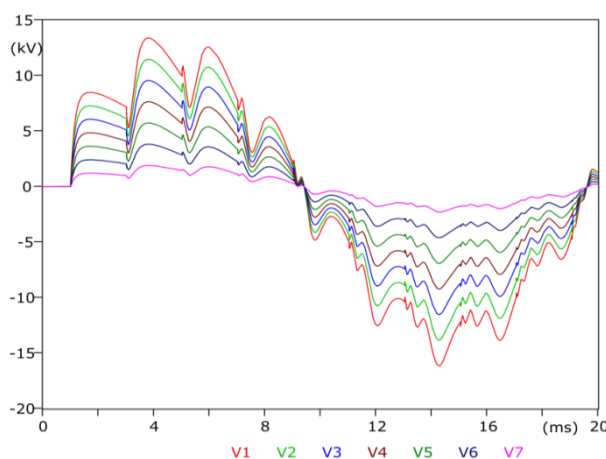


Figure 10. Voltage distribution along transformer disc windings modeled using the ATP-EMTP

Modeling a power transformer with a large number of disks in ATP-EMTP can be time-consuming. This is because each disk must either be drawn multiple times or a previously drawn disk must be copied repeatedly to extend the circuit. In contrast, the model employed in this study eliminates the need for extensive manual drawings. By simply defining the number of disks ( $N$ ), the matrices for a transformer with numerous disks can be generated efficiently, allowing simulations to be completed swiftly.

#### Conclusion and Recommendations

This paper investigates the transients in the winding of the high-voltage side of a disk-structured power transformer and the voltage-current waveforms on a single-phase distributed parameter transmission line, using the state-space method. In the disk-winding structure, the high voltage decreases from the first disk to the last disk. This indicates that insulation requirements for the first disks are more critical than for the last disks. Since the peak voltage levels differ across the disks, their winding insulations may need to vary accordingly. The results obtained with the state-space method were compared to those derived from the ATP-EMTP program, showing a high degree of consistency and agreement. This confirms that the state-space method can serve as a viable alternative for transient analysis of transformer

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models, including high-frequency power transformers often used in frequency response analysis (FRA). The method is applicable to power transformers with varying numbers of disks. Additionally, this approach enables the analysis of potential deformations in transformer windings, short circuit faults between disks, between windings, or between a disk and the transformer tank under operating voltages. The state-space method offers significant advantages in designing transmission lines and transformer protection equipment. It enables transient analysis of transmission lines and transformers without relying on any external simulation software, providing a versatile and efficient tool for engineers and researchers.

**Appendix A**

**State Space Equations**

The complexity of the equations derived depends on the number of sections (disks) in the transformer windings. For transformers with one, two, and three sections, the corresponding state-space equations are presented in (23), (24), and (25), respectively.

$$(23) \quad \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & (c_1 + c_2) & -c_2 \\ 0 & 0 & c_1 & c_3 \end{bmatrix} \cdot \frac{d}{dt} \begin{bmatrix} i_{Ls}(t) \\ i_{L1}(t) \\ v_{C1}(t) \\ v_{C3}(t) \end{bmatrix} = \begin{bmatrix} -\frac{Z_0}{L_s} & 0 & 0 & 0 \\ 0 & -\frac{R_1}{L_1} & \frac{1}{L_1} & -\frac{1}{L_1} \\ 0 & -1 & -\frac{1}{Z_0} & 0 \\ 0 & 0 & -\frac{1}{Z_0} & -\frac{1}{R_g} \end{bmatrix} \cdot \begin{bmatrix} i_{Ls}(t) \\ i_{L1}(t) \\ v_{C1}(t) \\ v_{C3}(t) \end{bmatrix} + \begin{bmatrix} \frac{Z_0}{L_s} & 0 & \frac{1}{L_s} \\ 0 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & -1 & 0 \end{bmatrix} \cdot \begin{bmatrix} I_k(t - \tau) \\ I_m(t - \tau) \\ U_s(t) \end{bmatrix}$$

$$(24) \quad \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & (c_1 + c_2) & -c_2 & 0 \\ 0 & 0 & 0 & c_1 & (c_3 + c_4) & -c_4 \\ 0 & 0 & 0 & c_1 & c_3 & c_5 \end{bmatrix} \cdot \frac{d}{dt} \begin{bmatrix} i_{Ls}(t) \\ i_{L1}(t) \\ i_{L2}(t) \\ v_{C1}(t) \\ v_{C3}(t) \\ v_{C5}(t) \end{bmatrix} = \begin{bmatrix} -\frac{Z_0}{L_s} & 0 & 0 & 0 & 0 & 0 \\ 0 & -\frac{R_1}{L_1} & 0 & \frac{1}{L_1} & -\frac{1}{L_1} & 0 \\ 0 & 0 & -\frac{R_2}{L_2} & 0 & \frac{1}{L_2} & -\frac{1}{L_2} \\ 0 & -1 & 0 & -\frac{1}{Z_0} & 0 & 0 \\ 0 & 0 & -1 & -\frac{1}{Z_0} & 0 & 0 \\ 0 & 0 & 0 & -\frac{1}{Z_0} & 0 & -\frac{1}{R_g} \end{bmatrix} \cdot \begin{bmatrix} i_{Ls}(t) \\ i_{L1}(t) \\ i_{L2}(t) \\ v_{C1}(t) \\ v_{C3}(t) \\ v_{C5}(t) \end{bmatrix} + \begin{bmatrix} \frac{Z_0}{L_s} & 0 & \frac{1}{L_s} \\ 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & -1 & 0 \\ 0 & -1 & 0 \end{bmatrix} \cdot \begin{bmatrix} I_k(t - \tau) \\ I_m(t - \tau) \\ U_s(t) \end{bmatrix}$$

$$(25) \quad \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & (c_1 + c_2) & -c_2 & 0 & 0 \\ 0 & 0 & 0 & 0 & c_1 & (c_3 + c_4) & -c_4 & 0 \\ 0 & 0 & 0 & 0 & c_1 & c_3 & (c_5 + c_6) & -c_6 \\ 0 & 0 & 0 & 0 & c_1 & c_3 & c_5 & c_7 \end{bmatrix} \cdot \frac{d}{dt} \begin{bmatrix} i_{Ls}(t) \\ i_{L1}(t) \\ i_{L2}(t) \\ i_{L3}(t) \\ v_{C1}(t) \\ v_{C3}(t) \\ v_{C5}(t) \\ v_{C7}(t) \end{bmatrix} = \begin{bmatrix} -\frac{Z_0}{L_s} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -\frac{R_1}{L_1} & 0 & 0 & \frac{1}{L_1} & -\frac{1}{L_1} & 0 & 0 \\ 0 & 0 & -\frac{R_2}{L_2} & 0 & 0 & \frac{1}{L_2} & -\frac{1}{L_2} & 0 \\ 0 & 0 & 0 & -\frac{R_3}{L_3} & 0 & 0 & \frac{1}{L_3} & -\frac{1}{L_3} \\ 0 & -1 & 0 & 0 & -\frac{1}{Z_0} & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 & -\frac{1}{Z_0} & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 & -\frac{1}{Z_0} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -\frac{1}{Z_0} & 0 & 0 & -\frac{1}{R_g} \end{bmatrix} \cdot \begin{bmatrix} i_{Ls}(t) \\ i_{L1}(t) \\ i_{L2}(t) \\ i_{L3}(t) \\ v_{C1}(t) \\ v_{C3}(t) \\ v_{C5}(t) \\ v_{C7}(t) \end{bmatrix} + \begin{bmatrix} \frac{Z_0}{L_s} & 0 & \frac{1}{L_s} \\ 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & -1 & 0 \\ 0 & -1 & 0 \\ 0 & -1 & 0 \end{bmatrix} \cdot \begin{bmatrix} I_k(t - \tau) \\ I_m(t - \tau) \\ U_s(t) \end{bmatrix}$$

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**TRANSIENT ANALYSIS OF LIGHTNING STRIKE ON DISTRIBUTED  
PARAMETER TRANSMISSION LINE USING THE STATE-SPACE METHOD**

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**Özet**

Güç iletim hatları, anahtarlama işlemleri, kısa devre arızaları, ani yük değişimleri ve yıldırım düşmeleri gibi olaylar nedeniyle geçici rejim koşullarına maruz kalmaktadır. Bu tür geçici olayların analiz edilmesi, iletim hatlarının sürdürülebilir işletimi ve uygun koruma cihazlarının seçimi için kritik öneme sahiptir. Bu çalışmada, bir fazlı dağıtık parametrelili bir iletim hattına yıldırım düşmesinin etkileri, yıldırım darbelerini temsil etmek için yaygın olarak kabul edilen Heidler modeli kullanılarak incelenmiştir. Yıldırım darbesinin etkisini analiz etmek amacıyla durum uzay yöntemi uygulanmıştır. Durum değişkenleri olarak indüktör akımları ve kapasitör gerilimleri seçilmiş ve bu değişkenlere ilişkin durum denklemleri türetilmiştir. Bu denklemler, sayısal entegrasyon teknikleri kullanılarak zaman domeninde çözülmüştür. Ayrıca, aynı iletim hattı modeli ATP-EMTP yazılımında uygulanmış ve elektromanyetik geçici rejim analizleri için standart bir araç olan bu yazılımda simüle edilmiştir. Hattın gönderici ve alıcı uçlarındaki gerilim ve akım dalga formları, her iki yöntem için elde edilmiş ve karşılaştırmalı olarak analiz edilmiştir. Durum uzay yöntemi ile ATP-EMTP simülasyonlarından elde edilen sonuçlar arasında güçlü bir uyum gözlemlenmiş ve önerilen metodolojinin doğruluğu doğrulanmıştır. Bu çalışma, durum uzay yönteminin geçici rejim analizleri için güvenilir bir alternatif olduğunu ortaya koymakta ve özel simülasyon yazılımlarına bağımlı olmadan ayrıntılı incelemeler yapma avantajı sunmaktadır. Çalışma, iletim hatlarının geçici rejim davranışlarının anlaşılması ve analiz edilmesi açısından önemli bir katkı sağlamaktadır.

**Anahtar Kelimeler:** İletim hattı, yıldırım düşmesi, durum uzay metodu, geçici rejim analizi

**TRANSIENT ANALYSIS OF LIGHTNING STRIKE ON DISTRIBUTED  
PARAMETER TRANSMISSION LINE USING THE STATE-SPACE METHOD**

**Abstract**

Power transmission lines are subject to transient conditions due to events such as switching operations, short circuit faults, sudden load changes, and lightning strikes. Conducting transient analyses is crucial for the sustainable operation of these lines and the appropriate selection of protection devices. In this study, the effects of a lightning strike on a single-phase distributed parameter transmission line were investigated using the Heidler model, a widely accepted representation for lightning impulses. To analyze the impact of the lightning strike, the state-space method was employed. Inductor currents and capacitor voltages were selected as state variables, and the corresponding state equations were derived. These equations were solved in the time domain using numerical integration techniques. Additionally, the same transmission line model was implemented and simulated using the ATP-EMTP software, a standard tool for electromagnetic transient analysis. Voltage and current waveforms at the sending and receiving ends of the line were obtained for both approaches and analyzed comparatively. The results from the state-space method and ATP-EMTP simulations showed strong agreement, validating the accuracy of the proposed methodology. This study demonstrates that the state-space method is a reliable alternative for transient analysis, offering the advantage of performing detailed investigations without relying on specialized simulation software.

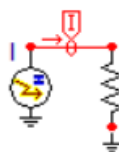
**Keywords:** Transmission line, lightning strike, state space method, transient analysis

**Lightning Strike Modelling**

Lightning strikes on transmission lines result in transient overvoltages and overcurrents. To conduct a detailed analysis of the effects of lightning strikes, it is essential to accurately model the lightning impulse. A review of the literature reveals that various models, such as CIGRE, Bruce-Golde, double exponential, and Diendorfer-Uman, have been utilized for this purpose (Cvetic et al., 1999). Another widely accepted model, also employed in this study, is the Heidler model. Although this model involves more parameters and is computationally more complex than other models, it yields more accurate results. The current equation associated with the Heidler model is provided in (1) (Heidler et al., 1999),(Heidler & Cvetic, 2002).

$$I(t) = \frac{I_{max}}{\eta} \cdot \frac{\left(\frac{t}{\tau_1}\right)^n}{1+\left(\frac{t}{\tau_1}\right)^n} \cdot e^{-\frac{t}{\tau_2}} \tag{1}$$

Here,  $I_{max}$  represents the peak lightning current,  $\eta$  is the peak correction factor,  $t$  denotes time,  $\tau_1$  and  $\tau_2$  are the rise and fall time constants of the current, respectively,  $n$  is the current steepness factor. In the analysis of lightning-induced transients, it is crucial not only to use accurate equations but also to employ appropriate modeling techniques. When modeling a lightning impulse, an impedance is connected in parallel to the lightning source, referred to as the lightning path impedance. The lightning path impedance used in this study is 400  $\Omega$  (Bewley, 1963).



*Figure 1. Lightning strike model with lightning path impedance*

**Transmission Line Modelling**

Power transmission lines can be modeled in two ways: as lumped parameter transmission lines or distributed parameter transmission lines. Both models consist of circuit elements such as resistance ( $R$ ), inductance ( $L$ ), capacitance ( $C$ ), and conductance ( $G$ ). In this study, the distributed parameter transmission line model is utilized. The primary characteristic of this model is the uniform distribution of circuit elements, such as resistance, inductance, capacitance, and conductance, along the length of the transmission line. Consequently, applying the Telegrapher's equations to any segment of the line yields spatially and temporally dependent differential equations specific to that segment (Koksal & Mamiş, 2000).

$$-\frac{\partial v}{\partial x} = ri + l \frac{\partial i}{\partial t} \tag{2}$$

$$-\frac{\partial i}{\partial x} = gv + c \frac{\partial v}{\partial t} \tag{3}$$

When  $r=0$  ve  $g=0$  (lossless line), the Bergeron equations can be utilized, where (2) and (3) generate forward and backward propagating waves (Bergeron et al., 1961), (Dommel, 1969);

$$v(x, t) + Z_0 i(x, t) = 2Z_0 f_1(x - vt) \tag{4}$$

$$v(x, t) - Z_0 i(x, t) = -2Z_0 f_2(x + vt) \tag{5}$$

Here  $Z_0$  represents the characteristic impedance, and  $v$  denotes the phase velocity. If these terms are expressed in terms of per-unit-length parameters:

$$Z_0 = \sqrt{L'/C'} \tag{6}$$

$$v = 1/\sqrt{L'/C'} \tag{7}$$

This approach is based on the method of characteristics, allowing the formulation of an equivalent circuit between the sending and receiving ends of the line. For a line of length  $\ell$ ,



with a wave travel time  $\tau$  and nodes  $s$  and  $r$ .

$$\tau = \ell/v = \ell\sqrt{LC} \quad (8)$$

When modeling a lossless transmission line, an equivalent two-port circuit is constructed using impedance elements and current sources.

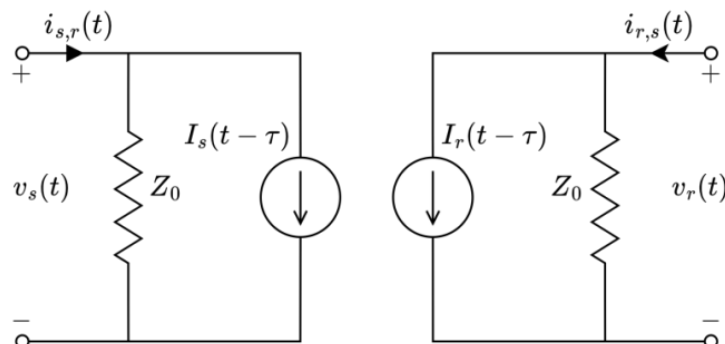


Figure 2. Equivalent circuit of distributed parameter transmission line

The current values of the sources  $I_s$  and  $I_r$  in the equivalent circuit at time  $t$  are calculated using past history currents at time  $(t-\tau)$ .

$$I_s(t - \tau) = -(1/Z_0)v_r(t - \tau) - i_{r,s}(t - \tau) \quad (9)$$

$$I_r(t - \tau) = -(1/Z_0)v_s(t - \tau) - i_{r,s}(t - \tau) \quad (10)$$

If the transmission line is lossy;

$$I_s(t - \tau) = \left(\frac{1+h}{2}\right) [(-1/Z)v_r(t - \tau) - hi_{r,s}(t - \tau)] + \left(\frac{1-h}{2}\right) [(-1/Z)v_s(t - \tau) - hi_{r,s}(t - \tau)] \quad (11)$$

$$I_r(t - \tau) = \left(\frac{1+h}{2}\right) [(-1/Z)v_s(t - \tau) - hi_{r,s}(t - \tau)] + \left(\frac{1-h}{2}\right) [(-1/Z)v_r(t - \tau) - hi_{r,s}(t - \tau)] \quad (12)$$

here  $h = (Z_0 - \frac{r\ell}{4}) / (Z_0 + \frac{r\ell}{4})$ .

### State-Space Method

The state-space technique is a method used for dynamic system modeling. Its general formulation in the time domain is:

$$\dot{x}(t) = Ax(t) + Bu(t) \quad (13)$$

$$y(t) = Cx(t) + Du(t) \quad (14)$$

Here  $x$  represents the state vector, the output variables, and  $u(t)$  the input vector.  $A$ ,  $B$ ,  $C$  and  $D$  are coefficient matrices. By selecting inductor currents and capacitor voltages as state variables based on the  $L$  and  $C$  parameters of the transmission line, the system can be transformed into the state-space form. Voltage and current values at the line's terminals can then be calculated using this method. Since past history currents influence transmission lines, updating current values at all time steps is necessary, achievable through numerical techniques. In this study, the trapezoidal rule was applied for numerical integration.

Assuming the value of  $x_k$  is known at time  $t_k = k\Delta t$ , (13) can be converted into a set of difference equations by applying the trapezoidal integration rule. The system response at the subsequent time step,  $t_{(k+1)} = (k+1)\Delta$ , is then determined from (15).

$$\left(I - \frac{\Delta t}{2}A\right) x_{k+1} = \left(I + \frac{\Delta t}{2}A\right) x_k + \frac{\Delta t}{2}B(u_k + u_{k+1}) \quad (15)$$

Here,  $k$  and  $k+1$  represent the subscripts of the state vector  $x$  and the input vector  $u$  at times  $t_k$  and  $t_{k+1}$ , respectively.  $\Delta t$  denotes the time step size. To compute the system response in the time

domain, the state must be evaluated at each discrete point. The alternative forms of Equation (15) are as follows:

$$\bar{A}x_{k+1} = b_k \quad (16)$$

$$\bar{A} = \left( I - \frac{\Delta t}{2} A \right)$$

(17)

$$b_k = \left( I + \frac{\Delta t}{2} A \right) x_k + \frac{\Delta t}{2} [B(u_k + u_{k+1})] \quad (18)$$

To obtain the system response, the vector  $x_{k+1}$  must be iteratively calculated starting from  $k=0$  using (16). While the matrix  $\bar{A}$  remains constant, the vector  $b_k$  must be updated at each time depending on whether the line is lossless or lossy, as described in (9), (10), (11), and (12) (Mamiş et al., 2010).

### Materials and Methods

In this study, a single-phase distributed-parameter power transmission line and the Heidler lightning model were utilized. The equivalent circuits used in the study are provided in Figures 3 and 4, while the parameters of the lightning model are presented in Table 1.

**Table 1.** Heidler model parameters

$I_{max}$	20 kA
$\tau_1$	$1.2 \times 10^{-6}$ s
$\tau_2$	$5 \times 10^{-5}$ s
$n$	10
$Z_H$	400 $\Omega$

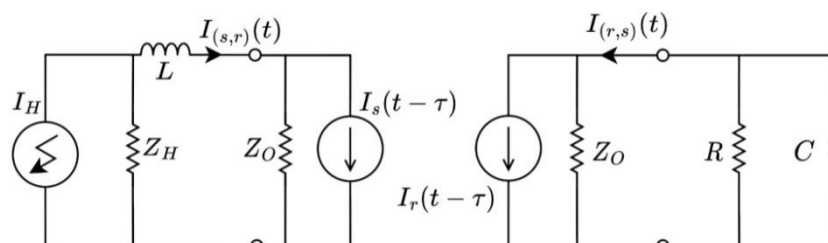


Figure 3. Equivalent circuit of single phase distributed parameter transmission line with lightning strike

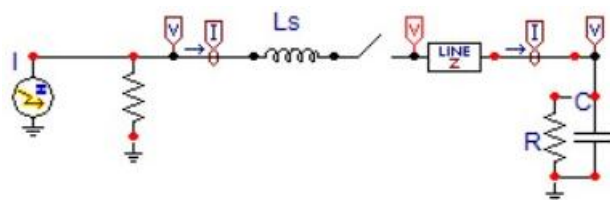


Figure 4. ATP-EMTP model of single phase distributed parameter transmission line with lightning strike

The length of the single-phase distributed parameter transmission line on which lightning strike is  $\ell = 300$  km. the series resistance of the line is  $r_\ell = 0.02 \Omega/\text{km}$  the series inductance of the line is  $l_\ell = 1.14 \text{ mH}/\text{km}$ , , the capacitance of the line  $c_\ell = 9.8 \text{ nF}/\text{km}$ , and the series inductance  $l_s = 50 \text{ mH}$  (Mamiş et al., 2010).

Using the transmission line and lightning model parameters depicted in Figure 3, the following

equations were derived.

$$\frac{di_L(t)}{dt} = \frac{Z_H}{L} \cdot I_H + \frac{Z_0}{L} I_S(t - \tau) - \left( \frac{Z_0}{L} + \frac{Z_H}{L} \right) \cdot i_L(t) \quad (19)$$

$$\frac{dV_C(t)}{dt} = -\frac{I_r(t-\tau)}{C} - \frac{V_C(t)}{C} \left( \frac{1}{Z_0} + \frac{1}{R} \right) \quad (20)$$

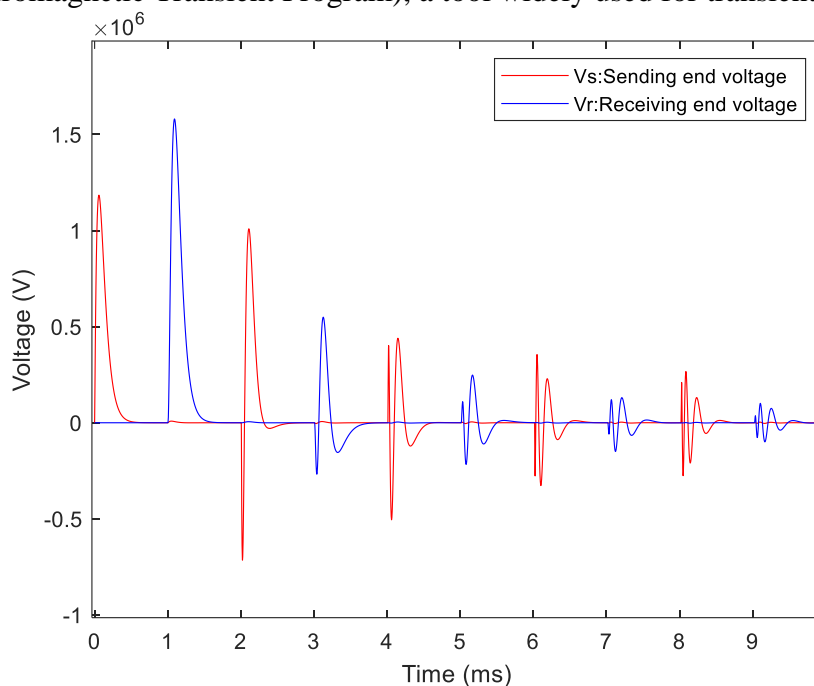
These equations were transformed into state-space form by utilizing capacitor voltages and inductor currents.

$$\frac{d}{dt} \begin{bmatrix} i_L(t) \\ V_C(t) \end{bmatrix} = \begin{bmatrix} -\left(\frac{Z_0+Z_H}{L}\right) & 0 \\ 0 & -\frac{1}{C} \left(\frac{1}{Z_0} + \frac{1}{R}\right) \end{bmatrix} \cdot \begin{bmatrix} i_L(t) \\ V_C(t) \end{bmatrix} + \begin{bmatrix} \frac{Z_H}{L} & \frac{Z_0}{L} & 0 \\ 0 & 0 & -\frac{1}{C} \end{bmatrix} \cdot \begin{bmatrix} I_H \\ I_S(t - \tau) \\ I_r(t - \tau) \end{bmatrix} \quad (21)$$

The state-space equations were solved iteratively for  $x_{k+1}$  at each time step by applying the trapezoidal rule. These calculations were implemented in MATLAB, without employing SIMULINK, through direct coding.

**Findings and Discussion**

The waveforms of the power transmission line subjected to a lightning strike were obtained using the state-space method and simulated in the ATP-EMTP program (Alternative Transients Program-Electromagnetic Transient Program), a tool widely used for transient analysis.



*Figure 5. Sending end and receiving end voltage waveforms of transmission line by using state space method*

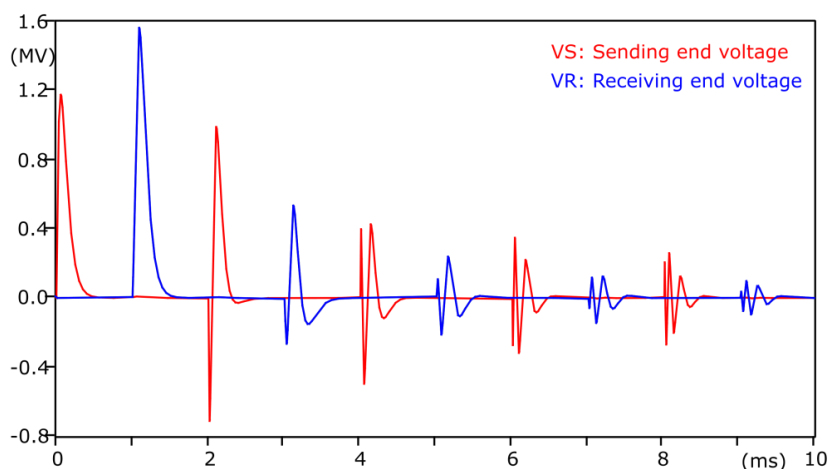


Figure 6. Sending end and receiving end voltage waveforms of transmission line by using ATP-EMTP

Voltage-time waveforms at the sending and receiving ends of the transmission line are shown in Figures 5 and 6. These figures indicate that the wave propagation time from the sending to the receiving end is approximately  $\tau=1$  ms, primarily determined by the line's characteristic equation  $\tau = \ell/\sqrt{lc}$ .

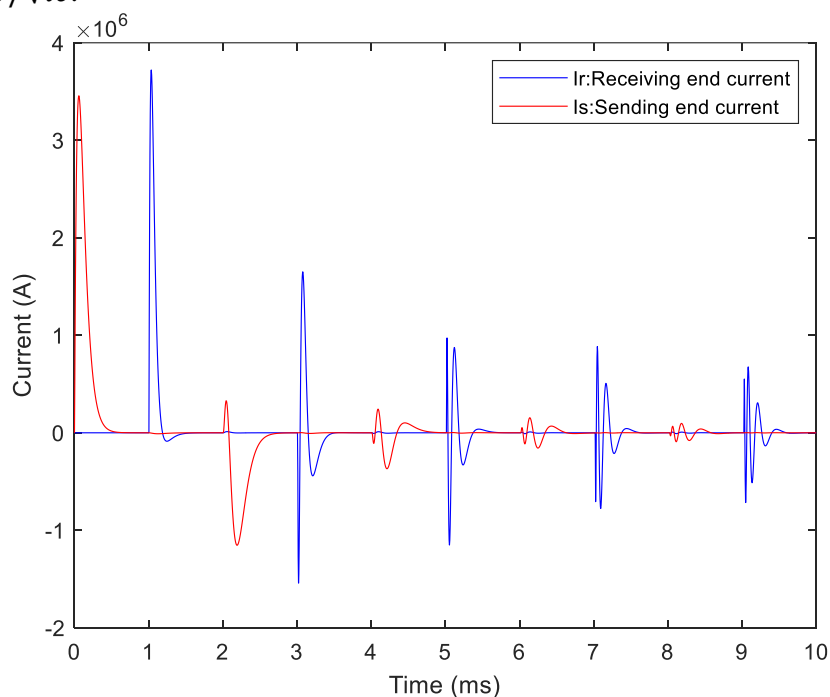


Figure 7. Sending end and receiving end current waveforms of transmission line by using state space method

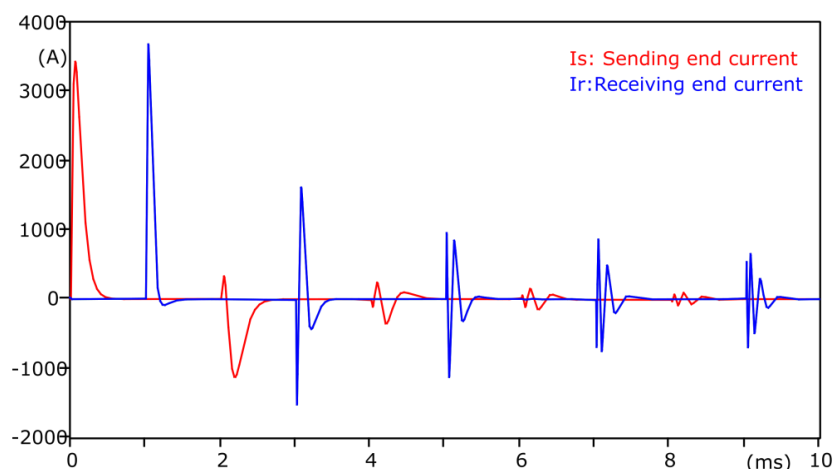


Figure 8. Sending end and receiving end current waveforms of transmission line by using ATP-EMTP

Current-time graphs of the transmission line are presented in Figures 7 and 8. Analysis of these graphs reveals that the current wave also reaches the receiving end with a delay. A comparison of the results obtained via the state-space method and ATP-EMTP simulation demonstrates near-perfect agreement between the two approaches.

#### Conclusion and Recommendations

This study investigated the effects of a lightning strike on the sending and receiving ends of a single-phase distributed-parameter power transmission line using the state-space method. The results confirmed that lightning strikes induce transient high-voltage and high-current waves in the transmission line. The compatibility between the data obtained from the state-space method and ATP-EMTP simulations underscores the validity of the approach. Furthermore, the state-space method provides an alternative for transient analysis without relying on simulation software, making it a viable option for analyzing transient regimes in transmission lines.

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**USING IPE CHASSIS FOR WEIGHT REDUCTION IN SEMI-TRAILER CHASSIS  
FOR LPG TANK TRANSPORTATION**

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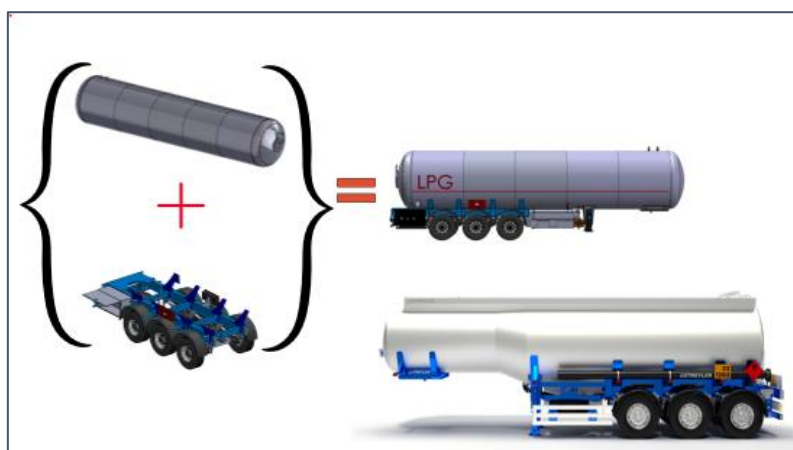
**Abstract**

LPG tank semi-trailers are an indispensable part of transportation in the logistics sector. These vehicles are specifically designed to ensure the safe and efficient transport of heavy loads. Their carrying capacity, durability, and long lifespan are critical for the success of logistics operations. However, balancing weight and durability has always been a significant concern for the industry. Therefore, making transport vehicles lighter, stronger, and more cost-effective is a crucial requirement for achieving more efficient performance in logistics processes. The weight of semi-trailer chassis directly impacts load safety, fuel consumption, and overall operational costs. Chassis manufactured using traditional mirror plates can increase weight, which in turn raises fuel consumption and costs. This weight increase becomes a critical efficiency issue for logistics companies, especially in long-distance transportation. Additionally, the use of heavy chassis can complicate loading and unloading processes, prolonging operational timelines. Thus, weight reduction solutions are of great importance for achieving higher carrying capacity, lower costs, and improved load safety. The use of IPE beams offers a lighter chassis design compared to traditional mirror plates, reducing the overall weight of the transported load. Furthermore, the durability and load capacity of IPE beams distribute stress more effectively across the chassis, enhancing safety. This becomes particularly critical when transporting heavy and high-capacity loads. Moreover, IPE chassis require fewer resources during production, reducing costs and contributing to budget management for logistics companies. When weight reduction and durability are considered together, chassis designed with IPE beams provide a more sustainable solution for the industry.

**Keywords:** Trailer, Lightning, IPE, Chassis, Strength

### Introduction

Liquefied Petroleum Gas (LPG) is an energy source composed of a specific mixture of butane and propane gases, characterized by high energy density and relatively low environmental emissions. However, since LPG transportation and storage require special safety measures, it is transported using high-pressure-resistant tanks and trailer systems. In this context, LPG transport trailers are considered one of the key components of the logistics sector. Additionally, a well-developed logistical infrastructure for LPG transportation plays a critical role in ensuring the continuity of energy supply. Figure 1 illustrates the basic structure of the semi-trailer LPG tank.



**Figure 1.** Semi-Trailer LPG Tank

Turkey, besides being a major producer of LPG tank semi-trailers, ranks as the second-largest trailer manufacturer in Europe. According to the 2024 data from the Turkish Trailer Industry Association, Turkey has an annual production capacity of 60,000 trailers, with 38,000 units produced in 2023, generating a revenue of \$1.2 billion (<https://treder.org.tr/tuik-veriler>). LPG transport tanks constitute a significant portion of this production volume, contributing to the growth of the sector. Although LPG transportation is a rapidly developing and expanding industry worldwide, several structural and operational challenges persist in this field. Due to the nature of the transported liquid, stringent safety measures must be implemented. However, some challenges remain in existing transport systems. One of the primary challenges is the issue of weight. The high mass of LPG semi-trailer tanks limits carrying capacity, increases braking distances, and consequently raises safety risks. Furthermore, increased weight leads to higher fuel consumption in transportation operations, raising operating costs and carbon emissions. The extensive welding processes used in conventional manufacturing extend production times, increase labour costs, and lead to manufacturing defects such as welding faults. Additionally, mechanical components experience wear and tear due to dynamic loads, which, in the long term, increases maintenance costs. Safety is one of the most important aspects of LPG transportation, and existing designs must be optimized, particularly in terms of impact resistance, pressure stability, and behaviour under dynamic loads. In this context, in addition to structural optimization, the development of innovative solutions in the field of materials engineering has become a necessity in the industry. A similar study analysed the design parameters of semi-trailer tankers and examined the effects of different cross-sectional geometries on transport performance. The study compared box-section and circular-section



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tank designs and evaluated their structural integrity using finite element analysis (FEA). The results showed that circular-section tanks provided a more uniform stress distribution compared to box-section tanks, ensuring longer service life and safer usage (Koulocheris & Vossou, 2018). This study addresses engineering solutions for optimizing the structural performance and safety of LPG transport trailers. The primary objectives include weight reduction, minimizing fuel consumption, reducing mechanical wear, and improving manufacturing efficiency. Accordingly, another study investigated weight reduction techniques in heavy-duty semi-trailer chassis, evaluating the effects of methods such as modifying material properties, optimizing cross-section dimensions, and incorporating weight reduction holes. The study utilized finite element analysis (FEA) and multi-body dynamic simulations (MBD) to analyse the structural strength and durability performance of different chassis designs. The results indicated that the use of ASTM A710 steel achieved a 0.7% weight reduction, while ASTM A514 steel provided a 0.65% reduction, all while maintaining structural integrity (Thang et al., 2021).

In conclusion to overcome the operational and structural challenges encountered in the LPG transportation sector, innovative approaches must be adopted. The use of lightweight and high-strength materials, the integration of new design methods, and the improvement of manufacturing processes play a critical role in enhancing the safety of LPG transportation systems and the efficiency of logistics operations.

Previous studies have identified the benefits of using such profiles. In a study analysing the design and evaluation processes of 40-ton capacity semi-trailer chassis, structural optimization techniques for heavy-load transportation were assessed. The study emphasized that I-section beams should be used as primary load-bearing members, and finite element method (FEM) analyses were conducted to determine maximum stress regions under various loading conditions. The results indicated that the structural stability of the chassis was most critical at the fifth-wheel connection point (Swamy & Anand, 2020).

Accordingly, a study examined the impact of a narrowed trailer chassis design on the structural strength of heavy vehicles and compared different chassis models using the finite element method (FEM). The analyses revealed that the new design was 7% lighter, providing significant advantages in terms of fuel consumption and environmental impact. Additionally, the fact that the structural strength of the narrowed chassis was maintained while being optimized ensured a more efficient design without compromising load capacity (Özgür & Karataş, 2021).

Specifically, reducing the size of the main load-bearing beams provided a 15% mass reduction without negatively affecting the overall load distribution (Iqbal et al., 2013). By minimizing welding processes, both weight and production costs are reduced. Compliance with TS EN 12252 standards Corrosion resistance is important for long-term use.

This study focuses on examining the advantages of using IPE profiles (Figure 2) in LPG transport trailer chassis in terms of weight reduction and structural durability. In this study, structural analyses were conducted comparatively with the traditional kingpin plate design, and the durability of different designs was tested under various loading scenarios. Indeed, even design optimizations alone can provide direct improvements.

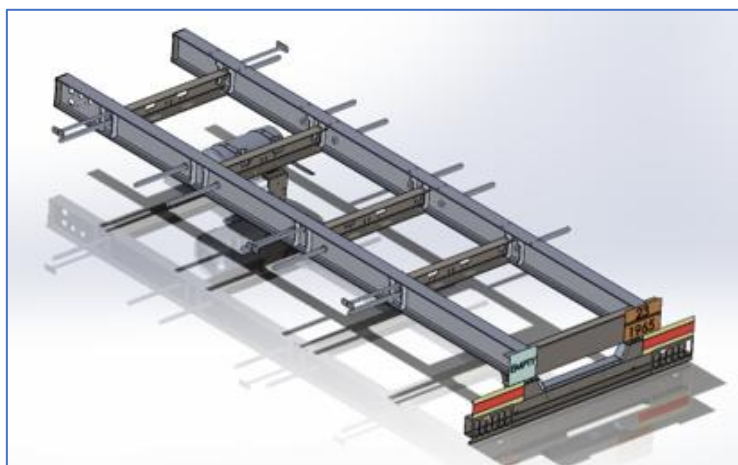


**Figure 2.** IPE profile

### **Materials and Methods**

This section provides a detailed examination of the research methods applied to optimize the structural performance and enhance the safety of LPG transport trailers. The employed analytical techniques, experimental and numerical simulation methods, material selection, manufacturing processes, and compliance with industry standards are all discussed within this scope.

*Numerical Modelling and Analysis Methods;* Structural analyses were conducted using SolidWorks and ANSYS, where two different trailer chassis models were created. Chassis with IPE Profile-Based Alternative Design (Figure 3). Chassis with Traditional Kingpin Plate (Figure 4).



**Figure 3.** LPG semi-trailer chassis designed using IPE profile

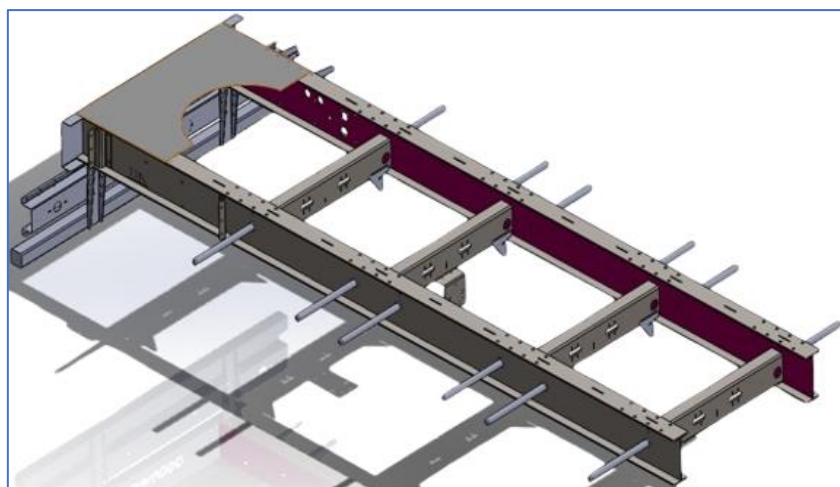


Figure 4. LPG semi-trailer chassis designed using kingpin plate

These models were evaluated using Finite Element Analysis (FEA) to examine the distribution of stress and deformation. Additionally, the effect of load balance on chassis strength was analysed in detail, identifying load concentrations in critical regions, and implementing design improvements accordingly.

*Mesh Settings and Loading Conditions;* In the analyses, a 10 mm element size mesh was used, with finer mesh applied in critical regions to enhance accuracy. The load distribution was modeled in compliance with TS EN 12252 standards. TS EN 12252 serves as a guideline for the design and safety of pressure vessels within the European Union. This standard was strictly followed in the analysis. Additionally, design updates were applied by evaluating parameters such as chassis rigidity and modulus of elasticity.

### Findings

Stress tests were conducted under various loading scenarios, and deformation behaviour in critical regions was examined in detail. Longitudinal Loading (Figure 5 – Figure 6): Maximum stress was measured at 236 MPa, remaining within the material limits. Stress distribution was homogeneous, and deformation was controlled. The results indicated a computed stress of 37 MPa, which is significantly below the 236 MPa threshold, confirming that the tank and chassis are safe under this load. The manual calculation performed according to TS EN 12252 yielded a value of 39.95 MPa, which closely matches the results obtained from computer-based analysis.

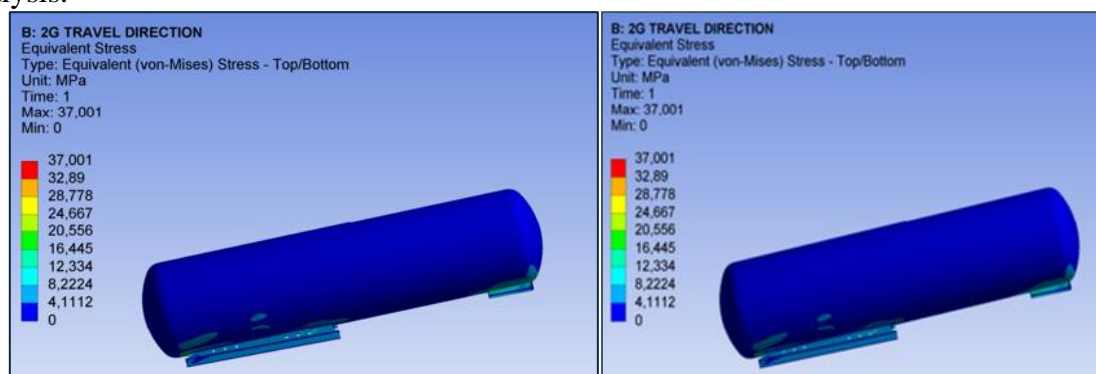


Figure 5. Longitudinal Direction (2g) von Mises results

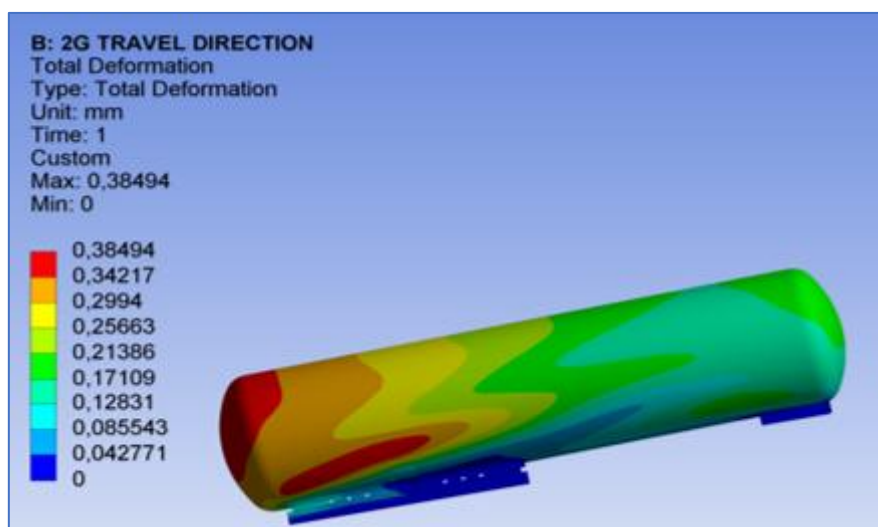


Figure 6. Longitudinal deformation results

The results showed a general stress of 90 MPa and a maximum stress concentration of 110 MPa. Both values are below the 236 MPa threshold, ensuring the structural integrity and safety of the design. Stress concentration in critical regions of the chassis has been minimized.

Vertical Loading (Figure 7): The maximum deformation was recorded as 9 mm. This value represents a 40% improvement compared to the 15 mm deformation observed in traditional chassis designs. The results indicated a general stress of 35 MPa and a maximum stress concentration of 40 MPa, both within the safe limits.

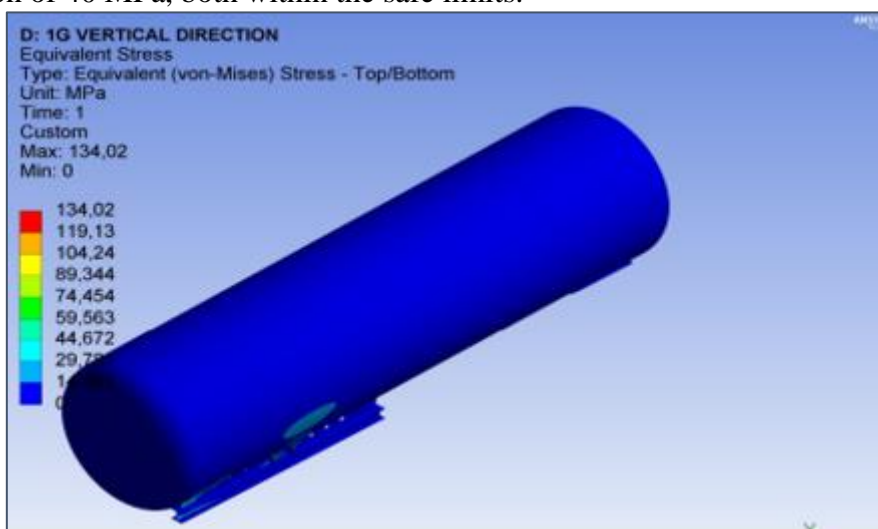


Figure 7. Vertical Direction (1g) von Mises results

### Discussion

The weight reduction and durability advantages achieved using IPE profiles present an innovative approach beyond existing designs in the industry. While traditional kingpin plate designs lead to weight and welding-related inefficiencies, IPE profiles provide an effective

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solution to these issues. Reducing logistics costs and optimizing operational processes are just a few of the long-term benefits of these designs. However, this study focuses solely on the potential benefits of IPE profiles, while topics such as different material combinations and dynamic loading scenarios emerge as critical areas for future research.

*Optimization of Maintenance and Repair Strategies;* Maintenance processes for trailer systems should be optimized to ensure longer service life and lower costs. Proactive maintenance strategies and digital monitoring systems can be recommended to enhance efficiency.

*Improvement Through Optimization of Different Components;* In this study, we focused on the optimization of the LPG tank semi-trailer chassis. However, optimizing other components could also provide significant advantages. For instance, an optimization study on the baffles inside the tank could improve braking distance, which is a crucial factor directly affecting fuel efficiency. A study focusing on baffles in pressure vessel semi-trailers analysed the dynamic behavior of tank container semi-trailers during hard braking and examined the effectiveness of baffles in enhancing safety in liquid transportation. Video analyses and dynamic simulations demonstrated that tank containers without baffles exhibited prolonged forward-backward sloshing movements after braking, significantly compromising road safety. In contrast, containers equipped with baffles showed a 40% reduction in liquid movement (Vrabel et al., 2019).

*Weight Reduction and Performance;* The use of IPE profiles in the chassis resulted in a 16% reduction in total weight. This not only increased the operational capacity of the trailer but also contributed to a more economical and environmentally friendly transportation system by reducing fuel consumption.

*Welding Reduction and Cost Advantages;* A 30% reduction in welding processes led to faster and more cost-effective production processes. This reduction resulted in a 25% decrease in labor costs and significantly accelerated assembly processes. Additionally, minimizing welding usage reduced manufacturing defects, thereby improving production quality. The reduction in welding volume also lowers environmental impact, aligning with sustainable manufacturing goals.

*Structural Strength and Safety;* It has been determined that IPE profiles, which do not require monolithic welding, increase bending strength by 15%. Finite Element Analysis (FEA) simulations revealed that stress concentrations in critical regions were reduced, resulting in a more uniform stress distribution. This contributed to maintaining structural stability against dynamic loads that may occur during transportation.

*Energy Efficiency and Carbon Footprint;* It has been concluded that a reduction in weight directly improves fuel consumption. This not only reduces operational costs but also minimizes carbon emissions, providing environmental benefits. The improvement in fuel consumption can be achieved not only through chassis optimization but also by optimizing the tank itself. Supporting this finding, another study analyzed various modifications aimed at increasing the aerodynamic efficiency of semi-trailer tankers and examined their impact on fuel consumption.

*Standardization and Compliance;* Within the scope of this study, designs were developed in accordance with TS EN 12252 standards, and computer-aided analyses were validated through manual calculations. Compliance with these standards enhances the acceptance of trailers in the European Union market, providing a competitive advantage in international trade.

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**DETERMINATION OF THE ACCURACY OF AVERAGE TEMPERATURE  
VALUES OBTAINED FROM DIFFERENT CLIMATE MODELS IN TR21 TRAKYA  
REGION**

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**Özet**

İklim değişikliğinin günümüzde etkileri belirgin bir şekilde gözlenmektedir dolayısıyla iklim değişikliğinin doğru bir şekilde tahmin edilebilmesi ve iklim değişikliği tahmin modellerinin güvenilirliğinin belirlenebilmesi, iklim değişikliğinin azaltım ve uyum stratejilerinin geliştirilebilmesi açısından çok önemlidir. Bu çalışma ile TR21 Trakya Bölgesi'nde bulunan üç ilde (Tekirdağ, Kırklareli, Edirne) yaşanan ortalama sıcaklık değerlerinin hem iklim değişikliği tahmin modelleri ile uyumuna bakılmıştır. Hem de modeller ile yapılan tahminlerden hangisinin ölçülen değerlere daha yakın olduğu belirlenmeye çalışılmıştır. Araştırmada TR21 Trakya Bölgesi'nde 2015-2024 yılları arasında Tekirdağ Meteoroloji Müdürlüğü'nden üç il için ölçülen aylık ortalama sıcaklık değerleri alınmıştır. Aynı dönem HadGEM2-ES Model ve MPI-ESM-MR Model RCP4.5 ve RCP8.5 senaryo sonuçlarından aylık ortalama sıcaklık değerleri elde edilmiştir. Ölçülen ve modellenen aylık ortalama sıcaklık verilerinin ne kadar uyumlu olduğu istatistiksel olarak değerlendirilmiştir. Sonuç olarak TR21 Trakya Bölgesi'nde ölçülen HadGEM2-ES ve MPI-ESM-MR Modeller ile tahmin edilen değerler arasında oldukça yüksek uyum belirlenmiştir (Nash Sutcliffe Model Etkinlik Katsayısı (0.861-0.920), Kök Ortalama Karesel Hata (1.980-2.986), R-Kare (0.903-0.929), Model Tutarlılık İndeksi (0.965-0.980), Ortalama Mutlak Yüzde Hatası (%14.30-%35.80), Ortalama Mutlak Hata (1.591-2.497)). Ortalama sıcaklıklara göre en fazla uyumun HadGEM2-ES Model RCP4.5 senaryo sonuçları ile Tekirdağ'da olduğunu söylemek mümkündür. Dolayısıyla yöneticilerin, karar vericilerin ve uygulayıcıların bu sonuçlar doğrultusunda iklim değişikliğini azaltmak için önlemler alması ve iklim değişikliğine uyum için stratejiler geliştirmeleri önerilir.

**Anahtar Kelimeler:** İklim değişikliği, iklim modelleri, verifikasyon, RCP senaryoları, HadGEM2-ES, MPI-ESM-MR

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**DETERMINATION OF THE ACCURACY OF AVERAGE TEMPERATURE  
VALUES OBTAINED FROM DIFFERENT CLIMATE MODELS IN TR21 TRAKYA  
REGION**

**Abstract**

Today, the effects of climate change are clearly observed, so it is very important to accurately predict climate change and to determine the reliability of climate change prediction models in order to develop climate change mitigation and adaptation strategies. In this study, the compatibility of the average temperature values experienced in three provinces in TR21 Thrace Region (Tekirdağ, Kırklareli, Edirne) with the climate change prediction models was examined. It was also tried to determine which of the predictions made with the models is closer to the measured values. In the study, monthly average temperature values measured for three provinces in TR21 Thrace Region between 2015-2024 were taken from Tekirdağ Meteorology Directorate. Monthly average temperature values were obtained from HadGEM2-ES Model and MPI-ESM-MR Model RCP4.5 and RCP8.5 scenario results for the same period. The compatibility between the measured and modeled monthly average temperature data was statistically evaluated. As a result, a very high agreement was determined between the measured HadGEM2-ES and MPI-ESM-MR Models and the predicted values in TR21 Thrace Region (Nash Sutcliffe Model Efficiency Coefficient (0.861-0.920), Root Mean Square Error (1.980-2.986), R-Squared Correlation (0.903-0.929), Index of Agreement (0.965-0.980), Mean Absolute Percentage Error (14.30%-35.80%), Mean Absolute Error (1.591-2.497)). According to the average temperatures, it is possible to say that Tekirdağ has the highest agreement with the HadGEM2-ES Model RCP4.5 scenario results. Therefore, it is recommended that managers, decision makers and practitioners take measures to mitigate climate change and develop strategies for adaptation to climate change in line with these results.

**Keywords:** Climate change, climate models, verification, RCP scenarios, HadGEM2-ES, MPI-ESM-MR



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## Introduction

The effects of climate change have started to be felt intensely today. Global climate change affects almost all areas directly or indirectly and significantly affects living life (Gül, 2023). Türkiye is located in the Eastern Mediterranean Basin where the effects of climate change will be felt intensely. For this reason, our country is recognized as one of the high-risk countries in terms of the adverse impacts of climate change. In this framework, there is a need for studies on climate, monitoring of changes and variability in climate and adaptation to the negative effects of climate change (Akçakaya et al., 2015).

Despite all its complexity and difficulties in implementation, climate modeling is the most important tool for predicting the future climate (Republic of Türkiye Ministry of Environment Urbanization and Climate Change General Directorate of Meteorology (RTEUCCGDM), 2025). Taking into account the current conditions, certain physical equations are used to calculate the change of these conditions and to draw a general framework of weather or climate conditions in a certain period of time (Akçakaya et al., 2015). Future climate projections are of great importance in determining actions to adapt to the impacts of climate change and developing targets to reduce greenhouse gas emissions (Collins, 2007).

TR21 Thrace Region is among the leading regions of Türkiye in terms of agriculture. While the total area excluding meadow and pasture areas is 239.712.314 decares in Türkiye, it is 10.103.142 decares in TR21 Thrace Region. Cereals and other crops cover 9.806.411 decares, vegetable gardens 76.345 decares, fruits, beverage and spice plants 208.618 decares, and ornamental plants 1.997 decares (TurkStat, 2024). These figures show that cereals and other plant products are predominant in the region. Agricultural production is directly related to climate and weather conditions. Changes in precipitation regime and increasing temperatures increase the water requirement in agriculture and cause a decrease in water resources (Şen & Topçu, 2024).

The reliability of climate change prediction models is very important, especially in agriculture. Several studies have been conducted around the world to investigate and determine the accuracy of climate change prediction models. Knutti et al. (2010) summarized the motivation for using ensembles of multiple models and discussed the challenges in interpreting them. Fildes and Kourentzes (2011) investigated the accuracy of predictions in climate change models. Shiru and Chung (2021) evaluated the performance of 13 global climate models (GCMs) of CMIP6 for precipitation, maximum and minimum temperatures in Nigeria during the period 1984-2014. Studies conducted in Turkey are quite limited. Sonuç (2012) performed a validation process using the forecast data of the RegCM Regional Climate Model. He developed an expert system for this purpose. Bağçaci et al. (2021) compared the change of mean temperature and precipitation parameters in the Mediterranean with CMIP6 (Coupled Model Intercomparison Project phase 6), which replaced CMIP5 (Intercomparison Project phase 5). Şen and Topçu (2024) validated the RegCM Model results with observation values and average, average maximum, average minimum, average minimum, maximum, minimum temperatures and precipitation values for the reference period of the model. In TR21 Thrace Region, many studies have been conducted using climate change prediction models. Some of these studies are climate change prediction for the region, determination of the effects of climate change on water resources, reference evapotranspiration, plant water consumption, soil moisture, evaporation, yield prediction, creation of climatic suitability maps for plants, determination of land use change (Altürk et al., 2019; Azlak, 2015; Azlak & Şaylan, 2019; Bağçaci et al., 2021; Çaldağ, 2009; Deveci, 2015; Deveci & Konukcu, 2024; Deveci et al.,

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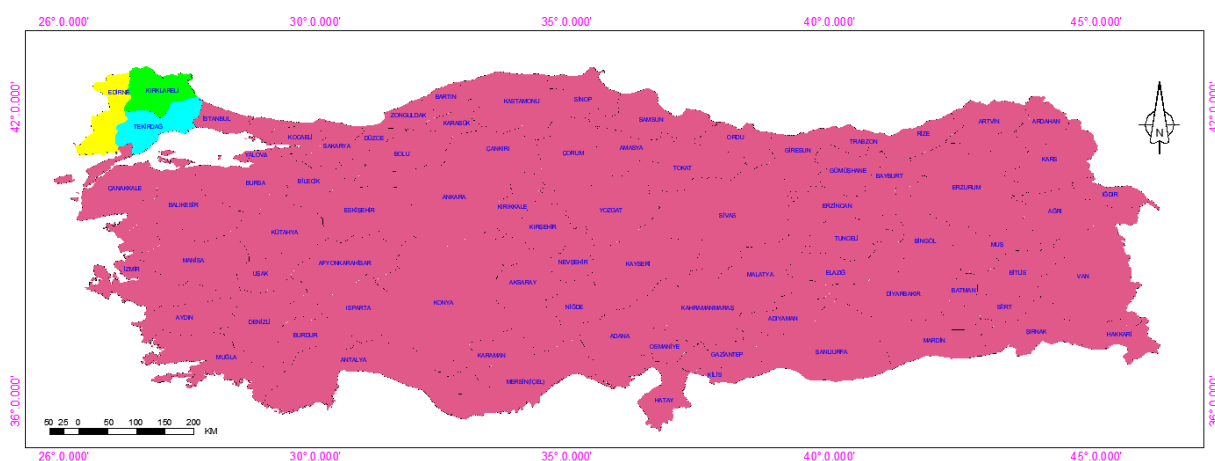
2019; Hanedar et al., 2019; Konukcu et al., 2020; Şen et al., 2024). There is no study on the verification of climate change prediction models with observational data in the region.

As a result, the aim of this study is to determine the agreement of the average temperature values realized in TR21 Thrace Region in the period 2015-2024 with climate change prediction models. For this purpose, the statistical agreement between the measured monthly average temperature values and the values obtained from HadGEM2-ES Model and MPI-ESM-MR Model RCP4.5 and RCP8.5 scenario results were evaluated. Thus, with this study, it is thought that the usability and reliability of climate change prediction models will be determined and will be a guide in climate change mitigation and adaptation studies.

## Materials and Methods

### Research area

TR21 Thrace Region covers the provinces of Tekirdağ, Edirne and Kırklareli. Its surface area (excluding lakes) is 18.665 km<sup>2</sup>. It constitutes a large part of Türkiye's territory on the European continent. It has 2.4% of Türkiye's total surface area (Thrace Development Agency (TDA), 2024). According to TUIK 2023 data, the agricultural areas of TR21 Thrace Region, excluding meadows and pastures, are 10.103.142 decares. The most commonly grown products in the region are wheat, sunflower, paddy, canola, maize, barley and sugar beet (TurkStat, 2024). The research area is shown in Figure 1.



**Figure 1.** Research area

### Climate of the research area

On the Black Sea coast of TR21 Thrace Region, the typical humid, cool and rainy Black Sea climate prevails. In the interior, a typical continental climate prevails, with cold winters and hot, dry summers. In the south and southwest, and locally on the Black Sea coast, there is a typical Mediterranean climate, with hot and dry summers and mild and rainy winters (Asan & Yarıç, 1993). Long-term climate data of the research area are shown in Table 1. According to average temperatures, Tekirdağ is the warmest province (14.1°C). The province with the highest precipitation (601 mm) is Edirne.

### Climate change prediction models and scenarios

HadGEM2-ES (Hadley Centre Global Environment Model version 2-Earth System) and MPI-ESM-MR (Max-Planck-Institute Earth System Model-Mixed Resolution), two of the global

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model data sets suitable for our region produced within the scope of CMIP5 (Coupled Model Intercomparison Project Phase 5), were used in this study. HadGEM2-ES is a 2nd generation global model developed by the Hadley Centre, a research organization of the United Kingdom Meteorological Service (Met Office). The HadGEM2 series includes a coupled atmosphere-ocean configuration and a land-system configuration that includes dynamic vegetation, ocean biology, atmospheric chemistry (Met Office, 2024). The MPI-ESM model is an integrated earth system model consisting of atmosphere, surface and ocean submodules developed by the Max Planck Institute in Germany (Max-Planck-Institut für Meteorologie (MPI), 2024). MPI-ESM utilizes the atmosphere, ocean and land surface within the model, assessing the exchange between energy, momentum, water and important trace gases such as carbon dioxide.

In AR5, the 5th assessment report of the IPCC (Intergovernmental Panel on Climate Change), RCPs (RCPs: Representative Concentration Pathways) replaced the Special Report on Emissions Scenarios (SRES) standards (IPCC, 2014). RCP4.5 and RCP8.5 scenario results were used in this study. The RCP8.5 scenario assumes that radiative forcing reaches  $8.5 \text{ W/m}^2$  in 2100 and equivalent  $\text{CO}_2$  concentrations reach around 1370 ppm. RCP4.5 is an intermediate stabilization pathway, where radiative forcing is assumed to reach  $4.5 \text{ W/m}^2$  and equivalent  $\text{CO}_2$  concentrations around 650 ppm in 2100 (Thomson et al., 2011).

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**Table 1.** Long-term monthly averages climate data (Tekirdağ (1940-2023), Edirne (1930-2023), Kırklareli (1959-2023)) (Turkish State Meteorological Service (TSMS), 2024a, 2024b, 2024c)

Location	Climate Parameters	January	February	March	April	May	June	July	August	September	October	November	December	Average/Total
Tekirdağ	Average Mean Temperature (°C)	4.9	5.5	7.3	11.7	16.7	21.1	23.7	23.9	20.3	15.7	11.3	7.3	14.1
	Average Maximum Temperature (°C)	8.1	9.0	11.0	15.7	20.6	25.3	28.1	28.3	24.5	19.5	14.8	10.5	18.0
	Average Minimum Temperature (°C)	2.0	2.5	4.1	8.1	12.7	16.7	19.1	19.4	16.2	12.1	8.2	4.4	10.5
	Average Daily Sunshine (hour)	2.8	3.4	4.2	6.0	7.4	8.5	9.4	8.4	6.8	4.9	3.2	2.5	5.6
	Precipitation (mm)	68.0	54.5	53.4	42.1	37.2	38.3	23.8	15.5	32.7	60.2	74.3	80.0	580.0
Edirne	Average Mean Temperature (°C)	2.7	4.4	7.6	12.8	18.0	22.2	24.7	24.5	20.1	14.5	9.2	4.6	13.8
	Average Maximum Temperature (°C)	6.7	9.4	13.4	19.3	24.8	29.2	32.0	32.0	27.4	20.8	14.2	8.6	19.8
	Average Minimum Temperature (°C)	-0.5	0.5	2.9	7.1	11.7	15.5	17.4	17.3	13.5	9.3	5.3	1.4	8.5
	Average Daily Sunshine (hour)	2.4	3.6	4.5	6.2	8.0	9.2	10.3	9.8	7.5	5.2	3.2	2.2	6.0
	Precipitation (mm)	65.0	52.2	50.1	48.7	52.4	47.1	31.7	23.3	35.9	56.7	67.3	70.6	601.0
Kırklareli	Average Mean Temperature (°C)	2.9	4.1	6.9	12.0	17.1	21.4	23.8	23.6	19.4	14.1	9.3	5.1	13.3
	Average Maximum Temperature (°C)	6.9	8.6	12.2	17.9	23.5	28.0	30.7	30.7	26.2	20.0	13.9	8.8	19.0
	Average Minimum Temperature (°C)	0.1	1.0	3.0	7.1	11.6	15.6	17.8	17.8	14.1	9.8	5.9	2.3	8.8
	Average Daily Sunshine (hour)	2.0	2.5	3.6	4.7	6.3	6.8	7.5	7.5	5.5	3.8	2.7	1.8	4.6
	Precipitation (mm)	65.0	51.3	48.7	45.4	49.3	52.6	27.8	21.5	32.8	51.5	66.7	71.1	583.7

## Statistical methods

*Nash Sutcliffe Model Efficiency Coefficient (NSE):*

NSE was developed Nash and Sutcliffe (1970) (Equation 1). NSE is a measure used to evaluate the performance of a model with respect to observed data. The NSE value varies between  $-\infty$  and 1. Here,  $NSE=1$  indicates that there is a perfect fit between the model and the measured values,  $NSE=0$  indicates that the mean values of the model and the measured values are very close, and  $NSE<0$  indicates that the model and the measured values are quite far apart (Deveci, 2015).

$$NSE = 1 - \frac{\sum_{i=1}^N (S_i - M_i)^2}{\sum_{i=1}^N (M_i - \bar{M})^2} \quad (1)$$

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N: Total number of observations

M<sub>i</sub>: Measured values

S<sub>i</sub>: Modeled values

$\bar{M}$ : Average of measured values (i=1 to N)

*Root Mean Square Error (RMSE):*

RMSE is an important measure for evaluating the performance and accuracy of prediction models. It is used to determine the error rate between observation data and model predicted data (Equation 2). An RMSE close to 0 indicates that the observation data and model data are compatible with each other (Arslan, 2024). RMSE range from 0 to  $\infty$ , with lower values indicating better model performance (AgriMetSoft, 2019).

$$RMSE = \sqrt{\frac{1}{N} \sum_{i=1}^N (S_i - M_i)^2} \quad (2)$$

N: Total number of observations

M<sub>i</sub>: Measured values

S<sub>i</sub>: Modeled values

*R-Squared Correlation (r<sup>2</sup>):*

It is one of the most common measures of dependence between two quantities (Equation 3). The r<sup>2</sup> can be defined as the square of the Pearson's product moment correlation coefficient describing the proportion of the total variance in the observed data which is explainable by the model (Legates & McCabe, 1999). The r coefficient is used to determine the degree and direction of the linear relationship between two variables. The correlation coefficient takes values between -1 and +1. When the coefficient approaches -1, it is assumed that there is an inverse relationship between the variables, when it approaches +1, it is assumed that there is a same directional relationship, and when it takes the value 0, it is assumed that there is no significant relationship between the variables (Deveci, 2015).

$$r_{x,y} = \frac{\sum_{i=1}^n (x_i - x_{ort})(y_i - y_{ort})}{\sqrt{\sum_{i=1}^n (x_i - x_{ort}) \sum_{i=1}^n (y_i - y_{ort})}} \quad (3)$$

r: Correlation coefficient

n: Total number of observations

x<sub>i</sub>: Measured value

y<sub>i</sub>: Estimated value

x<sub>avg</sub>: Average of measured values

y<sub>ort</sub>: Average of estimated values

*Index of Agreement (d):*

The Index of Agreement, introduced by Willmott (1981), stands as a standardized metric for quantifying the degree of prediction error in models, offering hydrologists a valuable tool for assessing model performance (Equation 4). This index, denoted by "d", ranges between 0 and 1, where a value of 1 signifies a perfect match between model predictions and observed data, while a value of 0 indicates no agreement whatsoever (AgriMetSoft, 2019).

$$d = 1 - \frac{\sum_{i=1}^n (O_i - P_i)^2}{\sum_{i=1}^n (|P_i - \bar{O}| + |O_i - \bar{O}|)^2} \quad (4)$$

O<sub>i</sub> = Measured values

P<sub>i</sub> = Modeled values

$\bar{O}$  = Average of measured values

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n = Total number of observations

*Mean Absolute Percentage Error (MAPE):*

MAPE also referred to as mean absolute percentage deviation (MAPD), serves as a statistical measure to assess the accuracy of a forecasting method. MAPE quantifies the magnitude of error in percentage terms, offering insight into the predictive performance of a model. It is computed as the average of the unsigned percentage errors (Equation 5) (AgriMetSoft, 2019).

$$MAE = 100 * \frac{1}{n} * \sum_{i=1}^n \left| \frac{O_i - M_i}{O_i} \right| \quad (5)$$

O<sub>i</sub>: Observed value

M<sub>i</sub>: Modeled values

n: Total number of observations

*Mean Absolute Error (MAE):*

MAE serves as a fundamental metric for assessing forecast accuracy, particularly in the context of continuous variables. It represents the average magnitude of errors between predicted and actual values, offering insights into the typical deviation of forecasts from observed data (Equation 6). MAE range from 0 to ∞, with lower values indicating better model performance (AgriMetSoft, 2019).

$$MAE = \frac{1}{n} * \sum_{i=1}^n |O_i - P_i| \quad (6)$$

O<sub>i</sub>: Observed value

P<sub>i</sub>: Predicted values

n: Total number of observations

## Methods

Monthly average temperature values measured from Tekirdağ Meteorological Directorate were taken for the years 2015-2024 in TR21 Thrace Region. Monthly average temperature values were obtained from HadGEM2-ES Model and MPI-ESM-MR Model RCP4.5 and RCP8.5 scenario results for the same period. These results are the results of the “Impact of Climate Change on Water Resources Project” carried out by the Republic of Türkiye Ministry of Agriculture and Forestry General Directorate of Water Management (ClimateWater, 2016). The compatibility between the measured and modeled monthly average temperature data was statistically evaluated. Six different statistical methods (NSE, RMSE, r<sup>2</sup>, d, MAPE, MAE) were used. These statistical analyzes were performed using AgriMetSoft (AgriMetSoft, 2019).

## Findings and Discussion

The 10-year average values and the difference between the monthly average temperature values obtained from Tekirdağ Meteorological Directorate between 2015 and 2024 in TR21 Thrace Region and the monthly average temperature values obtained from HadGEM2-ES Model and MPI-ESM-MR Model RCP4.5 and RCP8.5 scenario results for the same period are shown in Table 2. Accordingly, the lowest difference between measured and modeled values (-0.02°C) is in HadGEM2-ES Model RCP8.5 result in Tekirdağ. The highest difference (1.61°C) was observed in Edirne as a result of MPI-ESM-MR Model RCP8.5. Şen and Topçu (2024) in their study conducted in Çukurova, predicted average temperature values with deviations ranging from 2.8°C (Sarız) to -4.3°C (Ulukışla) compared to observation values. In these two studies, first of all, research areas, models used and periods differ. Therefore, it is considered normal for the results to differ. In fact, it is a desired and expected situation that the results of the two models and two different scenarios used in this region are in good agreement.

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**Table 2.** Measured and modeled (HadGEM2-ES and MPI-ESM-MR Model RCP4.5 and RCP8.5 scenarios) average temperature values between 2015-2024

Models	Location	Scenarios	Average Temperature Value (°C) (2015-2024)		Difference (°C)
			Measured	Modeled	
HadGEM2-ES	Edirne		15.69	14.76	0.94
	Kırklareli	RCP4.5	14.85	14.47	0.37
	Tekirdağ		15.50	15.19	0.31
	Edirne		15.69	15.12	0.58
	Kırklareli	RCP8.5	14.85	14.81	0.04
	Tekirdağ		15.50	15.52	-0.02
MPI-ESM-MR	Edirne		15.69	14.09	1.60
	Kırklareli	RCP4.5	14.85	13.77	1.07
	Tekirdağ		15.50	14.35	1.15
	Edirne		15.69	14.08	1.61
	Kırklareli	RCP8.5	14.85	13.76	1.08
	Tekirdağ		15.50	14.35	1.15

The statistical results of the measured and modeled monthly average temperature values for the period 2015-2024 are shown in Table 3. In TR21 Thrace Region, very high agreement was found between the measured HadGEM2-ES and MPI-ESM-MR Models and the predicted values (Nash Sutcliffe Model Efficiency Coefficient (0.861-0.920), Root Mean Squared Error (1.980-2.986), R-Square (0.903-0.929), Model Consistency Index (0.965-0.980), Mean Absolute Percentage Error (14.30%-35.80%), Mean Absolute Error (1.591-2.497)). Räisänen (2007) found that intercomparison of future climate changes between models shows a better fit for changes in temperature than for changes in precipitation and sea level pressure. In this study, the results of the two studies support each other as there is a fairly high agreement between temperatures. Similarly, Hausfather et al. (2020) found no evidence that climate models systematically over- or underestimated warming over projection periods and noted that the projection skill of 1970s models was particularly impressive given the limited observational evidence of warming at that time.

When the statistical test results are evaluated one by one, since the NSE value varies between 0 and 1 and the closer the values are to 1, the better the agreement between the measured and modeled values (Nash & Sutcliffe, 1970). Since the highest result in the NSE value is 0.920, it can be said that the best fit according to this result is in the RCP4.5 scenario in HadGEM2-ES Model in Tekirdağ. In the RMSE value, the lowest value shows the best performance. Accordingly, the lowest value with 1.980 is in the RCP4.5 scenario in Tekirdağ in the HadGEM2-ES Model. In  $r^2$ , it is important that the two groups compared are close to 1.  $R^2$  measures the strength of the relationship between two variables. Here, in the comparison of the measured values with the RCP4.5 scenario result in Tekirdağ in HadGEM2-ES Model,  $r^2$  is 0.924, the second largest value after 0.929. Shiru and Chung (2021) observed similar results to this study when NSE and  $r^2$  results were evaluated in 13 models. In other words, while the NSE value is high, the  $r^2$  value is low or vice versa. When Index of Agreement values are evaluated,

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the best match between measured and modeled values was observed in Tekirdağ (0.980) in the same model and scenario. Looking at MAPE, the lowest percentage deviation is in Tekirdağ in the same model and scenario. Finally, when MAE is evaluated, it is seen that the closest value to zero (1.591) is in the HadGEM2-ES Model in the RCP4.5 scenario in Tekirdağ. As a result, five of the six different statistical methods had the highest agreement, while only  $r^2$  had the second highest agreement.

**Table 3.** Statistical results of measured and modeled monthly mean temperature values (2015-2024)

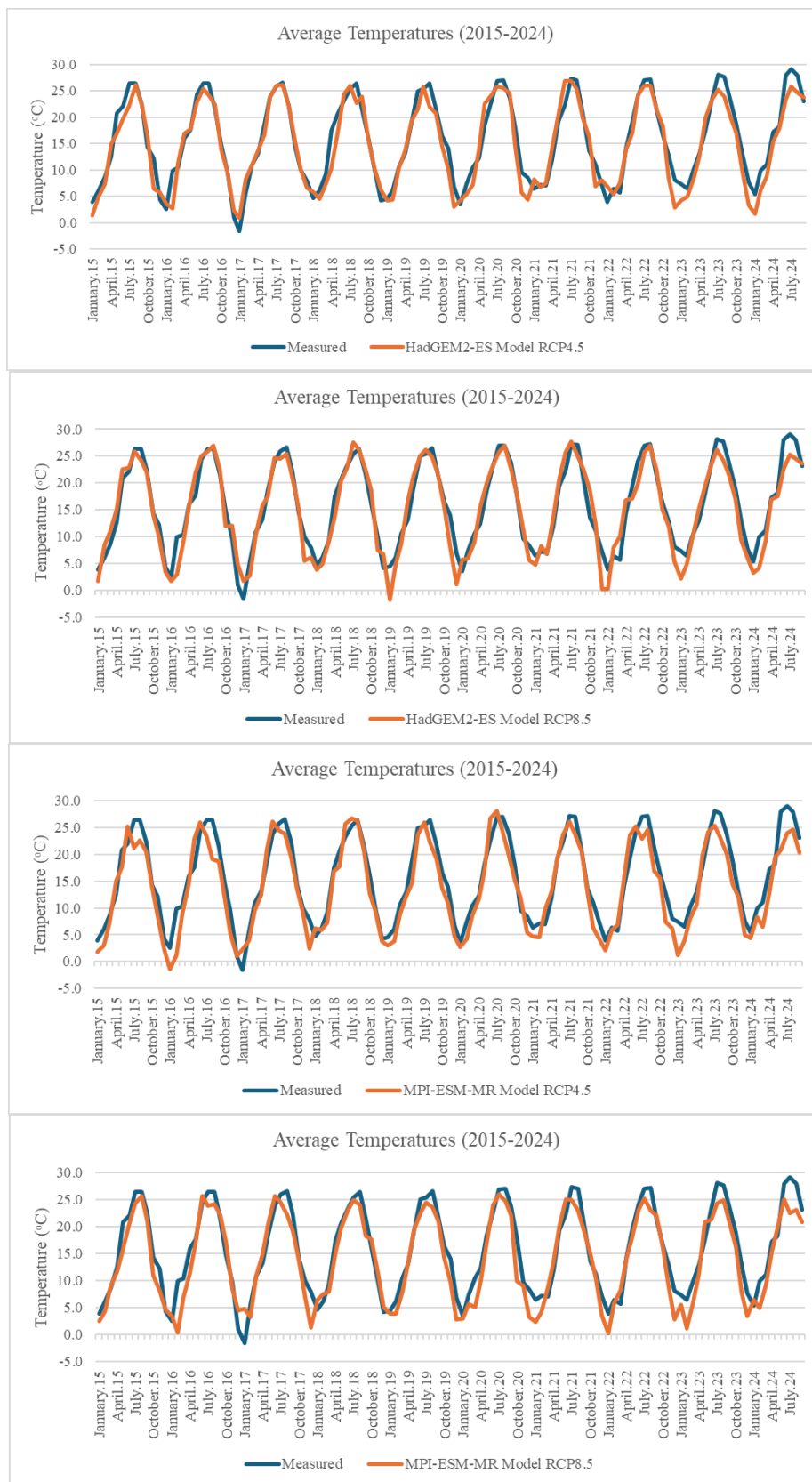
Models	Location	Scenarios	Statistical Analysis Type					
			NSE	RMSE	$r^2$	d	MAPE (%)	MAE
HadGEM2-ES	Edirne	RCP4.5	0.901	2.519	0.917	0.975	19.50	1.971
	Kırklareli		0.903	2.351	0.912	0.976	22.60	1.838
	Tekirdağ		0.920	1.980	0.924	0.980	14.30	1.591
	Edirne	RCP8.5	0.899	2.543	0.912	0.975	24.10	1.992
	Kırklareli		0.901	2.376	0.913	0.976	28.60	1.868
	Tekirdağ		0.915	2.031	0.922	0.979	16.20	1.613
MPI-ESM-MR	Edirne	RCP4.5	0.861	2.986	0.906	0.966	22.40	2.497
	Kırklareli		0.878	2.633	0.907	0.970	26.70	2.186
	Tekirdağ		0.900	2.211	0.929	0.975	15.10	1.827
	Edirne	RCP8.5	0.861	2.983	0.904	0.965	26.30	2.418
	Kırklareli		0.879	2.632	0.903	0.969	35.80	2.082
	Tekirdağ		0.891	2.309	0.919	0.972	16.80	1.815

In Figure 3, Figure 4 and Figure 5, the monthly average temperature values obtained from Tekirdağ Meteorological Directorate between 2015 and 2024 and the monthly average temperature values obtained from HadGEM2-ES Model and MPI-ESM-MR Model RCP4.5 and RCP8.5 scenario results for the same period are plotted for Edirne, Kırklareli and Tekirdağ provinces. Accordingly, it is seen in the graphs that the greatest agreement is in HadGEM2-ES Model RCP4.5 for Tekirdağ. As a result, it is possible to say that the highest agreement according to average temperatures is in Tekirdağ with HadGEM2-ES Model RCP4.5 scenario results both statistically and graphically.



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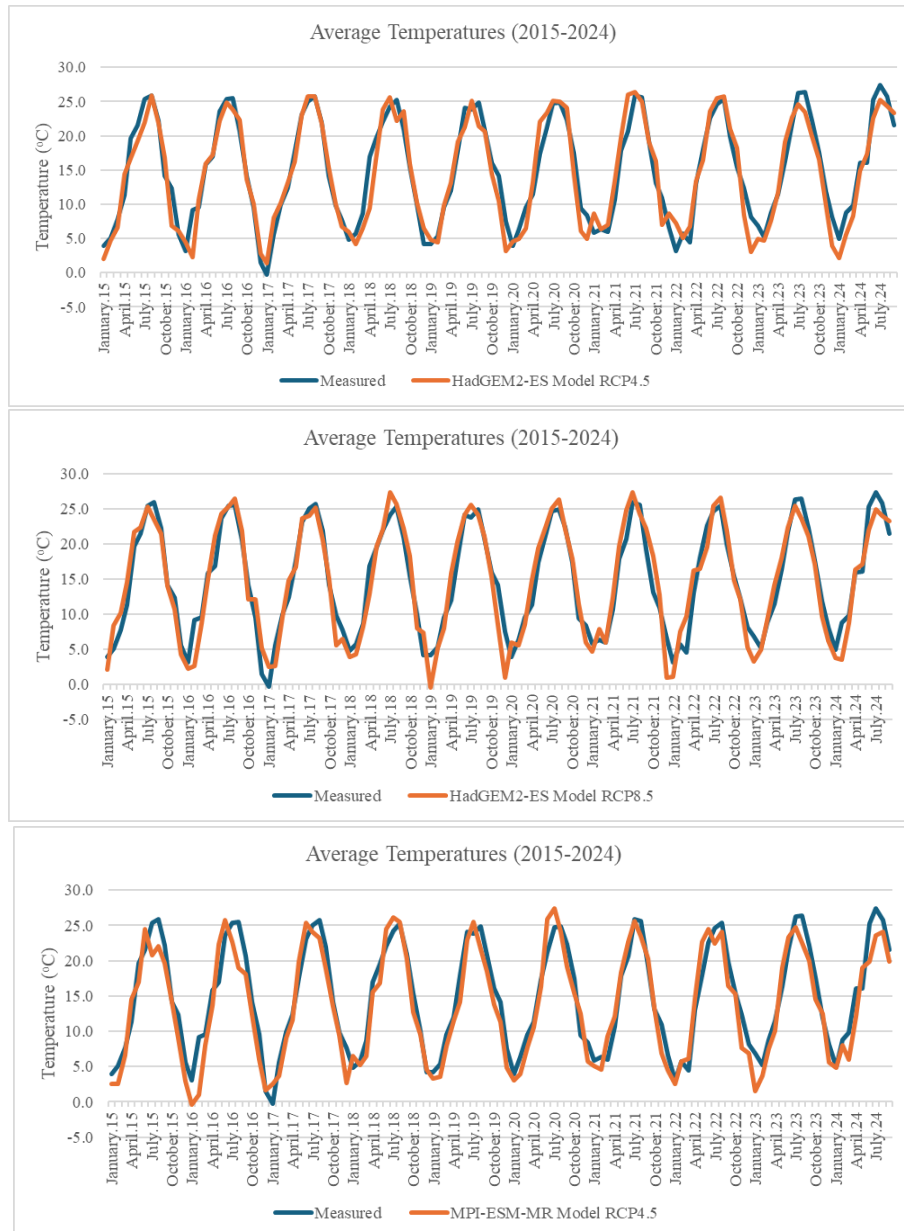


**Figure 3.** Measured and modeled (HadGEM2-ES and MPI-ESM-MR Model RCP4.5 and

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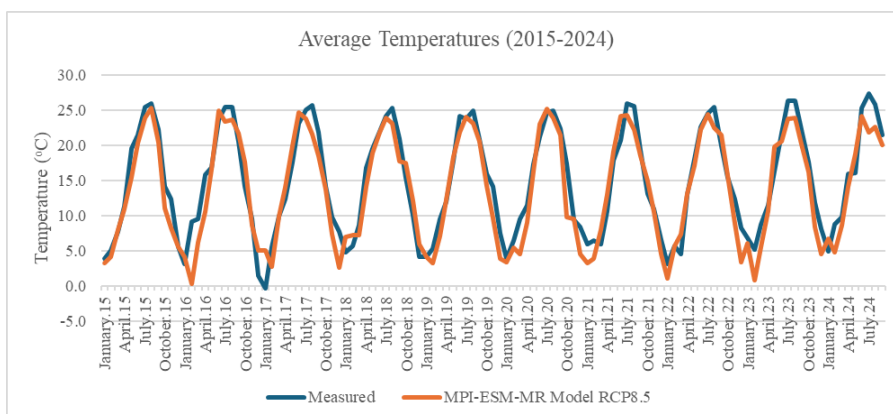
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RCP8.5 scenarios) average temperature values in Edirne province (2015-2024)

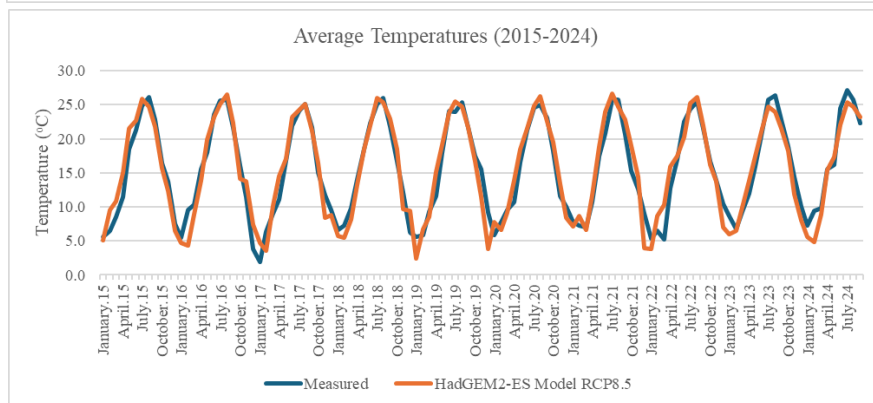
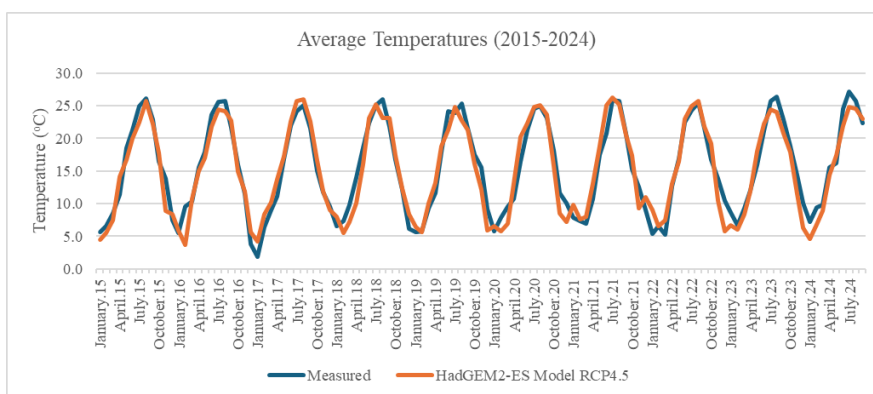


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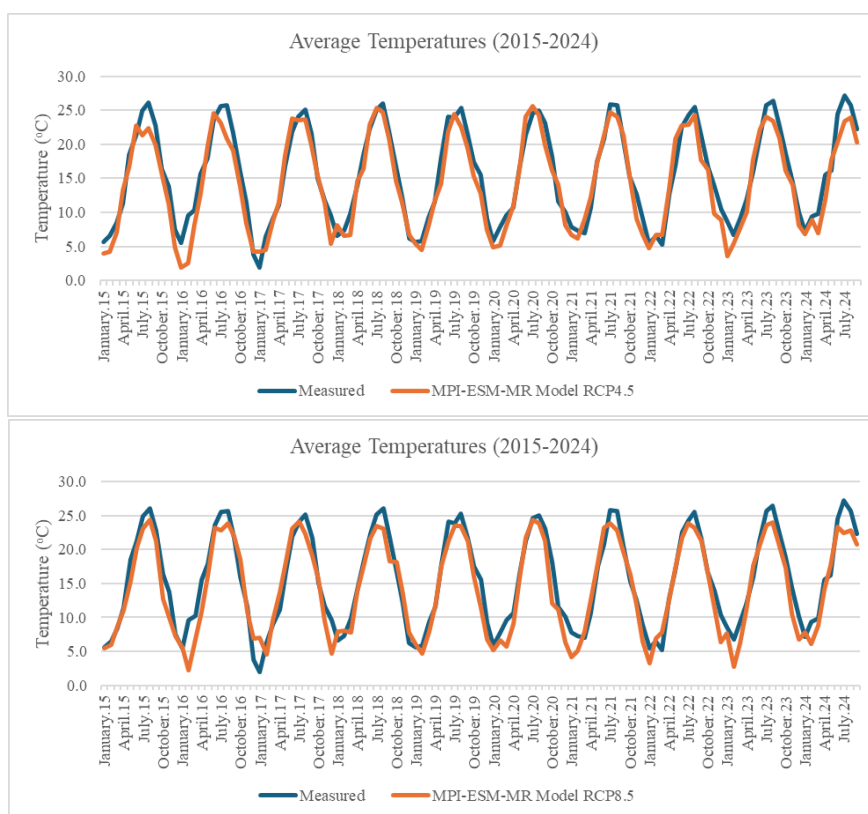


**Figure 4.** Measured and modeled (HadGEM2-ES and MPI-ESM-MR Model RCP4.5 and RCP8.5 scenarios) average temperature values in Kırklareli province (2015-2024)



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**Figure 5.** Measured and modeled (HadGEM2-ES and MPI-ESM-MR Model RCP4.5 and RCP8.5 scenarios) average temperature values in Tekirdağ province (2015-2024)

## Conclusion and Recommendations

In order for countries to be prepared for the consequences of climate change, they need to predict the climate very well. It is very important to verify the predictions made by climate models, especially in the agricultural sector and then in other sectors, in order to realize adaptation actions to climate change and then to determine mitigation actions. With this research, the agreement of the average temperature values realized in TR21 Thrace Region (Tekirdağ, Kırklareli, Edirne) in the period 2015-2024 with the climate change prediction models was determined. For this purpose, it was determined that the measured monthly average temperature values and the values obtained from HadGEM2-ES Model and MPI-ESM-MR Model RCP4.5 and RCP8.5 scenario results are statistically highly compatible. As a result, the highest agreement was found in the HadGEM2-ES Model RCP4.5 scenario in Tekirdağ. In order for countries to be prepared for the consequences of climate change, they need predictions about how the climate will be in the future. Because direct verification of future predictions cannot be done. Similar methods are recommended for precipitation and other climate parameters on a daily or even seasonal level over long periods of time.

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**MAGNITUDE OF POST HARVEST LOSSES IN SELECTED FOOD CROPS IN  
NIGER STATE, NIGERIA**

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**Abstract**

The study examines magnetite of post-harvest losses in selected food crops in Niger State, Nigeria, Nigeria. Multi-stage sampling techniques were employed to select 150 respondents on which primary data were elicited with the aid of a structured questionnaire with interview schedule using kobo tool box. Data collected were analyzed using descriptive statistics (such as mean, frequency distribution count and percentages). The study revealed that threshing is an important stage in the post-harvest process, and the high percentages of perceived losses 90.6% for maize, 83.1% for cowpea, and 83.8% for groundnut. Drying stage is another crucial stage in the post-harvest process, with perceived losses reported at 82.5% for maize, 78.1% for cowpea, and 77.5% for groundnut indicated its significant effects on overall yield. Also, improper storage is an important cause of post-harvest losses, as indicated by 80.0% of maize farmers, 62.5% of cowpea farmers, and 48.8% of groundnut farmers. In addition, groundnut suffered the highest losses during threshing, with an average loss of 9.34 kg, while maize experienced the least loss at 7.8 kg. This trend is consistent across the other stages; winnowing, drying and transportation where groundnut consistently recorded higher losses compared to cowpea and maize. The study recommended that farmers should adopt improved post-harvest handling techniques and invest in better storage facilities to reduce losses.

**Keywords:** Magnitude; Loss; Post-harvest; Food and Crops



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Agriculture remains the largest employer of labour as significant percentage of the country's population are employed in the sector. Larger proportions of farmers in Nigeria depends on agriculture as a means of their livelihood. Farming families produce diverse crops such as maize, cowpea, groundnuts, vegetables and fruits in order to boost food security and income generation (Pelemo *et al.*, 2019). Achieving food security continues to be a challenge as it is affected by a complexity of factors (Nicholas *et al.*, 2006; FAO, 2009; Dercon and Krishnan, 2015). Over recent decades, numerous countries have prioritized enhancements in agricultural output, land management, and population management in response to this mounting food demand. However, the issue of postharvest loss (phl) remain a critical concern that has been relatively neglected. The Food and Agriculture Organization of the United Nations (FAO) estimates that globally, one- third of all food produced is lost or wasted along the food supply chain, with significant losses occurring after harvest (FAO, 2019). Food losses or waste are the masses of food lost or wasted in the position of food chains leading to edible products going to human consumption (Gustavsson and Cederberg ,2011). Ukoh-Aviomoh *et al.* (2005) attributed losses in food quality to chemical changes, microbial attack, unhygienic ways of handling foods, exposure to high temperature and high relative humidity, insects and rodents attack, poor harvesting, poor storage and processing techniques and poor handling during distribution. Postharvest losses encompasses the wastage occurring throughout the food supply chain, from the moment food crops are harvested until they are consumed. These losses can be broadly classified into several categories, including weight loss resulting from spoilage, deterioration in quality, loss of nutritional value, diminished seed viability and commercial loss.

The extent of postharvest losses within the food supply chain varies significantly across different crops, regions, and economic contexts. In developing nations, efforts are made to maximize the utilization of harvested food; however, a substantial portion of produce is lost during postharvest operations due to factors such as limited knowledge, inadequate technology, and deficient storage infrastructure. Nonetheless, a significant proportion of food is wasted at the end of the supply chain, a phenomenon referred to as food waste. Food waste is encompasses food that is discarded, diverted for non-food purposes, or spoiled/expired (FAO 2014). Postharvest losses comprises both physical losses and quality degradation, leading in the economic worth of crops and rendering them unfit for consumption. In severe instances, these losses can amount to 80% of the production.

Food crops such as maize (*Zea mays*), cowpea (*vigna unguiculata*) and groundnut (*Arachis hypogaea*) is susceptible to spoilage and deterioration if not properly harvested, dried and stored. They are primary source of protein, calories and essential nutrient for many people in Niger state. A considerable amount of farmers in Niger state suffers financial loss due to postharvest losses, sources supplied may result in increased food prices making it less affordable for consumers, especially those with limited purchasing power. This can further exacerbate food insecurity and affect the overall well-being of household. This economic strain can affect their ability to invest in future agricultural activities and exacerbate poverty in rural communities. Based on the following the study was carried out to ascertain the stages of post-harvest losses; find out the causes of post-harvest losses and determine the magnitude of post-harvest loss (phl) in physical and monetary terms.

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## METHODOLOGY

The study was carried out in Niger State, Nigeria. Niger State is located between Latitudes 8°22'N and 11°30'N and Longitudes 3°30'E and 7°20'E. The State is bordered by Zamfara and Kebbi States in the North and North-west respectively, Kogi and Kwara States in the South and South-west respectively; while Kaduna State and the Federal Capital Territory (FCT), Abuja, border the State to the Northeast and Southeast respectively. The State shares an international boundary with the Republic of Benin at Babanna, in Borgu Local Government Area. Currently, the State covers an estimated total land area of 74,244sq.km, which is about 8% of Nigeria's total land area (Oni *et al.*, 2021). The population of the State is 3,950,249, comprising 2,082,725 males and 1,867,524 females (National Population Commission (NPC), 2006). The projected population of the State as at 2021 was 5,644,139 at 3.2% population growth (NBS, (2022).

Multi-stage sampling technique was employed in the selection food crop farmer's for the study. The first stage involved purposive selection of Bosso and Chanchaga Local Government Areas, this is due to their preponderance in food crop production in Niger State. The second stage involved random selection of three (3) villages from the each of the selected LGA namely; Bosso (*Garatu, Maikunkele, Gidan kwano*) Chanchaga (*Etsu Musa, Debbi and Ekpigi*). The last stage involved random selection of food crop farmers from each of the selected villages using Taro Yammane as used by Sallawu *et al.* (2017).

Where:

$n$  = Sample size required;

$N$  = Sampling frame;

$1$  = Constant; and

$e^2$  = level of precision (5%).

The population and sample size of the respondent in the LGA is summarized and presented in Table 3.1. A total of 214 food crop farmers will be used for the study.

**Table 3.1: Sampling frame and sample size of respondents**

LGA	Village/communities	Sampling frame	Sample size
Bosso	Garatu	53	33
	Maikunkele	50	31
	Gidan kwano	45	28
Chanchaga	Etsu Musa	38	24
	Debbi	35	22
	Ekpigi	20	12
Total	6	241	150

Source: Community-based records from Village Heads and *Niger State Agricultural Mechanization Authority (NAMDA)*

Primary data were used for the study. Data were obtained from the respondent with the aid of a structured questionnaire and interview schedule with the help of trained enumerators. Kobo collect mobile application was used for the data collection. The data collected were analysed using descriptive

**Result and discussion**

**Stages of post-harvest losses**

Table 1 present the result of stages of loses post-harvest in Maize, cowpea and groundnut. It revealed that farmers in the study area perceived losses in threshing, drying and cleaning across the food crops as most significant. Threshing is an important stage in the post-harvest process, and the high percentages of perceived losses 90.6% for maize, 83.1% for cowpea, and 83.8% for groundnut indicated its significant effects on overall yield. Threshing involves separating the grain from the chaff or pods, which can lead to considerable losses if not done carefully. Factors contributing to these losses include improper use of tools, lack of mechanization, and poor handling practices that result in grain damage or spillage. For maize, cowpea, and groundnut, manual threshing is still common, and this method is often labour-intensive and prone to errors. The high loss rates reflect the need for improved techniques, such as the introduction of mechanized threshers, better training on threshing methods, and more careful post-threshing handling to minimize spillage. Addressing these issues could significantly reduce post-harvest losses and improve overall food security and farmer incomes. This is similar to the study Kadir and Habib (2019) who reported that losses occur at the threshing stage of processing

The drying stage is another crucial stage in the post-harvest process, with perceived losses reported at 82.5% for maize, 78.1% for cowpea, and 77.5% for groundnut. Proper drying is essential to reduce moisture content in harvested crops, thereby preventing mold growth, insect infestations, and spoilage. However, in many cases, drying is done in open fields or on bare ground, exposing the crops to contamination, uneven drying, and adverse weather conditions, such as unexpected rain. The high loss rates suggest that farmers in the study area may lack access to adequate drying facilities or face challenges in managing the drying process effectively. Solutions could include the use of improved drying techniques, such as solar dryers or raised

Cleaning, the process of removing impurities and unwanted materials from harvested crops, is another stage where significant losses occur 79.4% for maize, 74.4% for cowpea, and 78.1% for groundnut. Effective cleaning is essential for ensuring that crops meet quality standards for both consumption and sale. However, the high levels of perceived losses suggest challenges such as inadequate cleaning equipment, lack of proper training, and the time-consuming nature of the process. Manual cleaning methods, which are still widely used, can lead to losses through spillage, breakage of grains, or incomplete removal of contaminants. These losses not only reduce the quantity of usable produce but also affect its market value.

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**Table 1: Stages of stages of post-harvest losses**

<b>Stages</b>	<b>Maize Frequency (%)</b>	<b>Cowpea Frequency (%)</b>	<b>Groundnut Frequency (%)</b>
Threshing	145 (90.6)	133 (83.1)	134 (83.8)
Drying	132 (82.5)	125 (78.1)	124 (77.5)
Cleaning	127 (79.4)	119 (74.4)	125 (78.1)
Storage	91 (56.9)	102 (63.7)	108 (67.5)
Milling	83 (51.9)	85 (53.1)	99 (61.9)
Winnowing	69 (43.1)	78 (48.8)	84 (52.5)
Transportation	76 (47.5)	78 (48.8)	87 (54.4)
Packaging	63 (39.4)	80 (50.0)	77 (48.1)
Shelling	69 (43.1)	73 (45.6)	81 (50.6)
Grinding	74 (46.3)	77 (48.1)	81 (50.6)
Bagging	59 (36.9)	77 (48.1)	76 (47.5)
Field drying	66 (41.3)	65 (40.6)	60 (37.5)
Sorting	52 (32.5)	42 (26.3)	54 (33.8)
Sales handle	36 (22.5)	40 (25.0)	46 (28.7)

Source: Field survey, 2024

**Causes of post-harvest losses**

Table 2 present the result of causes of post-harvest losses in Maize, cowpea and groundnut. Improper storage is an important cause of post-harvest losses, as indicated by 80.0% of maize farmers, 62.5% of cowpea farmers, and 48.8% of groundnut farmers. This issue arises from inadequate storage practices, which lead to exposure to pests, moisture, and other environmental factors that degrade crop quality. For maize, improper storage often results in mold growth, particularly aflatoxin contamination, which poses serious health risks and can render the crop unsellable. Similarly, cowpeas are highly susceptible to insect infestations during storage, while groundnuts are prone to spoilage due to high oil content that can turn rancid if not stored properly. The high percentage of losses due to improper storage underscores the need for better storage solutions, such as improved containers, proper drying before storage, and the use of pest control measures. Addressing these issues can significantly reduce losses and improve food security and farmers' livelihoods.

Inadequate storage facilities are another major cause of post-harvest losses, particularly for groundnuts (33.1%) and cowpeas (25.9%). These losses occur when farmers do not have access to proper storage infrastructure, such as silos, warehouses, or improved granaries, which are necessary to protect crops from environmental factors and pests. The lack of such facilities forces farmers to store their produce in suboptimal conditions, often in makeshift structures that are not sealed or protected from humidity, rodents, or insects. For groundnuts, inadequate storage can lead to increased vulnerability to mold and pests, while cowpeas, being highly perishable, can suffer from rapid quality degradation. The lower percentages for these crops compared to maize suggest that while the issue is recognized, it might be less acute due to alternative coping strategies. However, improving storage infrastructure is crucial for reducing these losses, ensuring that crops remain safe and marketable during storage.

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**Table 2: Causes of post-harvest losses**

<b>Causes</b>	<b>Maize</b>	<b>Cowpea</b>	<b>Groundnut</b>
Improper storage	128 (80.0)	100 (62.5)	78 (48.8)
Inadequate storage facilities	15 (9.4)	40 (25.0)	53 (33.1)
Theft	13 (8.1)	15 (9.4)	23 (14.4)
Rodents and pests	0 (0.0)	2 (1.3)	2 (1.3)
Inadequate cleaning	1 (0.6)	0 (0.0)	1 (0.6)
Mechanical damage	1 (0.6)	0 (0.0)	1 (0.6)
Poor shelling techniques	1 (0.6)	1 (0.6)	1 (0.6)
Poor transportation system	1 (0.6)	1 (0.6)	0 (0.0)
Contamination (Mycotoxins)	0 (0.0)	0 (0.0)	1 (0.6)
Mold and fungal growth	0 (0.0)	0 (0.0)	1 (0.6)

**Magnitude of post-harvest loss (phl) in physical**

Table 3 presents the results of the magnitude of post-harvest loss (PHL) in physical terms, highlighting the losses experienced during various stages of the post-harvest process, including threshing, winnowing, drying, transportation, and storage. The result reveals that post-harvest losses vary significantly across different crops and stages. Groundnut suffered the highest losses during threshing, with an average loss of 9.34 kg, while maize experienced the least loss at 7.8 kg. This trend is consistent across the other stages; winnowing, drying and transportation where groundnut consistently recorded higher losses compared to cowpea and maize. Maize, in contrast, consistently had the lowest losses throughout all the post-harvest stages. The higher losses observed in groundnut suggest that it may be more susceptible to damage or loss during mechanical operations like threshing and winnowing, possibly due to its physical characteristics or the techniques employed during these processes. The consistent lower losses for maize indicate that it may be more resilient to post-harvest handling, or that the existing methods used for maize are more effective in minimizing losses. This could be due to better-developed post-harvest technologies or practices for maize, reflecting a higher level of efficiency in its processing and storage.

**Table 3: Magnitude of post-harvest loss (phl) in physical**

<b>Quantity Losses at Various Stages</b>	<b>Maize (kg)</b>	<b>Cowpea (kg)</b>	<b>Groundnut (kg)</b>
Threshing	7.82	8.48	9.34
Winnowing	7.5	8.48	9.34
Drying	7.84	8.40	9.63
Transportation	7.55	8.90	9.84
Storage	8.14	12.5	9.95

Source: Field survey, 2024

Table 4 present the monetary loss incurred due to post-harvest losses. In terms of maize, the highest loss occurs during storage, amounting to ₦6512. This loss is attributed to issues like pest infestation, rodent damage, and poor storage conditions, which can significantly impact both the quantity and quality of maize stored. In terms of individual stages, the losses during threshing (₦6256), winnowing (₦6000), drying (₦6272), and transportation (₦6040) are

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relatively high, but storage represents the peak of financial loss, underscoring the importance of effective storage solutions to mitigate spoilage and deterioration. Cowpea, on the other hand, incurs the most substantial losses during storage as well, with a notable figure of ₦15000. This indicates severe issues in preserving the quality of cowpea post-harvest, likely due to the crop's susceptibility to pests and inadequate storage facilities. Losses are also considerable during threshing and winnowing, both pegged at ₦10176, highlighting challenges in efficiently processing cowpea beans. Transportation losses (₦10680). Groundnut showed same pattern where the highest loss occurs during storage, amounting to ₦6965. This is indicative of significant issues in maintaining groundnut quality over time, similar to the patterns observed in maize and cowpea. Other stages, including threshing (₦6538), winnowing (₦6538), drying (₦6741), and transportation (₦6888), also contribute to losses but not as extensively as the storage stage

Table 4: Monetary of post-harvest loss (phl)

<b>Quantity Losses at Various Stages</b>	<b>Maize (₦)</b>	<b>Cowpea (₦)</b>	<b>Groundnut (₦)</b>
Threshing	6256	10176	6538
Winnowing	6000	10176	6538
Drying	6272	10080	6741
Transportation	6040	10680	6888
Storage	6512	15000	6965
Price			
Maize	800		
Cowpea	1200		
Groundnut	700		

**Conclusion and recommendation**

Based on the findings of the study, it was concluded that respondents were food crop farmers experienced losses during various stages of the post-harvest process, including threshing, winnowing, drying, transportation and storage and groundnut consistently recorded higher losses compared to cowpea and maize throughout this stages. Furthermore improper storage and inadequate storage facilities were the major causes of post-harvest losses in the study area. In addition, Groundnut suffered the highest losses during threshing, with an average loss of 9.34 kg, while maize experienced the least loss at 7.8 kg. The study recommended that farmers should adopt improved post-harvest handling techniques and invest in better storage facilities to reduce losses. This could include using tarpaulins for drying, modern threshing equipment, and climate-controlled storage units. The government and agricultural NGOs should support farmers by providing access to affordable post-harvest technology and offering training on best practices.

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## CURRICULUM DESIGN, PLANNING AND DEVELOPMENT A THEORETICAL RESEARCH PAPER SUMMARY

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### **Abstract**

The urgent calls by educational stakeholders, particularly the Educational Center for Research and Development, to develop curricula highlight the significant role these curricula play in equipping learners with the skills, knowledge, and abilities needed for the country's essential specializations. However, despite numerous efforts, including workshops such as the second workshop initiated by the Educational Center on interactive curricula development, we have yet to witness a successful and effective educational plan that places curriculum development on the right track. These workshops emphasized shaping a generation that relies on interactive digital communication and enhancing teacher preparation.

This study, therefore, aims to shed light on the importance of designing modern curricula centered around the learner and based on competencies relevant to 21st-century needs. These curricula aim to equip learners with 21st-century skills. Through this study, we hope to highlight the significance of curriculum design by addressing several key questions:

- 1.1. What are the principles of curriculum design? What are its objectives and types?
- 1.2. How is curriculum planning carried out?
- 1.3. What role does curriculum development play in fostering 21st-century skills among learners?

By answering these questions, we will gradually move from defining curriculum design and its purpose to outlining its types, emphasizing the importance of planning, and shedding light on the reasons and importance of curriculum development. Ultimately, we aim to contribute to understanding how this development can be leveraged to enhance the quality of education and prepare learners with the skills necessary to keep pace with advancements in the field of education.

**Keywords:** Curriculum – Curriculum design - planning – development.

### **1. Definition of the curriculum**

The curriculum is considered one of the most important educational topics, as it forms the foundation of education. It occupies a distinctive position in both ancient and modern educational studies because it serves as a societal and global tool to achieve objectives aimed at building society and realizing comprehensive developmental plans, both long-term and short-term. It is a means of shaping and assessing the behaviors of individuals within society, both in the present and the future, as it equips students with concepts and facts that motivate them to engage in research and continue the pursuit of knowledge and learning.

The curriculum has been defined in various ways, reflecting the differing opinions and perspectives of authors and researchers. Some view it as a written plan, while others consider

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it a collection of subjects studied by students. However, due to scientific advancements and recent studies, the concept of the curriculum has expanded and become more comprehensive and objective compared to the past.

## 2. Foundations of Curriculum Design

Curricula at all educational levels are shaped by the nature of society, including its philosophy and culture, and thus vary from one society to another and even within the same society over different periods. Curricula reflect the prevailing intellectual patterns of a society, differing based on the philosophy adopted by each community. This philosophy is linked to the principles, goals, and values that serve as sources of the attitudes and beliefs governing behavior patterns and directing students' activities.

When a society adopts a specific philosophy, the curriculum is expected to reflect and embody that philosophy, utilizing all available resources to make its components integral to students' behavior. Here, philosophy refers to the way of life chosen by individuals, encompassing values, ideals, customs, traditions, and ideas that they believe in as a result of studying conflicting life values to live as effectively as possible. Consequently, curricula at all educational levels align with society's nature in terms of its philosophy and culture, leading to variations across societies and even within the same society over time.

Curricula reflect the dominant intellectual trends of societies, differing with the philosophy adopted by each. This philosophy is connected to principles, goals, and values that influence behavior patterns and direct students' activities. Through curricula that embody social philosophy, these principles are transformed into behaviors practiced by students in alignment with the various demands of life in the society they live in and belong to. Since schools are social institutions established by societies to ensure their continuity and prepare individuals to fulfill their responsibilities, it is natural for curricula to reflect societal aspirations.

Given the strong connection between philosophy and education—being two sides of the same coin, where the first represents theoretical life philosophy with its ideals and the second represents the practical method of implementing this philosophy—it is evident that educational movements stem from philosophical doctrines. Despite differences among these doctrines, educational philosophy governs all aspects of the educational process, including curricula, teaching methods, school administration, and human relations. This places a significant responsibility on curriculum planners to design curricula in accordance with the educational philosophy that guides the entire educational endeavor.

In addition to philosophical foundations, it is essential to center the student in the educational process. The success of this process depends on understanding the student's nature, which enhances the teacher's ability to guide them. Since humans are holistic beings, it is impossible to separate their various aspects of growth—intellectual, physical, emotional, and social. Furthermore, as individuals are inherently dynamic and capable of evolving based on their societal circumstances, curricula must address all aspects of their development. This requires considering the interaction of the student's physical, intellectual, social, emotional, and spiritual growth and recognizing that growth is a continuous and gradual process. Each stage of a student's development prepares them for the next, holding significance in their life. Therefore, curricula must be flexible and progressive, offering diverse experiences that adapt to students' developmental needs.

## 3. The purpose of curriculum design

After outlining the foundations of curriculum design, it is essential to address the key purposes

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of curriculum design, especially since this has become an urgent educational necessity in our time. The most important purposes of curriculum design include:

### **3.1. Enhancing Student Engagement**

Teachers can plan activities within curriculum design that enhance student participation in the classroom. For instance, they may plan educational games that encourage students to engage in discussions, dialogues, and interactive learning.

### **3.2. Improving the Learning Environment**

Teachers can improve the classroom environment by utilizing curriculum design, as it allows for better organization and efficiency in lesson planning.

### **3.3. Developing Learning Objectives**

Teachers can develop specific learning objectives for their classes by creating curriculum designs tailored to each goal. For example, if a class goal involves learning the alphabet by the end of the year, they can design lesson plans that teach the alphabet in a fun and innovative way.

### **3.4. Tracking Student Progress**

Teachers often design their curricula to help monitor student progress by including various assessments within their curriculum designs. This helps identify students who may need additional support in their coursework.

## **4. Types of curriculum design**

Teachers can choose the type of curriculum design they want to use based on the class size and the educational needs of their students. Schools may also combine subject-centered and learner-centered curricula to create a design that covers appropriate topics while accommodating a variety of learning styles. Below are the three most commonly adopted types of curriculum design according to experts:

### **4.1. Subject-Centered Design**

Experts use subject-centered curriculum design when creating a curriculum focused on a particular subject or educational topic. This type of curriculum emphasizes the content rather than teaching methods. For example, experts may design a curriculum that solely focuses on mathematical concepts using general activities that address diverse learning styles.

Subject-centered curriculum design includes detailed information about the topic being studied and typically provides specific details about activities, courses, and assessments that the teacher can implement for each subject. This type of design is commonly used for larger classes, as it is challenging for learner-centered curricula to address the needs of all students in a single classroom. Subject-centered designs are generally easier to implement for such settings.

### **4.2. Learner-Centered Design**

Learner-centered curriculum design focuses on students and involves creating a curriculum based on their needs. Curriculum experts can design a plan tailored to individual students or create a curriculum design for the entire class. For instance, an expert may develop a curriculum design for a student who struggles to maintain attention for long periods by incorporating

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numerous small activities requiring less concentration. If the entire class prefers group work, the curriculum might include activities requiring both small and large group collaborations. Learner-centered curriculum designs often allow students to choose their tasks, activities, and lessons based on their preferred learning style. This approach helps teachers motivate students to take ownership of their education. While this design can be challenging for teachers due to the need for detailed instructions catering to various learning styles, it can be beneficial for smaller classes or schools with fewer students, where teachers can more easily focus on the individual needs of each student.

### **4.3. Problem-Centered Design**

Problem-centered curriculum design focuses on specific educational challenges faced by students. Teachers can use this design after identifying areas where students need improvement. For example, if a teacher observes that a student struggles with a specific concept, this design can help address the issue and improve understanding.

Additionally, teachers can benefit from problem-centered curricula to address common teaching challenges. This type of design emphasizes practical problem-solving and helps students engage actively in overcoming obstacles, leading to a better understanding of the subject matter.

## **5. Curriculum planning**

Curriculum planning refers to the process of collecting relevant information from various sources, organizing, and classifying it to propose learning experiences or activities that help learners achieve curriculum objectives. This process considers the general and specific teaching objectives, based on social, psychological, philosophical, and cognitive foundations of the curriculum, as well as other essential standards for effective planning. It relies on operational tasks that can be summarized in the following steps:

### **5.1. Clarifying the Rationale**

This involves providing logical reasons for designing a new school curriculum before starting the process. The stronger and more pedagogically sound these justifications are, the more likely the new curriculum will be accepted by key stakeholders, such as teachers, supervisors, students, parents, and other educational stakeholders. This step should be approached carefully and presented convincingly, avoiding sudden announcements or rushed planning without consulting stakeholders, as this might lead to opposition, particularly from teachers.

For instance, curriculum planners in Lebanon justify the transition to a new competency-based approach as a replacement for the previous objective-based methodology, emphasizing that the older programs were designed decades ago and no longer align with current scientific, technological, and educational advancements.

### **5.2. Defining the Scope of the Curriculum**

Once planners gain stakeholder approval, the next step is to define the scope of the curriculum. This involves determining the focus of the new curriculum and the elements to prioritize. The focus could be:

**5.2.1. Student-Centered**, requiring a reduction in the volume of content and an increase in educational activities and experiences inside or outside the school.

**5.2.2. Society-Centered**, emphasizing the inclusion of societal issues across various

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fields, such as economics, politics, culture, health, and more.

**5.2.3.** Content-Centered, focusing on detailed subject matter while minimizing student activities.

In some cases, planners may decide to address all three aspects—students, society, and content—simultaneously.

## **5.3. Setting Curriculum Objectives**

This step is considered one of the most critical in curriculum planning. It involves specifying educational objectives that align with study areas distributed across the academic year. Clear objectives serve as a guide for both evaluating the previous planning phase and directing subsequent steps.

## **5.4. Selecting and Organizing Curriculum Content**

After defining objectives, planners must select and organize curriculum content, which serves as the primary tool for achieving these objectives. This involves carefully choosing relevant and appropriate content from a vast pool of available knowledge across various disciplines, guided by the following criteria:

**5.4.1.** Relevance: Content must align with set objectives and reflect verified, modern ideas.

**5.4.2.** Significance: Selected content should not only include facts but also hold importance for achieving objectives and be applicable in practice.

**5.4.3.** Student Interest: Content should engage students by addressing issues and scenarios that capture their interest.

**5.4.4.** Learnability: The curriculum must suit students' abilities, maturity, and prior knowledge while accounting for individual differences to maintain engagement.

**5.4.5.** From Whole to Part: Knowledge should progress from general concepts to detailed ones.

**5.4.6.** From Concrete to Abstract: Content should match students' cognitive development, transitioning to more abstract topics as they grow.

**5.4.7.** From Simple to Complex: Concepts should advance from easy-to-understand to more challenging topics.

**5.4.8.** From Known to Unknown: New knowledge should build on students' prior experiences.

## **5.5. Determining Learning Activities**

This step involves selecting activities and experiences that bring vitality to the learning process. Activities should enrich different learning styles, offer opportunities for individual work, and gradually transition from individual to group activities, considering varying levels of difficulty.

## **5.6. Choosing Teaching Methods and Educational Resources**

The selection of teaching methods and resources is central to curriculum planning. These must align with the subject matter, facilitating comprehension and maintaining students' interest in learning.

## **5.7. Defining Assessment Methods**

Implementing a curriculum will not meet its objectives unless teachers understand the

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importance of assessment. Assessment serves as the primary tool for evaluating various stages of the teaching-learning process and the achievement of educational goals. It is essential for teachers, students, parents, and educational authorities. Curriculum designers prioritize specifying various assessment methods, tools, and stages to assist teachers in identifying gaps and making informed judgments about their students and teaching effectiveness.

## **6. Reasons for Curriculum Development**

Curriculum development plays a vital role in enhancing the educational process and providing a better learning experience by addressing learners' needs and interests more effectively. This is achieved through delivering relevant and engaging content that motivates students, improves their understanding, and fosters their participation in the learning process. Below are the key reasons highlighting the importance of curriculum development:

### **6.1. Rapid Changes Due to Scientific Progress**

The fast pace of scientific advancements necessitates frequent updates to school textbooks to ensure they align with the latest developments across various fields.

### **6.2. Increased Societal Focus on Education**

Society's growing interest in education and its continuous questioning of the effectiveness of existing curricula are driven by dissatisfaction with the outcomes of educational processes and their results.

### **6.3. Addressing Weaknesses and Strengthening Strengths**

Curriculum development aims to improve the educational system by addressing the weaknesses and building on the strengths of current curricula, ensuring they meet learners' needs, resolve their challenges, and cater to their abilities.

### **6.4. Reducing Disparities in Learners' Needs**

The diversity in learners' abilities, interests, and learning styles necessitates flexible and varied curricula that cater to their individual needs, maximizing the benefits of the learning process.

### **6.5. Enhancing Learners' Skills**

Skills development can be better achieved through interactive and participatory curricula, incorporating practical projects and activities that enhance learners' practical and applied capabilities.

### **6.6. Promoting Critical Thinking**

Activities that encourage analysis and critical thinking can be integrated into curricula to develop students' ability to deeply understand and critically evaluate information.

### **6.7. Aligning with Modern Developments**

As the world evolves rapidly and technology and knowledge advance continuously, curricula must reflect the latest developments and information in various fields to remain relevant and engaging.

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## 6.8. Building Confidence and Achieving Excellence

Curriculum content can be designed to boost students' self-confidence and encourage the development of new skills, motivating them to perform better and reach their full potential.

## 6.9. Career Path Guidance

By aligning educational curricula with students' interests and providing practical information about the requirements of various fields, students are empowered to make informed decisions about their future career paths.

## 7. The Role of Curriculum Development in Enhancing 21st-Century Skills for Learners

The term 21st-century skills refers to identifiable, measurable, and teachable real-world skills that learners need to keep pace with today's global developments. These skills must be considered during curriculum development. According to the Partnership for 21st Century Skills, these competencies are essential for success in the modern workforce. Below are some key skills that curriculum development can help nurture:

### 7.1. Innovation Skills

Innovation enables learners to discover alternatives, brainstorm ideas, find solutions, rethink existing models, and generate new knowledge. However, innovation extends beyond mere "thinking outside the box." The 21st century requires openness to new and diverse ideas, the ability to provide constructive feedback, acknowledgment of the limits of new ideas, and the value of older ones. Transforming failure into opportunity is also essential. By incorporating innovative educational activities, curricula can foster creative thinking, problem-solving, and the ability to adapt to changing contexts.

### 7.2. Problem-Solving Skills

Problem-solving is crucial for navigating life's challenges and overcoming obstacles that hinder personal and professional growth. It equips learners with structured and diverse thinking strategies, fostering reflective and critical thought by leveraging prior knowledge and available data. Educational curricula should be enriched with problem-solving scenarios that stimulate curiosity and scientific inquiry, encouraging logical reasoning and data interpretation.

This approach strengthens collaboration by involving learners in group discussions and activities, providing opportunities to articulate their ideas, persuade others, and defend their perspectives. Such educational strategies prepare learners to evaluate multiple solutions, make informed decisions, and tackle real-world challenges effectively.

### 7.3. Critical Thinking Skills

Critical thinking entails the ability to identify problems, ask questions, classify information, evaluate evidence, weigh alternatives, consider different perspectives, analyze arguments, understand complexities, and address unfamiliar issues. While traditional curricula often integrate such skills in science, civics, and mathematics, the objective is to ensure their application across all life domains.

To cultivate this skill, educational practices should encourage inquiry-based learning, turning learners into curious explorers of the world. By asking thought-provoking questions and seeking answers, learners gain the ability to generate ideas, apply knowledge, and critically



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analyze information. A well-designed curriculum fosters a culture of inquiry, enabling educators and learners to engage in continuous discovery.

## 7.4. Communication Skills

Communication is vital for developing abilities such as reading, listening, interpreting, speaking, writing, persuading, negotiating, and debating. These skills are central to 21st-century education, which emphasizes active engagement and reflective learning.

Curricula should include activities that promote effective listening, open-ended questioning, collaborative discussions, and interactive storytelling. Such approaches ensure that learners not only master communication but also gain confidence in expressing their thoughts and engaging in meaningful exchanges.

## 7.5. Creative Thinking Skills

Creative thinking closely relates to problem-solving, as it involves cognitive processes that directly contribute to resolving complex or ambiguous situations. Creativity encompasses traits like fluency, flexibility, originality, sensitivity to problems, and elaboration. It combines abilities, readiness, and personal characteristics that can be nurtured to produce unique and innovative outcomes.

Developing creativity requires curricula that address learners' emotional, intellectual, and scientific needs while incorporating innovative teaching strategies like problem-based learning, exploratory learning, and brainstorming. By embedding such practices into learning experiences, educators can effectively foster creativity.

## 7.6. Collaboration Skills

Collaboration is essential in today's interconnected world. Most modern workplace challenges demand interdisciplinary skills and teamwork. Curricula should emphasize cooperative skills that enable individuals to set goals, allocate resources, fulfill group roles, manage time, negotiate, resolve conflicts, and build teams effectively.

Innovative teaching methods, such as collaborative games, storytelling, brainstorming, and group projects, can be integrated into curricula to promote teamwork. These approaches provide learners with a safe space to practice and develop their collaborative abilities, preparing them for diverse professional and social contexts.

## Conclusion

The development of curricula must focus on fostering 21st-century skills, ensuring that learners are equipped with interactive competencies necessary for academic and professional success. Integrating these skills into curricula creates a structured framework that engages learners in meaningful learning experiences. This, in turn, builds their confidence, fosters innovation, and prepares them for leadership and active participation in civic life.

Ultimately, modern educational philosophies should emphasize cultivating these skills as a core element of curriculum design. By embedding values, principles, and targeted objectives into educational systems, curriculum developers can align with the demands of an increasingly complex, specialized, and technologically advanced world.

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**REFORMULATION OF TWO STEP IMPLICIT LINEAR MULTI-STEP BLOCK  
HYBRID METHOD INTO RUNGE –KUTTA TYPE METHOD FOR THE  
SOLUTION OF SECOND ORDER INITIAL VALUE PROBLEM (IVP)**

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**Abstract**

Second-order ordinary differential equations (ODEs) is unavoidable in scientific and engineering fields. This research focuses on the reformulation of two-step implicit linear multistep block hybrid method into a seven-stage Runge-Kutta type method for the solution of second-order initial value problems (IVPs). A two-step, four-off-grid-point implicit block hybrid collocation method for first-order initial value problems was derived. Its order and error constants were determined, which shows that the schemes were of order 8, 8, 8, 8, 8 and 9 with respective error constants of  $\frac{275}{158723712}$ ,  $\frac{8}{6200145}$ ,  $\frac{1}{653184}$ ,  $\frac{8}{6200145}$ ,  $\frac{275}{158723712}$ , and  $-\frac{1}{3061800}$ . The derived block method was reformulated into a seven-stage Runge-Kutta type method (RKTm) for the solution of first-order ordinary differential equations; this reformulation was extended to handle the required second-order ordinary differential equations. The second-order Runge-Kutta-type method derived was implemented on numerical experiments. The method was found to be better than existing methods in the literature.

**Keywords:** Implicit, Hybrid block method, collocation, Runge-Kutta type method, linear multistep method.

### 1.0 Introduction

The accurate numerical solution of second-order initial value problems (IVPs) in ordinary differential equations (ODEs) remains a significant challenge in scientific and engineering computations (Datsko and Kutniv, 2024). These problems are mostly expressed in the general form:

$$y''(x) = f(x, y, y'), y(x_0) = y_0, y'(x_0) = y'_0 \quad (1)$$

that arise in several fields such as applied mathematics, physics and engineering (Denis, 2020). Conventional methods always reduce second-order ODEs into systems of first-order equations, hence it can cause additional computational burden and inefficiencies (Li *et al.*, 2024). To tackle these challenges, linear multi-step methods (LMMs) together with the hybrid and block scheme have been developed for direct solution of second-order ODEs (Olaleye and Fiyinfoluwa, 2023; Taiwo *et al.*, 2023).

Block hybrid linear multi-step methods are known for their ability to compute solutions at multiple points within single step, improving its multi solution processing ability and reducing approximating errors (Li *et al.*, 2024; Omole *et al.*, 2024). However, these methods mostly depend on already-computed starting values and cannot withstand variable step sizes (Sharma, 2021). Reformulating these methods into the Runge–Kutta Type method give an avenue to by-pass these challenges by bringing in a self-starting property and better adaptability to changing step sizes.

This work focuses on reformulating a two-step block hybrid linear multi-step method into a Runge–Kutta-Type scheme for directly solving second-order IVPs. By utilizing the adaptability of Runge–Kutta methods and the efficiency of hybrid block methods, the new proposed techniques seek to improve the numerical performance and flexibility of finding the solution of second-order ODEs. The theoretical analysis of the reformulated method, including its stability and convergence properties, is complemented by numerical experiments to demonstrate its effectiveness and accuracy. This study complement the advancement in the numerical methods for solving IVPs, offering a robust and versatile tool for current computational challenges.

### 2.0 Materials and Methods

The derivation of Seven – Stage Runge – Kutta Type method reformulated from two step block hybrid linear multistep method with four intra-step points is discussed in this section. First order two step block hybrid linear multistep method with four off-grids point was reformulated to first order Runge - Kutta Type method.

In general, initial value problem (IVP) in first Order Differential Equations (ODEs) is of the form of form:

$$y'(x) = f(x, y), y(x_0) = y_0 \quad (2)$$

We assume power series of the form:

$$y(x) = \sum_{i=0}^{l-1} a_i x^i, l = p + c$$

(3) Differentiating (3) gives:

$$y^1(x) = \sum_{i=0}^{l-1} i a_i x^{i-1} \quad (4)$$

We find  $a_i$ 's using matrix inversion techniques to obtain a continuous implicit scheme of the

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form:

$$y(x) = \alpha_0(x)y_n + h \left( \beta_{n+\frac{1}{3}}f_{n+\frac{1}{3}} + \beta_{n+\frac{2}{3}}f_{n+\frac{2}{3}} + \beta_{n+\frac{4}{3}}f_{n+\frac{4}{3}} + \beta_{n+\frac{5}{3}}f_{n+\frac{5}{3}} + \left(\sum_{i=0}^2 \beta_i(x)f_{n+i}\right) \right) \quad (5)$$

Interpolating (3) at  $x = \{x_n\}$  and collocating (4) at  $x = \left\{x_n, x_{n+\frac{1}{3}}, x_{n+\frac{2}{3}}, x_{n+1}, x_{n+\frac{4}{3}}, x_{n+\frac{5}{3}}, x_{n+2}\right\}$ .

It can be expressed in matrix form as:

$$\begin{bmatrix} 1 & x_n & x_n^2 & x_n^3 & x_n^4 & x_n^5 & x_n^6 & x_n^7 \\ 0 & 1 & 2x_n & 3x_n^2 & 4x_n^3 & 5x_n^4 & 6x_n^5 & 7x_n^6 \\ 0 & 1 & 2x_{n+\frac{1}{3}} & 3(x_{n+\frac{1}{3}})^2 & 4(x_{n+\frac{1}{3}})^3 & 5(x_{n+\frac{1}{3}})^4 & 6x_{n+\frac{1}{3}}^5 & 7x_{n+\frac{1}{3}}^6 \\ 0 & 1 & 2x_{n+\frac{2}{3}} & 3(x_{n+\frac{2}{3}})^2 & 4(x_{n+\frac{2}{3}})^3 & 5(x_{n+\frac{2}{3}})^4 & 6(x_{n+\frac{2}{3}})^5 & 7(x_{n+\frac{2}{3}})^6 \\ 0 & 1 & 2x_{n+1} & 3(x_{n+1})^2 & 4(x_{n+1})^3 & 5(x_{n+1})^4 & 6(x_{n+1})^5 & 7(x_{n+1})^6 \\ 0 & 1 & 2x_{n+\frac{4}{3}} & 3(x_{n+\frac{4}{3}})^2 & 4(x_{n+\frac{4}{3}})^3 & 5(x_{n+\frac{4}{3}})^4 & 6(x_{n+\frac{4}{3}})^5 & 7(x_{n+\frac{4}{3}})^6 \\ 0 & 1 & 2x_{n+\frac{5}{3}} & 3(x_{n+\frac{5}{3}})^2 & 4(x_{n+\frac{5}{3}})^3 & 5(x_{n+\frac{5}{3}})^4 & 6(x_{n+\frac{5}{3}})^5 & 7(x_{n+\frac{5}{3}})^6 \\ 0 & 1 & 2x_{n+2} & 3(x_{n+2})^2 & 4(x_{n+2})^3 & 5(x_{n+2})^4 & 6(x_{n+2})^5 & 7(x_{n+2})^6 \end{bmatrix} \begin{bmatrix} a_0 \\ a_1 \\ a_2 \\ a_3 \\ a_4 \\ a_5 \\ a_6 \\ a_7 \end{bmatrix} = \begin{bmatrix} y_n \\ hf_n \\ hf_{n+\frac{1}{3}} \\ hf_{n+\frac{2}{3}} \\ hf_{n+1} \\ hf_{n+\frac{4}{3}} \\ hf_{n+\frac{5}{3}} \\ hf_{n+2} \end{bmatrix} \quad (6)$$

Using Maple Mathematical software we find the values of  $a$ 's in (5) which gave the continuous formula

$$y(x) = \alpha_0(x)y_n + h \left[ \beta_n f_n + \beta_{n+\frac{1}{3}} f_{n+\frac{1}{3}} + \beta_{n+\frac{2}{3}} f_{n+\frac{2}{3}} + \beta_{n+1} f_{n+1} + \beta_{n+\frac{4}{3}} f_{n+\frac{4}{3}} + \beta_{n+\frac{5}{3}} f_{n+\frac{5}{3}} + \beta_{n+2} f_{n+2} \right] \quad (7)$$

Taking  $t = \frac{x-x_{n+1}}{h} \Rightarrow \frac{dt}{dx} = \frac{1}{h}$  (8)

Evaluating (6) at  $x = x_{n+1}, i = \frac{1}{3}, \frac{2}{3}, 1, \frac{4}{3}, \frac{5}{3},$  and 2 yields discrete implicit block method

$$\left. \begin{aligned} y_{n+2} &= y_n + h \left( \frac{41}{420} f_n + \frac{18}{35} f_{n+\frac{1}{3}} + \frac{9}{140} f_{n+\frac{2}{3}} + \frac{68}{105} f_{n+1} + \frac{9}{140} f_{n+\frac{4}{3}} + \frac{18}{35} f_{n+\frac{5}{3}} + \frac{41}{420} f_{n+2} \right) \\ y_{n+\frac{5}{3}} &= y_n + h \left( \frac{3715}{36288} f_n + \frac{725}{1512} f_{n+\frac{1}{3}} + \frac{2125}{12096} f_{n+\frac{2}{3}} + \frac{250}{567} f_{n+1} + \frac{3875}{12096} f_{n+\frac{4}{3}} + \frac{235}{1512} f_{n+\frac{5}{3}} - \frac{275}{36288} f_{n+2} \right) \\ y_{n+\frac{4}{3}} &= y_n + h \left( \frac{286}{2835} f_n + \frac{464}{945} f_{n+\frac{1}{3}} + \frac{128}{945} f_{n+\frac{2}{3}} + \frac{1504}{2835} f_{n+1} + \frac{58}{945} f_{n+\frac{4}{3}} + \frac{16}{945} f_{n+\frac{5}{3}} - \frac{8}{2835} f_{n+2} \right) \\ y_{n+1} &= y_n + h \left( \frac{137}{1344} f_n + \frac{27}{56} f_{n+\frac{1}{3}} + \frac{387}{2240} f_{n+\frac{2}{3}} + \frac{34}{105} f_{n+1} - \frac{243}{2240} f_{n+\frac{4}{3}} + \frac{9}{280} f_{n+\frac{5}{3}} - \frac{29}{6720} f_{n+2} \right) \\ y_{n+\frac{2}{3}} &= y_n + h \left( \frac{1139}{11340} f_n + \frac{94}{189} f_{n+\frac{1}{3}} + \frac{11}{3780} f_{n+\frac{2}{3}} + \frac{332}{2835} f_{n+1} - \frac{269}{3780} f_{n+\frac{4}{3}} + \frac{22}{945} f_{n+\frac{5}{3}} - \frac{37}{11340} f_{n+2} \right) \\ y_{n+\frac{1}{3}} &= y_n + h \left( \frac{19087}{181440} f_n + \frac{2713}{7560} f_{n+\frac{1}{3}} - \frac{15487}{60480} f_{n+\frac{2}{3}} + \frac{586}{2835} f_{n+1} - \frac{6737}{60480} f_{n+\frac{4}{3}} + \frac{263}{7560} f_{n+\frac{5}{3}} - \frac{863}{181440} f_{n+2} \right) \end{aligned} \right\}$$

Arranging the discrete scheme (8) in matrix equation form:

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} y_{n+\frac{1}{3}} \\ y_{n+\frac{2}{3}} \\ y_{n+1} \\ y_{n+\frac{4}{3}} \\ y_{n+\frac{5}{3}} \\ y_{n+2} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} y_{n-\frac{5}{3}} \\ y_{n-\frac{4}{3}} \\ y_{n-1} \\ y_{n-\frac{2}{3}} \\ y_{n-\frac{1}{3}} \\ y_n \end{bmatrix}$$

$$\begin{matrix}
 \begin{bmatrix}
 0 & 0 & 0 & 0 & 0 & \frac{19087}{4200} \\
 0 & 0 & 0 & 0 & 0 & \frac{181440}{1139} \\
 0 & 0 & 0 & 0 & 0 & \frac{11340}{137} \\
 0 & 0 & 0 & 0 & 0 & \frac{1344}{286} \\
 0 & 0 & 0 & 0 & 0 & \frac{2835}{3715} \\
 0 & 0 & 0 & 0 & 0 & \frac{36288}{41} \\
 0 & 0 & 0 & 0 & 0 & \frac{41}{4200}
 \end{bmatrix}
 \begin{bmatrix}
 f_{n-\frac{5}{3}} \\
 f_{n-\frac{4}{3}} \\
 f_{n-1} \\
 f_{n-\frac{2}{3}} \\
 f_{n-\frac{1}{3}} \\
 f_n
 \end{bmatrix}
 +
 \begin{bmatrix}
 \frac{2713}{35} & \frac{-15487}{140} & \frac{586}{105} & \frac{-6737}{140} & \frac{263}{35} & \frac{-863}{420} \\
 \frac{7560}{94} & \frac{60480}{11} & \frac{2835}{332} & \frac{60480}{-269} & \frac{7560}{22} & \frac{181440}{-37} \\
 \frac{189}{27} & \frac{3780}{387} & \frac{2835}{34} & \frac{3780}{-243} & \frac{945}{9} & \frac{11340}{-29} \\
 \frac{56}{464} & \frac{2240}{128} & \frac{105}{1504} & \frac{2240}{58} & \frac{280}{16} & \frac{6720}{-8} \\
 \frac{945}{725} & \frac{945}{2125} & \frac{2835}{250} & \frac{945}{3875} & \frac{945}{235} & \frac{2835}{-275} \\
 \frac{1512}{18} & \frac{12096}{9} & \frac{567}{68} & \frac{12096}{9} & \frac{1512}{18} & \frac{36288}{41} \\
 \frac{18}{35} & \frac{9}{140} & \frac{68}{105} & \frac{9}{140} & \frac{18}{35} & \frac{41}{420}
 \end{bmatrix}
 \begin{bmatrix}
 f_{n+\frac{1}{3}} \\
 f_{n+\frac{2}{3}} \\
 f_{n+1} \\
 f_{n+\frac{4}{3}} \\
 f_{n+\frac{5}{3}} \\
 f_{n+2}
 \end{bmatrix}
 \end{matrix}
 \tag{10}$$

## 2.1 Analysis of the Block Method

### 2.1.1 Order and error constant of the block method

We discuss the approximation of the order and error constant of the block using the difference equation:

$$L[y(x), h] = \sum_{i=0}^k [\alpha_i y(x + ih) - h\beta_i y'(x + ih)] \tag{11}$$

If we assume that  $y(x)$  has as many higher derivatives as we require, we can expand the terms in (11) as a Taylor series about the point  $x$  to obtain the expansion

$$L[y(x), h] = C_0 y(x) + C_1 h y^{(1)}(x) + \dots + C_q h^q y^{(q)}(x) + \dots \tag{12}$$

Where

$$C_0 = \alpha_0 + \alpha_1 + \dots + \alpha_k$$

$$C_1 = (\alpha_1 + \alpha_2 + \dots + k\alpha_k) - (\beta_0 + \dots + k^{(q-1)}\beta_k)$$

⋮

⋮

$$C_q = \frac{1}{q!} (\alpha_1 + \alpha_2 + \dots + k^q \alpha_k) - \frac{1}{(q-1)!} (\beta_1 + \dots + k^{(q-1)} \beta_k)$$

Where  $q = 2, 3, \dots, k$

$$\text{For } y_{n+2} = y_n + h \left( \frac{41}{420} f_n + \frac{18}{35} f_{n+\frac{1}{3}} + \frac{9}{140} f_{n+\frac{2}{3}} + \frac{68}{105} f_{n+1} + \frac{9}{140} f_{n+\frac{4}{3}} + \frac{18}{35} f_{n+\frac{5}{3}} + \frac{41}{420} f_{n+2} \right)$$

The order and error constant is obtained using these coefficient:

$$\alpha_0 = -1, \alpha_2 = 1, \beta_0 = \frac{41}{420}, \beta_{\frac{1}{3}} = \frac{18}{35}, \beta_{\frac{2}{3}} = \frac{9}{140}, \beta_1 = \frac{68}{105}, \beta_{\frac{4}{3}} = \frac{9}{140}, \beta_{\frac{5}{3}} = \frac{18}{35}, \beta_2 = \frac{41}{420}$$

The computation is given in the form:

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$$\begin{aligned}
 & \left[ \begin{array}{c} C_0 \\ C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_5 \\ C_6 \\ C_7 \\ C_8 \\ C_9 \end{array} \right] = \left[ \begin{array}{c} \alpha_2 + \alpha_0 \\ 2\alpha_2 - (\beta_0 + \beta_{\frac{1}{3}} + \beta_{\frac{2}{3}} + \beta_1 + \beta_{\frac{4}{3}} + \beta_{\frac{5}{3}} + \beta_2) \\ \frac{1}{2!} 2^2 \alpha_2 - \frac{1}{1!} \left( \frac{1}{3} \beta_{\frac{1}{3}} + \frac{2}{3} \beta_{\frac{2}{3}} + \beta_1 + \frac{4}{3} \beta_{\frac{4}{3}} + \frac{5}{3} \beta_{\frac{5}{3}} + 2\beta_2 \right) \\ \frac{1}{3!} 2^3 \alpha_2 - \frac{1}{2!} \left( \left( \frac{1}{3} \right)^2 \beta_{\frac{1}{3}} + \left( \frac{2}{3} \right)^2 \beta_{\frac{2}{3}} + \beta_1 + \left( \frac{4}{3} \right)^2 \beta_{\frac{4}{3}} + \left( \frac{5}{3} \right)^2 \beta_{\frac{5}{3}} + 2^2 \beta_2 \right) \\ \frac{1}{4!} 2^4 \alpha_2 - \frac{1}{3!} \left( \left( \frac{1}{3} \right)^3 \beta_{\frac{1}{3}} + \left( \frac{2}{3} \right)^3 \beta_{\frac{2}{3}} + \beta_1 + \left( \frac{4}{3} \right)^3 \beta_{\frac{4}{3}} + \left( \frac{5}{3} \right)^3 \beta_{\frac{5}{3}} + 2^3 \beta_2 \right) \\ \frac{1}{5!} 2^5 \alpha_2 - \frac{1}{4!} \left( \left( \frac{1}{3} \right)^4 \beta_{\frac{1}{3}} + \left( \frac{2}{3} \right)^4 \beta_{\frac{2}{3}} + \beta_1 + \left( \frac{4}{3} \right)^4 \beta_{\frac{4}{3}} + \left( \frac{5}{3} \right)^4 \beta_{\frac{5}{3}} + 2^4 \beta_2 \right) \\ \frac{1}{6!} 2^6 \alpha_2 - \frac{1}{5!} \left( \left( \frac{1}{3} \right)^5 \beta_{\frac{1}{3}} + \left( \frac{2}{3} \right)^5 \beta_{\frac{2}{3}} + \beta_1 + \left( \frac{4}{3} \right)^5 \beta_{\frac{4}{3}} + \left( \frac{5}{3} \right)^5 \beta_{\frac{5}{3}} + 2^5 \beta_2 \right) \\ \frac{1}{7!} 2^7 \alpha_2 - \frac{1}{6!} \left( \left( \frac{1}{3} \right)^6 \beta_{\frac{1}{3}} + \left( \frac{2}{3} \right)^6 \beta_{\frac{2}{3}} + \beta_1 + \left( \frac{4}{3} \right)^6 \beta_{\frac{4}{3}} + \left( \frac{5}{3} \right)^6 \beta_{\frac{5}{3}} + 2^6 \beta_2 \right) \\ \frac{1}{8!} 2^8 \alpha_2 - \frac{1}{7!} \left( \left( \frac{1}{3} \right)^7 \beta_{\frac{1}{3}} + \left( \frac{2}{3} \right)^7 \beta_{\frac{2}{3}} + \beta_1 + \left( \frac{4}{3} \right)^7 \beta_{\frac{4}{3}} + \left( \frac{5}{3} \right)^7 \beta_{\frac{5}{3}} + 2^7 \beta_2 \right) \\ \frac{1}{9!} 2^9 \alpha_2 - \frac{1}{8!} \left( \left( \frac{1}{3} \right)^8 \beta_{\frac{1}{3}} + \left( \frac{2}{3} \right)^8 \beta_{\frac{2}{3}} + \beta_1 + \left( \frac{4}{3} \right)^8 \beta_{\frac{4}{3}} + \left( \frac{5}{3} \right)^8 \beta_{\frac{5}{3}} + 2^8 \beta_2 \right) \end{array} \right] = \\
 & \left[ \begin{array}{c} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 1 \end{array} \right] \\
 & \qquad \qquad \qquad (14) \\
 & \qquad \qquad \qquad \frac{1}{3061800}
 \end{aligned}$$

Using similar procedures to obtain the order and error constants of the schemes (8).

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**Table 2.1: Order and error constants of the scheme (8)**

Scheme	Order	Error Constant
$y_{n+\frac{1}{3}} = y_n + h \left( \frac{19087}{181440} f_n + \frac{2713}{7560} f_{n+\frac{1}{3}} - \frac{15487}{60480} f_{n+\frac{2}{3}} + \frac{586}{2835} f_{n+1} - \frac{6737}{60480} f_{n+\frac{4}{3}} + \frac{263}{7560} f_{n+\frac{5}{3}} - \frac{863}{181440} f_{n+2} \right)$	8	$\frac{275}{158723712}$
$y_{n+\frac{2}{3}} = y_n + h \left( \frac{1139}{11340} f_n + \frac{94}{189} f_{n+\frac{1}{3}} + \frac{11}{3780} f_{n+\frac{2}{3}} + \frac{332}{2835} f_{n+1} - \frac{269}{3780} f_{n+\frac{4}{3}} + \frac{22}{945} f_{n+\frac{5}{3}} - \frac{37}{11340} f_{n+2} \right)$	8	$\frac{8}{6200145}$
$y_{n+1} = y_n + h \left( \frac{137}{1344} f_n + \frac{27}{56} f_{n+\frac{1}{3}} + \frac{387}{2240} f_{n+\frac{2}{3}} + \frac{34}{105} f_{n+1} - \frac{243}{2240} f_{n+\frac{4}{3}} + \frac{9}{280} f_{n+\frac{5}{3}} - \frac{29}{6720} f_{n+2} \right)$	8	$\frac{1}{653184}$
$y_{n+\frac{4}{3}} = y_n + h \left( \frac{286}{2835} f_n + \frac{464}{945} f_{n+\frac{1}{3}} + \frac{128}{945} f_{n+\frac{2}{3}} + \frac{1504}{2835} f_{n+1} + \frac{58}{945} f_{n+\frac{4}{3}} + \frac{16}{945} f_{n+\frac{5}{3}} - \frac{8}{2835} f_{n+2} \right)$	8	$\frac{8}{6200145}$
$y_{n+\frac{5}{3}} = y_n + h \left( \frac{3715}{36288} f_n + \frac{725}{1512} f_{n+\frac{1}{3}} + \frac{2125}{12096} f_{n+\frac{2}{3}} + \frac{250}{567} f_{n+1} + \frac{3875}{12096} f_{n+\frac{4}{3}} + \frac{235}{1512} f_{n+\frac{5}{3}} - \frac{275}{36288} f_{n+2} \right)$	8	$\frac{275}{158723712}$
$y_{n+2} = y_n + h \left( \frac{41}{420} f_n + \frac{18}{35} f_{n+\frac{1}{3}} + \frac{9}{140} f_{n+\frac{2}{3}} + \frac{68}{105} f_{n+1} + \frac{9}{140} f_{n+\frac{4}{3}} + \frac{18}{35} f_{n+\frac{5}{3}} + \frac{41}{420} f_{n+2} \right)$	9	$-\frac{1}{3061800}$

**2.2 Reformulation of  $k = 2$  Block Hybrid Linear Multistep Method into Runge – Kutta Type Method**

**2.2.1: Butcher's Runge - Kutta methods for the first order ordinary differential equations**

Muhammad, (2020) defined an s-stage implicit Runge - Kutta methods for fist order ODEs in the form:

$$\left. \begin{aligned} y_{n+1} &= y_n + h \sum_{i=0}^s a_{ij} k_i \\ \text{Where } i &= 1, 2, 3, \dots, s \\ k_i &= f \left( x_i + \alpha_i h, y_n + h \sum_{i=0}^s a_{ij} k_i \right) \end{aligned} \right\} \quad (10)$$

The parameters  $\alpha_j, k_j$  and  $a_{ij}$  defined the method. In Butcher array form, it can be written as

$$\begin{array}{c|c} \alpha & \beta \\ \hline & W^T \end{array}$$

The Butcher array conditions for first order differential equation is stated as:

(i).  $\sum_{j=1}^s a_{ij} = c_i$       (ii).  $\sum_{j=1}^s b_j = 1$ . (11)

Source:(Muhammad, 2020)

Hence 9 is modified to satisfy the conditions which gave rise to the Butcher table.

(17)



**2.2.2: Butcher's Runge Kutta methods for the second order ordinary differential equations**

Consider general second order differential equations (ODEs) with initial value problems (IVP) of the form

$$y''(x) = f(x, y, y'(x)), y(0) = \varphi, y'(0) = \psi \quad (18)$$

Muhammad, (2020) defined an s-stage implicit Runge - Kutta type methods for second order ODEs in the form:

$$\left. \begin{aligned} y_{n+1} &= y_n + \alpha_j h y'_n + h^2 \sum_{i=1}^s a_{ij} k_i \\ y'_{n+1} &= y'_n + h \sum_{i=1}^s \bar{a}_{ij} k_i, \text{ where } i = 1, 2, 3, \dots, s \\ k_i &= f \left( x_i + \alpha_j h, y_n + \alpha_j h y'_n + h^2 \sum_{i=1}^s a_{ij} k_i, y'_n + h \sum_{i=1}^s \bar{a}_{ij} k_i \right) \end{aligned} \right\} \quad (13)$$

The parameters  $\alpha_j, k_j, a_{ij}$  and  $\bar{a}_{ij}$  defined the method. In Butcher array form, it can be written as:

$\alpha$	$\bar{A}$	$A$
	$\bar{b}^T$	$b$

C	A						
0	0	0	0	0	0	0	0
1	19087	2713	-15487	293	-6737	263	-863
$\frac{6}{6}$	362880	15120	120960	2835	120960	15120	362880
1	1139	47	11	166	-269	11	-37
$\frac{3}{3}$	22680	189	7560	2835	7560	945	22680
1	137	27	387	17	-243	9	-29
$\frac{2}{2}$	2688	112	4480	105	4480	560	13440
$\frac{3}{3}$	143	232	64	752	29	8	-4
$\frac{5}{5}$	2835	945	945	2835	945	945	2835
$\frac{6}{6}$	3715	725	2125	125	3875	235	-275
1	72576	3024	24192	567	24192	3024	72576
	41	9	9	32	9	9	41
	840	35	280	105	280	35	840
b=1	41	9	9	34	9	9	41
	840	35	280	105	280	35	840

where

$$A = a_{ij} = \beta^2, \bar{A} = \bar{a}_{ij} = \beta, \beta = \beta l, \bar{b} = w, b = w^T \beta$$

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Extending (16) to Butcher array for second order ODEs as:

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	19087	2713	-15487	293	-6737	263	-86	647	275	12013	9	7289	323	79
1/6	362880	15120	120960	2835	120960	15120	36288	103680	18144	-725760	560	-725760	90720	1451
1	1139	47	11	166	-269	11	-37	337	299	16	79	53	31	1
3/1	22680	189	7560	2835	7560	945	2268	22680	5670	-567	2835	-3240	5670	126
1	137	27	387	17	-243	9	-29	125	3	171	5	219	9	31
2/2	2688	112	4480	105	4480	560	1344	5376	32	-8960	112	-8960	1120	2688
1	143	232	64	752	29	8	-4	2	76	16	232	16	9	4
3/3	2835	945	945	2835	945	945	2835	63	567	-2835	2835	-567	4	(20)
1	3715	725	2125	125	3875	235	-27	5825	3175	125	125	1625	2	...
6	72576	3024	24192	567	24192	3024	72576	145152	18144	20736	1008	-145152	18144	1451
1	41	9	9	32	9	9	41	41	3	3	17	3	3	...
1	840	35	280	105	280	35	840	840	14	140	105	280	70	0
1	41	9	9	32	9	9	41	41	3	3	17	3	3	...
1	840	35	280	105	280	35	840	840	14	140	105	280	70	...
1	41	9	9	32	9	9	41	41	3	3	17	3	3	...
1	840	35	280	105	280	35	840	840	14	140	105	280	70	...
1	41	9	9	32	9	9	41	41	3	3	17	3	3	...
1	840	35	280	105	280	35	840	840	14	140	105	280	70	...
1	41	9	9	32	9	9	41	41	3	3	17	3	3	...
1	840	35	280	105	280	35	840	840	14	140	105	280	70	...
1	41	9	9	32	9	9	41	41	3	3	17	3	3	...
1	840	35	280	105	280	35	840	840	14	140	105	280	70	...
1	41	9	9	32	9	9	41	41	3	3	17	3	3	...
1	840	35	280	105	280	35	840	840	14	140	105	280	70	...

The (18) Butcher array satisfied the conditions for second order differential equations which is:

$$(i). \sum_{j=1}^s b_j = \frac{1}{2}. \quad \text{Source: (Muhammad, 2020)}$$

From (21) seven stage implicit Ruge-Kutta type method was obtained as (21) – (29):

$$y_{n+1} = y_n + hy' + h^2 \left( \frac{41}{840} k_1 + \frac{3}{14} k_2 + \frac{3}{140} k_3 + \frac{17}{105} k_4 + \frac{3}{280} k_5 + \frac{3}{70} k_6 \right) \quad (21)$$

$$y'_{n+1} = y' + h \left( \frac{41}{840} k_1 + \frac{9}{35} k_2 + \frac{9}{280} k_3 + \frac{34}{105} k_4 + \frac{9}{280} k_5 + \frac{9}{35} k_6 + \frac{41}{840} k_7 \right) \quad (22)$$

$$k_1 = f(x_n, y_n, y') \quad (23)$$

$$k_2 = f \left( x_n + \frac{1}{6} h, y_n + \frac{1}{6} hy'_n + h^2 \left( \frac{647}{103680} k_1 + \frac{275}{18144} k_2 - \frac{12013}{725760} k_3 + \frac{9}{560} k_4 - \frac{7289}{725760} k_5 + \frac{323}{90720} k_6 - \frac{79}{145152} k_7 \right), y' + h \left( \frac{19087}{362880} k_1 + \frac{2713}{15120} k_2 - \frac{15487}{120960} k_3 + \frac{293}{2835} k_4 - \frac{6737}{120960} k_5 + \frac{263}{15120} k_6 - \frac{863}{362880} k_7 \right) \right) \quad (24)$$

$$k_3 = f \left( x_n + \frac{1}{3} h, y_n + \frac{1}{3} hy'_n + h^2 \left( \frac{337}{22680} k_1 + \frac{299}{5670} k_2 - \frac{16}{567} k_3 + \frac{79}{2835} k_4 - \frac{53}{3240} k_5 + \frac{31}{5670} k_6 - \frac{1}{1260} k_7 \right), y' + h \left( \frac{1139}{22680} k_1 + \frac{47}{189} k_2 + \frac{11}{7560} k_3 + \frac{166}{2835} k_4 - \frac{269}{7560} k_5 + \frac{11}{945} k_6 - \frac{37}{22680} k_7 \right) \right) \quad (25)$$

$$k_4 = f \left( x_n + \frac{1}{2} h, y_n + \frac{1}{2} hy'_n + h^2 \left( \frac{125}{5376} k_1 + \frac{3}{32} k_2 - \frac{171}{8960} k_3 + \frac{5}{112} k_4 - \frac{219}{8960} k_5 + \frac{9}{1120} k_6 - \frac{31}{26880} k_7 \right), y' + h \left( \frac{137}{2688} k_1 + \frac{27}{112} k_2 + \frac{387}{4480} k_3 + \frac{17}{105} k_4 - \frac{243}{4480} k_5 + \frac{9}{560} k_6 - \frac{29}{13440} k_7 \right) \right) \quad (26)$$

$$k_5 = f \left( x_n + \frac{2}{3} h, y_n + \frac{2}{3} hy'_n + h^2 \left( \frac{2}{63} k_1 + \frac{76}{567} k_2 - \frac{16}{2835} k_3 + \frac{232}{2835} k_4 - \frac{16}{567} k_5 + \frac{8}{405} k_6 - \frac{4}{2835} k_7 \right), y' + h \left( \frac{143}{2835} k_1 + \frac{232}{945} k_2 + \frac{64}{945} k_3 + \frac{752}{2835} k_4 + \frac{29}{945} k_5 + \frac{8}{945} k_6 - \frac{4}{2835} k_7 \right) \right) \quad (27)$$

$$k_6 = f \left( x_n + \frac{5}{6} h, y_n + \frac{5}{6} hy'_n + h^2 \left( \frac{5825}{145152} k_1 + \frac{3175}{18144} k_2 + \frac{125}{20736} k_3 + \frac{125}{1008} k_4 - \frac{1625}{145152} k_5 + \right) \right)$$

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$$\left(\frac{275}{18144}k_6 - \frac{275}{145152}k_7\right), y' + h\left(\frac{3715}{72576}k_1 + \frac{725}{3024}k_2 + \frac{2125}{24192}k_3 + \frac{125}{567}k_4 + \frac{3875}{24192}k_5 + \frac{235}{3024}k_6 - \frac{275}{72576}k_7\right) \quad (28)$$

$$k_7 = f\left(x_n + \frac{5}{6}h, y_n + \frac{5}{6}hy'_n + h^2\left(\frac{41}{840}k_1 + \frac{3}{14}k_2 + \frac{3}{140}k_3 + \frac{17}{105}k_4 + \frac{3}{280}k_5 + \frac{3}{70}k_6\right), y' + h\left(\frac{41}{840}k_1 + \frac{9}{35}k_2 + \frac{9}{280}k_3 + \frac{32}{105}k_4 + \frac{9}{280}k_5 + \frac{9}{35}k_6 + \frac{41}{840}k_7\right)\right) \quad (29)$$

**3.0 Findings and Discussion**

To verify the credibility of our proposed scheme, some problems were selected for testing and the results were compared with other existing literature.

**Test Problem 1:**  $\mu''(t) = -1001\mu' - 1000\mu, h = 0.05; \mu(0) = 1, \mu'(0) = -1.$

Exact solution is  $\mu(t) = e^{-t}$  (Akinnukawe and Okunuga, 2024)

**Test Problem 2:**

$$\mu'' = \mu', \mu(0) = 1, \mu'(0) = \frac{1}{2}, h = \frac{1}{100}, 0 \leq x \leq 1$$

Exact solution:  $y(x) = 1 - e^x$  (Akinnukawe and Okunuga, 2024)

**Table 3.1:** Comparison of the result between exact solution, Runge-Kutta type method and Akinnukawe and Okunuga, (2024) for test problem 1

x	Exact Solution	Proposed Method	Error in Proposed Method	Error in Akinnukawe and Okunuga, (2024)
0.1	0.95122942450071400910	0.95122942450071400909	1.00E -20	1.85296E-13
0.2	0.90483741803595957318	0.90483741803595957316	2.00E -20	3.35731E-13
0.3	0.86070797642505780725	0.86070797642505780723	2.00E -20	4.54636E-13
0.4	0.81873075307798185870	0.81873075307798185867	3.00E -20	5.48339E-13
0.5	0.77880078307140486828	0.77880078307140486825	3.00E -20	6.19726E-13
0.6	0.74081822068171786611	0.74081822068171786607	4.00E -20	6.72684E-13
0.7	0.70468808971871343440	0.70468808971871343435	5.00E-20	7.09821E-13
0.8	0.67032004603563930079	0.67032004603563930074	5.00E -20	7.34135E-13

Table 3.1 showed the absolute errors  $|Y(x_n) - y_n|$  of the Runge-Kutta Type method and Akinnukawe and Okunuga, (2024) on test problem 1 for  $h = 0.05$ , Clearly the table shows that the Runge-Kutta type method closer to the exact than Akinnukawe and Okunuga, (2024) . The Runge-Kutta Type method approaches the exact solution faster than Akinnukawe and Okunuga, (2024) within the interval of  $0 \leq x \leq 1$  for  $h = 0.05$  on test problem 1

**Table 3.2:** Comparison of the result between exact solution, Runge Kutta Type method and Akinnukawe and Okunuga, (2024) for test problem 2

x	Exact Solution	Proposed Method	Error in the proposed method	Error in Akinnukawe and Okunuga, (2024)
0.01	-0.0100501670841681	-0.010050167084168058	4.2 E-17	3.10862E-15
0.02	-0.0202013400267558	-0.020201340026755811	1.1E-17	1.39888E-14
0.03	-0.0304545339535169	-0.030454533953516857	4.3E-17	3.24185E-14
0.04	-0.0408107741923882	-0.040810774192388229	2.9E-17	6.12843E-14
0.05	-0.0512710963760240	-0.051271096376024043	4.3E-17	1.01918E-13
0.06	-0.0618365465453596	-0.061836546545359626	2.6E-17	1.56541E-13

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0.07	-0.0725081812542165	-0.072508181254216484	1.6E-17	2.28706E-13
0.08	-0.0832870676749586	-0.083287067674958561	3.9E-17	3.19744E-13
0.09	-0.0941742837052104	-0.094174283705210366	3.4E-17	4.33875E-13
0.1	-0.1051709180756476	-0.10517091807564763	3.0E-17	5.75096E-13

---

Table 3.2 showed the absolute errors  $|Y(x_n) - y_n|$  of the Runge-Kutta type method and Akinnukawe and Okunuga, (2024) on test problem 1 for  $h = 0.01$ . Clearly the table shows that the Runge-Kutta type method closer to the exact than Akinnukawe and Okunuga, (2024). The Runge-Kutta type method approaches the exact solution faster than Akinnukawe and Okunuga, (2024) within the interval of  $0 \leq x \leq 0.1$  for  $h = 0.01$  on test problem 2

#### **4.0 Conclusion**

Reformulation of the two-step implicit linear multi-step block hybrid method into a Runge-Kutta-Type scheme for the solution of second-order initial value problems (IVPs) in ordinary differential equations represents an important advancement in numerical methods for the solution of ordinary differential equations. The reformulated method propagates the efficiency and stability properties of the hybrid method it was reformulated from while incorporating the adaptability and self-starting type of Runge-Kutta schemes. The Runge-Kutta-Type method derived demonstrates uniform accuracy and computational efficiency because of its better performance in numerical experiments when compared to the existing methods in the literature. The method's capability to handle second-order ODEs without reduction provides a versatile tool for wide applications in science and engineering.

#### **5.0 Recommendation**

In view of the results obtained, it is recommended that advance research be conducted to extend the applicability of this method. Future studies could investigate its performance on its adaptation to variable step-size techniques for enhanced computational efficiency. Also, investigating its application to higher-order ordinary differential equations and large-scale systems would further validate its flexibility and reliability. The method's strength for parallel implementation should be examined too to support modern computational resources effectively. In summary, the proposed Runge-Kutta-Type method gives an unquantifiable contribution to the field of numerical analysis and holds great promise for solving advanced initial value problems.

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**ENHANCED AUTOMATION OF POINT CLOUD PROCESSING FOR BUILDING  
INFORMATION MODELING (BIM)**

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**Abstract**

The integration of point cloud data into Building Information Modeling (BIM) has gained significant attention in recent years. Managing existing projects necessitates the consolidation of scattered documentation related to technical infrastructure such as green spaces, lighting system, electrical systems, water supply, and drainage system, etc. Point clouds, collected using various techniques such as terrestrial or aerial laser scanning, serve as the foundational dataset for digitizing structures. However, the manual conversion of point cloud data into BIM models is both labor-intensive and inaccurate. This paper explores advancements in automating the scan-to-BIM process, evaluating contemporary tools that facilitate the creation of BIM models from point clouds. The author presents a semi-automated methodology tested on structural components such as walls. The results show that the proposed method can be applied to other structural components.

**Keywords:** Building Information Modelling (BIM), point cloud, terrestrial or aerial laser scanning.

## **I. Introduction**

The rapid development of remote sensing technology has enabled the capture of highly detailed spatial datasets in the form of point clouds, effectively bridging the gap between the physical and digital worlds. Point clouds, generated through terrestrial and aerial laser scanning, provide a dense representation of objects and environments. The conversion of such data into BIM models is traditionally a manual process requiring skilled professionals [1]. However, recent research efforts focus on automating this transformation to enhance efficiency and accuracy. Building Information Modeling (BIM) has become an essential tool in construction, architecture, and facility management. The integration of BIM with point cloud data facilitates the creation of highly accurate digital twins of existing structures. This is particularly useful for renovation projects, historical site preservation, and asset management. The process of translating point cloud data into BIM, commonly referred to as scan-to-BIM, involves numerous challenges related to data noise, occlusion, and variability in structural elements [2]. Addressing these challenges requires a combination of advanced computational techniques and human expertise.

The paper first introduces various methods for acquiring point cloud data, then explores storage formats, processing workflows, and available software for point cloud modeling. Lastly, it details the process of converting point clouds into BIM models and summarizes the main findings.

Point cloud acquisition methods include laser scanning. Laser scanning can be classified into terrestrial, aerial, and mobile scanning based on the platform used. Each method varies in precision and applicability depending on environmental conditions and project requirements. Terrestrial laser scanning (TLS) is widely used for detailed structural assessments, while aerial laser scanning (ALS) is preferred for large-scale infrastructure projects. Mobile laser scanning (MLS) mounted on vehicles provides efficient data collection for road networks and urban environments [3].

Processing point cloud data involves several stages: data acquisition, segmentation, classification, and model generation. Visualization techniques include raster-based rendering for large-scale datasets and point-based rendering for interactive analysis. Segmentation approaches, such as edge detection and region-growing algorithms, help classify objects within a point cloud. AI-driven methodologies, including deep learning models, are increasingly being used to automate object recognition and classification [4].

Raw point cloud data often contains noise and redundant information that must be filtered before further processing. Common noise reduction techniques include statistical outlier removal, radius-based filtering, and voxel down-sampling [5]. These methods enhance the clarity of structural details and improve the accuracy of automated object detection algorithms. Additionally, point cloud registration techniques, such as Iterative Closest Point (ICP), align multiple scans into a unified coordinate system, ensuring consistency across datasets.

Below is a comparison table outlining the advantages and disadvantages of several widely used point cloud and BIM processing software solutions:

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Table 1. The advantages and disadvantages of several widely used point cloud and BIM processing software solutions

Software	Advantages	Disadvantages
<b>Autodesk ReCap</b>	<ul style="list-style-type: none"> <li>- Excellent integration with Autodesk products (Revit, AutoCAD).</li> <li>- Supports multiple point cloud formats.</li> <li>- User-friendly interface.</li> </ul>	<ul style="list-style-type: none"> <li>- High cost.</li> <li>- Requires powerful hardware.</li> <li>- Limited features compared to specialized software.</li> </ul>
<b>CloudCompare</b>	<ul style="list-style-type: none"> <li>- Open-source and free.</li> <li>- Supports multiple file formats.</li> <li>- Powerful analysis tools.</li> </ul>	<ul style="list-style-type: none"> <li>- Not beginner-friendly.</li> <li>- Lacks BIM integration.</li> </ul>
<b>MeshLab</b>	<ul style="list-style-type: none"> <li>- Open-source and free.</li> <li>- Good cleaning and filtering tools.</li> <li>- Supports multiple file formats.</li> </ul>	<ul style="list-style-type: none"> <li>- Complex interface.</li> <li>- Lacks advanced analysis tools.</li> <li>- No BIM integration.</li> </ul>
<b>Leica Cyclone</b>	<ul style="list-style-type: none"> <li>- Powerful point cloud processing tools.</li> <li>- Good data registration and management.</li> <li>- Integrates well with Leica devices.</li> </ul>	<ul style="list-style-type: none"> <li>- High cost.</li> <li>- Requires powerful hardware.</li> <li>- Complex interface.</li> </ul>
<b>Agisoft Metashape</b>	<ul style="list-style-type: none"> <li>- Generates 3D models from images and point clouds.</li> <li>- Supports multiple file formats.</li> <li>- User-friendly interface.</li> </ul>	<ul style="list-style-type: none"> <li>- High cost.</li> <li>- Requires powerful hardware.</li> <li>- Limited functionality for laser scanner data.</li> </ul>

**II. Methodology**

Below is a complete end-to-end workflow for processing point cloud data into a BIM model, including detailed code for each step (Figure 1). This process combines open-source tools and specialized software (Python, CloudCompare, Autodesk ReCap/Revit) to achieve high accuracy.

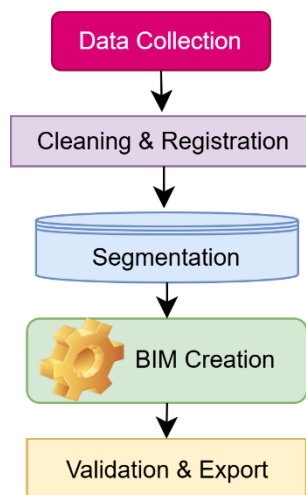


Figure 1. The proposed workflow



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## 1. Data Collection

Tools: 3D laser scanners (Faro, Leica) or drones.

Output: Point cloud files in .e57, .las, or .ply formats.

## 2. Data Cleaning and Registration

Tools: Python + CloudCompare + Open3D

Code:

```
import open3d as o3d
import numpy as np
# Load point cloud
pcd = o3d.io.read_point_cloud("input.ply")
# Step 1: Statistical Outlier Removal (SOR)
cl, ind = pcd.remove_statistical_outlier(nb_neighbors=20, std_ratio=2.0)
pcd_filtered = pcd.select_by_index(ind)
# Step 2: Downsampling using voxel grid
voxel_size = 0.05 # Adjust based on dataset
pcd_downsampled = pcd_filtered.voxel_down_sample(voxel_size)
# Step 3: Point cloud registration using ICP
source = pcd_downsampled
target = o3d.io.read_point_cloud("reference.ply") # Reference point cloud
threshold = 0.02 # Distance threshold
trans_init = np.identity(4) # Initial transformation
icp_result = o3d.pipelines.registration.registration_icp(
    source, target, threshold, trans_init,
    o3d.pipelines.registration.TransformationEstimationPointToPoint()
)
# Apply transformation
source.transform(icp_result.transformation)
# Save processed point cloud
o3d.io.write_point_cloud("output_registered.ply", source)
# Visualization
o3d.visualization.draw_geometries([source, target], window_name="Registered Point Cloud")
```

## 3. Data Segmentation

Tool: Python + Machine Learning (PyTorch)

Code: Applying RandLA-Net model to segment

# Install: pip install torch torchvision

import torch

from models.randla\_net import RandLANet

# Load pre-trained model

model = RandLANet(num\_classes=5) # 5 classes: wall, floor, door, window, furniture.

model.load\_state\_dict(torch.load("randla\_net.pth"))

model.eval()

# convert point cloud into tensor

points = np.asarray(aligned\_pcd.points)

points = torch.tensor(points, dtype=torch.float32).unsqueeze(0)

# Segmentation forecasting

with torch.no\_grad():

```
outputs = model(points)
labels = torch.argmax(outputs, dim=2).squeeze().numpy()
# Save the output of segmentation
segmented_pcd = o3d.geometry.PointCloud()
segmented_pcd.points = o3d.utility.Vector3dVector(points.squeeze().numpy())
segmented_pcd.colors = o3d.utility.Vector3dVector(np.random.rand(len(points), 3))
# Colors accordings to classes
o3d.io.write_point_cloud("segmented.ply", segmented_pcd)
```

#### **4. Generating a BIM Model from Segmented Data**

Tool: Autodesk Revit + Dynamo (Visual Scripting)

#### **5. Validation and Export**

Tool: Autodesk Navisworks + Python.

### **III. A Case Study**

To verify the effectiveness and accuracy of the proposed solution, the walls of the University of Transport and Communications (UTC) campus in Hanoi were selected as the case study. UAV-LiDAR (Matrice 350-RTK) and a handheld scanner (CHC RS10) were used for topographic analysis, supplemented by GPS-RTK, leveling instruments, and total stations. Existing maps and drawings were also referenced for comparison.

### **IV. Results and Discussion**

An edge detection algorithm is used in wall modeling to extract element boundaries from a prepared view and display them as a skeleton. By mapping points onto pixels, this process reduces the point cloud's three-dimensional data to two dimensions. To improve edge recognition, it is important to define the components to be included in the model while minimizing noise and shadows from nearby objects. Figure 2 illustrates the shape of the point cloud of a building before processing.



Figure 2. The shape of the point cloud of a building before processing

In addition to height, the cut-out's thickness is quite important. More points are captured by a thicker section, however the accuracy of detection may be impacted by noise introduction. On the other hand, a thinner portion might not give a full picture. Adjustments must be made according to the properties of the scanned region because there is no uniform criterion for determining the optimal cut thickness and height. Additionally, by minimizing noise and maximizing data quality, further honing the point cloud in processing software can improve its usability. Figure 3 illustrates the shape of the point cloud of a building after processing.



Figure 3. The shape of the point cloud of a building after processing

The selection of the wall's beginning and ending points comes next. In order for the algorithm to recognize the wall, the user must choose two or more reference points. In a well prepared point cloud, two points are usually enough for detection because walls are linear elements. Nevertheless, other reference points might be chosen to increase accuracy if the software is unable to precisely determine the wall's position and thickness using only two fixed points due to background noise or other objects.

#### **V. Conclusions**

Accurate modeling must take into consideration the fact that walls and buildings are not always exactly parallel or perpendicular in reality. As stated earlier, the UAV-LiDAR (Matrice 350-RTK) imaging scanner was used in this investigation. It was set up with a 10 mm density and a 10 m range. Our experience has shown that this configuration provides the best possible balance between file size and point cloud accuracy.

Many obstructions inside buildings produced noise and shadows during data collecting, which can obstruct precise reconstruction. However, contemporary BIM software makes use of

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sophisticated algorithms that estimate element dimensions and include them into the point cloud using reference points. We were able to represent walls that were significantly concealed by nearby items because to this functionality. The software anticipates and reconstructs the missing wall portions based on the data that is already available.

Verification was carried out at every stage to guarantee model fidelity, and graphical representations were produced at the end. Utilizing a high-precision reference point cloud with millimeter accuracy, the spatial dimensions and placement of features were ascertained. However, walls that are uneven, sloped, or have different thicknesses are hard for existing algorithms to recognize and precisely place in the model.

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**CHALLENGES AND MANAGEMENT OF RICE HELMINTHOSPORIOSIS  
(*BIPOLARIS ORYZAE*) IN MOROCCO: A REVIEW**

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**Abstract**

Rice Helminthosporiosis, caused by *Bipolaris oryzae*, is one of the major fungal diseases affecting rice crops in Morocco, leading to significant yield losses and quality degradation. This review addresses the challenges posed by this disease in Moroccan rice cultivation, focusing on its progression, environmental factors, and impact on rice production. The disease manifests primarily through the appearance of brown lesions on rice leaves, which reduces photosynthesis, affecting plant growth and development. Factors such as high humidity, poor field drainage, and the dense planting of rice fields facilitate the spread of *Bipolaris oryzae*, exacerbating its economic impact. Management strategies, including the use of resistant varieties, fungicide applications, and cultural practices such as crop rotation and field sanitation, are explored. Despite the availability of these approaches, the disease continues to challenge rice farmers, underscoring the need for integrated pest management (IPM) practices and the development of more resilient rice varieties.

The review also highlights ongoing research efforts in Morocco to better understand the genetic basis of resistance to *Bipolaris oryzae* and the potential role of biocontrol agents. Future directions for managing rice Helminthosporiosis in Morocco include improving disease

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surveillance, optimizing fungicide use, and promoting sustainable agricultural practices to ensure long-term rice productivity in the face of climate change.

**Keywords:** Helminthosporiosis, *Bipolaris oryzae*, Fungicide application, Rice, Morocco.

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## INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important staple crops worldwide, particularly in Asia and Africa. In Morocco, rice cultivation faces a series of challenges, including biotic and abiotic stresses that limit yield potential (Elwahab et al., 2023). Among the biotic factors, Helminthosporiosis, caused by the fungal pathogen *Bipolaris oryzae* (formerly *Helminthosporium oryzae*), is a significant concern. Rice *helminthosporiosis* is known to have caused an epidemic in India in 1942, resulting in yield reductions of 40-90%, which partly contributed to the Bengal famine that led to the death of 2 million people (Ghose et al., 1960; Padmanabhan, 1973).

In 2022, rice *helminthosporiosis* was encountered in nearly all rice-producing countries (CABI, 2022; Farr & Rossman, 2022). It is a concerning disease, particularly in Burkina Faso (Ouédraogo, 2008; Barro et al., 2021), the United States (Castell-Miller & Samac, 2019), Bangladesh (Hossain et al., 2014), Côte d'Ivoire (Bouet et al., 2015), Malaysia (Toher et al., 2016), India (Valarmathi & Ladhakshmi, 2018; Nayak & Hiremath, 2019), and Europe (Tharreau, personal communication).

Global rice production losses attributed to helminthosporiosis are estimated at 3.8% (Savary et al., 2019), making it the third most damaging disease of this crop. Furthermore, simulation studies predict an increase in epidemics in certain rice-producing countries by 2030 and 2050 in the context of climate change (Bregaglio et al., 2013).

*Bipolaris oryzae* (Breda de Haan) Shoemaker is the fungus most commonly associated with rice *helminthosporiosis*. It causes circular or oval brown spots on coleoptiles, leaves, glumes, and florets. However, these symptoms can be confused with those of *Pyricularia oryzae* (blast disease), *Curvularia* spp. (*curvulariosis*), *Cercospora* spp. (*cercosporiosis*), or *Ramularia* spp. (*ramulariosis*), especially during the early stages of infection (Archana, 2014; Majeed et al., 2016; Aslam et al., 2020; Terensan et al., 2021; Zhou et al., 2021; Imran et al., 2022). Furthermore, many species of *Bipolaris* have been isolated from brown leaf lesions of rice (Gnancadja-André et al., 2005; Motlagh & Kaviani, 2008; El-Shafey et al., 2011; Nazari et al., 2015). The morphological characteristics are not distinct enough between these different species to allow for precise identification based on microscopic observations (Archana, 2014). This disease manifests primarily as brown lesions on rice leaves, which leads to premature leaf death, reduced photosynthetic capacity, and ultimately, lower yields. The disease is widely distributed in rice-growing areas of Morocco, where climatic conditions, especially during the wet season, provide a conducive environment for its development (Elwahab et al., 2024). This review aims to explore the challenges posed by *Bipolaris oryzae* in Moroccan rice cultivation, evaluate the management strategies employed, and highlight future research directions for sustainable disease control.

### **Conidiophores of *Helminthosporium oryzae* and Pathogenic Cycle of *Bipolaris oryzae***

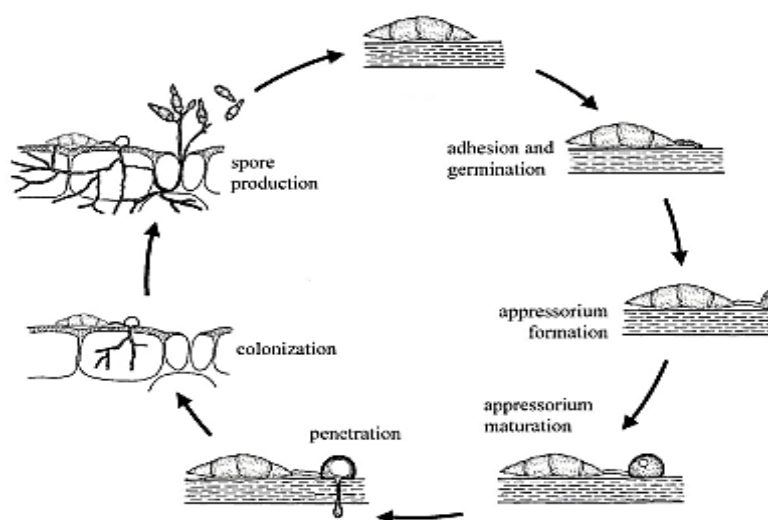
*Bipolaris oryzae* belongs to the phylum *Ascomycota*, the class *Dothideomycetes*, the order *Pleosporales*, and the family *Pleosporaceae* (GBIF, 2021, [www.gbif.org/fr/species/2615973](http://www.gbif.org/fr/species/2615973)). The species was first described as *Helminthosporium oryzae* by Breda de Haan (1900). It is the species most associated with rice *helminthosporiosis*. *Bipolaris oryzae* has conidiophores that are grouped or solitary, simple or branched, bearing conidia that are typically curved and vary in size (Figure 1).





**Figure 1:** Conidiophores and conidia of *Bipolaris oryzae* observed under a microscope. The scale bars represent A-C = 10  $\mu$ m and D-J = 5  $\mu$ m. Image source: Marin-Felix *et al.*, 2017.

The pathogenic cycle of *B. oryzae* can be summarized in four main stages (Figure 2). When the conidia come into contact with rice, they release germ tubes that adhere to the surface of the leaves via a mucilaginous substance. This is followed by the formation of an appressorium, which allows for direct penetration of the leaf cells (Hau & Rush, 1982; Ou, 1985). The mycelial hyphae invade the mesophyll and produce conidia, which are spread by wind and/or rainfall. *Bipolaris zizaniae*, previously distinguished from *B. oryzae* based on morphological characteristics, is now considered conspecific (Manamgoda *et al.*, 2014; Xiao *et al.*, 2015).



**Figure 2:** Pathogenic Cycle of *Bipolaris oryzae* (De Bruyne, 2015)

### Impact on Rice Production in Morocco

The economic impact of Helminthosporiosis in Morocco is substantial. The disease leads to

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significant yield losses, affecting the overall productivity of rice cultivation. In addition to yield reduction, the disease also affects the quality of the grains, making them unsuitable for both local consumption and export. In Morocco, where rice is an important crop for both domestic consumption and import substitution, the management of rice diseases like Helminthosporiosis is critical to maintaining food security and supporting the sustainability of the rice sector.

## Management Strategies for Rice Helminthosporiosis

Efforts to manage *Helminthosporiosis* in Morocco include a combination of cultural practices, chemical control, and the development of resistant rice varieties. Below, we discuss the key management strategies employed.

### 1. Use of Resistant Varieties

The development and adoption of resistant rice varieties are among the most effective long-term solutions for managing *Bipolaris oryzae*. Several rice breeding programs in Morocco focus on incorporating disease resistance into new varieties. These varieties offer natural protection against infection, reducing the need for chemical control. However, resistance levels vary depending on the cultivar and environmental conditions.

### 2. Fungicide Application

Fungicides are commonly used to control *Helminthosporiosis* in rice fields. Systemic fungicides, which are absorbed by the plant and provide longer-lasting protection, are applied during critical disease stages. However, the over-reliance on fungicides can lead to the development of resistant fungal strains, as well as environmental and health concerns. Therefore, fungicide use must be integrated with other management strategies to minimize its negative effects.

### 3. Cultural Practices

Cultural practices play a significant role in managing Helminthosporiosis. Key practices include:

- **Field Sanitation:** Removing infected plant debris and controlling volunteer rice plants can reduce the inoculum load in the field, preventing the spread of the disease.
- **Crop Rotation:** Rotating rice with non-host crops reduces the buildup of fungal spores in the soil, thereby breaking the disease cycle.
- **Improved Irrigation Management:** Proper drainage helps reduce the humid conditions that favor the growth of *Bipolaris oryzae*.

### 4. Integrated Pest Management (IPM)

An integrated approach that combines resistant varieties, fungicides, and cultural practices is essential for effective disease management. IPM minimizes the reliance on chemical inputs and promotes sustainable farming practices. Monitoring disease incidence, applying fungicides at the right time, and selecting appropriate cultivars are crucial elements of a successful IPM program.

## Research Directions and Future Perspectives

While significant progress has been made in understanding and managing rice Helminthosporiosis, further research is needed to enhance disease control. Future research priorities include:

- **Molecular Breeding:** Using molecular markers to identify and incorporate resistance genes into rice cultivars will accelerate the development of more resistant varieties.
- **Biocontrol Agents:** Investigating the potential of biocontrol agents, such as beneficial fungi and bacteria, offers an environmentally friendly alternative to chemical fungicides.

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- **Climate Change Impact:** As climate change alters rainfall patterns and temperatures, further studies are needed to understand how these changes may affect disease dynamics and to develop adaptive management strategies.

## CONCLUSION

Rice *Helminthosporiosis*, caused by *Bipolaris oryzae*, remains a major challenge to rice production in Morocco. While progress has been made in managing the disease through the use of resistant varieties, fungicides, and cultural practices, integrated approaches that combine these strategies are essential for sustainable disease control. Ongoing research in molecular breeding and biocontrol offers promising avenues for improving rice health and securing future yields. Addressing the challenges of rice *Helminthosporiosis* is vital for maintaining Morocco's rice industry, ensuring food security, and contributing to the resilience of agricultural systems in the face of environmental changes.

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**ANALYZING THE QUALITY OF TOURISM HUMAN RESOURCES IN AN BINH  
ISLET, LONG HO DISTRICT, VINH LONG PROVINCE, VIETNAM**

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**Abstract**

Tourism is considered one of the key economic sectors in Vietnam. The number of tourists visiting Vietnam has been steadily increasing over the years. To further enhance the quality of tourism, it is essential to focus on developing the human resources serving this industry. An Binh Islet, located in Vinh Long Province, Vietnam, benefits from year-round alluvial deposits, resulting in fertile land and thriving agriculture with many lush fruit gardens. It has become a highly attractive destination for both domestic and international tourists. This study is based on a survey of 165 workers in the tourism sector on An Binh Islet to evaluate the quality of local tourism human resources in terms of their knowledge, skills, and attitudes. The survey data was processed using SPSS 20 software, employing descriptive statistics, reliability assessments of measurement scales, and exploratory factor analysis. The research findings indicate that the workers' knowledge, skills, and attitudes are at a moderate to good level, with knowledge rated the highest and skills rated the lowest. The study also identified six factors influencing the quality of tourism human resources on An Binh Islet: skills, professional knowledge, social knowledge, work attitude, work ethic, and work spirit.

**Key words:** An Binh, human resources, tourism, Vietnam

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## 1. Introduction

In tourism development, fostering the local workforce is one of the key issues that require attention. Workforce development is a critical factor in tourism growth, as human resources are not merely a labor source but also play a role as a tourism product itself (Ladkin, 2013). Human resources in the tourism industry are a crucial factor, providing direct services to tourists and determining their level of satisfaction (dos Anjos et al., 2017). The quality of human resources contributes to enhancing the success and potential success of businesses. Tourism is a labor-intensive activity where products and services are evaluated based on the quality of human resources (Herman and Zoonosis, 2015). Therefore, to develop tourism at the local level, it is essential to assess the local human resources in order to implement appropriate policies and solutions for human resource development, thereby promoting local tourism growth.

Human resources encompass the entire population capable of working, regardless of the industry, sector, or area they are engaged in, and can be considered as the social human resource (Nguyen, 2008). Human resources are reflected in two aspects: in terms of quantity, it includes the total number of people of working age as defined by the government and the amount of labor time that can be mobilized from them; in terms of quality, it pertains to the health, professional qualifications, knowledge, and skill levels of the workforce (Nguyen, 2014). Human resource development requires a preliminary assessment of skills, knowledge, attitudes, and values to meet market demands (Garavan et al., 2000). Assessing human resources should focus on the knowledge, skills, and talents of the workforce to meet job requirements (Mihanović, 2021).

Research on human resources has been widely and extensively published worldwide from an early stage. Hope et al. (1998) analyzed the relationship between total quality management and human resource management practices in tourism. Baum (2007) examined key themes influencing the role of tourism human resources and the management of tourism human resources. Grenčíková et al. (2013) assessed the importance of human resource quality for tourism development and analyzed the correlation between human resource quality and the quality of tourism services in relation to tourism development.

In Vietnam, research on the quality of human resources has also gained attention in recent years. Vu (2009), through a literature review and secondary data, assessed the current state of Vietnam's tourism human resources and the current state of tourism workforce training, proposing several solutions to enhance human resource quality. Pham and Vo (2023) developed a measurement scale consisting of three factors—knowledge, skills, and attitudes—with 19 observed variables to evaluate the quality of tourism human resources, focusing on the case of Thua Thien Hue.

Overall, research on tourism human resources has received attention both globally and in Vietnam. However, there are almost no published studies on the human resources meeting the needs of tourism development on An Binh Islet, Vinh Long Province. Therefore, studying the tourism human resources that support local tourism development is essential, especially given the increasing investment and focus on tourism development in the area today.

## 2. Research Methodology

Based on studies of human resources both globally and in Vietnam, as well as the actual conditions in the research area, the study evaluates the quality of tourism human resources on An Binh Islet, Vinh Long, through three factors: Knowledge, Skills, and Attitude.

The Knowledge factor is assessed through the following observed variables: Knowledge of

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laws, economics, and society (X1), Knowledge of history, culture, and geography (X2), Knowledge of specialized fields (X3), Knowledge of customer service standards and tourism products (X4), Knowledge of the organizational operations of restaurants, hotels, and travel agencies (X5), Knowledge of using restaurant and hotel equipment (X6), Knowledge of dress codes and personal hygiene in the service industry (X7), Knowledge of hygiene and food safety (X8), Knowledge of safety and security (X9).

The Skills factor is assessed through the following observed variables: Skills to apply professional knowledge in work (X10), Communication skills (indirect: via phone, email, etc.) (X11), Communication skills (direct) (X12), Problem-solving skills (X13), Time management skills (X14), Independent working skills (X15), Teamwork skills (X16), Observation skills during work (X17), Skills in using new technology and equipment (X18), Customer persuasion skills (X19), Skills in adapting to the work environment (X20), Organizational and management skills (X21).

The Attitude factor is assessed through the following observed variables: Attitude towards following organizational rules and policies (X22), Positive and polite attitude in work (X23), Passionate and enthusiastic attitude in work (X24), Responsible attitude in work (X25), Honest and ethical attitude in professional conduct (X26), Patience, willingness to learn, and progressive attitude (X27), Dynamic, flexible, and sharp attitude (X28), Attitude of caring for, listening to, and supporting customers (X29), Professional and serious demeanor (X30), Creative and innovative spirit (X31), Cooperative attitude with colleagues (X32), Ability to handle high pressure in work (X33).

The study conducted a questionnaire survey with 165 workers in the tourism sector on An Binh Islet, Vinh Long Province, focusing on issues related to their self-assessed job performance. The research employed a non-probability sampling method using convenience sampling techniques. The collected data was processed using SPSS 20 software, applying descriptive statistics, scale reliability assessment, and exploratory factor analysis.

### 3. Result and discussion

#### 3.1. Overview of An Binh Islet, Vinh Long Province, VietNam

An Binh Islet is located in Long Ho District, Vinh Long Province, Vietnam. It is a fertile land formed by the alluvial deposits of the Tien and Co Chien Rivers. The islet covers an area of approximately 60 km<sup>2</sup>, consisting of 4 communes and 30 hamlets, with a population of about 40,545 people (Trong, 2022). An Binh Islet is part of the upper section of the Minh Islet chain, situated between the Tien and Co Chien Rivers.

An Binh Islet has fertile land with rich alluvial soil deposited by the Tien and Co Chien Rivers throughout the year, creating favorable conditions for the growth and development of various fruit tree species: longan (accounting for 80%), rambutan, mango, durian, orange, tangerine, plum, lime, and more. This has resulted in lush orchards that attract tourists for sightseeing and enjoyment.

Due to its geographical location along the Tien and Co Chien Rivers, the area enjoys an abundant supply of water. Characterized by the terrain of the Mekong Delta, it features a dense network of canals, rivers, and waterways. With a significant and stable tidal range, it is highly favorable for irrigation, crop cultivation, and freshwater aquaculture in ponds, gardens, and along rivers and canals.



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## **3.2 Overview of the research data**

The study surveyed 165 workers employed in the tourism sector on An Binh Islet. Among them, 44% were male, and 56% were female, ranging in age from 15 to 59 years old, with the majority (87.5%) aged between 20 and under 45. Most of the workers were of the Kinh ethnicity, accounting for 97.6%, with the remainder being Hoa and Khmer. The survey covered workers across most tourism-related fields on An Binh Islet, including food and beverage services (33.3%), accommodation (20%), house hold-operated attractions (20%), tourist areas (10.3%), travel companies (6.7%), souvenir businesses (4.8%), and tour guides (4.8%).

Out of the 165 workers surveyed, 92.1% were employees, 4.2% were managers, and 3.7% were business owners. Among them, 31.5% had received training, while 68.5% had not undergone formal professional training. Of those who had received training, 10% specialized in tourism-related fields such as tour guiding, hospitality, tourism management, and Vietnamese studies.

## **3.3. Evaluating the quality of tourism human resources in An Binh islet, Vinh Long province**

### **3.3.1. Knowledge**

The "knowledge" factor comprises a total of 9 observed variables. Most workers rated the variables of this factor as ranging from good to very good (see at Table 1). It means that the knowledge of workers in tourism on An Binh Islet meets the requirements of their jobs. Both basic life knowledge and specialized work-related knowledge are rated as good to very good. Workers have been adequately equipped with the necessary knowledge to meet the demands of their current jobs.

However, there is almost no workforce with postgraduate qualifications. According to a survey of 165 workers engaged in tourism activities in the area, the group with a high school diploma accounted for the highest proportion, at 67.9%. This indicates that the educational level of workers in the tourism sector on An Binh Islet is not high and lacks specialized training, relying primarily on experience. The main reason is that highly educated individuals tend to seek employment in major cities for higher income opportunities. The proportions of workers with intermediate, college, and university qualifications show little difference, at 9.7%, 9.1%, and 13.3%, respectively. Workers consistently express a desire for further training in tourism-related knowledge, with 64.8% of surveyed respondents indicating their interest in improving their knowledge through education.

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**Table 1. Evaluating the knowledge of tourism human resources in An Binh islet, Vinh Long**

Observed variable	Mean	Standard deviation	Evaluation level
Knowledge of laws, economics, and society	4,44	0,608	Very good
Knowledge of history, culture, and geography	4,43	0,674	Very good
Knowledge of specialized fields	4,41	0,680	Very good
Knowledge of customer service standards and tourism products	4,33	0,700	Very good
Knowledge of the organizational operations of restaurants, hotels, and travel agencies	4,21	0,810	Very good
Knowledge of using restaurant and hotel equipment	4,09	0,903	Fair
Knowledge of dress codes and personal hygiene in the service industry	4,09	0,847	Fair
Knowledge of hygiene and food safety	4,18	0,850	Fair
Knowledge of safety and security	4,24	0,826	Very good

(Source: Data analysis results 2024, n=165)

### 3.3.2. Skills

The "skills" factor consists of 12 observed variables, most of which are rated at a fair level (see table 2). Among these, **problem-solving skills** received the highest rating, while **teamwork skills** received the lowest. Skills such as *adapting to the work environment, observation skills during work, customer persuasion skills, organizational and management skills, time management skills, the ability to apply professional knowledge at work, and communication skills (indirectly via phone, email, etc.)* are only rated as fairly good. According to the survey, workers primarily develop their skills through self-practice over time, with only a small number receiving formal training in workplace skills. However, this number is relatively low, as only 31.5% have undergone formal training, while the rest have not received professional education. Workers consistently demonstrate a willingness to improve their skills to enhance their job performance. According to the survey, 60.5% of workers expressed a need for further training in tourism-related skills.

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**Table 2. Evaluating the Skills of tourism human resources in An Binh islet, Vinh Long**

<b>Observed variable</b>	<b>Mean</b>	<b>Standard deviation</b>	<b>Evaluation level</b>
Skills to apply professional knowledge in work	4,02	0,728	Fair
Communication skills (indirect: via phone, email, etc.)	4,11	0,917	Fair
Communication skills (direct)	4,23	0,838	Very good
Problem-solving skills	4,33	0,768	Very good
Time management skills	3,99	0,859	Fair
Independent working skills	4,14	0,840	Fair
Teamwork skills	3,92	0,879	Fair
Observation skills during work	3,98	0,837	Fair
Skills in using new technology and equipment	4,01	0,862	Fair
Customer persuasion skills	3,98	0,833	Fair
Skills in adapting to the work environment	3,95	0,828	Fair
Organizational and management skills	3,99	0,845	Fair

*(Source: Data analysis results 2024, n=165)*

### **3.3.3 Attitude**

According to the results in Table 3, the attitude of tourism workers in An Binh Islet are generally rated as fairly good. Two observed variables are rated as very good: *Responsible attitude in work* and *Honest and ethical attitude in professional conduct*. The remaining observed variables are rated as fairly good, including *Creative and innovative spirit*; *Professional and serious demeanor*; *Attitude towards following organizational rules and policies*; *Dynamic, flexible, and sharp attitude*; *Ability to handle high pressure at work*; *Attitude of caring for, listening to, and supporting customers*; *Positive and polite attitude at work*; *Cooperative attitude with colleagues*; *Patience, willingness to learn, and progressive attitude*; and *Passionate and enthusiastic attitude at work*. Among these, the lowest-rated observed variable is *Creative and innovative spirit*.

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**Table 3. Evaluating the Attitude of tourism human resources in An Binh islet, Vinh Long**

Observed variable	Mean	Standard deviation	Evaluation level
Attitude towards following organizational rules and policies	4,10	0,683	Fair
Positive and polite attitude in work	4,11	0,749	Fair
Passionate and enthusiastic attitude in work	4,16	0,665	Fair
Responsible attitude in work	4,25	0,695	Very good
Honest and ethical attitude in professional conduct	4,25	0,687	Very good
Patience, willingness to learn, and progressive attitude	4,13	0,658	Fair
Dynamic, flexible, and sharp attitude	4,10	0,650	Fair
Attitude of caring for, listening to, and supporting customers	4,11	0,672	Fair
Professional and serious demeanor	4,08	0,690	Fair
Creative and innovative spirit	4,06	0,650	Fair
Cooperative attitude with colleagues	4,13	0,694	Fair
Ability to handle high pressure in work	4,11	0,733	Fair

*(Source: Data analysis results 2024, n=165)*

**3.4. Analysis of factors affecting the quality of tourism human resources in An Binh islet, Vinh Long province**

To ensure the reliability of the scale and observed variables, the scale reliability evaluation method was utilized. Each scale was assessed based on the Cronbach's Alpha coefficient to identify and remove insignificant observed variables in the research model. A scale is considered reliable if its Cronbach's Alpha coefficient is  $\geq 0.6$  (Nunnally, 1978; Peterson, 1994; Slate, 1995; as cited in Huy et al., 2012). Scales with a Cronbach's Alpha ranging from 0.6 to 0.8 are deemed usable, while those with a Cronbach's Alpha of 0.8 or higher are regarded as excellent measures by many researchers, indicating a higher level of correlation. For observed variables, reliability is ensured when the adjusted item-total correlation coefficient is  $\geq 0.3$  (Nunnally & Bernstein, 1994; as cited in Tho, 2011). According to the results of the scale reliability evaluation, 3 scales and 26 observed variables are found to be reliable (see Table 4)

**Table 4. Evaluation of Scale Reliability**

No.	Scale	Number of Reliable Observed Variables	Cronbach's Alpha	Corrected Item-Total Correlation
1	Knowledge	8	0,843	0,370-0,688
2	Skills	8	0,876	0,465-0,702
3	Attitude	10	0,711	0,312-0,492

*(Source: Data analysis results 2024, n=165)*

Based on the results of the reliability assessment of the scale, the factors, including the observed variables, meet the following conditions:

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The “**Knowledge**” scale consists of 9 observed variables with a Cronbach's Alpha coefficient of 0.824, and corrected item-total correlations ranging from 0.161 to 0.650, which do not meet the required standards. After removing the variable “*Knowledge of history, culture, and geography*”, the Cronbach's Alpha coefficient increased to 0.843, and the corrected item-total correlations ranged from 0.370 to 0.688. A total of 8 observed variables were retained.

The “**Skills**” scale consists of 12 observed variables with a Cronbach's Alpha coefficient of 0.772, and corrected item-total correlations ranging from 0.072 to 0.619, which do not meet the required standards. After removing the variables “*Skills to apply professional knowledge in work*”, “*Communication skills (indirect: via phone, email, etc.)*”, “*Communication skills (direct)*”, and “*Problem-solving skills*”, the Cronbach's Alpha coefficient increased to 0.876, and the corrected item-total correlations ranged from 0.465 to 0.702. A total of 8 observed variables were retained.

The “**Attitude**” scale consists of 12 observed variables with a Cronbach's Alpha coefficient of 0.719, and corrected item-total correlations ranging from 0.243 to 0.476, which do not meet the required standards. After removing the variables “*Passionate and enthusiastic attitude in work*” and “*Ability to handle high pressure in work*,” the Cronbach's Alpha coefficient was 0.711, and the corrected item-total correlations ranged from 0.312 to 0.492. A total of 10 observed variables were retained.

According to the results of the KMO and Bartlett's test, the KMO coefficient is 0.768 ( $> 0.5$ ), which exceeds the minimum threshold of 0.5, confirming that the data is appropriate for factor analysis (Hair et al., 2010). Bartlett's test of sphericity yielded a p-value of 0.000, indicating that the observed variables are correlated in the population and thus suitable for factor analysis. The total variance explained by the data is 64.476%, which is greater than the minimum acceptable level of 50%, ensuring that the variables meet an acceptable level of explanatory power (Hair et al., 2010). Thus, the data is suitable for EFA analysis. Using principal components extraction and Varimax rotation, with Eigenvalues greater than 1 and a minimum factor loading coefficient of 0.5, the data was grouped into six factors as shown in Table 5.

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**Table 5. Rotated component matrix<sup>@</sup>**

Observed Variable	Component					
	1	2	3	4	5	6
X21	0,803					
X17	0,788					
X19	0,782					
X14	0,739					
X20	0,728					
X15	0,713					
X8		0,880				
X7		0,866				
X5		0,775				
X9		0,514				
X1			0,772			
X3			0,762			
X4			0,755			
X22				0,753		
X23				0,707		
X29				0,549		
X31					0,794	
X32					0,789	
X26						0,779
X25						0,764
Sig. = 0.000						
KMO=0.768						

*(Source: Data analysis results 2024, n=165)*

The results after factor rotation are as follows:

Factor 1 is influenced by six measurement variables: X21, X17, X19, X14, X20, X15. This factor is named Skills.

Factor 2 is influenced by four measurement variables: X8, X7, X5, X9. This factor is named Professional Knowledge.

Factor 3 is influenced by three measurement variables: X1, X3, X4. This factor is named Social Knowledge.

Factor 4 is influenced by three measurement variables: X22, X23, X29. This factor is named Work Attitude.

Factor 5 is influenced by two measurement variables: X31, X32. This factor is named Work Spirit.

Factor 6 is influenced by two measurement variables: X26, X25. This factor is named Work Ethics.

According to Trong and Ngoc (2008), to evaluate the level of influence of each observation

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case, the factor equation is as follows:

$$F_i = W_{i1} X_1 + W_{i2} X_2 + W_{i3} X_3 + W_{i4} X_4 + \dots + W_{ik} X_k$$

Where:  $F_i$ : Estimated value of the  $i^{\text{th}}$  factor;  $W_i$ : Factor weights;  $k$ : Number of variables.

**Table 6. Component Score Coefficient Matrix**

Observed Variable	Factor					
	1	2	3	4	5	6
X21	0,231					
X17	0,239					
X19	0,222					
X14	0,209					
X20	0,216					
X15	0,187					
X8		0,390				
X7		0,374				
X5		0,280				
X9		0,138				
X1			0,380			
X3			0,420			
X4			0,358			
X22				0,545		
X23				0,468		
X29				0,360		
X31					0,556	
X32					0,549	
X26						0,564
X25						0,573

*(Source: Data analysis results 2024, n=165)*

Based on the factor score matrix, the equations representing the impact of each observed variable on each factor are as follows:

$$F_1 = 0.231X_{21} + 0.239X_{17} + 0.222X_{19} + 0.209X_{14} + 0.216X_{20} + 0.187X_{15}$$

**Factor 1** is influenced by six measurement variables: All variables have a positive impact on Factor F1. Among them, **X17** has the strongest impact on the factor “Skills” due to having the highest factor score. This means that if X17 increases or decreases by 1 unit, Factor F1 will increase or decrease by 0.239 units.

Therefore, to enhance the skills of workers in the tourism industry in An Binh Islet, agencies and employers should focus on training to improve workers' observational skills during their tasks. Following X17 are the variables X21, X19, X20, X14, and X15, with factor scores of 0.231, 0.222, 0.216, 0.209, and 0.178, respectively.

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$$F2=0,390X8+0,374X7+0,280X5+0,138X9$$

**Factor 2** is influenced by four measurement variables: All variables have a positive impact on the factor **Professional Knowledge**, with **X8** having the strongest influence due to having the highest factor score. This means that if X8 increases or decreases by 1 unit, Factor F2 will increase or decrease by 0.390 units.

Therefore, to enhance workers' professional knowledge, it is essential to focus on improving knowledge about hygiene and food safety. Following X8 are the variables X7, X5, and X9, with factor scores of 0.374, 0.280, and 0.138, respectively.

$$F3=0,380X1+0,420X3+0,358X4$$

**Factor 3** is influenced by three measurement variables: All variables have a positive impact on the factor **Social Knowledge**, with **X3** having the strongest influence due to having the highest factor score. This means that if X3 increases or decreases by 1 unit, Factor F3 will increase or decrease by 0.420 units.

Therefore, to enhance workers' social knowledge, it is important to focus on their understanding of specialized fields. Following X3 are the variables X1 and X4, with factor scores of 0.380 and 0.358, respectively.

$$F4=0,545X22+0,468X23+0,360X29$$

**Factor 4** is influenced by three measurement variables: All variables have a positive impact on the factor **Work Attitude**, with **X22** having the strongest influence due to having the highest factor score. This means that if X22 increases or decreases by 1 unit, Factor F4 will increase or decrease by 0.545 units.

Therefore, a good work attitude among employees indicates their strong compliance with the regulations and policies of their organization. Following X22 are the variables X23 and X29, with factor scores of 0.468 and 0.360, respectively.

$$F5=0,556X31+0,549X32$$

**Factor 5** is influenced by two measurement variables: Both variables positively impact the factor **Work Spirit**, with **X31** having the strongest influence due to having the highest factor score. This means that if X31 increases or decreases by 1 unit, Factor F5 will increase or decrease by 0.556 units.

Therefore, a high work spirit among employees indicates a high level of creativity and innovation. Following X31 is the variable X32, with a factor score of 0.549.

$$F6=0,564X26+0,573X25$$

**Factor 6** is influenced by two measurement variables: Both variables positively impact the factor **Work Ethics**, with **X25** having the strongest influence due to having the highest factor score. This means that if X25 increases or decreases by 1 unit, Factor F6 will increase or decrease by 0.573 units.

Therefore, good work ethics among employees indicate a strong sense of responsibility in their work. Following X25 is the variable X26, with a factor score of 0.564.

## 4. Conclusion

An Binh Islet is blessed with abundant fruit gardens and hospitable residents, making it one of the prominent tourist destinations in Vinh Long in particular and the Mekong Delta in general. One of the key factors contributing to the success of tourism activities is the human element. The workforce plays a vital role in ensuring tourists' satisfaction with An Binh Islet tourism. The quality of the labor force serving tourism on An Binh Islet is evaluated as relatively good based on observed variables related to knowledge, skills, and attitude. However, certain variables, such as Knowledge of using restaurant and hotel equipment, Knowledge of dress



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codes and personal hygiene in the service industry, Teamwork skills, and Creative and innovative spirit, are not rated highly and need to be prioritized for training and improvement. The analysis results indicate that six factors impact the quality of human resources: skills, professional knowledge, social knowledge, work attitude, work ethic, and work spirit. Based on these findings, to enhance the quality of human resources, it is crucial to focus on improving skills, professional knowledge, social knowledge, work attitude, work ethic, and work spirit, especially the strongly influencing variables such as Observation skills during work, Knowledge of hygiene and food safety, Knowledge of specialized fields, Attitude towards following organizational rules and policies, Creative and innovative spirit, and Responsible attitude in work.

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## ARTIFICIAL INTELLIGENCE IN EDUCATION: A PHENOMENOLOGICAL APPROACH TO EXPLORING PRE-SERVICE TEACHERS' EXPERIENCE

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### Abstract

Artificial intelligence (AI) has rapidly evolved, significantly influencing various domains, including education. Recent advancements in generative AI (GenAI), such as ChatGPT, have introduced innovative solutions for personalized learning, task automation, and interactive content creation. However, the integration of GenAI into educational settings raises critical questions about its acceptance and perceived value among future educators. This phenomenological study investigates pre-service teachers' attitudes toward GenAI tools, focusing on their perceived usefulness in supporting educational tasks. Grounded in the Technological Acceptance Model (TAM), this research provides insights into how ease of use and perceived usefulness influence technology adoption among final-year computer science education students at Ahmadu Bello University, Zaria, Nigeria. Semi-structured interviews with six pre-service teachers revealed five key themes. Participants highlighted ease of use as a critical factor, with ChatGPT simplifying complex academic tasks and enabling efficient information retrieval. The theme of perceived usefulness emphasized ChatGPT's role in enhancing academic performance through personalized learning and time-saving solutions. However, concerns about dependency emerged, with participants warning against over-reliance, which could hinder critical thinking and academic integrity. Additionally, participants praised ChatGPT's personalized learning capabilities, which align with diverse educational needs, and its capacity to reduce workload, thereby supporting effective time management. The findings underscore a crucial interplay between enthusiasm for ChatGPT's benefits and caution about its limitations. While its intuitive functionality and resourcefulness make it an attractive tool for education, issues such as accuracy, ethical concerns, and the risk of overdependence necessitate thoughtful integration into teaching practices. This study recommends structured training programs and guidelines for responsible use to maximize the potential of GenAI tools while mitigating associated risks. The implications highlight the importance of equipping future educators with the skills to leverage AI effectively, ensuring its ethical and transformative integration into education.

**Keywords:** Generative AI, CHATGPT, technology acceptance model, pre-service teachers.

## **1. INTRODUCTION**

Artificial intelligence (AI) has significantly transformed modern society, becoming a cornerstone in domains such as healthcare, finance, and education. Its origins can be traced to the 1950s, with the work of pioneers like Alan Turing, who proposed the concept of machines capable of mimicking human intelligence (Russell & Norvig, 2021). Early AI systems focused on rule-based problem-solving, as demonstrated by projects such as the General Problem Solver (GPS). By the 1970s, AI began making strides in education through computer-assisted instruction (CAI), exemplified by systems like PLATO, which offered programmed lessons on various subjects (Sadykov et al., 2023). The evolution of AI from symbolic reasoning to machine learning in the 1990s paved the way for intelligent tutoring systems (ITS), such as AutoTutor, which tailored learning experiences to individual student needs (Sadykov et al., 2023). The integration of neural networks and natural language processing (NLP) in recent years has brought generative AI (GenAI) to the forefront. Tools like ChatGPT leverage these technologies to simulate conversational interactions and generate adaptive content, further enriching educational ecosystems (Rahman & Watanobe, 2023). This historical progression underscores AI's increasing influence in education, highlighting its potential to democratize learning and foster more inclusive pedagogical approaches.

The transition from traditional AI applications to GenAI has introduced revolutionary tools capable of content creation and interactive engagement. Gen AI models, particularly those based on the transformer architecture like GPT (Generative Pre-trained Transformer), leverage vast datasets to learn language patterns and generate human-like text (Kusal et al., 2022). These models utilise attention mechanisms to process and retain contextual relationships within input sequences, ensuring coherent and relevant outputs. Training involves two phases: pre-training and fine-tuning. During pre-training, models analyse massive corpora of text to identify statistical relationships between words and phrases. Fine-tuning adapts the model to specific applications, enhancing its performance in tasks such as summarisation, translation, and dialogue generation (Kusal et al., 2022). For instance, GPT models predict the next word in a sequence by considering the preceding context, enabling them to generate responses that are both accurate and contextually appropriate. The rise of GenAI in education demonstrates its versatility. Tools like ChatGPT can assist in drafting essays, simulating debates, and providing instant feedback to learners (Rahman & Watanobe, 2023). This functionality reflects the technological sophistication underpinning GenAI and its potential to redefine the boundaries of traditional teaching and learning practices.

GenAI tools, such as GPT, have reshaped educational practices by offering innovative solutions for learners, educators, and institutions. For students, these tools provide personalised learning opportunities while addressing individual knowledge gaps and enhancing self-directed study (Firat, 2023). ChatGPT, for instance, assists learners by answering subject-specific queries, summarising readings, and generating practice questions that enable greater autonomy in the learning process. Educators benefit from the capacity of AI-based tools to streamline administrative tasks, such as marking assignments, preparing instructional materials, and analyzing student performance data (Koroleva & Jomezai, 2024). By automating these responsibilities, teachers can dedicate more time to mentoring and facilitating critical discussions. At the institutional level, GPT-powered systems enhance operational efficiency. AI-driven chatbots handle administrative queries, while data analytics tools offer insights into enrollment trends and academic outcomes, aiding decision-making processes (Koroleva & Jomezai, 2024). These multifaceted applications illustrate how GenAI tools align with the goals

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of modern education while enhancing greater engagement across learning environments. Despite its potential benefits, GenAI in education raises ethical, cognitive, and practical concerns. One significant issue is the risk of dependency, as students may rely excessively on AI-generated answers, which can undermine critical thinking and problem-solving abilities (Zhai et al., 2024). Furthermore, GenAI systems can unintentionally perpetuate biases embedded in their training datasets, leading to skewed or discriminatory outputs (Zhai et al., 2024). Privacy concerns also loom large, given the extensive personal data required for training and customisation, posing challenges around data security and compliance with national and international ethical regulations. For educators, the integration of AI can generate anxieties about job displacement and a diminished role in the learning process. Additionally, the potential for misuse, such as employing GenAI for plagiarism or circumventing academic integrity policies, threatens the credibility of educational systems (Dempere et al., 2023). While these challenges highlight the need for ethical oversight and responsible usage, they also emphasise the importance of understanding pre-service teachers' attitudes toward the use of GenAI in education. Addressing both the promises and perils of GenAI requires enhancing informed perspectives among future educators to ensure its effective and ethical integration into teaching practices.

Therefore, this study aims to investigate the attitudes toward GenAI tools and the usefulness of these tools from the perspectives of pre-service teachers. By pre-service teachers I mean, final-year undergraduate students enrolled in the computer science education programme at Ahmadu Bello University, Zaria. To achieve this aim, I raised and addressed the following research questions:

1. What are pre-service teachers' attitudes towards GenAI tools in education?
2. What is the perceived usefulness of GenAI tools in education among pre-service teachers?

The pre-service teachers' attitudes reflect their evaluative dispositions, shaped by how effectively they believe these GenAI tools support educational tasks. Understanding pre-service teachers' attitudes is essential because these individuals will soon transition into professional roles, where their acceptance and effective use of such tools could shape their pedagogical practices and influence student outcomes. Likewise, perceived usefulness in this study examines whether GenAI is viewed as enhancing their academic performance and teaching preparation. Insights into the perceived usefulness of GenAI tools can inform the development of targeted training programs that will ensure pre-service teachers acquire the necessary skills and confidence to use these technologies effectively. These two constructs (attitudes toward and usefulness of GenAI) situate this study in the framework of the Technological Acceptance Model (TAM). TAM posits that two primary factors—*perceived usefulness* and *perceived ease of use*—influence an individual's attitude toward a technology, which subsequently determines their intention to use it (Davis & Granić, 2024). Situating this research within TAM provides a robust framework for interpreting how pre-service teachers form their perspectives about emerging technologies. It also helps contextualize their adoption tendencies, as GenAI tools continue to gain prominence in educational settings. By anchoring the study within TAM, this research contributes to a deeper understanding of technology acceptance in the education sector, specifically in the context of future educators in computer science education.

## 2. METHODOLOGY

### 2.1 Research Design

The study adopted a phenomenology approach within the qualitative research methodology (Creswell & Creswell, 2017) to explore the attitudes towards and perceptions of preservice teachers on the use of GenAI in education. According to Creswell and Creswell (2017), the phenomenological approach is used in qualitative research whenever the intent is to explore and describe individuals' lived experiences of a phenomenon. It emphasises understanding the essence of these experiences, focusing on participants' perspectives without imposing preconceived notions. Thus, the phenomenology approach is found relevant to this study as the intent is to examine the lived experience of preservice computer science teachers while interacting with GenAI tools.

### 2.2 Participants

Using a purposive sampling procedure, we selected six preservice computer science teachers who had previously used any form of GenAI tools for educational purposes. The non-probability sampling technique is appropriate in this regard as I seek to explore the lived experience of preservice teachers who have extensively used GenAI tools. This sample included five males with varying levels of teaching experience mainly during their teaching practice. Table 1 presents the participants' pseudonyms, gender, experience in teaching, and experience with the types of GenAI tools previously used. The table shows that ChatGPT is the most popular among the preservice computer science teachers.

Table 1

*Participants' detail and experience in teaching and GenAI tools*

SN	Pseudonyms	Gender	Teaching Experience	GenAI tool experience
1	Rukaya	Female	Teaching practice experience and found it stressful and frustrating yet fun.	ChatGPT and Meta AI.
2	Adam	Male	Teaching practice experience and hosted secondary school lessons.	ChatGPT, Gemini AI, Co-pilot, and Claude AI.
3	Joseph	Male	Teaching practice experience and secondary school with summer tutorials.	ChatGPT, Gemini AI, Claude AI, and CoPilot.
4	Clement	Male	Teaching practice experience and found it enjoyable.	ChatGPT
5	Ubaydah	Male	Teaching practice experience.	ChatGPT
6	Dada	Male	Teaching practice experience.	ChatGPT

### 2.3 Data Collection

The data collection involved conducting individual semi-structured interviews with the participating preservice teachers, guided by a self-developed interview protocol. The interview protocol was developed based on TAM with some insights from the literature while following the best practices in the qualitative research paradigm (Braun & Clarke, 2013). The interview protocol contained 13 open-ended questions (three introductory questions, five on attitudes towards GenAI tools, and five on the perceived usefulness of GenAI tools). The interviews, averaging 14 minutes each, were recorded and transcribed verbatim for thematic analysis

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(Braun et al., 2019). All the preservice computer science teachers gave individual written consent to participate in the study and agreed to audiotape the interviews. The interviews were conducted by six trained research assistants who were also preservice teachers of computer science.

## 2.4 Data Analysis

The procedure for data analysis involved multiple steps as outlined by Creswell and Creswell (2017). These steps include organising and preparing the data for analysis, reading through the data, coding the data to identify themes (hand or software), and interpreting the themes. In organising the preparing raw data, I rearrange the transcripts question by question with corresponding responses of all the preservice teachers under each question. Then, I read through the organised data to get familiar with them. Instead of using the traditional approach of coding manually or using standalone software, I employed ChatGPT-4o to conduct both open coding and axial coding of the organized transcripts. Initially, I conducted open coding using ChatGPT-4o. The first prompt instructed the system to code the transcripts while retaining all original respondent quotes. I reviewed and adjusted the generated codes as needed. In the second phase, I performed axial coding using ChatGPT-4o. This stage used a prompt based on research objectives, research questions, and the TAM framework. The thematic prompt asked ChatGPT-4o to develop themes for each category while maintaining the original respondent quotes. I carefully analysed the proposed themes and finalized them through a cross-validation process involving two independent researchers. These steps revealed cross-cutting themes capturing the pre-service computer science teachers' attitudes toward and perception of the usefulness of GenAI in education. The results are presented in the subsequent section.

## 3. RESULTS AND DISCUSSION

### 3.1 Theme 1: Ease of Use and Accessibility

The results show ease of use is a pivotal factor driving positive attitudes toward ChatGPT. Many participants highlighted ChatGPT's accessibility and simplicity, which resonate. By streamlining complex tasks like research and assignments, ChatGPT significantly reduces the cognitive and logistical barriers associated with traditional educational methods. **Rukaya** exemplifies this view by stating, "ChatGPT has made study very easy for students and individuals." This reflects the tool's capacity to simplify learning processes and eliminate the time-intensive effort of searching through books or online articles. This echoes earlier findings by Zakariya et al. (2024), who found that accessibility is crucial in shaping user perceptions of educational technology. However, some studies, such as Garcia Castro et al. (2024), caution that ease of use alone does not guarantee deep learning outcomes, suggesting the need for complementary pedagogical strategies.

Similarly, **Adam** notes, "It provides easy access to information, aiding in research and personalising learning." His comment underscores ChatGPT's dual role as both an information repository and a personalised assistant. This reflects the potential of GenAI tools to bridge gaps in traditional educational resources. ChatGPT's intuitive interface and instant retrieval of information also align with the observations of Rahman and Watanobe (2023), who emphasised the role of ease of use in promoting technology adoption in education. According to TAM, the ease with which users interact with a technology positively influences their likelihood of adopting it (Davis & Granić, 2024). The straightforward interface and intuitive functionality of ChatGPT align with this principle, making it particularly attractive to pre-service teachers who

may lack advanced technical skills. The ability to retrieve instant answers without navigating complex systems reinforces its appeal, especially in time-sensitive scenarios like classroom teaching or assignment deadlines. This theme directly addresses the first research question by revealing that the positive attitudes of preservice teachers stem largely from ChatGPT's perceived simplicity, a critical determinant of technology acceptance.

### 3.2 Theme 2: Perceived Usefulness

The second dominant theme centres on ChatGPT's utility in enhancing the educational experience. The preservice teachers frequently described how the tool aids in research, assignments, and personalised learning. This emphasises the role of GenAI tools as efficient and resourceful assistants. These insights align with the TAM dimension of *perceived usefulness*, which asserts that the degree to which technology improves task performance drives its adoption (Davis & Granić, 2024). **Joseph** illustrates this perspective when he said "ChatGPT is good for educational purposes because it contains research and information that is hard to find offline." This statement highlights ChatGPT's role as a bridge to otherwise inaccessible knowledge, particularly in contexts where physical resources are limited. This aligns with Garcia Castro et al. (2024), who argued that AI technologies provide access to diverse and otherwise inaccessible resources, especially in under-resourced contexts. **Dada** corroborated this point by saying "ChatGPT can provide quick access to information... reducing the stress of searching extensively for answers." The emphasis on reducing effort and stress highlights ChatGPT's utility as a time-saving tool that alleviates the workload associated with traditional research methods.

These observations are consistent with findings from Koroleva and Jomezai (2024), who identified time efficiency and stress reduction as significant benefits of integrating digital tools in education. However, Zhai et al. (2024) warn that over-reliance on AI technologies for research and assignments could lead to surface-level engagement with content, a concern that warrants attention. Furthermore, preservice teachers provided concrete examples of the utilities of GenAI in education as follows:

1. **Assignment Assistance:** **Clement** noted, "It helps me with assignments and research," highlighting its role in simplifying academic tasks.
2. **Content Creation:** **Adam** remarked, "It assists significantly in assignments and content creation by providing ideas and aiding in research."
3. **Resource Efficiency:** **Ubaydah** commented, "Instead of spending hours in a library searching for books, you can get instant answers."

The results of this study consistently link ChatGPT's utility to practical benefits like time savings, enhanced learning efficiency, and access to diverse resources. These features align with the teachers' professional and academic needs, reinforcing their acceptance of ChatGPT. This finding confirms the postulation of TAM that states that technologies perceived as highly useful are more likely to be embraced (Davis & Granić, 2024). This theme addresses the second research question as it shows a consensus among the preservice teachers regarding GenAI as a transformative tool that enhances educational practices.

### 3.3 Theme 3: Personalised Learning and Adaptability

A recurring theme was the ability of ChatGPT to personalise learning experience that caters for individual needs and preferences. The preservice teachers appreciated the tool's flexibility in adapting to diverse learning styles, which enhances engagement and motivation. **Adam** encapsulated this sentiment when he said: "ChatGPT helps personalise learning experiences by offering interactive, user-specific responses." The notion of interactivity suggests that



ChatGPT transcends its role as a static information provider, functioning instead as a dynamic learning companion. This resonates with Firat (2023), who highlighted the role of adaptive learning technologies in fostering active and inclusive education. **Joseph** added, “It provides various approaches to studying and allows students to choose the method that suits them best.” This versatility reflects ChatGPT’s potential to accommodate different learning preferences which could make education more inclusive and accessible. However, studies such as Zhai et al. (2024) caution against over-reliance on AI-driven personalization, noting potential risks like algorithmic bias and reduced exposure to diverse perspectives.

TAM’s emphasis on perceived usefulness intersects with personalised learning by highlighting how technologies that align with user preferences drive adoption (Davis & Granić, 2024). ChatGPT’s ability to tailor responses nurtures deeper engagement which aligns with pedagogical goals of enhancing active and self-directed learning. This theme provides important insights into the second research question, illustrating how ChatGPT’s adaptability enhances its perceived usefulness. By enabling personalized learning, ChatGPT addresses diverse educational challenges, particularly in under-resourced contexts.

#### **3.4 Theme 4: Workload Reduction and Time Management**

The results show that the preservice teachers consistently noted ChatGPT’s role in alleviating their workload and improving time management. These observations emphasise the tool’s efficiency in automating routine tasks and providing quick access to information. For instance, **Ubaydah** remarked that: “It reduces stress and saves time. Instead of spending hours analysing physical books, ChatGPT provides quick and accurate information.” This highlights the dual benefits of efficiency and stress reduction, which are critical for pre-service teachers juggling academic and practical responsibilities. This finding supports the work of Koroleva and Jomezai (2024), who observed that digital tools streamline academic tasks, enabling educators to focus on core responsibilities. **Clement** reinforced this perspective when he said: “Once it helps me complete my assignments and research, I can accomplish more tasks in less time.” The ability to multitask and allocate time effectively aligns with the professional demands of teaching.

The theme of workload reduction resonates strongly with TAM’s focus on usefulness. By automating repetitive tasks and streamlining information retrieval, ChatGPT directly addresses pain points that hinder productivity. This alignment with user needs strengthens its perceived value. This theme elaborates on both research questions, demonstrating how ChatGPT’s practical benefits influence attitudes and perceptions. By reducing workload, ChatGPT supports pre-service teachers in balancing their educational and professional obligations. Despite these advantages, scholars such as Garcia Castro et al. (2024) argue that technology’s potential for workload reduction must be balanced with training to ensure meaningful integration into teaching practices.

#### **3.5 Theme 5: Concerns Over Dependency**

Despite its benefits, the preservice teachers raised concerns about over-reliance on ChatGPT. This theme reflects apprehensions about the potential negative impact of excessive dependence on AI technologies, particularly in encouraging laziness or reducing critical thinking. **Adam** voiced this concern when he said: “The disadvantages, such as making students lazy because they rely too much on AI to do everything for them, are a concern.” Similarly, **Joseph** observed that: “It can make some students lazy, especially when they rely on AI for assignments that require personal effort.” Both comments highlight the tension between ChatGPT’s convenience and its potential to undermine academic rigour. This aligns with Zhai et al. (2024), who noted that dependence on digital tools could undermine critical thinking and academic

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rigour. Moreso, the preservice teachers also noted accuracy issues with ChatGPT. **Dada** stated, “ChatGPT is not always 100% accurate. Sometimes, it may provide incomplete or partially correct answers.” This scepticism reflects an awareness of the tool’s limitations that underscores the need for critical engagement with its outputs.

These concerns about dependency and accuracy align with TAM’s discussion of external variables that moderate acceptance. While ChatGPT’s ease of use and usefulness are compelling, negative perceptions about its potential drawbacks temper its adoption. This ambivalence suggests that while ChatGPT is a valuable tool, it requires careful management to avoid misuse. This theme expands the analysis by addressing implicit concerns underlying the research questions. While participants largely embrace ChatGPT, their reservations about dependency and accuracy highlight areas for improvement in integrating AI into education.

The findings of this study align closely with the study’s objective of investigating pre-service teachers’ acceptance of ChatGPT in education. The themes reveal a significant interplay between enthusiasm for ChatGPT’s benefits and caution about its limitations. While *ease of use* and *usefulness* dominate positive perceptions, concerns about dependency and accuracy temper this acceptance, reflecting a balanced perspective. Based on these findings, I recommend that educational institutions should develop guidelines for incorporating GenAI tools into teaching and learning, addressing concerns about over-reliance. Also, teachers should receive training on effectively using ChatGPT, emphasising critical evaluation of its outputs. Furthermore, GenAI tools should complement, rather than replace, traditional learning resources to ensure a balanced approach to education.

#### 4. CONCLUSION

This study explored preservice teachers’ attitudes toward and perceptions of using GenAI tools with a particular reference to ChatGPT. Rooted in the technological acceptance model, the study employed a phenomenology approach to probe six purposively selected preservice experience of GenAI through semi-structured interviews. The results highlight ease of use, perceived usefulness, adaptability, and impact on workload management as some affordances of GenAI tools albeit with some reservations. Findings reveal that ChatGPT’s accessibility and intuitive interface significantly reduce cognitive and logistical barriers. This, in turn, enhances positive attitudes toward the adoption of GenAI tools in educational contexts. Their utility in simplifying research, assignments, and content creation aligns with the TAM, which underscores ease of use and perceived usefulness as key determinants of technology adoption. Moreover, GenAI tools’ ability to personalise learning experiences demonstrates its potential to accommodate diverse learning preferences and promote engagement. These benefits are particularly valuable in under-resourced contexts, where the tool bridges gaps in traditional educational resources and enhances efficiency. Thus, enabling preservice teachers to better manage academic and professional demands.

However, the findings also underscore critical concerns, particularly regarding over-reliance on GenAI tools and the accuracy of their responses. While participants acknowledged the tools’ transformative potential, they emphasised the need for balanced usage to avoid undermining critical thinking and academic rigour. These reservations highlight the importance of integrating AI literacy into teacher education programs to enhance the responsible and effective use of such technologies. Additionally, scepticism about the tools’ accuracy underscores the necessity of critical engagement with their outputs. In sum, this study contributes to the growing body of literature on generative AI in education by offering important insights into its benefits and challenges. By addressing these concerns, stakeholders can maximise the potential

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of GenAI tools like ChatGPT while mitigating risks, and paving the way for innovative, equitable, and sustainable educational practices. Future research should further investigate the long-term impacts of generative AI tools on teaching and learning across diverse educational settings.

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**TEACHING GENERATION Z STUDENTS FOR PRODUCTIVE LEARNING:  
INTRODUCING INQUIRY-DRIVEN COLLABORATIVE LEARNING MODEL**

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**Abstract**

Teaching Generation Z students in Nigerian secondary schools demands a paradigm shift in mathematics education to accommodate their digital nativeness, learning preferences, and need for engagement. This chapter explores strategies for enhancing productive learning tailored to this cohort. Generation Z's characteristics—technological fluency, preference for collaborative and hands-on activities, and demand for relevance—necessitate an evolution from traditional teacher-centred methods to interactive, student-centred approaches. Central to this discourse is the integration of flexible and active learning spaces, which leverage adaptable physical setups and digital tools to enhance collaboration and critical thinking. This chapter examines three belief models influencing teaching practices: blame-the-student, blame-the-teacher, and student-centred, advocating for the latter as the most effective for Gen Z. The Inquiry-Driven Collaborative Learning (IDCL) model, designed by the author, is presented as an innovative framework combining inquiry-based and collaborative strategies to deepen engagement and understanding. Constructive alignment among learning outcomes, activities, and assessments is emphasised to ensure coherence and promote higher-order thinking. Further, the chapter recommends a balanced approach to formative and summative assessments, underpinned by criterion-referenced standards, to optimise learning outcomes. By bridging the gap between innate academic achievers and less motivated students, the proposed methodologies equip teachers with actionable insights to transform mathematics classrooms into environments that cater to the diverse needs of Generation Z.

**Keywords:** Generation Z, productive learning, mathematics education, active learning spaces, Inquiry-Driven Collaborative Learning, constructive alignment.

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## 1. INTRODUCTION

Secondary schools in Nigeria are facing a new wave of challenges that stem from the high enrolment of a generation of students who are regrettably distracted and obsessed with technologies for social networking and fun. This generation of students is named Generation Z (Gen Z) in the literature (Latterell, 2024; Schroth, 2019; Turner, 2015). Students from Gen Z, born between 1997 and 2013, are considered the quintessential digital natives (Schroth, 2019). Gen Z is the first generation of students to grow up with ubiquitous access to mobile phones and to witness the surge of online education, particularly catalysed by the pandemic. They were born in the aftermath of 9/11 and have never lived in what might be considered a universally "safe" period (Latterell, 2024). Gen Z is characterised by greater privacy, increased diversity, and a higher level of acceptance of differences compared to preceding generations. They are often noted for their loyalty, passion, diligence, and open-mindedness (Latterell, 2024). They maintain extensive global social networks and are motivated by a desire to positively impact the lives of others. Notably, more Gen Z individuals were home-schooled than any previous generation, even before the pandemic. They have always had access to Google, a tool that has significantly influenced their approach to education and the scope of their learning (Latterell, 2024).

Mathematics teachers should be aware that the era of academic students is expiring. Students who are academically committed and want to learn with or without teachers' supervision are becoming less in our classrooms. The intrinsically motivated students who are interested in their studies and want to do well in mathematics with clear academic or career plans belong to the generation before Gen Z called Generation X (Latterell, 2024). We are now in an era of less academically inclined students who only want to pass the subject with minimal effort. They are in school not out of a driving curiosity about a particular subject, or a burning ambition to excel in a particular profession. Instead, they are in school simply to follow their parents' instructions or to obtain a qualification for a decent job. It has become imperative for teachers to organise their teaching and learning activities such that Gen Z students engage in productive learning. By productive learning, I refer to teaching and learning activities that ensure most Gen Z students engage in the necessary cognitive processes to achieve the intended outcomes, similar to the way more academically inclined students do naturally. In other words, productive learning involves creating a learning environment where students are actively thinking, creative, and applying knowledge in a way that helps them meet their educational goals. This approach aims to bridge the gap between students who naturally excel academically and those who might need more structured support to reach the same level of understanding and skill. The idea is to ensure that all students, regardless of their initial academic abilities, are given the tools and opportunities to succeed in their learning endeavours. The purpose of this paper is to explore various approaches through which mathematics teachers can facilitate productive learning among Gen Z students with a special focus on a new model of inquiry-based mathematics education.

## 2. TEACHER BELIEFS FOR GEN Z STUDENTS

The first consideration in teaching Gen Z students is teacher beliefs. The teacher's beliefs profoundly influence how mathematics is taught, especially in the context of Gen Z students. These beliefs encompass personal convictions regarding education and the teacher's role, significantly shaping instructional strategies and classroom dynamics (Tan & Caleon, 2023). In Nigeria, teacher perceptions of students' abilities play a critical role. High expectations foster positive environments that encourage students to reach their potential, whereas low

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expectations often perpetuate underachievement (Hollenstein et al., 2024). Additionally, beliefs about the teacher's role vary, ranging from knowledge transmitters to facilitators, with differing impacts on instructional approaches and student relationships (Nguyen & Tran, 2023; Rupnow, 2023). Teacher beliefs have been conceptualised, operationalised, and categorised into three levels. The Level 1 (Blame-the-Student) model of teacher beliefs views students as the primary factor in learning outcomes. Teachers operating under this model categorise students into high and low achievers, attributing success or failure to student characteristics such as ability, motivation, and prior background (Biggs, 2012). Teaching in this framework involves uniform content delivery through direct instruction, with assessments used primarily to differentiate student abilities. This "blame-the-student" mentality promotes rote memorisation, overlooks conceptual understanding, and absolves teachers of responsibility for student learning outcomes. In mathematics, where comprehension is essential, this approach stifles the development of critical thinking and problem-solving skills, perpetuating a cycle of static teaching practices and student disengagement.

In the Level 2 (Blame-the-Teacher) model, responsibility shifts to the teacher's methods and strategies. While this approach still focuses on knowledge transmission, it emphasises refining teaching skills to enhance effectiveness (Biggs et al., 2022). Teachers are encouraged to adopt clear rules, effective classroom management, and strong communication techniques. However, the focus on competencies, such as developing tests or integrating technology, often addresses surface-level skills rather than the deeper goal of facilitating meaningful learning. Although this model holds teachers accountable for instructional quality, it risks framing teaching as a technical exercise rather than an adaptive, student-centred process. Teaching effectiveness requires skill mastery and purposeful application to improve learning outcomes. The Level 3 (Student-Centred) model emphasises student actions and learning outcomes over teaching inputs. This approach prioritises defining clear learning objectives, understanding content deeply, and designing activities that actively engage students to achieve these objectives (Biggs et al., 2022). For mathematics, this entails moving beyond presenting formulas to fostering exploration, application, and problem-solving. Teachers continuously assess and adapt strategies to address gaps in student understanding, ensuring personalized and effective learning experiences.

Gen Z students, accustomed to digital, interactive environments, benefit greatly from the Level 3 model. Active learning strategies, such as collaborative projects and technology integration, align with their preferences and enhance engagement. This model supports critical thinking and application of mathematical concepts, enabling students to tackle real-world problems. Moreover, its emphasis on differentiated instruction accommodates diverse needs and prior knowledge levels while enhancing students' learning outcomes. Regular assessment and adaptation further ensure that intended learning objectives are met, preparing students for the demands of a complex, technological world (Zakariya et al., 2022). In Nigerian mathematics classrooms, adopting the Level 3 model addresses critical gaps by encouraging deep understanding, personalised learning, and adaptability—key to equipping Gen Z students with skills for future challenges.

### **3. CHOOSING APPROPRIATE LEARNING SPACES**

Learning environments play a crucial role in shaping student engagement and academic outcomes, particularly in mathematics. Secondary schools offer various physical and virtual learning spaces, each with unique advantages and limitations. In Nigeria, resource constraints necessitate careful consideration of these spaces to optimise teaching strategies (Aga, 2023;

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Benade, 2019). Traditional classrooms, characterised by rigid, front-facing seating arrangements, support structured, teacher-led instruction (Benade, 2019) are the oldest type of learning spaces. While effective for large groups and content delivery, they often limit student-centred learning and interaction. Overcrowding, a common issue in Nigerian schools, exacerbates these limitations by restricting individualised attention and group work opportunities. Flexible learning spaces, featuring movable furniture and multiple instructional focal points, promote collaboration, creativity, and interactive learning are another crucial type of learning space. They empower students to view teachers as partners rather than authority figures which can enhance a fear-free environment for expression. However, implementing such spaces requires substantial investment and teacher training (Benade, 2019). Similarly, outdoor spaces enable experiential learning, particularly in practical mathematics, by linking concepts to real-world contexts (Mettis & Våljataga, 2021). However, weather conditions, safety concerns, and inadequate infrastructure limit their consistent use.

Further, some learning spaces can be identified as a result of the proliferation of digital tools in education. For instance, virtual learning spaces offer flexibility, enabling asynchronous and synchronous learning through digital platforms. Despite their benefits, accessibility challenges such as limited internet connectivity and digital literacy remain significant barriers in Nigeria (Akaeze & Akaeze, 2024). Similarly, we have digital classrooms. The digital classrooms, integrating technology into traditional settings, enhance learning through interactive tools and online resources. Yet, maintenance and infrastructure limitations pose challenges for widespread adoption. Finally, active learning spaces blend technology with flexible setups, creating collaborative, hands-on educational environments. These spaces address resource constraints, large class sizes, and diverse learning needs by integrating elements like flexible furniture, breakout areas, and interactive displays. They align with Gen Z students' preferences for technology-rich, application-based learning, fostering critical thinking and teamwork (Freeman et al., 2014). However, overcoming digital divides and ensuring sustainable infrastructure are crucial for their success in Nigeria.

#### **4. TEACHING AND LEARNING ACTIVITIES**

Teachers need to take a lead role in deliberately organising the teaching and learning activities to foster productive learning among Gen Z students. There is an accumulation of evidence that suggests an active learning approach to teaching and learning process is a viable option in fostering such productive learning in mathematics (Freeman et al., 2014; Laursen & Rasmussen, 2019). Thus, teachers should adopt the active learning approach to teach mathematics among Gen Z students. Meanwhile, active learning is a pedagogical approach that has been defined and understood differently by various educators and researchers. Despite these differences, there is a consensus on certain core elements that constitute active learning. These elements include deep engagement with the learning material, interactive peer-to-peer learning, leveraging students' thought processes to enhance learning, and ensuring that every student has equal opportunities to succeed. Secondary school mathematics teachers can incorporate these foundations by designing lessons that require students to actively participate and engage deeply with mathematical concepts. This can be achieved through activities such as solving complex problems, discussing mathematical concepts in groups, and applying concepts to real-world scenarios. These activities can be enhanced with online mathematics platforms, interactive simulations digital tools such as Google Forum, WhatsApp and Facebook. Teachers should facilitate discussions and group work, allowing students to express their understanding and challenge each other's thinking. This approach aligns well with the



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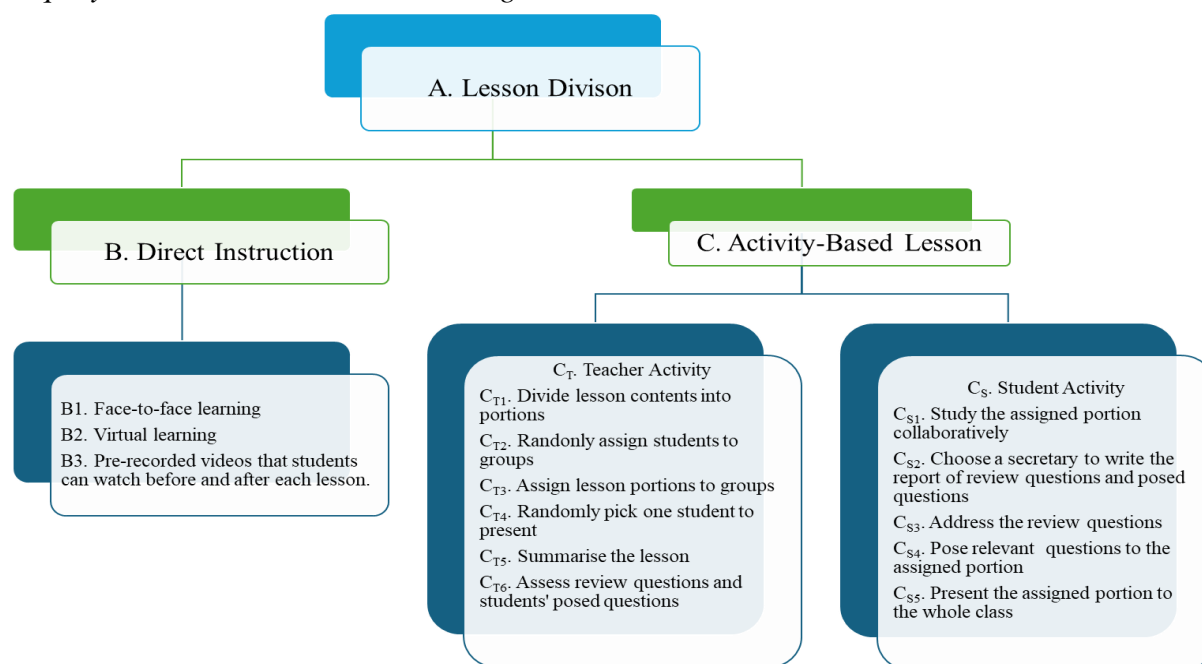
characteristics and learning preferences of Gen Z students, who thrive in interactive and technology-enhanced learning environments (Latterell, 2024).

Several models of active learning approach exist in the literature each with its strengths and weaknesses. In some instances, these models lead to incoherent outcomes in students' learning. It is against this background that I drew from my experience to develop an Inquiry-Driven Collaborative Learning (IDCL) model to enhance student learning. This model combines inquiry-based learning with collaborative activities, providing a structured approach that encourages students to actively participate and engage deeply with the content. The IDCL model is designed to integrate multiple active learning techniques, creating a comprehensive framework for effective teaching. The IDCL model was implemented in an undergraduate course at Ahmadu Bello University and outcomes in students' learning were promising.

The structure of the IDCL model involves dividing the lesson into two segments: direct instruction and activity-based lessons. The direct instruction provides foundational knowledge using a mixture of face-to-face learning, virtual learning, and pre-recorded videos that students can watch before and after each lesson. The activity-based lesson encourages students to engage with the material, think critically, and collaborate with peers. For each activity-based lesson, I randomly divide students into groups and assign each group portion of the lesson note. Students in each group study their portion, answer ill-structured review questions relevant to the note, pose their questions, present their understanding of the assigned portion in class, and then submit their answers to the reviewed questions as well as their posed questions relevant to the assigned portion of the note. By dividing students into random groups and assigning them specific tasks, the model ensures diverse interactions and shared responsibility for learning. As the teacher, I reinforce their learning through scaffolding (support that is gradually removed as students become more competent), ensuring that each student has the support needed to succeed in the course. Furthermore, I provide qualitative formative feedback by assessing students' answers to the reviewed questions as well as their posed questions at the end of each activity and recommend areas for improvement. This model combines inquiry methods, cooperative learning, collaborative learning, problem-solving, problem-posing, and presentation skills to enhance students' learning experience. The feedback from students highlights the effectiveness of the IDCL model in enhancing their understanding and satisfaction with the learning process. The emphasis of the model on deep engagement, collaborative learning, and equitable participation creates a supportive and productive learning environment tailored to the needs of Gen Z students. Figure 1 presents a summary of activities involved in the IDCL model.

Figure 2.

*Inquiry-Driven Collaborative Learning Model*



Secondary school mathematics teachers can adapt the IDCL model by structuring their lessons to include both direct instruction and activity-based lessons. For example, teachers can implement this structure by starting each lesson with a clear and concise explanation of the day's topic. Following this, students can be grouped to work on specific problems or projects that require them to apply the concepts they have just learned. Teachers should provide guiding questions that encourage critical thinking and discussion, and then facilitate group presentations where students share their findings and solutions. Alternatively, mathematics teachers can alternate between direct instruction classes and activity-based classes. It is a good idea for technology to be integrated into direct instruction classes. This is especially fascinating for Gen Z students. The teacher's role in the activity classes is to scaffold learning by providing initial support, such as step-by-step problem-solving guides, and gradually reducing this support as students become more confident. Encouraging students to pose and solve reviewed problems will foster critical thinking and a deeper understanding of mathematical concepts. The teacher needs to assess students' answers to the reviewed questions to provide formative feedback and not to grade the students. Further, teachers should assess the posed questions by the students for their solvability – solvable or unsolvable, reasonability – reasonable or unreasonable, mathematical structure – result unknown model or start unknown model, context – routine or non-routine, and language – clarity or obeying grammar rules (Cankoy & Özder, 2017). I contend that by fostering an environment that emphasises deep engagement, collaboration, and equity, the IDCL model will effectively support the learning needs of Gen Z students in mathematics.

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### 5. THE ASSESSMENT TASKS

Assessment in mathematics education serves as a systematic process to evaluate students' knowledge, skills, attitudes, and beliefs. It involves gathering both qualitative and quantitative evidence to make informed judgments about student learning, which can guide instruction, enhance student growth, and align curriculum, instruction, and assessment (Sangwin, 2013). Assessments provide crucial feedback to teachers, students, and parents, offering insights into academic progress and the effectiveness of instruction (Black & Wiliam, 2006). Two primary philosophical perspectives that influence assessment practices have been identified in the literature: measurement and standards. The measurement perspective focuses on comparing students' performance against peers using standardised assessments. It supports consistent evaluation across schools and regions, ensuring educational standards are met. For instance, national mathematics assessments measure knowledge in areas like algebra or geometry. While providing objectivity and comparability, this approach often emphasises memorization over creativity, may fail to assess non-cognitive skills, and can induce stress (Shepard, 2000)(Shepard, 2000). In contrast, the standard perspective employs criterion-referenced assessments, judging students against predefined standards. Tools like rubrics assess mathematical tasks based on accuracy, problem-solving, and presentation. This approach promotes equity by setting uniform expectations and measurable targets, but it may overlook individual strengths, cultural diversity, and creativity (Stiggins, 2004).

For Generation Z students, who favour interactive and technology-driven learning, a balanced approach incorporating the standards perspective, formative, and summative assessments is recommended. Standards-based assessments ensure equity and clear expectations, while formative methods provide continuous feedback and engagement. Summative assessments validate overall learning and complement formative strategies. Moreover, assessments should be varied and authentic, providing opportunities for students to demonstrate their understanding in multiple ways, thus catering to diverse learning styles and abilities. Such an approach not only makes mathematics more engaging and accessible for Gen Z students but also equips them with the necessary skills to tackle complex problems in their future academic and professional endeavours.

### 6. CONCLUSION

Teaching for productive learning in mathematics classrooms, especially for Gen Z students, necessitates a shift from traditional teaching methods to more interactive and student-centred approaches. The emphasis on active learning strategies, such as the Inquiry-Driven Collaborative Learning (IDCL) model, is crucial in engaging Gen Z students who thrive in interactive and technology-enhanced learning environments. By integrating technology, enhancing collaboration, and promoting critical thinking, teachers can create a more engaging and effective learning environment that meets the unique needs of Gen Z students. This approach not only enhances students' understanding and retention of mathematical concepts but also prepares them for the challenges of a rapidly changing world. Moreover, the alignment between intended learning outcomes, teaching-learning activities, and assessment tasks, known as constructive alignment, is fundamental in ensuring that students achieve the desired educational goals. By clearly defining what students are expected to learn, designing activities that facilitate this learning, and assessing students' understanding accurately, teachers can foster a more coherent and focused learning experience. This approach is particularly beneficial for Gen Z students, who appreciate clear goals, interactive learning, and real-world applications of their studies. Ultimately, the goal is to bridge the gap between students who naturally excel

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academically and those who need more structured support, ensuring that all students are given the tools and opportunities to succeed in their learning endeavours.

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**KUDUMBASHREE: FINANCIAL INCLUSION OF WOMEN**

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**Abstract**

The Government of Kerala in India has developed a program called Kudumbashree, a famous project aimed at alleviating poverty via women's empowerment. Through its community-driven concept, the program aims to empower women by fostering economic independence and providing them with possibilities for financial inclusion. This is accomplished through the provision of opportunities. This research paper aims to investigate the significance of Kudumbashree towards the advancement of financial inclusion among women. The essay focuses on Kudumbashree's role in building self-reliance, supporting entrepreneurship, and improving access to credit and financial services. Additionally, the study sheds light on the barriers women encounter when attempting to achieve financial independence and the tactics that Kudumbashree utilized to triumph over these constraints. In the paper's final section, the author discusses the influence that Kudumbashree has had on the socio-economic well-being of women and the scope of its potential to be implemented in other locations.

**Keywords:** Kudumbashree, Women's Financial Inclusion, Empowerment, Microfinance, Kerala, Poverty Alleviation, Entrepreneurship.

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## INTRODUCTION

Inclusion in the financial system refers to the provision of individuals, particularly those who belong to marginalized and disadvantaged groups, with access to financial products and services that are both affordable and appropriate. There are several obstacles that women, particularly those living in economically disadvantaged and rural areas, must overcome to gain access to financial services. These obstacles include cultural restrictions, restricted access to credit, and a lack of financial awareness. As a consequence of this, ensuring that women have access to financial services has become a primary focus to achieve sustainable economic development.

In the Indian state of Kerala, a pioneering program called Kudumbashree has evolved to enhance the socio-economic situation of women. The Kerala State Poverty Eradication Mission (KSPEM) initiated the initiative in 1998 to empower women at the grassroots level. This is accomplished by providing them with the opportunity to gain access to financial services, cultivate skills in entrepreneurship, and contribute to the economic growth of their communities. In addition to facilitating financial inclusion through microfinance programs and other community-driven activities, the effort also involves the development of women's self-help groups, often known as SHGs. This article investigates the role that Kudumbashree plays in increasing women's financial inclusion. It analyzes the influence that Kudumbashree has had on initiatives to alleviate poverty, empower women economically, and encourage women to start their businesses. In addition, the study analyzes how Kudumbashree's concept could be used as a model for boosting the financial inclusion of women in India and other developing countries.

## FINDINGS AND ANALYSIS

### Empowerment through Self-Help Groups (SHGs)

At the grassroots level, Kudumbashree's concept places a significant emphasis on Self-Help Groups (SHGs), which serve as the cornerstone for empowering women. Women gather together to pool their financial resources and make collective decisions about their activities to operate these groups, which are based on the notion of collective action. Not only do the groups assist women in achieving financial independence, but they also assist them in developing abilities in critical leadership, decision-making, and management. To dismantle old gender stereotypes that restrict women's economic engagement, the development of self-help groups (SHGs) provides a formal platform for fostering solidarity among women. This is an essential component in the process. Each self-help group (SHG) typically has between ten and twenty members who are affiliated with a community-based organization in the area. Each member contributes a small amount to the pooled fund to form the SHG. After that, these funds are put to use for the common benefit of the organization, which includes the provision of micro-loans to members who need finance for a variety of economic endeavours.

The strong sense of community and mutual support that exists among SHGs is a significant factor in the fight against the social isolation that women in rural regions frequently experience. In addition, women gain self-assurance and expertise in managing finances and resolving problems through the process of attending frequent meetings and making decisions collectively. This has long-term benefits for the women's personal empowerment and social position. As a result, Kudumbashree has developed a structure that not only caters to the monetary requirements of women but also guarantees their active involvement in the decision-making processes that take place at the community level.



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### **Microfinance and Access to Credit**

Kudumbashree's attempts to promote financial inclusion will also include microfinance, which is another key component of these activities. Because women often do not have collateral, formal employment, or credit records, traditional financial institutions are frequently reluctant to lend money to women, particularly in rural areas. This is especially true among rural women. This gap is filled by Kudumbashree, which offers access to micro-loans without the strict requirements that are typically associated with them. Kudumbashree's microfinance program has resulted in the formation of a large number of businesses that are owned and operated by women. Agriculture-based businesses, small retail shops, and businesses that provide services such as catering, tailoring, and dairy farming are all kinds of businesses that fall under this category. The loans are often modest in size, but they are adequate to enable women to make investments in their enterprises, which ultimately results in higher household earnings and a larger degree of economic autonomy.

The collaboration between the program and banks and other financial institutions helps to streamline access to credit, and the SHGs ensure that loans are repaid in a timely way, which helps to promote a culture of financial discipline. It is important to note that the low interest rates on these loans, in conjunction with the availability of training in financial literacy, make it simpler for women to manage their debt and steer clear of financially problematic situations. In addition, having access to credit makes it easier for women to lessen their reliance on informal lenders, who frequently charge excessive interest rates. This, in turn, contributes further to the financial independence and security of women.

### **Entrepreneurship Development and Skill Training**

Kudumbashree has played a vital role in advancing women's entrepreneurship through the provision of skill development and business training opportunities. The program encompasses diverse skill-development programs in domains such as poultry farming, tailoring, small-scale manufacturing, organic agriculture, and handicrafts. These courses aim to provide women with the information and skills necessary to operate sustainable enterprises. Kudumbashree provides entrepreneurial programs alongside technical training to cultivate business management competencies, encompassing budgeting, marketing, and customer service. Kudumbashree promotes a culture of entrepreneurship, empowering women to assume roles historically held by men, such as company owners and employers, so altering power dynamics within families and communities.

The success of women entrepreneurs is bolstered by support networks and mentorship facilitated by Kudumbashree's comprehensive network of local and regional representatives. This network offers continuous support, including marketing advice, product distribution channels, and access to larger markets, which are frequently the primary obstacles encountered by small-scale women entrepreneurs. Kudumbashree's emphasis on fostering sustainable and socially responsible enterprises guarantees that women contribute to the local economy while enhancing environmental sustainability. A significant number of enterprises established under Kudumbashree concentrate on organic agriculture, renewable energy initiatives, and trash management, hence fostering beneficial effects on society and the environment.

### **Challenges to Achieving Financial Inclusion**

Despite the significant progress it has made, Kudumbashree is still confronted with a number of obstacles in its efforts to attain comprehensive financial inclusion. One of the most significant obstacles is the fact that a sizeable proportion of the women who are participating retain their lack of knowledge regarding financial matters. Even though Kudumbashree

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provides training in financial literacy, there is a need for ongoing education to ensure that women have a complete understanding of various financial concepts. These concepts include the management of savings, the administration of loans, and the comprehension of interest rates etc.

Another obstacle is the strongly rooted socio-cultural norms that restrict the mobility of women and their ability to make decisions within their households. Women are still predominantly regarded as caregivers in many rural communities, and their capacity to manage finances or operate enterprises is sometimes questioned. This is especially true in rural areas. Their capacity to access and make good use of financial services is hindered as a result of this. Furthermore, even though the microfinance model has been successful in providing women with access to modest loans, there are constraints in terms of scaling up these loans for larger businesses. It is difficult for many female entrepreneurs to extend their enterprises beyond a particular scale since they do not have access to larger financing. This lack of access could potentially limit the potential for economic growth when it comes to women entrepreneurs. In addition, the women who are active in Kudumbashree's entrepreneurial endeavors face hurdles in the form of rivalry from larger enterprises, fluctuations in the market, and environmental issues such as climate change. To address these external concerns, Kudumbashree, governmental bodies, and the business sector will need to collaborate to give women with the resources they require to successfully manage these hazards.

Some essential measures need to be followed for Kudumbashree to maintain its success and broaden its influence. At the outset, efforts must be made to expand the scope of financial literacy programs. This will ensure that women are aware of the complexities of financial products and the management of businesses. In the second place, women need to have more access to larger loans or cash for them to expand their businesses beyond the level of micro-enterprises. To help bridge this gap, expanding collaborations with larger financial institutions and providing financial products that are suited to individual needs will be successful.

In addition, Kudumbashree could reap the benefits of incorporating digital financial tools and platforms to broaden its reach and make financial services more accessible, particularly in locations that are geographically isolated. Promoting digital literacy among women may also make it possible for them to participate in online banking, engage in e-commerce, and have access to financial services on a broader scale. Finally, Kudumbashree ought to keep working toward the goal of removing the socio-cultural obstacles that stand in the way of women's access to financial services. To do this, it will be necessary to advocate for policies that are sensitive to gender issues, to raise knowledge about the economic rights of women, and to provide men with opportunities to support the empowerment of women through financial inclusion.

### **CONCLUSION**

Kudumbashree has made remarkable strides in promoting the financial inclusion of women in Kerala, contributing significantly to women's empowerment, poverty alleviation, and the socio-economic development of communities. Through its SHG-based model, microfinance initiatives, and entrepreneurship development programs, Kudumbashree has created a transformative impact on the lives of women, enabling them to achieve financial independence and contribute to their communities' economic growth. However, to ensure its sustainability and broader impact, further efforts are needed to address the challenges related to financial literacy, social norms, and institutional support. By overcoming these barriers, Kudumbashree can serve as a model for other states in India and developing nations looking to promote

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financial inclusion and empower women.

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**STORE AMBIENCE AND CUSTOMER PREFERENCE: A STUDY OF SHOPPING  
MALLS IN FEDERAL CAPITAL TERRITORY ABUJA, NIGERIA**

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**Abstract**

The research examined the relationship between store ambience and customers preference for shopping malls in the Federal Capital Territory (FCT) Abuja and by extension Nigeria in general. The study specifically investigated how parking space, product display, and location as dimensions of store ambience influence customers choice or preference for one shopping mall over another in terms of patronage motive, repeat purchase, and referral. A survey design anchored on the philosophy of mixed research method was adopted for the research. While the number of shopping malls in the Federal Capital Territory as at November, 2024 stood at 80 according to Federal Capital Development Administration (FCDA) business premises unit, it was extremely difficult to determine the population of customers of the shopping malls. It was on this premise that the researcher used an estimated customer population of 480 which also served as the sample size for the study. The 480 customers which now formed the respondents were distributed equally to the six area councils that make up the Federal Capital territory – Abaji, Abuja, Bwari, Gwagwalada, Kuje, and Kwali with judgmental sampling method with each council having 80 respondents while the individual respondents were randomly selected through convenience sampling technique. The research instrument for the study was questionnaire. The data collected were analyzed with Spearman rank Order Correlation with the assistance of SPSS version 22. At the end of the analysis and interpretation of results, the research revealed that all the dimensions of store ambience – parking space, product display, and location positively and significantly influenced the buying behaviour of the customers in terms of preference for one shopping mall over another. Based on the findings, the study concluded that store ambience has significant relationship with customers preference for one shopping mall over another in the Federal Capital Territory Abuja and by implication, Nigeria as a whole. The management of the shopping malls were therefore advised to give adequate attention to store ambience planning and implementation as a business strategy to attract customers to their malls but were equally admonished to once in a while engage in consumer opinion research to find out appropriate ambience that suits their target market in order not only to attract customers but also to retain them for future transactions.

**Key Words:** Parking space, product display, location, patronage motive, repeat purchase, referral

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## 1.0 Introduction

Generally, customer preference is a marketing term that deals with how customers choose products, services, and even retail outlets based on their likes, dislikes, and satisfaction. In the words of Myers (2010), customer preference or choice is the act of choosing, picking, or deciding between two or more alternatives. Explaining further, Myers pointed out that preference is the range of different things from which one can choose from. He therefore argued that preference in the area of purchasing decisions is all about the freedom to choose between or among alternative products, services, and outlets that offers maximum satisfaction and value for money.

In the world of business, several factors influence customers purchasing decisions in terms of reference for store shopping mall to patronize among numerous alternatives and store ambience is one of them.

Store ambience refers to the physical environment and atmosphere of a retail store. It encompasses the tangible elements that create an immersive experience for customers, influencing their emotions, behaviour, and perception of a brand. According to Gowrishankar (2017), store ambience represents an environment that is created to generate a stimulus among the customers perceptions and emotions that will affect their purchasing behaviour.

## 1.1 Statement of the Problem

The problem of this study is centred on the recent complain by the Federal Capital Development Administration (FCDA) on what the administration called unprofessional design in terms of lighting, parking space, music, product display, etc and siting of shopping malls in the city with their attendant social and economic implications on both the master plan of the city and the social life of residents of the city.

While some people believe that the various designs and siting of shopping malls in terms of location, lighting, noise, product display, parking space, etc are marketing strategies meant to attract and convince customers to patronize a particular mall instead of other competitors, others assert that they are just new trends in the management and operation of shopping malls and therefore have nothing to do with marketing strategies of attracting or even retaining customers.

It is the zeal to ascertain the actual relationship between store ambience and customers preference for one shopping mall over another that prompted the researcher to engage in this research with Federal Capital Territory Abuja Nigeria as the study area.

## 1.2 Conceptual Framework

A conceptual framework explains how the variables in research interact and affect each other in order to achieve the research objective(s). Miles and Huberman (1994) opined that a conceptual framework can be in written pattern or graphical in nature. A graphical demonstration of the conceptual framework for the current research is shown below.

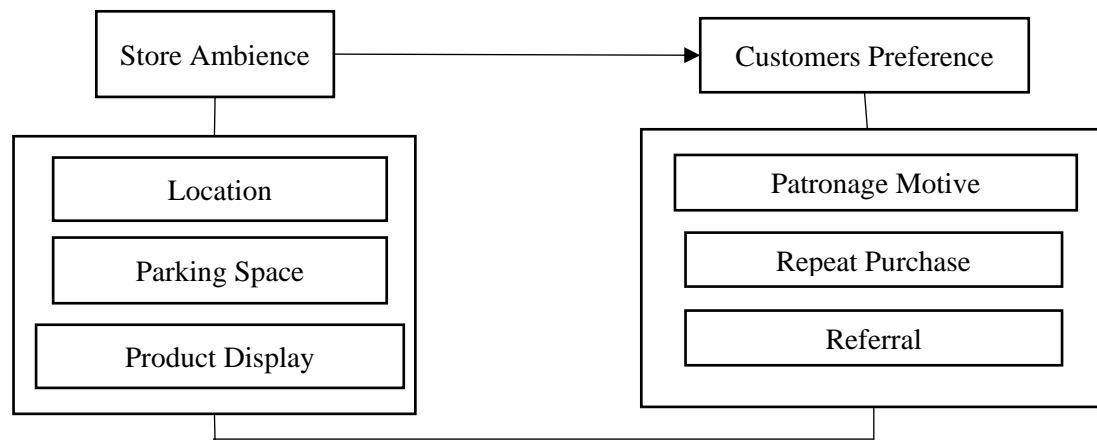


Figure 1.1 A Conceptual Framework Illustrating the Influence of Store Ambience on Customers Preference for Shopping Malls in the Federal Capital Territory Abuja, Nigeria.

Source: Adapted from Miles & Huberman (1994).

### 1.3 Aim and Objectives of the Study

The aim of the research was to ascertain the influence of store ambience on customers preference for one shopping mall over another with Federal Capital territory Abuja Nigeria as the study area. The specific objectives are to:

1. assess the influence of location on customers patronage motive for shopping malls.
2. examine the influence of location on customers repeat purchase from shopping malls.
3. find the influence of location on customers referral for shopping malls.
4. Verify the influence of parking space on customers patronage motive for shopping malls.
5. ascertain the influence of parking space on customers repeat purchase from shopping malls.
6. evaluate the influence of parking space on customers referral for shopping malls.
7. examine the influence of product display on customers patronage motive for shopping malls.
8. ascertain the influence of product display on customers repeat purchase from shopping malls.
9. Find the influence of product display on customers referral for shopping malls.

### 1.4 Statement of Hypotheses

- Ho<sub>1</sub>: Location does not influence customers patronage motive for shopping malls.  
Ho<sub>2</sub>: Location has no influence on customers repeat purchase from shopping malls.  
Ho<sub>3</sub>: Location does not influence customers referral for shopping malls.  
Ho<sub>4</sub>: Parking space has no influence on customers patronage motive for shopping malls.  
Ho<sub>5</sub>: Parking space does not influence customers repeat purchase from shopping malls.  
Ho<sub>6</sub>: Parking space does not influence customers referral for shopping malls.  
Ho<sub>7</sub>: Product display has no influence on customers patronage motive for shopping malls.  
Ho<sub>8</sub>: Product display does not influence customers repeat purchase from shopping malls.  
Ho<sub>9</sub>: Product display does not influence customers referral for shopping malls.

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## 2.0 Review of Related Literature

In this section, information about the predictor and criterion variables of the research were critically examined under conceptual review and some extant researches relevant to the current study analyzed by discussing their similarities and differences where necessary.

## 2.1 Conceptual Review

The review here is on store ambience and its dimensions and customer preference and its measures.

**2.1.1 Store Ambience.** Store ambience is a major part of the store design and it covers the dominant sensory effects created by the store's design. In their opinion, Julie et al (2020) stated that store ambience refers to all the physical and non-physical elements of a store that can be controlled to enhance and manipulate the purchasing behaviour of customers to patronize the store and its offerings. They asserted that the elements present a multitude of possibilities including ambient cues such as colour, smell, music, lighting, texture as well as artificial and architectural elements. Oliver (2021) in an attempt to explain the crucial role of store ambience in business operation, pointed out that it creates emotional connections with customers, influences customers behaviour and purchasing decisions, differentiates a brand from competitors, and enhances overall shopping experience. Tijmen and Lewison (2019) emphasized that by carefully designing and managing store ambience, retailers can create an engaging and memorable experience for their customers.

Although there are many components of store ambience, the content of this research only covered location, parking space, and product display.

**Location.** Location refers to the geographical position or site of a shopping mall, including its proximity to surrounding areas, transportation networks, and other relevant factors. Location is crucial in siting shopping malls for several reasons such as accessibility to actual and potential customers, competition, infrastructure and amenities, safety and security, and many more. Considering these factors, a well-chosen location can significantly contribute to the success of a shopping mall while a poor location can lead to low customers traffic, reduced sales, and ultimately business failure.

**Parking Space.** A parking space is a designated area where vehicles can be parked in a shopping mall, offices, street or any other area designed for such purpose. Parking spaces are typically marked by lines, signs, or other indicators to guide and direct customers on how and where to park their vehicles and any other mobile machines in order to effectively manage available space. Parking spaces are an essential component of shopping malls as they provide a safe and organized area for mobile machines to park.

**Product display.** Product display refers to the visual presentation and arrangement of products in a retail environment, such as a store, showroom, or exhibition. The goal of product display is to attract customers attention, showcase the products' features and benefits and ultimately drive sales. By crafting an engaging and informative product display, businesses can increase customer engagement, drive sales, and build a strong brand presence.

**2.1.2 Customer Preference.** Customer preferences are the judgments and evaluations customers/consumers make about the products, services, and outlets available to them based on factors such as price, quality, convenience, and many more. The theory is based on the idea that consumers are rational and will choose the product, service, or outlet they believe will



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satisfy their needs. Patel (020) in his submission stated that preference refers to the ability or freedom of consumers to decide which business outlet to patronize or which product or service to purchase among a range of possible options.

In practice, there are several indices that marketers use as measures of customers preference for one product, service, or outlet over another but in this study, the researcher made use of patronage motive, repeat purchase, and referral.

**Patronage Motive.** Patronage motive refers to the reasons or motivations that drive a customer to choose a particular store over others. It encompasses the underlying factors that influence a customer's decision to patronize a business outlet.

**Repeat Purchase.** A repeat purchase is when a customer buys a product or service from a brand more than once. Repeat purchases are usually a sign of customer satisfaction and loyalty and can be an opportunity for businesses to build long-term relationships with customers.

**Referral.** In marketing, a referral is a recommendation or endorsement of a product, service, or business outlet by a satisfied customer, friend, or family members. Referral can be a powerful marketing tool, as it is often based on personal experience and can build trust and credibility with potential customers.

### 2.1.3 Empirical Review

In this section, some extant researches that are related in one way or the other with the current research were reviewed. Their similarities identified and differences highlighted.

Ilakya et al (2021) conducted research on the influence of store ambience on consumers purchase behaviour. The study was carried out at Coimbatore. The study specifically examined the influence of storefront, product display, lighting, colour, etc on consumers buying behaviour. It was descriptive research. The population for the research was 120 respondents which also served as the sample size for the study. Information for the study was collected with structural questionnaire. The data collected were analyzed with Analysis of Variance (ANOVA) with the help of SPSS software. At the end of the research, the results showed that all the ambience variables under consideration positively and significantly influenced consumers purchasing behaviour.

Pradeep (2019) did research on the effects of store ambience on consumers choice of retail store format. The study area was Khaghuli Gwahati in India. He specifically assessed how ambience variables affect store format and therefore consumers buying behaviour. The study was survey research. The researcher worked with a population of 177 respondents which equally formed the sample size for the research. Questionnaire was the data collection instrument for the research. The data collected were analyzed with Chi-Square with the assistance of SPSS software. The results of the research revealed that store ambience such as storefront, lighting, product display, temperature and others greatly affect retailers' decisions on store format and therefore influence consumers purchasing behaviour.

Dashrath and Kishor (2021) organized research in the area of effects of store ambience on consumers shopping experience. The study was carried out at Pune City in India. The study specifically examined the effects of store ambience factors such as lighting, music, colour, etc on consumers shopping experience. Survey formed the research design for the study. The population for the study was 100 respondents that were individually selected through convenience sampling method. Questionnaire was the data collection instrument for the research. The data collected were analyzed with Linear Regression with the aid of SPSS version

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21. At the end of the research, the results showed that ambience factors positively and significantly affected consumers shopping experience.

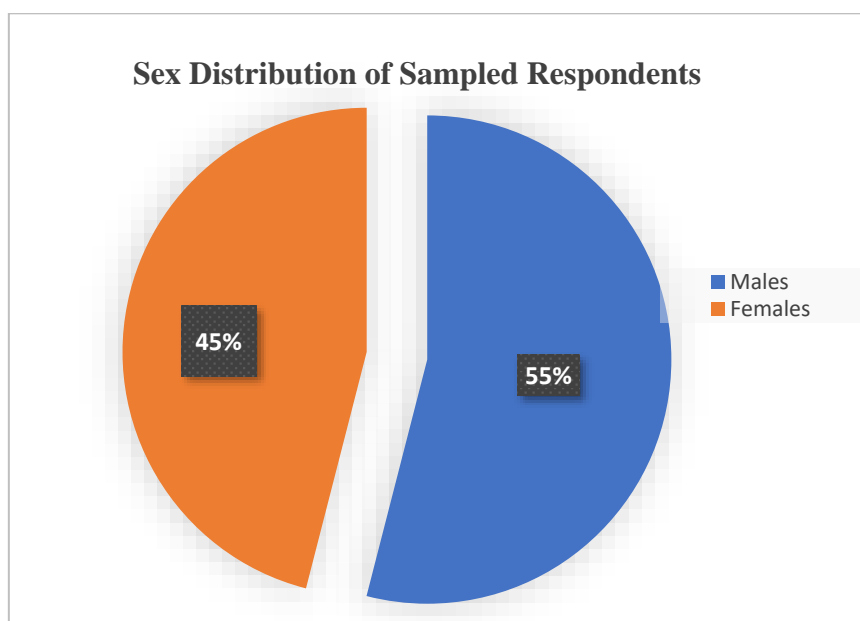
### 3.0 Methodology

This is a survey design anchored on the philosophy of mixed research method. The population for the research consists of an estimate of 480 respondents which also formed the sample size for the study. With judgmental sampling, the 480 respondents were shared equally to the six area councils that make-up Federal Capital Territory Capital Abuja – Abaji, Abuja, Bwari, Gwagwalada, Kuje, and Kwali with each having 80 respondents. Individual respondents from the councils were randomly selected through convenience sampling technique. Questionnaire was the data collection instrument for the research. Data collected were analyzed with Spearman Rank Order correlation with the assistance of SPSS version 22.

### 4.0 Data Presentation, Analysis, and Results

480 copies of questionnaire were distributed to respondents and they were properly filled and collected back. Therefore, all decisions on this research are made on the strength of the valid 480 questionnaires.

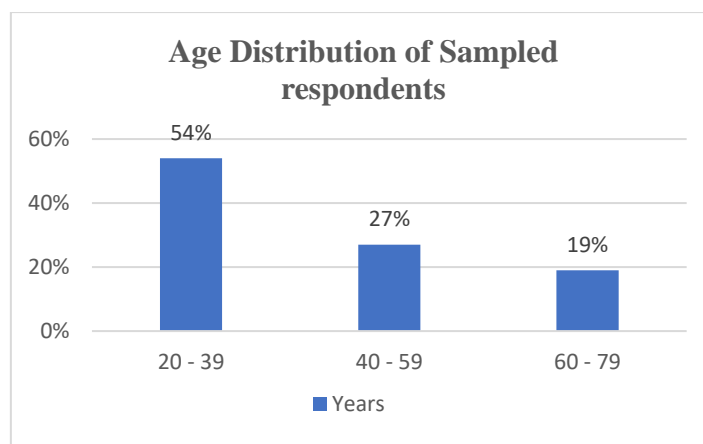
#### 4.1 Biodata Analysis of the Sampled Data



The above pie chart shows that 216 respondents which represent 45% are females while 264 that stands for 55% are males.

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Information from the bar chart indicates that 54% of the respondents are within the age bracket of 20-39 years, 27% of them 40-59 years while 19% are within 60-79 years.

**4.2 Bivariate Analysis of Sampled Data i.e. Hypotheses Testing**

9 hypotheses were tested in the research and the test done with Spearman Rank Order Correlation with the help of SPSS version 22.

Ho<sub>1</sub>: Location does not influence customers patronage motive for shopping malls.

**Table 4.1**

			Location	Patronage motive
Spearman (rho)	Location	Correlation Coefficient	1.000	.80**
		Sig. (2 tailed)	.	.001
		N	480	480
	Patronage Motive	Correlation Coefficient	.80**	1.000
		Sig. (2 tailed)	.001	.
		N	480	480

\*\*Correlation is significant at 0.01 levels (2 tailed)

\*Correlation is significant at 0.05 levels (2 tailed)

*Source: SPSS-generated Output*

The result above shows that location has very high positive correlation with customer patronage motive (rho = .80\*\*) and this correlation is significant at 0.01 level as indicated by the symbol \*\*

Ho<sub>2</sub>: Location has no influence on customers repeat purchase from shopping malls.

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**Table 4.2**

			Location	Repeat Purchase
Spearman (rho)	Location	Correlation Coefficient	1.000	.75**
		Sig. (2 tailed)	.	.001
		N	480	480
	Repeat Purchase	Correlation Coefficient	.75**	1.000
		Sig. (2 tailed)	.001	.
		N	480	480

\*\*Correlation is significant at 0.01 levels (2 tailed)

\*Correlation is significant at 0.05 levels (2 tailed)

*Source: SPSS-generated Output*

Information from table 4.2 above demonstrates that location has very high positive correlation with repeat purchase ( $\rho = .75^{**}$ ) and the symbol \*\* signifies that this correlation is significant at 0.01 level.

Ho<sub>3</sub>: Location does not influence customers referral for shopping malls.

**Table 4.3**

			Location	Referral
Spearman (rho)	Location	Correlation Coefficient	1.000	.60**
		Sig. (2 tailed)	.	.001
		N	480	480
	Referral	Correlation Coefficient	.60**	1.000
		Sig. (2 tailed)	.001	.
		N	480	480

\*\*Correlation is significant at 0.01 levels (2 tailed)

\*Correlation is significant at 0.05 levels (2 tailed)

*Source: SPSS-generated Output*

Table 4.3 above shows that location has high positive correlation with referral ( $\rho = .60^{**}$ ) and the symbol \*\* signifies that this correlation is significant at 0.01 level.

Ho<sub>4</sub>: Parking space has no influence on customers patronage motive for shopping malls.

**Table 4.4**

			Parking Space	Patronage Motive
Spearman (rho)	Parking Space	Correlation Coefficient	1.000	.53**
		Sig. (2 tailed)	.	.001
		N	480	480
	Patronage Motive	Correlation Coefficient	.53**	1.000
		Sig. (2 tailed)	.001	.
		N	480	480

\*\*Correlation is significant at 0.01 levels (2 tailed)

\*Correlation is significant at 0.05 levels (2 tailed)

*Source: SPSS-generated Output*

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Statistics from table 4.4 above reveal that parking space has moderate positive correlation with patronage motive ( $\rho = .53^{**}$ ) and the symbol **\*\*** signifies that this correlation is significant at 0.01 level.

H<sub>05</sub>: Parking space does not influence customers repeat purchase from shopping malls.

**Table 4.5**

			Parking Space	Repeat Purchase
Spearman (rho)	Parking Space	Correlation Coefficient	1.000	.55**
		Sig. (2 tailed)	.	.001
		N	480	480
	Repeat Purchase	Correlation Coefficient	.55**	1.000
		Sig. (2 tailed)	.001	.
		N	480	480

\*\*Correlation is significant at 0.01 levels (2 tailed)

\*Correlation is significant at 0.05 levels (2 tailed)

*Source: SPSS-generated Output*

Table 4.5 result reveal that parking space has moderate positive correlation with repeat purchase ( $\rho = .55^{**}$ ) and the symbol **\*\*** signifies that this correlation is significant at 0.01 level.

H<sub>06</sub>: Parking space does not influence customers referral for shopping malls.

**Table 4.6**

			Parking Space	Referral
Spearman (rho)	Parking Space	Correlation Coefficient	1.000	.48**
		Sig. (2 tailed)	.	.001
		N	480	480
	Referral	Correlation Coefficient	.48**	1.000
		Sig. (2 tailed)	.001	.
		N	480	480

\*\*Correlation is significant at 0.01 levels (2 tailed)

\*Correlation is significant at 0.05 levels (2 tailed)

*Source: SPSS-generated Output*

Table 4.6 result shows that parking space has low positive correlation with referral ( $\rho = .48^{**}$ ) and the symbol **\*\*** signifies that this correlation is significant at 0.01 level.

H<sub>07</sub>: Product display has no influence on customers patronage motive for shopping malls.

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**Table 4.7**

			Product Display	Patronage Motive
Spearman (rho)	Product Display	Correlation Coefficient	1.000	.61**
		Sig. (2 tailed)	.	.001
		N	480	480
	Patronage Motive	Correlation Coefficient	.61**	1.000
		Sig. (2 tailed)	.001	.
		N	480	480

\*\*Correlation is significant at 0.01 levels (2 tailed)

\*Correlation is significant at 0.05 levels (2 tailed)

*Source: SPSS-generated Output*

Table 4.7 above demonstrates that product display has only high positive correlation with patronage motive (rho = .61\*\*) and the symbol \*\* signifies that this correlation is significant at 0.01 level.

Ho<sub>8</sub>: Product display does not influence customers repeat purchase from shopping malls.

**Table 4.8**

			Product Display	Repeat Purchase
Spearman (rho)	Product Display	Correlation Coefficient	1.000	.63**
		Sig. (2 tailed)	.	.001
		N	480	480
	Repeat Purchase	Correlation Coefficient	.63**	1.000
		Sig. (2 tailed)	.001	.
		N	480	480

\*\*Correlation is significant at 0.01 levels (2 tailed)

\*Correlation is significant at 0.05 levels (2 tailed)

*Source: SPSS-generated Output*

Statistics from table 4.8 above indicate that product display has high positive correlation with repeat purchase (rho = .63\*\*) and the symbol \*\* signifies that this correlation is significant at 0.01 level.

Ho<sub>9</sub>: Product display does not influence customers referral for shopping malls.

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**Table 4.9**

			Product Display	Referral
Spearman (rho)	Product Display	Correlation Coefficient	1.000	.46**
		Sig. (2 tailed)	.	.001
		N	480	480
	Referral	Correlation Coefficient	.46**	1.000
		Sig. (2 tailed)	.001	.
		N	480	480

\*\*Correlation is significant at 0.01 levels (2 tailed)

\*Correlation is significant at 0.05 levels (2 tailed)

*Source: SPSS-generated Output*

The result from table 4.9 above reveals that product display has low positive correlation with referral (rho = .46\*\*) and the symbol \*\* signifies that this correlation is significant at 0.01 level.

**5.0 Conclusion and Recommendations**

Based on the findings, the study concluded that store ambience has positive and significant relationship with customers preference for one shopping mall over another in the Federal Capital Territory Abuja and by implication, Nigeria as a whole.

Managers of the shopping malls were therefore advised to give adequate attention to store ambience planning and implementation as a business strategy to attract customers to their malls but were equally admonished to once in a while engage in consumer opinion research to identify appropriate ambience that suits their target market in order not only to attract customers but also to retain them for future transactions.

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**ÜST EKSTREMİTE SPORLARINDA PENÇE KUVVETİ**

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**Özet**

El kavrama gücü (HGS), yani pençe kuvveti, vücudun genel kuvvetinin önemli bir göstergesidir. Aynı zamanda HGS, fiziksel hareketliliğin bilişsel durumu, sağlıkla ilgili yaşam kalitesi ve genel fiziksel işlevle de ilişkili olabilecek önemli bir parametre olarak kabul edilmektedir. Bu çalışmanın amacı, son on yıl içerisinde üst ekstremite sporlarında el kavrama gücünün önemini inceleyen yayınları değerlendirerek, kavrama gücünün sporcu performansındaki rolünü ve etkilerini araştırmaktır. Sistemantik derleme formatında hazırlanan çalışmada, Science Citation Index (SCI), SCI Expanded, Social Science Citation Index (SSCI) ve PubMed/MEDLINE veri tabanlarında yer alan makaleler incelenmiştir. Çalışmalarda, üst ekstremitenin dominant olduğu branşlar ile kavrama gücü arasındaki ilişkiyi ele alan ve 2015-2025 yılları arasında yayımlanan tam metinler analiz edilmiştir. Araştırmalarda, "upper extremity sports", "grip strength" ve "claw force" anahtar kelimeleri kullanılmıştır. Bu araştırmalar, kavrama gücünün üst ekstremite sporlarında performans, dayanıklılık ve verimliliği artıran önemli bir faktör olduğunu göstermektedir. Çalışmalarda, el kavrama gücünün farklı spor branşlarındaki performansla ilişkisi ortaya konmuş ve HGS'nin, toplam vücut gücünün etkili bir göstergesi olduğu sonucuna varılmıştır.

**Anahtar Kelimeler:** Üst Ekstremitte Sporları, Kavrama Gücü, Pençe Kuvveti

**CLAW STRENGTH IN UPPER EXTREMITY SPORTS**

**Abstract**

Handgrip strength (HGS), i.e. grip strength, is an important indicator of the overall strength of the body. At the same time, HGS is considered an important parameter that may also be related to cognitive status of physical mobility, health-related quality of life and general physical function. The aim of this review is to investigate the role and effects of grip strength on athlete performance by evaluating publications examining the importance of hand grip strength in upper extremity sports in the last decade. In the study prepared in systematic review format, articles in Science Citation Index (SCI), SCI Expanded, Social Science Citation Index (SSCI) and PubMed/MEDLINE databases were examined. In the studies, full texts published between 2015 and 2025 that addressed the relationship between upper extremity dominant branches and grip strength were analyzed. In the research, the keywords "upper extremity sports", "grip strength" and "claw force" were used. These studies show that grip strength is an important factor that increases performance, endurance and efficiency in upper extremity sports. Studies have demonstrated the relationship between hand grip strength and performance in different sports branches and it has been concluded that HGS can be an effective indicator of total body strength.

**Keywords:** Upper Extremity Sports, Grip Strength, Claw Strength

## GİRİŞ

Pençe kuvveti, izometrik bir gerilme olup, el kavrayış gücüyle tanımlanan hareketsiz ve sürekli kas gerilmesiyle ortaya çıkar. Bu durumda, kasa giden kan akışı, dinamik kuvvetle kıyaslandığında farklılık gösterir. El kavrama gücü (HGS), yani pençe kuvveti, vücudun genel kuvvetinin bir göstergesi olarak kabul edilir ayrıca HGS, fiziksel hareketliliğin bilişsel durumu, sağlıkla ilgili yaşam kalitesi ve genel fiziksel işlevle ilişkili olabilecek önemli bir gösterge olarak kabul edilmektedir (Cooper vd., 2010; Stevens vd., 2012; Leong vd., 2015; Musalek ve Kirchengast, 2017; Zammit vd., 2019; Jordre ve Schweinle, 2020). Ayrıca, HGS gelişim sürecinde yapılan sporların türüne bağlı olarak farklılık gösterebilir. Özellikle ekipman tutmayı gerektiren gençlik sporları, el kavrama gücünü geliştirmede etkili olabilir (Abe vd., 2024). HGS, sadece güç kapasitesinin bir ölçüsü olmakla kalmaz, aynı zamanda fonksiyonel engellilik ve yaşa bağlı sağlık sorunlarıyla da ilişkilidir (Collins vd., 2020). Güçlü eller ve parmaklar, vücut gücünün genel bir göstergesi olarak, daha fazla ağırlık kaldırmak ve bu ağırlıkları daha uzun süre tutabilmek için büyük önem taşır (Ruprai vd., 2015). HGS el fonksiyonunun önemli bir bileşeni olup, güvenilir bir şekilde ölçülebilen bir parametredir ve genellikle Jamar Dinamometresi gibi ekipmanlarla değerlendirilir (Mathiowetz vd., 1984). Bu çalışmanın amacı, son on yıl içerisinde üst ekstremitelerde sporlarında el kavrama gücünün önemini inceleyen yayınları değerlendirerek, kavrama gücünün sporcu performansındaki rolünü ve etkilerini araştırmaktır.

### Üst Ekstremitelerde Sporlarında El Kavrama Gücünün Önemi

Üst ekstremitelere yönelik fonksiyonel tercihler, insan vücudunun diğer segmentlerinde bilateral farklılıkların ortaya çıkmasını etkileyebilir (Burdukiewicz vd., 2020). Bu farklılıklar, özellikle spor performansında belirginleşir. Beyzbol, tırmanma, golf, hokey, kürek çekme, yüzme, tenis, halter ve güreş gibi kavrama ve kuvvet uygulamasının kritik olduğu sporlar, performansı optimize etmek ve yaralanmaları önlemek için yüksek derecede HGS gerektirir (Cronin vd., 2017).

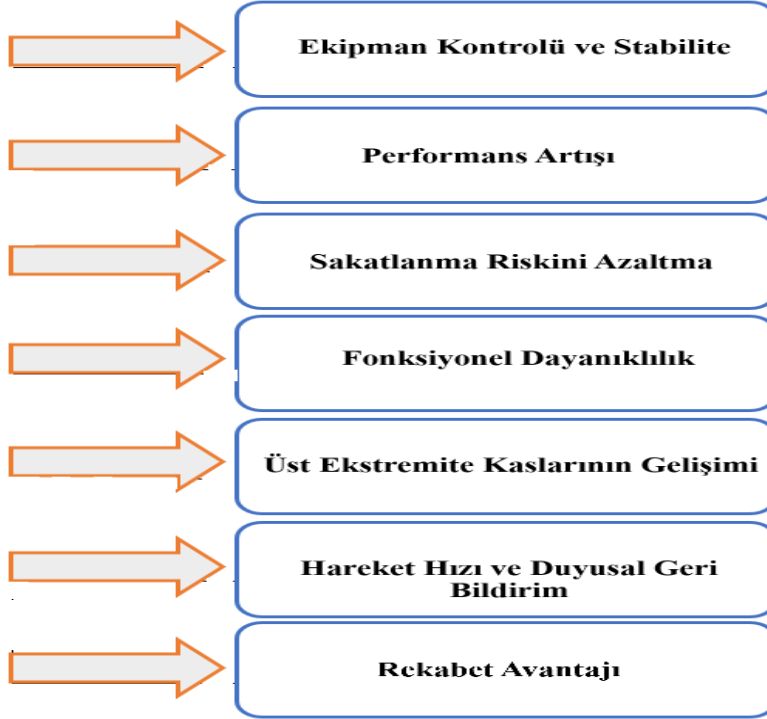
Birçok araştırma, HGS ile farklı spor branşlarındaki performans arasındaki ilişkiyi derinlemesine incelemiş ve HGS'nin, toplam vücut gücünün etkili bir göstergesi haline geldiğini ortaya koymuştur (Suazo ve DeBeliso, 2021). El, üst ekstremitenin işlevselliğini etkileyen en önemli bileşenlerden biridir. Elin kavrama fonksiyonu, günlük yaşam aktivitelerinin devamlılığı için büyük önem taşır ve bu nedenle kavrama gücü, üst ekstremitelerde performansının değerlendirilmesinde nesnel bir ölçüm olarak kabul edilmektedir. Çalışmalar, el kavrama gücünün sadece üst ekstremitelerde kas gücüyle değil, aynı zamanda genel vücut kas gücü ve akciğer kas gücüyle de ilişkili olduğunu göstermiştir (Çalışkan vd., 1997; Yonca vd., 2017).

HGS, bireyin kas gücünün bir göstergesi olmasının yanı sıra, üst ekstremitenin fonksiyonel bütünlüğünün objektif bir bileşeni olarak kabul edilmektedir (Çalışkan vd., 1997). El kavrama gücünün üst ekstremitelerde sporlarındaki genel önemi ise birçok faktörle bağlantılıdır:

El kavrama gücünün üst ekstremitelerde sporlarındaki önemi, birçok önemli faktörle ilişkilidir ve bu faktörlerden bazıları aşağıda sıralanmıştır:

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## Pençe Kuvvetini Geliştirme Yöntemleri

Pençe kuvvetini artırmak için uygulanabilecek yöntemler şunlardır;

<b>Grip Güçlendiriciler (Hand Grippers):</b> Bu cihazlar, parmakları ve avuç içini kullanarak yapılan sıkma egzersizleriyle kavrama gücünü artırır.
<b>Dead Hang (Asma):</b> Bir bar ya da tırmanma duvarına asılarak yapılan bu egzersiz, pençe ve bilek kaslarını güçlendirir.
<b>Ağırlıkla Çalışmalar:</b> Dambıl veya halterle yapılan egzersizler, parmakları ve bilekleri kuvvetlendirir. Örneğin, farmer's walk (ağırlıkla yürütüş) etkili bir tekniktir.
<b>El Sıkma Topları:</b> El sıkma toplarını sıkmak, parmakları ve avuç için güçlendirir.
<b>Tırmanma Egzersizleri:</b> Tırmanmak, eller ve parmaklar üzerinde sürekli kuvvet uygular ve kavrama gücünü geliştirir.
<b>Bilek Egzersizleri:</b> Bilek bükme ve döndürme gibi hareketler, el kavrama gücünü artıran önemli tekniklerdir.
<b>Kavrayış Tutuşları (Static Hold):</b> Ağırlıkları uzun süre tutarak yapılan egzersizler, kavrama gücünü artırır.

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Bu tekniklerle düzenli çalışarak, el kavrama gücünde belirgin bir artış sağlanabilir.

## **Pençe Kuvveti Test Yöntemleri**

Pençe kuvveti test etmek için kullanılan başlıca yöntemler:

**-Jamar Dinamometresi Testi:** Jamar dinamometresi, pençe kuvvetini ölçmek için sıkça kullanılan bir cihazdır. Kişi, elini cihazın tutma kısmına yerleştirip kuvvet uygulayarak sıkma hareketi yapar. Bu test, sağ ve sol elin kuvvetini ölçer ve sonuçları sayısal değerlerle verir. Çoğunlukla fiziksel terapi ve spor bilimlerinde kullanılır.

**-Grip dinamometresi Testi:** El kaslarının gücünü ölçmek için kullanılan kompakt ve taşınabilir bir cihazdır. Jamar dinamometresi ile benzer şekilde çalışır, ancak genellikle daha küçük ve kullanışlıdır.

**-Isokinetik Kuvvet Testi:** Isokinetik testlerde, sabit hızda hareket eden cihazlar kullanılarak kuvvet ölçülür. Bu cihazlar, kullanıcının belirli bir hızda kuvvet üretmesini sağlar. Isokinetik testler, genellikle fiziksel rehabilitasyon süreçlerinde ve sporcu performans değerlendirmelerinde kullanılır.

**- Isometrik Testler:** Isometrik kuvvet testlerinde, kişi bir cihazla sabit bir dirençle karşı karşıya gelir. Bu test, kasların hareketsiz bir şekilde sürekli gerilmesini sağlayarak, kavrama gücünü ölçer. Sonuçlar, sabit bir noktadaki kuvvet değişimini gösterir.

**-Kavrama Testi (Grip Strength Test):** Kavrama testleri, belirli kuvvet seviyelerinde yapılan kavrayış hareketleriyle pençe kuvvetini değerlendirir. Bu test, kişinin kavrama gücünün dayanıklılığını ve toplam kuvvet kapasitesini belirlemek için kullanılır.

El kavrama kuvvetinin ölçümlerinde genellikle, Amerikan El Terapistleri Derneği (AETD) tarafından önerilen ve birçok çalışmada yüksek geçerlilik ve güvenilirlik gösteren, bu nedenle altın standart olarak kabul edilen Jamar el dinamometresi kullanılır (Shechtman vd., 2005; Jackson vd., 2020). Çalışmamızda incelediğimiz araştırmalarda, test yöntemi olarak Jamar Dinamometresi kullanılan çalışmalara yer verilmiştir.

Sunulan çalışma sistematik derleme formatında hazırlanmış olup “Son on yıl içerisinde üst ekstremitte sporlarında el kavrama gücünün önemini inceleyen yayınları değerlendirerek, kavrama gücünün sporcu performansındaki rolünü ve etkileri nelerdir?” soruna cevap aranmıştır. Sorunun yanıtına ulaşabilmek için Science Citation Index (SCI), SCI-Expanded, Social Science Citation Index (SSCI) ve PubMed/MEDLINE veri tabanlarındaki dergilerde veri tabanlarında yer alan makaleler incelenmiştir. Çalışmalarda, üst ekstremitenin dominant olduğu branşlar ile kavrama gücü arasındaki ilişkiyi ele alan ve 2015-2025 yılları arasında yayımlanan tam metinler analiz edilmiştir. Araştırmalarda, "upper extremity sports", "grip strength" ve "claw force" anahtar kelimeleri kullanılmıştır. Sırasıyla “başlık” ve “özet” incelemesinden sonra çalışma kapsamında değerlendirilen makalelerde üst ekstremitte sporlarında el kavrama gücünün önemin yanı sıra uygulanan test yöntemlerine vurgu yapılması şartı aranmıştır.

## **Literatür Örnekleri**

Çalışmalarda el kavrama gücü, vücut gücünün önemli bir göstergesi olarak farklı spor branşlarındaki performansla olan ilişkisi bakımından önemli bir parametre olarak kabul edilmektedir. Yapılan araştırmalar, el kavrama gücünün sporcuların fiziksel performansını etkileyen ve farklı spor disiplinlerinde başarıya doğrudan etki eden bir faktör olduğunu ortaya koymuştur. El kavrama gücünün yalnızca belirli spor branşlarında değil, genel olarak atletik performansı ölçmek için etkili bir gösterge olduğunu ortaya koymuştur. El kavrama gücünün sporcular üzerindeki etkisini daha ayrıntılı incelemek amacıyla, çoğu araştırmada Jamar Dinamometresi gibi güvenilir ve geçerli ölçüm araçları kullanılmıştır (Tablo 1).

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**Tablo 1.** Üst ekstremitenin baskın olduğu spor branşlarında el kavrama gücünün performansa etkisini inceleyen literatür araştırmaları

Yazarlar	Amaç	Katılımcı Grubu	Test Cihazı	Sonuç
Kim vd., (2022)	Bezbol oyuncularında pliometrik antrenmanın fiziksel uygunluk ve kas hasarı üzerine etkilerini araştırmak	21 erkek bezbol oyuncusu	El Dinamometresi	8 haftalık pliometrik antrenmandan sonra sol el kavrama gücünde anlamlı farklılık tespit edilmiştir.
Priya vd., (2021)	Profesyonel basketbolcularda üst ekstremitte dengesi ile el kavrama gücü arasındaki ilişkiyi incelemek	20 profesyonel basketbol oyuncusu	El Dinamometresi	Profesyonel basketbolcularda üst ekstremitte dengesi ile el kavrama gücü arasında pozitif yönlü ilişki tespit edilmiştir.
Mbada vd., (2020)	Çalışma, üniversite erkek basketbol oyuncularının el kavrama gücü, bacak patlayıcı gücü ve dikey sıçrama performansı arasındaki ilişkiyi incelemek	60 erkek gönüllü öğrenci (30 basketbolcu ve 30 sporcu olmayan)	El Dinamometresi	Sadece basketbolcularda el kavrama gücü ile vücut kitle indeksi arasında anlamlı bir pozitif korelasyon bulunmuştur. El kavrama gücü ile dikey sıçrama arasında ise anlamlı bir ilişki tespit edilmemiş, ancak dikey sıçrama performansı, basketbolcularda bir öngörücü olarak değerlendirilmiştir.
Patel vd., (2024)	Basketbol ve voleybol oyuncularının el kavrama gücünü ve el-kol antropometrik ölçümlerini değerlendirmek	30 voleybol oyuncusu ve 30 basketbol oyuncusu	El Dinamometresi	Basketbol oyuncularının el kavrama gücünün voleybol oyuncularının el kavrama gücünden daha fazla olduğu tespit edilmiştir.
Jackson vd., (2020)	Çalışma, düzenli tenis oynamanın, kas-iskelet sistemi işlevini artırmada daha etkili olup olmadığını incelemeyi amaçlamaktadır	43 tenis oyuncusu (18 erkek, 25 kadın) ve 47 tenisçi olmayan (26 erkek, 21 kadın)	El Dinamometresi	Tenis oyuncuları, yaşları eşleştirilmiş aktif olmayan tenisçilerle karşılaştırıldığında önemli ölçüde gelişmiş MSK fonksiyonu gösterdiği tespit edilmiştir.
Popov vd., (2023)	Çalışmanın amacı, 20 günlük yoğun bir antrenman rejiminin elit haltercilerde el kavrama kuvveti ve maksimal çaba sürdürme süresi üzerindeki etkisini belirlemek	23 profesyonel halterci (11 kadın 12 erkek)	El Dinamometresi	20 günlük yoğun antrenman programı, erkek haltercilerde kavrama gücünü ve maksimal efor sürdürme süresini artırmak için yeterliydi. Kadın halterciler için sonuçlar daha düşüktü olduğu tespit edilmiştir.
Abe vd., (2024)	Genç sporcularda kavrama içeren sporları (kendo), kavrama içermeyen sporlarla (futbol) karşılaştırarak el kavrama gücündeki farklılıkların ortaya çıktığı yaşı incelemeyi amaçlamıştır	222 erkek sporcu (115 kendo ve 107 futbol)	El Dinamometresi	Kendo sporcularının futbol sporcularından önemli ölçüde daha yüksek el kavrama gücüne sahip olduğu tespit edilmiştir. Johnson-Neyman prosedürünü kullanarak 8,48 yaş ve üzeri sporlar arasında istatistiksel olarak anlamlı farklılıklar olduğu tespit edilmiştir
Patil (2020)	Pliometrik egzersizlerin kadın kolej basketbol oyuncularının bacak kas gücü ve el gücü üzerindeki etkisini incelemek	30 kadın basketbol oyuncusu	El Dinamometresi	Kadın kolej basketbol oyuncularının bacak kas gücü ve el gücü üzerinde olumlu ve önemli bir etki olduğu sonucuna vardı.

Yapılan bu araştırmada, üst ekstremitenin baskın olduğu spor branşlarında kavrama gücünün rolünü ve önemini ele alan yayınlar kapsamlı bir şekilde değerlendirilmiştir. Yapılan incelemeler sonucunda, kavrama gücünün, özellikle üst ekstremitte dayalı spor dallarında, sporcuların performansını artıran, dayanıklılıklarını ve verimliliklerini yükselten kritik bir faktör olduğu ortaya konmuştur. Kavrama gücünün, sporcuların fiziksel kapasitesini en üst düzeye çıkarmada önemli bir etken olduğu ve bunun da başarı üzerindeki etkilerinin belirgin şekilde gözlemlendiği sonucuna varılmıştır.

Çalışmalar incelendiğinde kavrama gücü ile performans arasında pozitif yönlü ilişkiler bulunmuştur (Jackson vd., 2020; Patil, 2020; Priya vd., 2021).

Literatürde, cinsiyete göre yapılan analiz, tüm yaş gruplarında erkeklerin daha yüksek kavrama gücüne sahip olduğunu göstermektedir. Yaş grubuna göre yapılan analiz ise, kavrama gücünde 40'lı yaşlarda bir zirve olduğunu ve ardından her iki cinsiyette de kavrama gücünde kademeli bir düşüş yaşandığını ortaya koymaktadır (Nara vd., 2022). Bunun nedeni erkeklerin genellikle daha yüksek kas kütlesine ve daha fazla testesteron seviyelerine sahip olmaları, yaşla birlikte

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kas kütlesinin azalması, eklem hareketliliğinin sınırlanması ve sinir sistemi yanıtlarında yaşa bağlı değişikliklerden kaynaklanmış olabilir.

Kavrama gücü bir performans belirleyicisi olarak kullanılır. Basketbolda farklı oyun pozisyonları üzerinde yapılan çalışma, kavrama gücü ile dikey sıçrama ve diğer antropometrik değişkenler arasında anlamlı ilişki olduğunu bildirmiştir (Gledson vd., 2018). Hentbol oyuncusunun atış hızı kavrama gücüyle önemli ölçüde ilişkilidir (Tsakalou vd., 2015). Kavrama gücünün, farklı spor branşlarındaki performans ve başarı üzerinde belirleyici bir rol oynadığını ve sporcuların genel fiziksel kapasitesine katkı sağladığı görülmektedir.

El kavrama gücü, üst ekstremitenin genel gücünün bir göstergesidir (Chen vd., 2011) ve üst ekstremitte fonksiyonu, bu parametre kullanılarak değerlendirilebilir (Joshi ve Sathe, 2018). Birçok araştırma, Jamar el tipi dinamometresinin açık kinetik zincirde el kavrama gücünü ölçmek için yüksek geçerlilik, güvenilirlik, test ve tekrar test ile değerlendiriciler arası ve değerlendirici içi güvenilirlik sağladığını ortaya koymuştur (Priya vd., 2021).

## **SONUÇ VE ÖNERİ**

Bu çalışma, el kavrama gücünün üst ekstremitte sporlarında sporcu performansını artırmada önemli bir rol oynadığını ortaya koymaktadır. Çeşitli spor branşlarında yapılan araştırmalar, kavrama gücünün performans, dayanıklılık ve verimlilik üzerinde belirgin etkiler yarattığını göstermektedir. Ayrıca, HGS'nin, vücudun genel gücünü yansıtan etkili bir parametre olduğu ve sporcuların fiziksel kapasitesini en üst düzeye çıkarabileceği sonucuna varılmıştır.

Gelecek çalışmalarda, farklı spor branşlarındaki sporcuların kavrama gücü seviyelerinin daha geniş çaplı örneklem gruplarıyla incelenmesi önerilmektedir. Ayrıca, kavrama gücünün antrenman programlarına entegre edilerek sporcuların genel performanslarının iyileştirilmesi için daha fazla araştırma yapılması önemlidir. Kavrama gücünün ölçümü ve değerlendirilmesi, sporcuların sağlık durumlarının izlenmesinde ve antrenman süreçlerinde önemli bir araç olarak kullanılabilir.

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**Özet**

Yapılan araştırmalar ve mevcut literatür incelendiğinde, kanserin insidansının her yıl artmakta olduğu açıkça görülmektedir. Bu artışın pek çok nedeni bulunmaktadır, bunlardan en önemlileri arasında hareketsizlik, fiziksel aktivite eksikliği, teknolojinin ilerlemesi, evden çalışma düzenlerinin yaygınlaşması, pandemi sürecinde evde geçirilen zamanın artması, zaman kısıtlamaları, obezite, genetik faktörler ve yanlış beslenme alışkanlıkları yer almaktadır. Bu etmenler, bireylerin çeşitli sağlık sorunlarına yakalanma riskini artırmaktadır. Özellikle hastalıkların büyük bir kısmının, fiziksel aktivitenin yetersizliğinden kaynaklandığı söylenebilir. Fiziksel aktivite ve egzersiz eksikliği, kanserin gelişiminde çok önemli bir rol oynamaktadır. Çalışmalar, hareketsizliğin ve düşük düzeyde fiziksel aktivitenin birçok kanser türünün oluşmasına ve ilerlemesine zemin hazırladığını ortaya koymaktadır. Fiziksel aktivite, kaslar ve eklemler aracılığıyla yapılan her türlü hareketi ifade eder ve vücudun genel sağlığını iyileştirme, hastalıklara karşı direnç oluşturma konusunda önemli katkılar sağlar. Aynı zamanda, egzersiz yapmamak, sağlık üzerindeki olumsuz etkilerinin yanı sıra, kanser gibi ciddi hastalıkların gelişme riskini artıran bir faktördür. Bu bağlamda, egzersiz ve fiziksel aktivite, hem kanserin önlenmesinde hem de tedavi süreçlerinde önemli bir yer tutmaktadır. Bu çalışmanın amacı, egzersiz ve kanser ilişkisini derinlemesine inceleyerek, fiziksel aktivitenin kanserin gelişimi üzerindeki rolünü ve potansiyel faydalarını ortaya koymaktır. Egzersiz düzenli uygulanması, kanser tedavisinin yan etkilerini, özellikle yorgunluk, depresyon ve fiziksel hareketsizlik gibi semptomları azaltmada önemli bir rol oynayabilir. Bu bağlamda, egzersiz yalnızca bir fiziksel aktivite değil, kanser tedavisinin tamamlayıcı bir bileşeni olarak da kabul edilebilir.

**Anahtar Kelime:** Egzersiz, Fiziksel aktivite, Kanser, Spor

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**THE ROLE OF EXERCISE IN CANCER**

**Abstract**

Upon reviewing the existing literature and research, it is evident that the incidence of cancer has been steadily increasing each year. There are several factors contributing to this rise, with some of the most significant including physical inactivity, lack of exercise, technological advancements, the widespread adoption of remote working arrangements, increased time spent at home during the pandemic, time constraints, obesity, genetic factors, and poor dietary habits. These factors collectively increase the risk of individuals developing various health issues. Notably, it can be argued that a significant portion of these diseases stem from insufficient physical activity. Lack of physical activity and exercise plays a crucial role in the development of cancer. Studies have shown that inactivity and low levels of physical activity create a favorable environment for the formation and progression of various types of cancer. Physical activity refers to any movement of the body through muscles and joints and contributes significantly to improving overall health and building resistance against diseases. Moreover, the absence of exercise, in addition to its negative effects on health, is a factor that increases the risk of developing serious illnesses such as cancer. In this context, exercise and physical activity play an essential role both in cancer prevention and in the treatment process. The aim of this study is to thoroughly investigate the relationship between exercise and cancer, highlighting the role of physical activity in the development of cancer and its potential benefits. Regular exercise can play a vital role in reducing the side effects of cancer treatment, particularly symptoms such as fatigue, depression, and physical immobility. Therefore, exercise can be considered not only as a form of physical activity but also as a complementary component of cancer treatment.

**Keywords:** Exercise, Physical activity, Cancer, Sports

## GİRİŞ

Cerrahi, kemoterapi, radyoterapi ve hormon tedavisi gibi kanser tedavileri genellikle aylarca veya yıllarca sürebilir ve yaşam kalitesini büyük ölçüde düşürebilir. Kanser yaygın psikolojik ve duygusal sonuçları arasında depresyon, anksiyete, stres, beden imajı kaygıları, azalmış özsaygı ve kontrol duygusunun kaybı yer alır. Kanser fiziksel ve fonksiyonel etkileri arasında

- Asteni
- Ataksi
- Kaşeksi
- Azalmış kardiyovasküler ve pulmoner fonksiyon
- Kas zayıflığı ve atrofi
- Kilo değişimi
- Uyku güçlükleri
- Yorgunluk
- Bulantı
- Kusma ve ağrı yer alabilir.

Yan etkiler tedavi sırasında zirveye ulaşırsa, tedaviyle ilgili semptomlar tedaviden sonraki aylarda veya yıllarda devam edebilir (Courneya vd., 2000).

Asteni terimi (Yunanca a = mahrumiyet, yokluk, ve sthenos = neşe, güç) kelime anlamı olarak güçsüzlük, canlılık eksikliği anlamına gelir. Asteni'nin klinik belirtileri, genellikle belirgin bir sebep olmaksızın yorgunluk, keyifsizlik, kas zayıflığı ve enerji kaybı duygularıdır. Asteni hastalarının ana şikayetlerinin bir miktar öznel olmasına ve bu duruma dair herhangi bir patolojik altyapının sıklıkla bulunmamasına rağmen, asteni sendromu olan hastalar arasındaki kısıtlamaların ve algılanan engelliliğin dereceleri son derece yüksektir (Vasenina vd., 2022). Anoreksiya, asteni, sarkopeni ve anemi, kaşeksinin klinik belirtilerindedir ve bu durumlar yaşam kalitesinin düşmesine yol açmaktadır. Anoreksiya, genellikle yetersiz beslenmenin bir sonucu olarak ortaya çıkar ve kaşeksi gelişiminde önemli bir rol oynar. Kanser kaşeksisi, tümör türüne bağlı olarak kanserli hastaların yaklaşık %50-80'ini etkiler. Ayrıca, kanser kaşeksisi, hastaların %20-25'inin ölümüne neden olmaktadır (Mısırlıoğlu ve Köse, 2023)

Fiziksel egzersizin, birçok kronik hastalıkta inflamasyonu modüle ettiği gösterilmiştir. Kaşeksi bağlamında incelenen iki ana egzersiz kategorisi şunlardır:

1. Aerobik egzersiz, sürekli bir şekilde yapılan ve yoğunluğunun maksimum oksijen tüketiminin %40 ile %70 arasında değiştiği, önerilen sürenin haftada 3 ila 5 kez 30 ila 60 dakika olduğu egzersiz
2. Kuvvet egzersizi, çeşitli egzersiz yüklerinin (vücut ağırlığı veya ekipman) kullanıldığı ve değişken yoğunluklarla (genellikle maksimum tekrarın yüzdesi olarak ifade edilir) yapılan, belirli bir süresi olmayan egzersiz türüdür (Lira vd., 2014).

Fiziksel aktivite, iskelet kaslarını kullanarak yapılan her türlü hareketi ifade eder. Fiziksel aktivite dört ana alt grupta sınıflandırılabilir. Bu alt gruplar,

- Mesleki (iş yerinde yapılan aktiviteler)
- Evsel (evde yapılan aktiviteler)
- Ulaşım (ulaşım için yapılan aktiviteler)
- Rekreatif veya boş zaman (eğlence ve/veya keyif amacıyla yapılan aktiviteler) olarak ayrılır (Caspersen vd., 1985).

Fiziksel aktivite aynı zamanda farklı yoğunluklarda olabilir, bunlar hafif, orta ve şiddetli yoğunluk olarak sınıflandırılır. Aşırı kilo, obezite ve fiziksel hareketsizlik, bir dizi kanserin

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gelişme riskine katkıda bulunur. Aşırı kilo ve obezite fiziksel aktiviteden ayrı gibi görünebilir, ancak her iki kavram da enerji dengesiyle ilişkilidir. Optimal bir enerji dengesinin sürdürülmesi, kalori harcaması ile kalori alımı arasındaki ilişki, kanserin birincil korunması, tanı sonrası hayatta kalma ve primer kanserin nüksü ile ilişkilidir. Bu nedenle, aşırı kilo veya obezite ile fiziksel hareketsizlik arasındaki sinerjik ilişkiyi kanserin korunması ve hayatta kalma süreci boyunca kabul etmek gereklidir (Brown vd., 2012).

Egzersiz, moleküler düzeyden tüm organizmaya kadar birçok etkiler yaratır. Sağlıklı bireyler, egzersizden başlıca kardiyorespiratuar iyileşmeler ve kısa ile uzun vadeli hücrel adaptasyonlar sayesinde fayda sağlarlar. Bu adaptasyonlar arasında artan enzimatik fonksiyon, metabolik kapasite, damarlaşma, kardiyovasküler performans, kas gücü ve hipertrofi yer alır. Ancak kanser tanısı almış bireylerde, bunun tersine, fiziksel uygunlukta olumsuz değişiklikler gözlemlenmiştir. Egzersiz, kanser hastalarında semptomları ve yan etkilerin kötüleşmesini engellemek için etkili bir strateji olarak uygulanabilir (Ficarra, 2023). Direnç antrenmanı, sağlıklı ve klinik popülasyonlar arasında kas fonksiyonunu, fonksiyonel performansı ve sağlık parametrelerini iyileştirmek için yaygın ve etkili bir yöntemdir. Birçok beklenen sonucun arasında, kas boyutunun ve gücünün artması, bireyler ve klinik uzmanlar tarafından performans ya da sağlık ve fonksiyonel iyileşme amacıyla önemli ve arzu edilen bir hedef olarak kabul edilmektedir (Lopez vd., 2020). Kanser Hayatta Kalanlar İçin Egzersiz Kılavuzları: Uluslararası Çok Disiplinli Yuvarlak Masa Toplantısından Ortak Görüş Bildirgesi olarak yayımlanan bir çalışmada, egzersiz eğitiminin ve testlerinin kanser hayatta kalanlar için genellikle güvenli olduğu ve her hayatta kalan kişinin "hareketsizlikten kaçınması" gerektiği sonucuna varılmıştır. Ayrıca aerobik egzersiz, kombine aerobik artı direnç antrenmanı ve/veya direnç antrenmanının, anksiyete, depresif semptomlar, yorgunluk, fiziksel işlev ve sağlıkla ilgili yaşam kalitesi gibi yaygın kanserle ilişkili sağlık sonuçlarını iyileştirebileceğinin sonucuna varılacak kadar yeterli kanıt mevcut olduğunu ve Periferik nöropati, bilişsel işlev gibi diğer sonuçlar için etkilerin belirsizliğini koruduğu sonucuna varılmıştır (Campbell vd., 2019). Egzersizin kanser prognozu ve tedavisindeki potansiyel rolüyle ilgili olarak, fiziksel aktivitenin hastalık nüksü riskini (meme kanseri ve kolon kanseri gibi) azalttığı bildirilmiştir. Ancak, diğer kanser türlerinde daha fazla veriye ihtiyaç vardır ve egzersizin türü ile zamanlaması hakkında pek fazla bilgi bulunmamaktadır. Ayrıca, egzersizin kanser riski ve prognozu üzerindeki etkisinin mekanizması büyük ölçüde bilinmemektedir (Idorn ve Straten, 2017).

Meme kanseri, kadınlar arasında en yaygın görülen kanser türüdür ve hormonal, çevresel ve üreme faktörleriyle bağlantılıdır. Meme kanseri insidansı, birçok ülkede oldukça yüksektir. 2020 yılı itibarıyla, dünya genelinde yaklaşık 2,3 milyon yeni vakayla en sık karşılaşılan kanser türü olmuştur (Akay ve Karadibak, 2022). Li ve arkadaşları (2022) Egzersizin Meme Kanseri Üzerindeki Etkisi: Hayvan Deneylerinin Sistemik İncelemesi ve Meta-Analizi çalışması yapmış ve sonuç olarak; Egzersizin meme kanseri modelindeki fare ve sıçanlarda tümör ağırlığını, hayvan başına tümör sayısını ve tümör insidansını azaltabileceği Ancak, prelinik çalışmalarda yanlılık riski unsurları ve raporlama yönergelerinin dikkate alınması gerektiği sonucuna varmışlardır. Gelecekteki araştırmalar, prelinik çalışmaların yürütülmesi ve raporlanması için standartları göz önünde bulundurmalı ve meme kanseri için egzersizle ilgili daha yüksek kaliteli kanıtlar elde etmek için uygun egzersiz protokolünü seçilmesi gerektiğini de eklemişlerdir.

Hiensch ve arkadaşları (2021) Çalışmalarında Kemoterapi planlanan 240 kadın, 16 hafta boyunca direnç ve yüksek yoğunluklu interval antrenman (RT-HIIT), orta yoğunluklu aerobik ve yüksek yoğunluklu interval antrenman (AT-HIIT) veya geleneksel bakım (UC) gruplarına

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rastgele yerleştirilerek İnflamasyonun Meme Kanseri Hastalarında Egzersizin Yorgunluk Üzerindeki Etkilerini araştırmıştır. Sonuç olarak hem direnç hem de yüksek yoğunluklu aerobik antrenman içeren egzersiz, kemoterapi kaynaklı inflamasyonu ve sonraki yorgunluğu azaltmak için etkili bir tedavi olarak önermişlerdir.

Demmelmaier ve arkadaşları (2021) Meme kanseri, Prostat kanseri ve Kolorektal kanserli hastalarda Aerobik + direnç egzersizleri, ev denetimli egzersizleri yaptırarak egzersiz yoğunluğu, (neo-)adjuvan kanser tedavisi sırasında yorgunluk düzeylerini incelemiş ve sonuçlarda yüksek yoğunluklu egzersiz grubuna dahil olan katılımcılar, düşük-orta yoğunluklu egzersiz grubuna kıyasla daha düşük fiziksel yorgunluk yaşadığı, diğer kanserle ilişkili yorgunluk boyutlarında ve davranış değişikliği desteği konusunda herhangi bir fark gözlemlenmediği belirtilmiştir. Az sayıda küçük yan etki rapor edilmiş. Meme, prostat veya kolorektal kanser tedavisi gören hastalar için, kanserle ilişkili yorgunluk açısından, yüksek veya düşük-orta yoğunlukta egzersiz yapmak, bireylerin kendi tercihlerine göre güvenli bir seçenek olarak uygulanabilir. Denetimli ve iyi kontrollü egzersiz müdahalelerinde, ek davranış değişikliği desteği, kanserle ilişkili yorgunluğu azaltmada ek bir fayda sağlamayacağı sonucuna varılmıştır.

Samuel ve arkadaşları (2019) Kemoterapi-radyoterapi tedavisi gören baş ve boyun kanseri hastalarında egzersize dayalı rehabilitasyonun fonksiyonel kapasite, yaşam kalitesi, yorgunluk, hemogloblin ve trombosit sayıları üzerindeki etkinliğini değerlendirmişlerdir. Sonuç olarak, Kemoterapi-radyoterapi tedavisi gören baş ve boyun kanseri hastalarında 11 haftalık yapılandırılmış bir egzersiz programının fonksiyonel kapasiteyi ve yaşam kalitesini iyileştirdiğini, ayrıca egzersiz grubunda yorgunluk seviyelerinin kötüleşmesini engellediğini sonucuna varmışlardır.

Rutkowska ve arkadaşları (2019) akciğer kanseri olan kişiler 4 hafta ve haftada 5 gün Aerobik + direnç egzersizleri, nefes egzersizleri yaptırmış ve kemoterapi sırasında küçük hücreli olmayan akciğer kanseri (NSCLC) hastalarında egzersiz eğitiminin etkilerini karşılaştırmışlardır. Sonuçlar ise, müdahale öncesi ve sonrası değerleri karşılaştırıldığında, EEG grubunda 6 dakikalık yürüyüş mesafesinde bir artış gözlemlenmiş, fiziksel performans testlerinde: Up and Go Testi, sandalye kalkışı ve kol bükme gibi tüm testlerde anlamlı iyileşmeler görülmüş. Spirometri değerlerinde de iyileşmeler olduğu sonuçlar arasındadır.

Yukarıdaki hem hayvan hem de insan çalışmaları ışığında egzersizin kanserli hastalar üzerinde pozitif etkisi olduğu sonucuna varılmaktadır. Ayrıca sadece kanser oluşuktan sonra değil aynı zamanda oluşum aşamasında da etkisi olduğu söylenebilir.

### SONUÇ

Yapılan çalışmalar ve literatür incelendiğinde kanser insidansının her geçen yıl arttığı kaçınılmaz sonuçlar arasındadır. Hareketsizlik, fiziksel aktivite kısıtlılığı, teknolojinin gelişmesi, ev çalışma ortamlarının artması, pandemi sürecinde insanların daha çok evde vakit geçirmesi, zaman problemleri, obezite, genetik hastalıklar, yanlış beslenme alışkanlıkları gibi sebeplerden dolayı insanların çeşitli hastalıklara yakalanma olasılıkları gitgide artmaktadır. Hastalıkların büyük bir çoğunluğunu fiziksel aktivite ve egzersiz yoksunluğundan kaynaklandığı söylenebilir. Bu çalışmamızın amacı egzersiz ve kanser ilişkisini araştırmaktır. Fiziksel aktivite ve egzersiz yoksunluğu, kanserin gelişiminde önemli bir rol oynamaktadır. Literatür ve yapılan araştırmalar, fiziksel hareketsizliğin birçok kanser türünün tetiklenmesinde ve ilerlemesinde etkili olduğunu göstermektedir. Fiziksel aktivite, kaslar ve eklemler aracılığıyla gerçekleştirilen her türlü hareketi kapsar ve sağlığın korunmasına, iyileştirilmesine katkıda bulunur.

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Kanser, genellikle fiziksel açıdan değil, psikolojik ve duygusal açıdan da büyük bir yük getirir. Depresyon, anksiyete, stres, beden imajı kaygıları, azalmış özsaygı ve kontrol duygusunun kaybı, kanserin yaygın psikolojik etkilerindedir. Ancak egzersizin, yalnızca fiziksel sağlık üzerinde değil, bu duygusal ve psikolojik etkilere karşı da olumlu etkiler yarattığı gösterilmiştir. Özellikle egzersizin, depresyon ve anksiyetenin tedavisinde faydalı olabileceği öne sürülmektedir. Fiziksel egzersizin, kronik hastalıklar üzerinde de olumlu etkileri vardır, çünkü inflamasyonu modüle etme yeteneğine sahiptir. Kanser gibi hastalıklarla mücadelede, inflamasyonun azaltılması oldukça önemlidir. Egzersizin, hücresele seviyede başlattığı iyileşmeler organizmanın tamamına yayılır. Örneğin, sağlıklı bireyler egzersizle kardiyorespiratuar sistemlerinde iyileşme, hücresele adaptasyonlar, damarlaşma ve kas gücünde artış gibi faydalar elde ederler. Ancak kanser hastalarında bu süreç biraz farklı işler. Fiziksel egzersiz, kanser tedavisi ve hastalığın kendisinden kaynaklanan olumsuz değişikliklerin etkilerini azaltabilir, ancak bu hastalarda genellikle fiziksel uygunlukta olumsuz değişiklikler gözlemlenir. Buna rağmen, fiziksel egzersiz, kanser hastalarının tedavi sürecinde semptomları yönetmek, yan etkileri azaltmak ve genel sağlıklarını iyileştirmek için etkili bir strateji olarak kullanılabilir. Egzersizin düzenli uygulanması, kanser tedavisinin yan etkilerini, özellikle yorgunluk, depresyon ve fiziksel hareketsizlik gibi semptomları azaltmada önemli bir rol oynayabilir. Bu bağlamda, egzersiz yalnızca bir fiziksel aktivite değil, kanser tedavisinin tamamlayıcı bir bileşeni olarak da kabul edilebilir.

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**EFFECTS OF HYPOXIA ON PROLIFERATION AND DIFFERENTIATION OF  
ADIPOSE STEM CELLS**

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**Abstract**

Adipose tissue stem cells are advantageous for regenerative treatments as it is easy to isolate and access subcutaneously. Besides it, they have potential to differentiate into other cells and can self-renew. As they have a wider range of convenient sources than other stem cells, including adipose tissue in the abdomen and limbs, they gained the importance for treatments. In human body, adipose stem cells naturally inhabit a microenvironment with a comparatively low oxygen tension, or hypoxia. Low oxygen levels encourage stemness and cell proliferation, which increases the number of cells that may be able to differentiate into many lineages and increases the likelihood of long-term growth. In order to guarantee the safe application of ASCs in regenerative treatment, it is better to understand their proliferation and differentiation capacity to not cause diseases in their physiological state. The current review contains information of hypoxia on viability, proliferation and differentiation potentials of adipose stem cells

**Keywords:** Adipose Stem Cells, Differentiation, Hypoxia, Proliferation

### **Introduction**

Adipose stem cells (ASCs) are becoming more widely acknowledged as an essential source of cells for regenerative medicine's cell-based treatment (Kølle et al., 2013). ASCs have been demonstrated for several benefits, including as ease of collection, accessibility, low immunogenicity, and the capacity to self-renew and differentiate into diverse lineages (Bunnell et al., 2008). As clinical application requires a large number of ASCs, several research have focused on the impact of in situ normoxia on cell growth. According to the majority of research, ASCs proliferated and survived longer in low oxygen concentrations than at normal oxygen concentrations (Estrada et al., 2012). Hypoxia is a significant contender among variables that govern ASC characteristics in their natural physiological microenvironment. The oxygen environment appears to have a critical role in sustaining MSCs' self-renewal ability and multipotency, as well as greatly influencing MSC differentiation and proliferation (Chung et al., 2012). It is known that ASC proliferation is higher in hypoxic environments compared to normal oxygen levels (Hung et al., 2012). Hypoxia enhances the chondrogenesis of ASCs (Wang et al., 2005) with low oxygen levels (2%), but, they also appear to reduce osteogenesis of mouse ASCs (Malladi et al., 2006) as well as the osteogenesis and adipogenesis of ASCs of human (Lee and Kemp, 2006). As there are differences between differentiation potential of between species, it is important to understand their differentiation and proliferation potentials for better approaches the treatment of diseases.

### **Cell Viability of ASCs Under Hypoxia**

The viability of hypoxic-treated ASCs has been evaluated using viability assays, including the annexin V assay and MTT assay (Choi et al., 2015). The majority of research revealed that hypoxia (0.1–2% O<sub>2</sub>) improves ASC viability. According to the annexin V-PI test, hypoxic-ASCs (1.5 and 2% O<sub>2</sub>) exhibit a smaller proportion of apoptotic cells than normoxic ASCs (Feng et al., 2014). It has been discovered that hypoxia increases prolyl hydroxylase 3 and decreases cleaved caspase-3, which results in less activation of caspase-3, an apoptosis mediator, and therefore less cell apoptosis (Bekhite et al., 2014). Additionally, it was shown that VEGF-A also contributed to the protective impact of hypoxia on the viability of ASCs (Stubbs et al., 2012).

### **Proliferation Potential of ASCs Under Hypoxia**

Several studies have found that ASC proliferation is more strongly affected under hypoxia than normoxia in vitro. Hypoxia has been shown to stimulate ASC proliferation and does not alter ASC phenotype (Fotia et al., 2015). According to Lee et al. (2009), hypoxia increased the proliferation of human ASCs. Moreover, Yamamoto et al. (2013) found that ASCs grown in 2% O<sub>2</sub> proliferated after 6 weeks of culture. In addition, Rasmussen et al. (2011) investigated the effects of different oxygen levels of hypoxic culture on the proliferation of human ASCs. It was found that ASCs in 5% oxygen environment significantly increased ASC proliferation. Hypoxia increases the survival, migration and differentiation capacity of ASCs both in vitro and in vivo (Lee et al., 2009; Stubbs et al., 2012). Hypoxia plays an important role not only in ASC proliferation (Kakudo et al., 2015) but also in differentiation through activation of the Hypoxia-inducible factor-1 alpha (HIF-1 $\alpha$ ) pathway (Choi et al., 2014). Some studies have shown that under hypoxia, HIF-1 $\alpha$  improves the stem cell properties of ASCs while inhibiting their differentiation potential, while other researchers have revealed an enhanced differentiation potential via HIF-1 $\alpha$  (Amarilio et al., 2007).

### **Differentiation Potential of ASCs Under Hypoxia**

The adipogenic, osteogenic, and chondrogenic differentiations of ASCs were shown to be maintained by oxygen tension at 1 and 1.5%, whereas the differentiation was found to be considerably impacted (either enhanced or decreased) by oxygen tension between 2 and 5. Following hypoxic treatment of ASCs that were stimulated to develop into chondrogenic-like cells, the presence of proteoglycan and cartilage stained with Alcian Blue (Fotia et al., 2015; Merceron et al., 2010). According to studies using alcian blue staining, ASCs cultured at 2% O<sub>2</sub> had more glycosaminoglycans and higher levels of expression of chondrogenic genes, such as COL-2, SOX-9, and ACAN (Choi et al., 2014). The chondrogenic induction medium of hypoxic-treated ASCs (5% O<sub>2</sub>) had greater levels of total sulfated glycosaminoglycan and cartilage than ASCs cultivated under atmospheric conditions (normoxic-treated ASCs). Hypoxia limits MSCs ability to differentiate into osteogenic and adipogenic tissues. For osteogenic differentiation, it was shown that there was a significant reduction in calcium deposition under hypoxia compared to normoxia. Hypoxia lowered the expression of osteogenic markers confirming that it inhibited ASC osteogenic development (Choi et al., 2014). Furthermore, the expression level of OSC (Caetano-Lopes et al., 2007) did not significantly increase following the stimulation of osteogenic differentiation under hypoxia, indicating that the majority of the cells may still be in the early differentiation stage. Researchers found that ASCs under hypoxia had a lower adipogenic differentiation capacity (Valorani et al, 2010) or did not develop into adipocytes (Lin et al., 2006). It was also reported that Hypoxia (1% oxygen) significantly enhanced the production of reactive oxygen species, up-regulated HIF-1a, and hindered adipocyte development in 3T3 pre-adipocytes (Carriere et al., 2004). Overall, most studies have found that ASCs have a lower osteogenic and osteogenic potential when exposed to hypoxia.

### **Conclusion**

ASCs are widely used in the treatment of diseases because they are easy to obtain and have differentiation potential. Since tissues in hypoxic conditions revive normal physiological body conditions, it is beneficial for stem cell research to be in this direction. Therefore, culturing and differentiating adipose tissue stem cells in hypoxic conditions is of great importance in order to revive these physiological conditions and to reveal differences between species. These cells in hypoxic conditions should be investigated further and used in treatments in accordance with the results.

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LİKOPENİN SAĞLIK ÜZERİNE ETKİLERİ

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**Özet**

Likopen, doğada 600'den fazla çeşidi bulunan, sebze, meyve ve çiçeklerin renkli olmasını sağlayan karotenoid ailesinin kırmızı renginden sorumlu bir pigmentidir. Başta domates olmak üzere birçok sebze ve meyvede yer alan likopenin insan sağlığı üzerindeki olumlu etkilerinin araştırmalarla ortaya konması, likopen ve likopen içerikli besinlere olan ilgiyi her geçen gün arttırmaktadır. Likopen, güçlü antioksidan ve antiinflamatuvar özellikleri sayesinde oksidatif stresin neden olduğu hücrel hasarı azaltarak çeşitli kronik hastalıklara karşı koruyucu rol oynamaktadır. Yapılan araştırmalar, likopenin düzenli tüketildiğinde başta prostat kanseri olmak üzere bazı kanser türlerinin ve kardiyovasküler hastalıkların önlenmesine katkı sağladığını göstermektedir. Ayrıca, kalp sağlığını koruma, inflamasyonu azaltma, yaşlanma belirtilerini geciktirme ve cilt sağlığını destekleme gibi birçok olumlu etkisi olduğu belirlenmiştir. Bu çalışma, likopenin insan sağlığı üzerindeki biyolojik etkilerini ve mekanizmalarını ele alarak, bu bileşiğin beslenme ve hastalık önleme stratejilerindeki önemini vurgulamaktadır. Gelecekte yapılacak klinik çalışmalar, likopenin dozu, biyoyararlanımı ve uzun vadeli etkileri konusunda daha kesin bilgiler sağlayarak, bu bileşiğin sağlık üzerindeki etkilerini daha iyi anlamamıza yardımcı olacaktır.

**Anahtar kelimeler:** Carotenoid, Lycopen, Antioxidant, Anti-inflammatory, Cancer.

**EFFECTS OF LYCOPENE ON HEALTH**

**Abstract**

Lycopene is a pigment responsible for the red color of the carotenoid family, which has more than 600 varieties in nature and provides colorful vegetables, fruits and flowers. The positive effects of lycopene, which is found in many vegetables and fruits, especially tomatoes, on human health have been revealed through research, and interest in lycopene and foods containing lycopene is increasing day by day. Lycopene, thanks to its powerful antioxidant and anti-inflammatory properties, plays a protective role against various chronic diseases by reducing cellular damage caused by oxidative stress. Studies have shown that lycopene, when consumed regularly, helps prevent certain types of cancer, especially prostate cancer, and cardiovascular diseases. It has also been shown to have many positive effects, such as protecting heart health, reducing inflammation, delaying signs of aging, and supporting skin health. This study addresses the biological effects and mechanisms of lycopene on human health, highlighting the importance of this compound in nutrition and disease prevention strategies. Future clinical studies will provide more precise information on the dosage, bioavailability and long-term effects of lycopene, helping us to better understand the effects of this compound on health.

**Keywords:** Curcumin, Turmeric, Antioxidant, Anti-inflammatory

## GİRİŞ

Beslenmemizde önemli yer tutan bitkiler, yapılarında pek çok aktif bileşik bulundurmaktadırlar. Bu bileşikler arasında karotenoidler, klorofiller, antosiyanidinler, betainler ve izoflavonlar bulunmaktadır (Caseiro ve ark., 2020). Bu bileşikler yalnızca bitkiye renk vermezle kalmaz aynı zamanda sağlık açısından da önemli etkiler gösterirler. Bitkilerin sarı, turuncu ve kırmızı renklerinden sorumlu olan karotenoidler, dikkat çekici özellikleriyle önemli bir araştırma konusu haline gelmiştir.

Karotenoidler yapılarına göre genel olarak iki ana gruba ayrılırlar: karbon ve hidrojenen oluşanlar ( $\beta$ -karoten ve likopen gibi) ve karbon, hidrojen ve oksijenden oluşan ksantofiller (lutein, astaksantin gibi). Bu çalışmada bir karotenoid olan likopen ( $\psi, \psi$ -karoten) ve likopenin insan sağlığı üzerindeki etkileri ele alınmıştır (Caseiro ve ark., 2020; Imran ve ark., 2020). Likopen ( $C_{40}H_{56}$ ), adını domatesten (*Solanum lycopersicum*) alan ve insan plazmasında en bol bulunan kırmızı doğal bir pigmenttir. Likopen, 11 konjuge karbon-karbon çift bağına sahip ve 8 izopren biriminden oluşan alifatik bir hidrokarbondur (Kun ve ark., 2006; Przybylska, 2020; Przybylska ve Tokarczyk 2022). Likopen yapısında bulundurduğu çift bağlar nedeniyle kromofor özellik taşır ve likopenin kırmızı renginden ve antioksidan özelliklerinden sorumlu olan bu bağlardır (Imran ve ark., 2020; Viuda-Martos ve ark., 2014). Likopen lipofilik yapısından dolayı suda, metil alkol ve etil alkolde çözünmez fakat tetrahidrofuran (THF), aseton ve kloroform gibi organik çözücülerde çözünür (Camara ve ark., 2013; Caseiro ve ark., 2020). Likopen A vitamini aktivitesi olmayan bir karotenoiddir (Hedayati ve ark., 2019; Imran ve ark., 2020; Kun ve ark., 2006). Ağırlıklı olarak domateste bulunan bu madde, aynı zamanda karpuz, kayısı, kırmızı üzüm, balkabağı, nar, portakal, kuşburnu, patlıcan, şeftali ve mango gibi sarı, turuncu ve kırmızı renkli sebze ve meyvelerin yanı sıra kuşkonmaz ve maydanoz gibi yeşil renkli bitkilerde de bulunur (Camara ve ark., 2013; Caseiro ve ark., 2020; Hedayati ve ark., 2019; Imran ve ark., 2020; Kun ve ark., 2006). Bu pigment insanlar tarafından sentezlenemediği için (Caseiro ve ark., 2020; Imran ve ark., 2020; Kun ve ark., 2006), dışarıdan diyetle alınması gerekmektedir. İnsanlarda likopenin %85'i domates ve domatesin ketçap, sos, domates suyu, salça gibi işlenmiş ürünlerinden elde edilmektedir (Caseiro ve ark., 2020; Kun ve ark., 2006).

Likopen sadece gıda sektöründe değil, aynı zamanda kozmetik sektöründe de kullanılan bir antioksidandır (Caseiro ve ark., 2020). Likopen her bitkide farklı miktarlarda bulunmaktadır. Örneğin; papayada  $2,0-5,3 \text{ mg } 100 \text{ g}^{-1}$ , karpuzda  $2,3-7,2 \text{ mg } 100 \text{ g}^{-1}$ , havuçta  $0,65-0,78 \text{ mg } 100 \text{ g}^{-1}$  ve balkabağında ise  $0,38-0,46 \text{ mg } 100 \text{ g}^{-1}$  bulunur. İşlenmiş gıdalarda ise likopen miktarı işlenmemiş gıdalara kıyasla daha fazladır (ketçaplar  $16,6 \text{ mg } 100 \text{ g}^{-1}$ , soslar  $23,88 \text{ mg } 100 \text{ g}^{-1}$  ve domates suları  $5-7 \text{ mg } 100 \text{ g}^{-1}$ ) (Przybylska, 2020).

Likopenin rengi izomerik formuna bağlı olarak değişiklik gösterir. Likopenin termodinamik olarak en kararlı izomeri all-trans formudur. Likopenin yapısı ışık, sıcaklık veya kimyasal reaksiyonlar ile all-trans formlarından cis formlarına dönüşmektedir. Bu nedenle domateslerde doğal olarak bulunan likopenin çoğu (yaklaşık %90'ı) trans izomerler formundadır ve işlenmiş gıdalarda ise cis- formundadır. Likopenin cis formu daha biyoaktif ve daha fazla emilime sahiptir (Camara ve ark., 2013; Caseiro ve ark., 2020; Imran ve ark., 2020; Kun ve ark., 2006; Przybylska, 2020; Przybylska ve Tokarczyk 2022; Viuda-Martos ve ark., 2014).

Likopen ısıya ve oksidatif işlemlere karşı oldukça hassastır. Bu nedenle likopeni ışıktan, oksijenden, yüksek sıcaklıktan, asitlerden, katalizörden ve metal iyonlarından korumak gerekmektedir (Camara ve ark., 2013; Caseiro ve ark., 2020; Kun ve ark., 2006; Przybylska, 2020). Likopen biyoyararlanımı, içerisinde bulunan gıdanın işlenmesi, pişirilmesi, çiğnenmesi



gibi işlemler neticesinde değişmektedir. İşlenmiş gıdalarda bulunan likopenin biyoyararlanımı daha yüksektir. Bunun nedeni ise ısı ile birlikte likopenin bitkilerdeki doku matrisinden salınması, tüm-trans-likopenin cis-izomerlere dönüşmesi ve ısı ile birlikte likopen-protein komplekslerinin zayıflamasıdır (Camara ve ark., 2013; Kun ve ark., 2006). Likopen toksik bir madde olmadığından dolayı ABD Gıda ve İlaç Dairesi tarafından güvenli olarak kabul edilmiştir (Przybylska, 2020). Kanda yüksek miktarda likopen bulunması kişinin cildinin sarımsı-turuncu bir renk almasına (likopenemi) neden olur fakat diyetle likopenin miktarı düşürüldüğünde cilt belli bir süre sonunda kendi rengine döner (Camara ve ark., 2013). Likopen için literatürde alınabilecek günlük likopen miktarları değişiklik göstermektedir. Farklı epidemiyolojik çalışmalara göre, günlük likopen alımının günde 2-20 mg olması önerilebilir (Imran ve ark., 2020). Bazı yazarlar günde 3 g/kg likopen alınmasının olumsuz etkilere neden olmadığını ifade etmektedirler. Literatürdeki bu farklılığın nedeninin likopenin toksik özellik göstermeyişinden kaynaklandığı düşünülmektedir. Likopen ağırlıklı olarak testisler, adrenal bezler, karaciğer ve prostat gibi çeşitli dokularda birikmekle beraber akciğer, beyin, yumurtalık, pankreas, cilt ve böbreklerde de düşük konsantrasyonlarda bulunmaktadır (Camara ve ark., 2013; Caseiro ve ark., 2020; Imran ve ark., 2020; Kun ve ark., 2006; Przybylska, 2020). Likopen atılımı dışkı yoluyla ve çok daha düşük miktarlarda idrar yoluyla gerçekleşir; bir miktar likopen yağ bezleri yoluyla da atılabilir (Camara ve ark., 2013). Likopen antikarsinojenik, antioksidan, antiinflamatuvar, antidiyabetik, antiaterojenik, hipolipidemik ve antineoplastik aktiviteye sahip bir karotenoiddir (Camara ve ark., 2013; Imran ve ark., 2020; Viuda-Martos ve ark., 2014). Likopen, kardiyovasküler hastalıklar ve kanser gibi insan sağlığını ciddi anlamda tehdit eden hastalıklar başta olmak üzere hipertansiyon, ateroskleroz, alzheimer, parkinson, diyabet, kolesterol, göz hastalıkları, cilt ve kemik hastalıkları gibi pek çok hastalığın da önlenmesinde önemli bir yere sahiptirler (Camara ve ark., 2013; Caseiro ve ark., 2020). Likopen aynı zamanda vücudu toksik ajanların zararlı etkilerine karşı da korumaktadır (Hedayati ve ark., 2019). Likopenin tam etki mekanizmaları henüz net olarak anlaşılamamışsa da bu bileşiğin insan sağlığı üzerindeki rolünün genel olarak bu bileşiğin antioksidan özelliklerinden kaynaklandığına inanılmaktadır. Fakat son çalışmalar likopenin bu olumlu etkilerinin sadece onun antioksidan özelliğinden kaynaklanmadığını ve bu etkilerden sorumlu başka mekanizmaların da olduğunu göstermektedir. Bunlar; hücreler arası boşluk bağlantısı iletişimi, hormonal ve bağışıklık sistemi modülasyonu ve metabolik yollarıdır. Likopen; bir antioksidan olarak hücreleri oksidatif hasara karşı koruyarak, reaktif oksijen türlerini (ROS) hapsederek, hücre-hücre iletişimini artırarak, tümör hücrelerinin çoğalmasını engelleyerek, antitümör bağışıklık tepkilerini iyileştirerek ve metabolizmayı düzenleyerek hastalıklara karşı koruyucu etki gösterir (Camara ve ark., 2013; Kun ve ark., 2006). Likopenin insan sağlığı üzerinde etkilerinden bazıları aşağıda verilmiştir

### LİKOPENİN ANTIOKSIDAN ETKİSİ

Reaktif serbest radikaller, çok sayıda biyomoleküle (lipid, protein, DNA) zarar verme potansiyeline sahip eşlenmemiş elektrona sahip yapılarıdır. Hücrelerimizin tükettiği oksijenin %1-3'ü serbest radikallere veya reaktif oksijen türlerine (ROS) dönüşmektedirler. Vücudumuzda serbest radikallerin veya ROS'un üretimi antioksidanlar (örn., askorbik asit,  $\alpha$ -tokoferol, fenolik bileşikler, likopen) vasıtasıyla engellenir. Likopen, hidrojen peroksit, nitrojen dioksit ve hidroksil radikalleri gibi diğer serbest radikaller üzerinde oldukça etkilidir. Likopen, antioksidan etkisi nedeniyle lipitleri, proteinleri ve DNA'yı oksidatif hasardan koruyabilen ve astaksantinden sonra gelen en güçlü antioksidandır (Camara ve ark., 2013;

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Caseiro ve ark., 2020; Imran ve ark., 2020). Bu nedenle insanlar diyetlerinde serbest radikal oluşumuna engel olacak kadar antioksidanı almak zorundadırlar.

Likopen yapısında çok sayıda konjuge çift bağ bulundurması nedeniyle, ROS'u yakalayan antioksidan görevi görür ve karotenoidler arasında, serbest radikallerinin tekli türleri için en yüksek temizleme yeteneğine sahiptir (Camara ve ark., 2013; Przybylska ve Tokarczyk 2022). Yüksek derecede ROS'u söndürme ve temizleme potansiyeline sahip olan likopen,  $\beta$ -karotenden iki kat ve  $\alpha$ -tokoferolden on kat daha fazla singlet oksijeni giderebilir (Imran ve ark., 2020; Przybylska, 2020; Przybylska ve Tokarczyk 2022; Viuda-Martos ve ark., 2014). Likopen aynı zamanda ROS oluşumuna katkıda bulunan enzimlerin aktivitesini de düzenlemektedir (Przybylska, 2020). Likopenin serbest radikallere karşı aktivitesi,  $\beta$ -karoten, fitoen ve fitofluen gibi diğer domates fitokimyasallarının varlığıyla sinerjik olarak artar (Caseiro ve ark., 2020).

Likopen serbest radikallere veya oksidasyon ajanlarına maruz kaldığında, çift bağlar ayrılabilir veya eklenebilir ve polien zinciri kesintiye uğrayabilir. Bu reaksiyonlar neticesinde likopen parçalanabilir ve rengini kaybedebilir (Caseiro ve ark., 2020; Przybylska, 2020; Przybylska ve Tokarczyk 2022). Likopen ve serbest radikaller arasındaki reaksiyonlar aynı anda birden fazla yolla meydana gelebilir. Likopen, yüksek konsantrasyonlarda prooksidan, düşük konsantrasyonlarda ise antioksidan olarak işlev görür. Bir pro-oksidan olarak likopen, biyolojik sistemlerde yalnızca yararlı veya zararlı etkiler üretmekle kalmaz, aynı zamanda insan hastalıklarının ilerlemesini de etkileyebilir (Caseiro ve ark., 2020). Likopenin biyolojik sistemdeki reaktivitesi, moleküler ve fiziksel yapılarına, hücreler içindeki konumlarına veya etki alanlarına, diğer antioksidanlarla etkileşime girme yeteneklerine ve konsantrasyonlarına bağlıdır (Przybylska, 2020).

### LİKOPEN VE KANSER

Likopenin, kanser ve koroner kalp hastalığı gibi serbest radikal reaksiyonları sonucu oluşan hastalıklara karşı koruma sağladığı yapılan pek çok çalışma ile desteklenmektedir. Likopenin, oksidatif strese duyarlılığı azaltan ve lipid peroksidasyonunu ve DNA hasarını önleyen "reaktif oksijen türleri temizleme aktivitesi" bulunmaktadır. Likopen başta prostat kanseri olmak üzere, meme, yumurtalık, mide, serviks, mesane, lösemi, rektal, pankreas, akciğer gibi bazı kanserleri önlediği veya kanser hücrelerinin büyümesini geciktirdiği bilinen bir gerçektir (Camara ve ark., 2013; Caseiro ve ark., 2020; Imran ve ark., 2020; Kun ve ark., 2006; Przybylska, 2020). Likopenin kanseri önlemesi antioksidan, antikanser özelliğine atfedilmektedir (Caseiro ve ark., 2020).

Likopenin antioksidan özelliklerine ek olarak, hücre-hücre iletişimini başlattığı ve hormonal, bağışıklık sistemleri ve diğer metabolik yolları düzenlediği, tümör hücrelerinin çoğalmasının engellendiği, hücre döngüsü ilerlemesini inhibe ettiği, detoksifikasyon sistemlerini düzenlediği, mutagenezi azalttığı, melanom ilerlemesini kesintiye uğratarak bloke ettiği ve büyüme faktörü sinyalleme sisteminin düzenlenmesine de katkıda bulunduğu bilinmektedir (Camara ve ark., 2013; Caseiro ve ark., 2020; Przybylska, 2020; Viuda-Martos ve ark., 2014). Bu etkiler de kanserin önlenmesi, yayılması veya ilerlemesinin durdurulması açısından oldukça önemlidir (Kun ve ark., 2006). Likopen tek başına gösterdiği bu etkileri, diğer antioksidan bileşiklerle bir aradayken oluşan sinerjik etkiden dolayı daha güçlü bir biçimde yerine getirebilir (Caseiro ve ark., 2020). Örneğin, gerçekleştirilmiş olan in vitro çalışmalar göstermiştir ki likopen ve  $\alpha$ -tokoferol kombinasyonunun prostat kanseri üzerinde tek başına likopenden daha etkili olduğu görülmüştür (Camara ve ark., 2013).

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Prostat kanseri, prostat bezinin kronik bakteriyel iltihabı sonucunda ROS üretiminin artması ve DNA'nın oluşan ROS'tan zarar görerek mutasyona uğraması ile tümör oluşumunun gerçekleşmesi ile meydana gelmektedir (Przybylska, 2020). Yapılan çalışmalar, enflamasyonun kanser sebebi olduğunu ortaya koymaktadır (Imran ve ark., 2020). Prostat kanseri hastalarında yeterli miktarda alınan likopen oksidatif stresi azaltır ve bunun sonucunda plazma lipoproteinlerinin, serum proteinlerinin DNA'nın hasarını azaltır (Caseiro ve ark., 2020). Diyetlerinde en fazla likopen bulunan erkeklerde (günde 6,5 mg veya daha fazla) prostat kanseri riski en az tüketenlere kıyasla %21 oranında azaldı. Literatürde yer alan çalışmalar, likopen ağırlıklı diyetle beslenen kişilerin yukarıda sayılan kanser türlerine yakalanma risklerinin ciddi oranda azaldığını göstermektedir (Kun ve ark., 2006).

### LİKOPEN VE KARDİYOVASKÜLER HASTALIKLAR

Kardiyovasküler hastalıklar tüm dünyada ölümlere neden olan hastalıklar arasında önde sıralarda yer almaktadır. Dünya Sağlık Örgütü (WHO) göre, kardiyovasküler hastalıklar hipertansiyon, kalp yetmezliği, periferik arter hastalığı ve koroner arter hastalığı da dahil olmak üzere hem kalp hem de damar bozukluklarını kapsamaktadır. Kardiyovasküler hastalıkların oluşmasında rol oynayan pek çok faktör bulunmaktadır. Bu faktörler arasında sağlıklı beslenme, fiziksel hareketsizlik, yüksek tansiyon, obezite gibi faktörlerin yanı sıra yaş, ırk, cinsiyet gibi faktörler de yer almaktadır (Przybylska ve Tokarczyk 2022).

Likopen kardiyoprotektif bir karotenoiddir. Likopenin kardiyovasküler hastalıkları önlemedeki yeteneği, antioksidan özelliğinden ve kolesterol metabolizmasını düzenleme yeteneğinden kaynaklanmaktadır (Imran ve ark., 2020). Yapılan çalışmalar, likopenin kan basıncını düşürdüğünü ve düşük yoğunluklu lipoprotein (Low Density Lipoprotein → LDL) oksidasyonunu önleyerek koroner kalp hastalıkları riskini azaltabileceğini göstermiştir (Kun ve ark., 2006; Viuda-Martos ve ark., 2014). Hipertansif özelliklere sahip olan likopen LDL'yi düşürürken yüksek yoğunluklu lipoproteinlerin (High Density Lipoprotein → HDL) seviyesinin de artmasına neden olur (Imran ve ark., 2020; Przybylska ve Tokarczyk 2022). LDL, çeşitli kardiyovasküler hastalıkların (CVD) gelişiminde önemli bir rol oynayan bir faktördür. Likopen, LDL'nin düşürülmesine katkıda bulunarak anti-kolesterol etki gösterir. Diyetle likopen alımı, ateroskleroz ve CVD için bir risk faktörü olan lipid peroksidasyonunu önlemede etkilidir. Likopen CVD oluşumuna neden olan LDL kolesterol seviyelerini düşürerek aterosklerotik plakların oluşumunu engeller (Camara ve ark., 2013). İnsanlarda günde 10 mg likopen alınmasının koroner kalp hastalığı riskini %50 oranında azalttığı bilimsel çalışmalar ile gözler önüne serilmiştir (Imran ve ark., 2020).

### LİKOPEN VE DİĞER HASTALIKLAR

Gelişen teknoloji ile birlikte insanların toksik maddelere maruziyeti de her geçen gün artmaktadır. Araba yakıtlarında bulunan kurşun, endüstriyel faaliyetlerde kullanılan civa, tarımda kullanılan pestisitler, vb. pek çok toksik ajan başta kanser olmak üzere insan sağlığı üzerinde çok fazla olumsuz etkiye sahiptirler. Literatürdeki çalışmalar incelendiğinde likopenin insanları bu toksik ajanlara karşı da koruduğu belirlenmiştir (Hedayati ve ark., 2019). Likopenin sağlık üzerindeki koruyucu etkisi ve ilişkili olduğu diğer bazı hastalıklar da aşağıda verilmiştir.

### ***Likopenin Antiinflatuar Etkisi***

İnflamasyonun koroner kalp hastalığı gibi çeşitli hastalıkların sebebi olduğu bilinmektedir. Likopen, IL-1 $\beta$ , IL-6, IL-8 ve TNF- $\alpha$  dahil olmak üzere proinflatuar sitokinlerin sentezini ve salınımını engelleyerek inflamasyonu önler (Przybylska ve Tokarczyk 2022). Likopenin anti-inflatuar aktivitesinin, nükleer faktör  $\kappa$ B'nin (NF- $\kappa$ B) inhibisyonu, mitojenle aktive olan protein kinazın (MAPK) düzenlenmesi, indüklenbilir nitrik oksit sentazın (iNOS) kontrolü ve araşidonik asit metabolizmasında yer alan siklooksijenaz-2 (COX-2) ve lipoksijenaz (LOX) enzimlerinin inhibisyonu gibi çeşitli mekanizmalar aracılığıyla gerçekleştiği düşünülmektedir (Caseiro ve ark., 2020; Przybylska ve Tokarczyk 2022).

### ***Cilt Hastalıkları***

Yapılan çalışmalar likopenin cildi, UV-B'nin sebep olduğu fotohasardan, yaşlanmadan ve DNA hasarından koruduğunu göstermiştir (Camara ve ark., 2013; Caseiro ve ark., 2020). UV-B, ciltte lipid oksidasyonunu tetikleyerek serbest radikallerin birikmesine ve buna bağlı olarak kırışıklıkların ve yaşlanma sürecinin hızlanmasına neden olur (Camara ve ark., 2013). Likopen topikal olarak da uygulanabilir. Topikal uygulama, hücre zarındaki prostaglandin ve fosfolipid bileşenlerinin sentezini destekleyerek cilt koruma mekanizmalarını güçlendirir ve böylece inflamatuvar infiltrasyonu azaltabilir. Başta likopen olmak üzere karotenoid destekli beslenmenin cilt kırışıklıklarının oluşumunu da azalttığı bilinmektedir. Bu etkileri sayesinde likopen, yaşlanma karşıtı kremler, yüz ve göz kremleri gibi kozmetik ürünlerde kullanılmaktadır (Caseiro ve ark., 2020).

### ***Nörodejeneratif Hastalıklar***

Nörodejeneratif hastalıklar arasında Alzheimer ve Parkinson hastalıkları vakaların yaklaşık %60'ını oluşturmaktadır. Olumsuz çevresel faktörler, ROS türlerinin artması, inflamatuvar süreçler ve genetik yatkınlık bu hastalıklardan sorumlu faktörler arasında bulunmaktadır. Likopenin, beyin antioksidan savunma mekanizmalarını hızlandırması ve nitrik oksit yollarını aşağı yönlü düzenlemesi sayesinde nörodavranışsal eksiklikleri tersine çevirebileceği ve bilişsel fonksiyonları geliştirebileceği öne sürülmektedir. Kişinin işlev görme yeteneğini azaltan/sınırlayan, hafıza kaybına ve davranışsal bozukluklara neden olan Alzheimer hastalığı (Przybylska, 2020), beyinde  $\beta$ -amiloid birikimi, özellikle  $\beta$ -Amiloid<sub>1-42</sub> (A $\beta$ <sub>1-42</sub>) ile ilişkilidir. Likopenin A $\beta$ <sub>1-42</sub> kaynaklı mitokondriyal disfonksiyonu, NF- $\kappa$ B, IL-1 $\beta$ , TNF- $\alpha$  ve dönüştürücü büyüme faktörü (TGF)- $\beta$  gibi inflamatuvar sitokin mediatörlerini ve beyindeki kaspaz-3 aktivitesini önemli ölçüde azalttığı ve bu sayede alzheimer hastalığının önlenmesine katkı sunduğu düşünülmektedir. Likopenin sadece Alzheimer hastalığı değil, istemli hareketlerin yavaşlaması, dinlenme halinde titreme ve duruşsal dengesizlikle kendini gösteren Parkinson hastalığının da önlenmesinde etkili olduğu düşünülmektedir (Caseiro ve ark., 2020). Dopaminerjik nöronların hasar görmesi ile oluşan bu hastalığa oksidatif stresin neden olduğu düşünülmektedir. Büyük miktarda (%20) oksijen tüketen beyin, oluşan ROS'larla hasar görebilmektedir. Likopenin beyni nörodejeneratif hastalıklara karşı koruması bu bileşiğin antioksidan özelliği sayesinde. Lipofilik yapısı ve antioksidan özellikleri sayesinde likopen, kan-beyin bariyerini kolayca geçerek oksidatif stres kaynaklı lezyonların oluşumunu önleyebilir. Ayrıca likopen bakımından zengin bir diyetle beslenen bir hastada depresyon ve bilişsel işlev kusurlarını hafiflediği de görülmüştür (Przybylska, 2020).

Likopen yukarıda sayılan etkilerinin dışında bağışıklığı da arttırdığı (Caseiro ve ark., 2020), kemik sağlığını koruyarak insanları osteoporozla karşı koruduğu (Przybylska, 2020), insanları

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ağız ve diş hastalıklarından koruduğu, antidiyabetik etki gösterdiği ve sperm sayısını ve hareketliliğini iyileştirdiği (Imran ve ark., 2020) yapılan çalışmalarla desteklenmiştir.

**SONUÇ**

Bu çalışmada, likopenin insan sağlığı üzerindeki etkileri ele alınmış ve mevcut bilimsel kanıtlar doğrultusunda çeşitli hastalıklarla olan ilişkisi incelenmiştir. Antikanser, antioksidan ve antiinflamatuvar gibi önemli biyolojik özelliklere sahip olan likopenin, insan sağlığı üzerinde birçok olumlu etkisi bulunmaktadır. Likopen, güçlü antioksidan özellikleri sayesinde oksidatif stresi azaltır, biyomolekülleri oksidatif hasardan korur ve böylece hücrel sağlığın korunmasına katkıda bulunurken iltihaplanma süreçlerini de baskılar. Likopen bu özelliklerini benzersiz kimyasal yapısına borçludur. Likopenin, düzenli tüketiminin özellikle kanser, kardiyovasküler hastalıklar ve nörodejeneratif hastalıklar üzerinde olumlu etkileri bulunmaktadır. Yapılan araştırmalar, likopenin insanları toksik ajanların zararlı etkilerinden de koruduğunu ortaya koymuştur. Literatürde belirtilen tüm olumlu etkilerine rağmen, likopenin etki mekanizması tam olarak aydınlatılamamış olup, daha fazla bilimsel çalışmaya ihtiyaç duyulmaktadır. Bu doğrultuda, likopen içeren takviye gıdaların üretiminin artırılması, toplumun likopenin sağlık üzerindeki faydaları konusunda daha fazla bilinçlendirilmesi ve kullanımının teşvik edilmesi önem arz etmektedir. Likopenin stabilitesi, biyoyararlanımı ve çözünürlüğünün iyileştirilmesiyle birlikte, yalnızca gıda sektöründe değil, kozmetik ve ilaç sanayisinde de kullanımının teşvik edilmesi gerekmektedir.

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**ELAEAGNUS ANGUSTIFOLIA L.: SAĞLIK VE BESLENME ÜZERINE ETKİLERİ**

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**Özet**

Yaygın olarak iğde veya Rus zeytini olarak bilinen *Elaeagnus angustifolia L.*, Elaeagnacea familyasından yaprak dökken bir bitkidir. Bu bitki, çeşitli çevre koşullarına uyum sağlayarak hayatta kalabilmektedir. Meyvesi, yaprakları, kabuğu ve çiçekleri zengin vitamin, mineral, flavonoid ve fenolik bileşikler içermekte olup, geleneksel tıpta geniş bir kullanım alanına sahiptir. Yapılan bilimsel çalışmalar, bu bitkinin antioksidan, antiinflamatuvar, yara iyileştirici, kardiyoprotektif, analjezik ve antitümör etkiler gösterdiğini kanıtlamaktadır.

Özellikle yara iyileşmesini hızlandırıcı etkileri, kollajen üretimini artırarak doku onarımına katkıda bulunması ve fibroblast aktivitesini desteklemesi açısından dikkat çekmektedir. Kardiyovasküler hastalıkların önlenmesi ve tedavisinde de potansiyel taşıyan *E. angustifolia*, miyokardiyal iskemi-reperfüzyon hasarına karşı koruyucu etki gösterebilmektedir. Ayrıca, gastrointestinal sistem rahatsızlıklarında, peptik ülser tedavisinde ve ağrı yönetiminde geleneksel kullanımı destekleyen bilimsel veriler bulunmaktadır.

Kanser hücreleri üzerinde yapılan çalışmalar, *E. angustifolia* özütlerinin antitümör aktivite gösterebileceğini ve bazı bileşenlerinin sitotoksik etkiler oluşturabileceğini ortaya koymaktadır. Ancak, bu etkilerin mekanizmalarının daha iyi anlaşılması ve klinik uygulamalara yönelik potansiyelinin netleştirilmesi için ileri araştırmalara ihtiyaç duyulmaktadır.

Genel olarak, *Elaeagnus angustifolia L.*, içerdiği biyoaktif bileşenler sayesinde hem besinsel hem de farmakolojik açıdan önemli bir bitkidir. Gelecekte yapılacak çalışmalar, bu bitkinin tıbbi ve farmasötik kullanımlarını daha da genişletebilir ve alternatif tedavi yaklaşımlarına katkı sağlayabilir. Gelecekte gerçekleştirilecek araştırmalar, bu bitkinin tıbbi ve farmasötik uygulamalarını daha kapsamlı hale getirebilir ve alternatif tedavi yaklaşımlarına bilimsel düzeyde katkı sunabilir.

**Anahtar Kelimeler:** antioksidan, *Elaeagnus angustifolia L.*, sağlığa faydaları, antikanser

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**HEALTH AND NUTRITIONAL BENEFITS OF *ELAEAGNUS ANGUSTIFOLIA L.***

**ABSTRACT**

*Elaeagnus angustifolia L.*, commonly known as oleaster or Russian olive, is a deciduous plant from the Elaeagnacea family. This plant can survive by adapting to various environmental conditions. Its fruit, leaves, bark and flowers contain rich vitamins, minerals, flavonoids and phenolic compounds and have a wide range of uses in traditional medicine. Scientific studies prove that this plant has antioxidant, anti-inflammatory, wound healing, cardioprotective, analgesic and antitumor effects. It is particularly notable for its wound healing accelerating effects, contributing to tissue repair by increasing collagen production and supporting fibroblast activity. *E. angustifolia*, which also has potential in the prevention and treatment of cardiovascular diseases, can have a protective effect against myocardial ischemia-reperfusion injury. In addition, there is scientific data supporting its traditional use in gastrointestinal disorders, peptic ulcer treatment and pain management. Studies on cancer cells have shown that *E. angustifolia* extracts may exhibit antitumor activity and some of its components may have cytotoxic effects. However, further research is needed to better understand the mechanisms of these effects and to clarify its potential for clinical applications. In general, *Elaeagnus angustifolia L.* is an important plant both nutritionally and pharmacologically due to the bioactive components it contains. Future studies may further expand the medical and pharmaceutical uses of this plant and contribute to alternative treatment approaches. Future studies may further expand the medical and pharmaceutical applications of this plant and contribute to alternative treatment approaches at a scientific level.

**Keywords:** antioxidant, *Elaeagnus angustifolia L.*, health benefits, anticancer



## 1. GİRİŞ

Çin'de Qilixiang, Xiangliu, Yageda ve Hongdou olarak bilinen; Avrupa'da ise Oleaster veya Rus Zeytini adıyla tanınan *Elaeagnus angustifolia* L., Elaeagnus cinsine ait, Elaeagnaceae familyasından yaprak döken bir ağaç veya küçük ağaç türüdür. Bu bitkinin kuru ve olgun meyvesi, Uygur halkı arasında hem tıbbi hem de besin kaynağı olarak yaygın şekilde kullanılmaktadır (Niknam ve ark., 2016). Elaeagnus cinsine ait dünya genelinde 90'dan fazla tür bulunmaktadır. Bu türler ağırlıklı olarak Asya, Avrupa ve Kuzey Amerika'nın bazı subtropikal bölgelerinde yayılmıştır (Saboonchian ve ark., 2014). *Elaeagnus angustifolia*, 80-100 yıl kadar yaşayabilen uzun ömürlü bir ağaçtır. Hızla büyüyerek 10 metre yüksekliğe ve 30 cm çapa ulaşabilir. Meyve vermeye ise genellikle 5-6 yaşından itibaren başlamaktadır (Kiseleva ve ark., 2011). Bu ağaç; sel, şiddetli kuraklık, taşlı ve kumlu topraklar ile yüksek tuzluluk veya alkaliniteye sahip zorlu çevre koşullarına dayanabilir. Rus zeytininin farklı bölümleri, çeşitli tıbbi amaçlar için, parfüm endüstrisinde ve ayrıca ahşap işçiliği ile müzik aletleri üretiminde kullanılmaktadır (Asadiar ve ark., 2013).

*E. angustifolia* meyveleri, yüksek besin değerine sahip olup protein, şeker, A, B, C, K vitaminleri, potasyum, fosfor tuzlar ve mineraller açısından zengindir (Taheri ve ark., 2010). *E. angustifolia* meyveleri yüksek besin değerlerine sahiptir ve taze veya çoğunlukla kurutulmuş halde tüketilir (Taheri ve ark., 2010). Küçük, hoş kokulu ve sarımsı beyaz renkte olan çiçekleri, bal arıları için önemli bir nektar kaynağıdır ve likör üretiminde tatlandırıcı olarak kullanılmıştır (Kiseleva ve ark., 2011). Ayrıca, geleneksel tıpta tetanoz tedavisinde de kullanıldığı bilinmektedir (Wang ve ark., 2013).

*E. angustifolia*'nın meyvesi, çiçeği, yaprağı ve kabuğu, geleneksel olarak çeşitli hastalık ve semptomların tedavisinde kullanılmak üzere kaynatılarak veya infüzyon şeklinde hazırlanmıştır. Meyvesi çiğ ya da haşlanmış olarak tüketildiğinde; boğaz ağrısı, öksürük, grip, soğuk algınlığı, ateş, mide bulantısı, kusma, sarılık, astım, ishal ve diğer bazı hastalıkların tedavisine yardımcı olduğu bilinmektedir (Asadiar ve ark., 2013). İran halk tıbbında, *E. angustifolia* meyveleri romatoid artrit hastalarında ağrı ve iltihabı azaltmak için kullanılmıştır. Ayrıca, yaraların daha hızlı iyileşmesini desteklemek amacıyla da tercih edilmiştir (Sahan ve ark., 2013).

## 2. KOMPOZİSYON

*Elaeagnus angustifolia* meyveleri geleneksel olarak tokoferol, karoten, C vitamini, tiamin B1 gibi vitaminler ve kalsiyum, magnezyum, potasyum, demir ve manganez gibi mineraller açısından zengin bir kaynak olduğu için taze veya kurutulmuş olarak tüketilmektedir (Boudraa ve ark., 2010). Yapılan araştırmalar, *E. angustifolia* L.'nin farklı bölümlerinde çeşitli mineral konsantrasyonlarının bulunduğunu göstermiştir. Kök, kök kabuğu, dallar, gövde kabuğu ve yapraklar; demir, kurşun, bakır, kadmiyum, çinko, krom, nikel ve kobalt içermektedir (Khan ve ark., 2016). *E. angustifolia* L. meyvesinde en yüksek oranda bulunan mineral potasyumdur (8504 mg/kg). Onu sırasıyla sodyum (1731 mg/kg) ve fosfor (635 mg/kg) takip etmektedir (Cansev ve ark., 2011). *E. angustifolia* L. meyve özütü üzerinde yapılan çalışmalar, bu özütün flavonoidler, polisakkaritler, sitosteroller, glikozitler, terpenoidler, kumarinler, fenol karboksilik asitler, amino asitler, saponinler, karotenoidler, vitaminler ve tanenler gibi bileşikler içerdiğini göstermiştir. Flavonoidler, özellikle fenolik hidroksil grupları sayesinde meyve ve sebzelerde yaygın olarak bulunmaktadır. Bu bileşikler, metalleri bağlayarak lipid peroksidasyonunu azaltabilir ve aynı zamanda yüksek antioksidan özellikleri ile serbest radikalleri etkili bir şekilde temizlemektedir (Okmen & Turkcan 2014).

Bu bitkiden izole edilip tanımlanan flavonoid bileşikler arasında 4(+)-kateşin, (-)-epikateşin, (+)-gallokateşin, (-)-epigallokateşin, kaempferol, kuersetin, luteolin, izoramnetin ve izoramnetin-3-0-β-D-galaktopiranosid gibi bileşikler bulunmaktadır (Okmen & Turkcan 2014).

*E. angustifolia* bitkisinde en bol bulunan fenolik bileşikler, benzoik gruptan 4-hidroksibenzoik asit (45,8 mg/100 g kuru ağırlık) ve sinamik gruptan kafeik asittir (32 mg/100 g kuru ağırlık). Çözünebilen şekerler arasında ise, fruktoz (%27,1 kuru ağırlık) ve glikoz (%22,3 kuru ağırlık), bu meyvenin tatlı tadından sorumlu başlıca monosakkaritlerdir ve fenolik bileşiklerle birlikte bulunmaktadır (Ayaz & Bertoft, 2001).

*E. angustifolia* L., yüksek miktarda yoğunlaştırılmış tanen içermektedir. Bu tanenlerin miktarı, bitkinin farklı kısımlarında değişir. Ağacın kabuğu en yüksek tanen içeriğine sahipken, bunu yapraklar ve dallar izlemektedir (Zeng ve ark., 2009).

Birçok çalışmada, çaylar, kırmızı şaraplar ve bazı meyve ile sebzelerde bulunan yoğunlaştırılmış tanenlerin sağlık faydaları kanıtlanmıştır. Tanenlerin vücudumuzda kolesterolü düşürücü, iltihap önleyici, kanser karşıtı, kalp sağlığını koruyucu ve kanser gelişimini engelleyici etkileri olduğu gösterilmiştir. Ayrıca, cilt dokularındaki yaralı bölgelerde anjiyogenez (yeni damar oluşumu) aktivitelerini artırarak iyileşme sürecini hızlandırdığı da bulunmuştur (Zeng ve ark., 2009).

Çalışmada, *E. angustifolia* L. meyvesinin özütünde laurik, tridekanoik, miristik, pentadekanoik, palmitik, palmitoleik, heptadekanoik, linoleik, linolenik, oleik, stearik, eikosanoik ve dokozanoik asit gibi bazı yağ asitleri tespit edilmiştir (Yıldırım, 2015). Örneklerdeki başlıca yağ asitleri ise palmitik asit (%34,31), oleik asit (%26,23) ve lignoserik asit (%17,47) olarak belirlenmiştir. Ayrıca, *E. angustifolia* L. meyve kabuğunda bol miktarda palmitoleik asit, tohumlarında ise yüksek oranda linoleik asit ve palmitik asit bulunduğu bildirilmiştir (Sahan ve ark., 2015). Bu farklılıkların, bitkinin genotipi, iklim koşulları ve toprak kompozisyonundaki çeşitlilikten kaynaklanmaktadır (Sahan ve ark., 2015).

Sonuç olarak, *E. angustifolia* L. meyvesi, insan sağlığına faydalı besin maddeleri, mineraller, kimyasal bileşikler ve antioksidanlar açısından zengin bir kaynaktır.

### 3. ELAEAGNUS ANGUSTIFOLIA L. SAĞLIK ÜZERİNDEKİ ETKİLERİ

#### 3.1. Yara İyileşmesi

Yara iyileşmesi, yaralanmaya yanıt olarak hasarlı dokuya işlevini geri kazandıran temel ve aktif bir süreçtir. Bu süreç dört net ve programlanmış aşamadan oluşur: hemostaz (kanamanın durdurulması), inflamasyon, proliferasyon ve doku onarımı. Hemostaz aşamasını takiben, inflamasyon fazı enfeksiyöz mikroorganizmaların temizlenmesi, iyileşme faktörlerinin yaralı bölgeye salınması ve proliferasyon fazına geçiş için hücre göçünü ve bölünmesini sağlamak açısından çok önemlidir. İnflamasyon aşamasının kısa sürmesi gereklidir çünkü bu fazın uzaması iyileşme sürecini engelleyebilmektedir (Natanzi ve ark., 2012). Proliferatif faz, bağ dokusunun önemli bir bileşeni olan ve yaraların iyileşmesinde ile doku onarımında kritik rol oynayan kolajen adlı proteinin dokuda birikmesini içermektedir (Bigoniya ve ark., 2013).

Kolajenin ana bileşeni, dokudaki kollajen biyosentezinin temel göstergesi olan hidroksiprolindir. Hidroksiprolin, prolin ve hidroksiprolin amino asitlerinden oluşmaktadır. Bu bileşik, döngüsel düzenlemesiyle kollajene yapı ve güç sağlar. Ayrıca, kollajen dokuya güç verir ve daha sonraki aşamalarda yeniden epitelizeasyon sürecine yardımcı olmaktadır (Ponrasu ve ark.2013). Yapılan çalışmalarda, *E. angustifolia* L. meyvesi özütünün yaralı bölgeye uygulanmasının ardından, kolajen yapımında önemli bir rol oynayan hidroksiprolin içeriğinin

dokuda arttığını göstermektedir. Ayrıca, başka bir çalışma, *E. angustifolia* L. meyve özütlerinin sıçanlarda yara iyileşme sürecini hızlandırmada, iltihap ve ağrıyı azaltmada önemli bir etkiye sahip olduğunu ortaya koymaktadır (Mehrabani ve ark., 2011).

İran geleneksel tıbbında, kurutulmuş ve toz haline getirilmiş iğde yaprakları, kanamayı kontrol etmek ve yara iyileşme sürecini hızlandırmak için bir çare olarak kullanılmıştır. Çalışma, iğde yaprağı özütünün uygulanmasının yara alanını önemli ölçüde azalttığını ve tedavi edilen grupta, kontrol grubuna kıyasla fibroblast sayısını önemli ölçüde artırdığını göstermektedir. Fibroblastlar, cilt bağ dokusunda yer alan ve yapışan hücrelerdir, ayrıca yara iyileşme sürecinde önemli bir rol oynarlar. *E. angustifolia* L. özütünün flavonoid ve antioksidan içerikleri, yara iyileşme sürecinde önemli faktörlerdir. Flavonoidler, yara kapanma hızını ve ciltteki epidermin yenilenmesini artırmaya yardımcı olan antimikrobiyal aktiviteleriyle bilinirken, antioksidanlar dokuları oksidatif hasarlardan korumada önemli bir rol oynar ve yara iyileşme sürecinde DNA sentezini desteklemektedir. Bu bitkinin farmakolojik özelliklerinden sorumlu aktif bileşenleri ve etki mekanizmasının daha ileri fitokimyasal çalışmalarla belirlenip izole edilmesi, gelecekte yara iyileşme sürecinde tedavi edici bir ajan olarak kullanılmasına olanak tanıyabilir ve klinik uygulamalarda etkili bir alternatif tedavi seçeneği sunabilmektedir (Natanzi ve ark., 2012).

### 3.2. Kardiyoprotektif Aktivite

Kalp krizi veya akut miyokard enfarktüsü (MI), kardiyovasküler hastalıklar arasında en önemli ölüm nedenlerinden biridir. Kalp atardamarlarının kısmi veya tam tıkanması, kalp kasına giden kan akışının azalmasına yol açarak miyokardiyal veya kardiyak iskemiye neden olabilir. Bu durum, kalp kasına zarar vererek pompalama yeteneğini azaltabilir ve kalbin oksijen tedarikini engelleyebilir. Kalp hasarını azaltmanın en etkili yolu, kan tedarikinin kalbe hızlı bir şekilde geri dönmesidir. Ancak, kan tedarikinin bir süre sonra dokuya geri dönmesi, dokuya iltihaplanma ve oksidatif stres hasarına neden olarak, miyokardiyal iskemi-reperfüzyon (I/R) hasarı olarak bilinen kalp hasarını tetikleyebilir. Bir dizi çalışma, E vitamini, katalaz (CAT), melatonin ve süperoksit dismutaz (SOD) gibi bazı antioksidanların, iskemi-reperfüzyon hasarına karşı koruyucu bir etkiye sahip olabileceğini göstermektedir (Wang ve ark., 2014). Bir çalışmada, *E. angustifolia* yapraklarının sulu özütünün etkinliği ve indüklenen iskemi/reperfüzyondaki (I/R) kardiyoprotektif aktivitesi izole edilmiş sıçan kalbinde gösterilmiştir. Sonuçlar, 0,5 mg/mL ve 1,0 mg/mL dozajlarındaki *E. angustifolia* özütünün, kardiyak fonksiyonun restorasyonunu sağladığını ve miyokardiyal biyokimyasal değerleri normal seviyelere doğru önemli ölçüde iyileştirdiğini göstermiştir. Bu sonuç, *Elaeagnus angustifolia* yaprağı özütünün miyokardiyal iskemi-reperfüzyon hasarı üzerinde koruyucu bir etkiye sahip olduğunu ve bu etkinin, özütün miyokardiyal dokudaki antioksidan aktivitesinin artmasına bağlı olabileceğini göstermektedir (Wang ve ark., 2014).

### 3.3. Gastrointestinal İyileşme

İğde meyvelerinin preparatları, peptik ülser hastalarında yara iyileşme dokusunun oluşum hızını artırdığı için Avrupa ve Orta Asya'nın bazı bölgelerinde yaygın olarak kullanılmaktadır. Bir çalışmada ise, iğde meyvesi yağının karotenoid fraksiyonunun gastrointestinal ülsere karşı koruyucu bir etkiye sahip olduğu kanıtlanmıştır (Gürbüz ve ark., 2003).

Başka bir çalışmanın sonuçları, etanol ile ülser oluşturulan sıçanlara *E. angustifolia* L.'nin metanol meyve ekstraktının uygulanmasının ardından yapılan histopatolojik inceleme ve ülser indeksi tayini sonucunda, dokuda güçlü bir gastroprotektif aktivitenin gözlemlendiğini

göstermektedir (Mohammed ve ark., 2006). Ayrıca *E. angustifolia* L. meyvesindeki polifenolik bileşiklerin bir konsantrasyonundan elde edilen pshatin adlı bir ilaç da Ermenistan'da uzun süredir kolit ve diğer gastrointestinal sistem hastalıklarının tedavisinde kullanılmaktadır (Abizov ve ark., 2008).

*E. angustifolia* L. özütünün nöronlar, vasküler ve solunum düz kas hücreleri üzerindeki etkileri ve etki mekanizması hakkında daha fazla araştırma yapılması önerilmektedir. İleri fitokimyasal çalışmalar, bitkinin biyolojik aktivitelerine katkıda bulunan başlıca maddeleri belirleyecektir.

### 3.4. Antinosiseptif ve Antiinflamatuvar Etkiler

İğde, ağrı kesici ve iltihap giderici özellikleriyle İran halk hekimliğinde uzun süredir kullanılmaktadır. *E. angustifolia* L. meyve özütünün fitokimyasal çalışmaları, flavonoidlerin ve terpenoidlerin bu etkilerin ana bileşenleri olduğunu göstermektedir (Mohammed ve ark., 2006).

Yapılan bir çalışmada, *E. angustifolia* L. özütünün kronik ağrı ve inflamasyonu (formalin enjeksiyonuna bağlı) azaltmadaki etkinliğinin, indometasin ve deksametazon gibi kimyasal ilaçlarla benzer düzeyde olduğunu göstermektedir (Farahbakhsh ve ark., 2011).

Kesin etki mekanizması açık olmasa da, *E. angustifolia* L.'nin meyve ve çekirdek özütü üzerinde yapılan çalışmalar, özütün sıçanlarda anti-inflamatuvar ve antinosiseptif etkilere sahip olduğunu göstermiştir. Son yapılan araştırmalar ise, flavonoidlerin ve sitosterollerin bu bitkinin anti-inflamatuvar ve analjezik etkilerinden sorumlu olduğunu ileri sürmektedir (Natanzi ve ark., 2012).

### 3.5. Anti-Tümör Aktivitesi

Elaeagnus ailesinin kanser hücrelerine karşı sitotoksik aktiviteleri bilinen birkaç türü vardır; bunlar arasında *E. angustifolia* L., *Elaeagnus umbellate*, *Elaeagnus pungens* ve *Elaeagnus glabra* yer almaktadır. Bu türlerden izole edilen triterpenoid, flavonoid, lignanoid ve bezenoid gibi bazı biyoaktif bileşenler, antitümör aktivitelerinden sorumlu olabilir (Liao ve ark., 2014). Bir deneyde, *Elaeagnus angustifolia* L. asetik eterinin farklı fraksiyonlarının antioksidan ve anti-tümör aktivitesi incelendi. Her bir numunenin konsantrasyonu ve polarite seviyesi arttıkça, antioksidan ve radikal temizleme aktiviteleri de nispeten arttı. Çalışma, daha yüksek konsantrasyonda *E. angustifolia* özütü kullanımının, in vitro HeLa hücrelerinin (insan servikal kanserinden elde edilen, laboratuvar ortamında sürekli olarak çoğalabilen ilk hücre hattıdır) çoğalması üzerinde önemli bir inhibitör etki gösterdiğini ortaya koymuştur (Ya ve ark., 2014). Tümör büyümesinin ve metastazının temel aşaması, anjiyogeneze (yeni kan damarlarının oluşumu) bağlıdır. Çalışmada, *E. angustifolia* L. hidroalkolik özütünün insan karın endotel hücreleri üzerindeki etkisi incelenmiştir. Sonuçlar, 200 mg/ml'lik *E. angustifolia* L. çiçeği özütünün insan karın endotel hücreleri anjiyogenez aktivitesini inhibe edebileceğini, bu nedenle özütün anjiyogeneze ilişkili bozuklukları önlemek ve tedavi etmek için potansiyel bir aday olabileceğini göstermektedir (Li ve ark., 2009; Badrhadad ve ark., 2012).

### 3.6. Osteoartrit

Geleneksel olarak İran'da, demlenmiş iğde meyvesi romatoid artrit hastalarında ağrıyı hafifletmek için analjezik bir madde olarak kullanılmıştır. Çalışmalar, özütün flavonoid bileşenlerinin antinosiseptif ve anti-inflamatuvar etkilere sahip olduğunu göstermiştir. Ayrıca, özütün kas gevşetici aktivitesi, onu bazı kas-iskelet sistemi rahatsızlıkları için uygun bir tedavi seçeneği haline getirmektedir (Hosseinzadeh ve TAHERI, 2000).

Osteoartrit, genellikle yaşla birlikte ilerleyen ağrılı bir kronik eklem rahatsızlığıdır. Ağrı ve rahatsızlığı gidermek için genellikle steroid olmayan anti-inflamatuar ilaçlar (NSAID'ler), seçici siklooksijenaz-2 (COX-2) inhibitörleri ve eklem içi tedaviler kullanılmaktadır; ancak bu ilaçların kullanımı bazı yan etkilere neden olmaktadır. Yapılan bir çalışmada, zencefil ve *E. angustifolia* L. meyve özlerinin birlikte kullanılmasıyla ağrı ve iltihabın giderilmesi konusunda bazı yararlı etkiler bildirilmiştir. Rapor, sekiz hafta boyunca 200 mg *E. angustifolia* L. meyve ve zencefil özü alan hastaların ağrı yoğunluğu ve ağrı oluşumunda önemli iyileşmeler gösterdiğini belirtmektedir (Rabiei ve ark., 2015).

### 3.7. Antioksidan Aktivite

Sentetik antioksidanların toksik ve tehlikeli yan etkileri ile karşılaştırıldığında, meyve, sebze ve diyet antioksidanlarında bulunan doğal antioksidanlar ve fenolik bileşiklerin yaşam kalitesini iyileştirme ve bazı hastalık risklerini azaltma konusundaki önemli faydaları, bireylerin diyetlerinde daha fazla doğal antioksidan tüketme eğilimlerini artırmıştır (Saboonchian ve ark., 2014). *E. angustifolia*'nın yaprak ve çiçek özleri, hücreleri oksidatif hasarlardan koruyan ve birçok dejeneratif hastalığın riskini azaltan veya geciktiren fenolik ve flavonoid bileşikleridir (Saboonchian ve ark., 2014). Yapılan çalışmalar, fenolik ve flavonoid bileşiklerinin miktarının, iğde bitkisinin yapraklarında çiçeklere kıyasla daha yüksek olduğunu ortaya koymuştur. Bu fark, yapraklarda gerçekleşen fotosentez sürecine ve yapraklarda diğer organlardan daha fazla flavonoid biyosentetik yol öncüllerinin bulunmasından kaynaklanmaktadır (Saboonchian ve ark., 2014).

Yapılan çalışmalar, *E. angustifolia* L.'nin amino asitler, flavonoidler, fenolik bileşikler, polisakkaritler ve diğer bazı temel elementler de dahil olmak üzere çeşitli kimyasal bileşiklerden oluştuğunu ortaya koymuştur. Polisakkaritler, *E. angustifolia* L.'nin anti-radyasyon, antioksidan ve bağışıklık düzenleyici aktivitelere sahip önemli bileşenlerindedir. Bu bitkinin meyvelerinden iki polisakkarit (*E. angustifolia* L. polisakkarit-1 (PEA-1) ve PEA-2) hazırlanarak, antioksidan aktiviteleri incelenmiştir. Elde edilen sonuçlar, PEA-1 ve PEA-2'nin in vitro güçlü antioksidan aktivite, orta düzeyde radikal temizleme özellikleri ve lipit peroksidasyonunu inhibe etme etkisi gösterdiğini ortaya koymuştur. Bununla birlikte, bu bitkinin güvenliği ve bazı yeni doğal ilaçların geliştirilmesi için potansiyel kullanımı konusunda daha fazla araştırmaya ihtiyaç duyulmaktadır (Chen ve ark., 2014).

### 3.8. Hafızaya Etkisi

Alzheimer hastalığı, genellikle kolinerjik sistemin azalmış aktivitesinden kaynaklanan bilişsel ve hafıza işlevlerinin bozulmasıyla karakterizedir. Yapılan bir çalışmada, *E. angustifolia* L. su özütünün etkisi, skopolamin enjeksiyonuyla hafıza ve öğrenme işlevleri geçici olarak bozulan sıçanlar üzerinde incelenmiştir. Elde edilen sonuçlar, *E. angustifolia* L. su özütünün dozajına bağlı olarak, skopolaminle uyarılan sıçanların mekansal öğrenme ve hafıza yetilerini iyileştirdiğini göstermektedir (Tamtaji ve ark., 2014).

## 4. YAN ETKİLERİ

Çalışmaya göre, ekstraktların yüksek dozlarının kullanımıyla bile, insanlarda veya sıçanlarda büyüme gecikmesi veya anormalliklerin indüklenmesi gibi zararlı yan etkiler gözlemlenmemiştir (Malihezaman ve ark., 2007). Bununla birlikte, *E. angustifolia* L. poleni üzerine yapılan bir çalışma, bu alerjenlerin solunmasının bazı duyarlı bireylerde burun tahrişi semptomlarına yol açabileceğini ortaya koymaktadır (Sastre ve ark., 2004).

## 5. SONUÇ

*Elaeagnus angustifolia L.* meyvesi, içerdiği zengin vitamin, mineral ve biyoaktif bileşikler sayesinde hem besin kaynağı hem de geleneksel tıpta önemli bir şifa kaynağı olarak kullanılmaktadır. Yüksek besin değeriyle dikkat çeken bu meyve, flavonoidler, fenolik bileşikler, yağ asitleri ve antioksidanlar açısından oldukça zengindir. Bu bileşenler, güçlü antioksidan ve iltihap önleyici özellikleriyle vücudu serbest radikallerin zararlı etkilerinden koruyarak birçok hastalığın önlenmesine katkı sağlayabilir. Geleneksel tıpta yara iyileşmesini hızlandırıcı, ağrı kesici ve iltihap giderici etkileriyle bilinen *E. angustifolia L.*, bilimsel araştırmalarla da bu özelliklerini kanıtlamıştır. Özellikle flavonoidler ve antioksidanların etkisiyle doku onarımını desteklediği, kolajen üretimini artırarak cilt ve bağı dokusunun iyileşme sürecini hızlandığı gösterilmiştir. Aynı zamanda kardiyovasküler sistem üzerinde koruyucu etkileri olduğu, kalp hastalıkları riskini azaltabileceği ve miyokardiyal iskemi-reperfüzyon hasarına karşı fayda sağlayabileceği belirlenmiştir. Gastrointestinal sistem üzerinde de olumlu etkileri bulunan bu bitkinin, mide ülserlerini iyileştirici ve bağırsak sağlığını destekleyici özellikleri olduğu görülmüştür. Ayrıca, geleneksel olarak ağrı kesici ve iltihap önleyici olarak kullanılan *E. angustifolia L.*, yapılan çalışmalarla da bu özelliklerini doğrulamış ve anti-inflamatuar bileşenler içerdiği belirlenmiştir. Bunun yanı sıra, yapılan bazı araştırmalar, bitkinin antitümör potansiyeline sahip olabileceğini ve belirli kanser türlerine karşı koruyucu etkiler gösterebileceğini ortaya koymuştur. Tüm bu veriler, *E. angustifolia L.*'nin farmakolojik özelliklerinin daha fazla araştırılmasını ve tıbbi kullanım potansiyelinin değerlendirilmesini gerektirmektedir. Özellikle biyoaktif bileşenlerinin etki mekanizmalarının ayrıntılı olarak incelenmesi, gelecekte bu bitkinin ilaç ve sağlık ürünlerinde daha yaygın bir şekilde kullanılmasına olanak tanıyabilir. Dolayısıyla, *Elaeagnus angustifolia L.*, hem besleyici değeri hem de sağlık üzerindeki olumlu etkileriyle önemli bir bitkisel kaynak olmayı sürdürmektedir.

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**HEALTH EFFECTS OF BLACK ELDERBERRY (*SAMBUCUS NIGRA L.*): A  
NUTRITIONAL PERSPECTIVE**

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**Abstract**

Black elderberry (*Sambucus nigra L.*) has garnered significant attention in recent years due to its potential health benefits and rich nutritional profile. This review examines the nutritional composition of black elderberry and its associated health effects. Rich in anthocyanins, flavonoids, and other polyphenolic compounds, black elderberry demonstrates potent antioxidant and anti-inflammatory properties. Studies have shown its efficacy in supporting immune function, particularly in reducing the severity and duration of upper respiratory tract infections. Additionally, emerging research suggests potential benefits in cardiovascular health, glucose metabolism, and neuroprotection. The berries' high content of vitamins C and A, as well as essential minerals, contributes to their nutritional value. While promising, many of these health effects require further clinical investigation to establish definitive therapeutic applications. This review synthesizes current knowledge on black elderberry's nutritional aspects and their implications for human health, highlighting areas for future research and potential applications in functional foods and nutraceuticals.

**Keywords:** Black elderberry, Health Effect, Nutritional Composition

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## 1. Introduction

Black elderberry (*Sambucus nigra L.*), a species of the Adoxaceae family, is a deciduous shrub native to Europe, North America, and parts of Asia. This perennial plant, which can grow up to 6 meters in height, is characterized by its dark purple berries and cream-white flowers (Atkinson & Atkinson, 2002). Historically used in traditional medicine across various cultures, black elderberry has been employed to treat a wide range of ailments, including respiratory infections, fever, and inflammatory conditions (Vlachojannis et al., 2010). In recent years, black elderberry has gained significant attention in the scientific community due to its potential health benefits and nutritional value. This renewed interest is largely attributed to the plant's rich phytochemical profile, particularly its high content of anthocyanins, flavonoids, and other polyphenolic compounds (Sidor & Gramza-Michałowska, 2015). These bioactive compounds have been associated with various health-promoting effects, including antioxidant, anti-inflammatory, and immunomodulatory properties (Hawkins et al., 2019). The cultivation and use of elderberry can be traced back to prehistoric times, with archaeological evidence suggesting its presence in Neolithic sites (Senica et al., 2017). Throughout history, different parts of the elderberry plant, including its berries, flowers, and bark, have been utilized for medicinal, culinary, and even cosmetic purposes. In folk medicine, elderberry preparations were commonly used to treat colds, flu, and other respiratory ailments, a practice that has found some support in modern scientific studies (Tiralongo et al., 2016). The nutritional composition of black elderberry has been extensively studied in recent years. Research has shown that the berries are rich in vitamins (particularly vitamin C), minerals, dietary fiber, and various bioactive compounds (Veberic et al., 2009). This nutritional profile has led to increased interest in incorporating elderberry into functional foods and dietary supplements. Moreover, the potential health benefits of black elderberry extend beyond its traditional uses. Recent studies have explored its effects on cardiovascular health, glucose metabolism, and cognitive function (Ciocoiu et al., 2012; Duymuş et al., 2014; Travica et al., 2020). These investigations have opened new avenues for research and potential applications in preventive medicine and nutraceuticals. As global interest in natural remedies and functional foods continues to grow, black elderberry has emerged as a subject of both scientific inquiry and commercial interest. Its long history of traditional use, combined with emerging scientific evidence, positions black elderberry as a promising candidate for further research in the fields of nutrition, pharmacology, and public health (Ulbricht et al., 2014).

## 2. Nutritional Composition

### 2.1 Macro/Micronutrients

Black elderberries are known for their low calorie content and rich nutrient profile (Table 1). According to Veberic et al. (2009), 100 grams of fresh black elderberries typically provide 73 kcal of energy, containing 18.4 g of carbohydrates, 0.7 g of protein, 0.5 g of fat, and a notable 7 g of fiber. This nutritional composition makes black elderberries a valuable addition to a healthy diet, offering substantial fiber content while being relatively low in calories and fat. (Veberic et al., 2009). Black elderberries are renowned for their rich content of essential vitamins and minerals. As reported in scientific literature, 100 grams of fresh black elderberries provide a significant nutritional boost, containing 36 mg of Vitamin C (which meets 40% of the daily recommended value), 600 IU of Vitamin A, 280 mg of Potassium, 38 mg of Calcium, and 1.6 mg of Iron. This diverse array of micronutrients contributes to the berries' reputation as a nutritionally dense food source.

## **2.2 Phytochemicals**

The health benefits of black elderberry are largely attributed to its rich phytochemical profile (Table 1):

1. Anthocyanins: These compounds are responsible for the dark color of elderberries and possess strong antioxidant properties. The main anthocyanins in elderberries are cyanidin-3-glucoside and cyanidin-3-sambubioside (Veberic et al., 2009).
2. Flavonoids: Elderberries contain quercetin, kaempferol, and isorhamnetin, which have anti-inflammatory properties (Sidor & Gramza-Michałowska, 2015).
3. Phenolic acids: Chlorogenic acid, neochlorogenic acid, and caffeic acid contribute to the antioxidant capacity of elderberries (Mikulic-Petkovsek et al., 2015).
4. Terpenoids: Compounds such as  $\alpha$ -amyrin and  $\beta$ -sitosterol are among the bioactive components of elderberries (Senica et al., 2017).

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**Table 1. Nutritional and Bioactive Composition of Sambucus nigra (Elderberry)**  
(Pascariu et al., 2022)

Category	Components	Quantity
<b>General Information</b>	Family: Adoxaceae (Caprifoliaceae)	-
	Found in subtropical and temperate areas	-
	Fruit size: 0.4–0.6 cm (diameter)	-
	Fruit color: Bright red to dark purple	-
<b>Phenolic Compounds</b>	Phenolic acids: Gallic acid, gentisic acid	3.45 µg/100 g DW, 2.16 µg/100 g DW
	Flavonoids: Rutin, quercetin	813.08 µg/100 g DW, 228.83 µg/100 g DW
	Anthocyanins: Cyanidin 3-O-sambubioside, Cyanidin 3-O-glucoside	344.48 mg/100 g FW, 190.63 mg/100 g FW
	Elderberry flowers: Chlorogenic acid, 5-p-coumaroylquinic acid, dicaffeoylquinic acid	-
	Flavonols and flavanones: Rutin, naringenin	3265.13 mg/kg FW, 734.15 mg/kg FW
<b>Terpenoid Compounds</b>	Monoterpenes (flowers/fruits)	47/42 compounds
	Sesquiterpenes (flowers/fruits)	13/20 compounds
	Norisoprenoids (flowers/fruits)	5/14 compounds
	Triterpenoids: Ursolic acid, Oleanolic acid	-
<b>Sugars &amp; Polysaccharides</b>	Total sugar	6.85–10.42 g/100 g FW
	Peptic polysaccharides: Arabinose, rhamnose, xylose, mannose, etc.	-
	Individual sugars: Glucose, fructose, sucrose	29.03–50.23 g/kg FW, 26.81–52.25 g/kg FW, 0.47–10.46 g/kg FW
<b>Protein Content</b>	Total proteins	2.7–2.97 g/100 g FW
	Essential amino acids	9 out of 16 identified
	Major amino acids: Glutamic acid, Aspartic acid, Alanine, Leucine, Tyrosine	-
<b>Lipids &amp; Fatty Acids</b>	Total fat content	0.35 g/100 g FW
	Essential oil content	0.01 g/100 g FW
	Monounsaturated Fatty Acids (MUFA)	12.96–14.21 g/100 g
	Polyunsaturated Fatty Acids (PUFA)	75.15–77.69 g/100 g
	Saturated Fatty Acids (SFA)	9.35–10.64 g/100 g
	Major fatty acids: Linoleic acid (ω-6), α-Linolenic acid (ω-3), Oleic acid (ω-9), Palmitic acid	39.47–42.4%, 32–41%, 12.6–13.2%, 6.59–9.3%
<b>Vitamins</b>	Vitamin B complex (B2, B7, B9)	65 mg/100 g, 17 mg/100 g, 1.8 mg/100 g
	Vitamin C	34.10–116.70 mg/100 g FW
	Vitamin A	600 /100 g

**Notes:** DW: Dry Weight; FW: Fresh Weight; FW measurements vary depending on genotype, growth conditions, and climate.

### **3. Health Effects**

#### **3.1 Antioxidant Activity**

Black elderberry exhibits high antioxidant capacity. Studies have shown that elderberry extracts perform well in various antioxidant activity tests such as DPPH, ABTS, and FRAP (Vlachojannis et al., 2010). This antioxidant activity is attributed to the anthocyanins, flavonoids, and phenolic acids present in elderberries (Table 2).

#### **3.2 Immune System Effects**

Elderberry is known for its immune-boosting properties. Clinical studies have demonstrated that elderberry supplementation can reduce the duration and severity of upper respiratory tract infections (Tiralongo et al., 2016). This effect is thought to be due to the ability of elderberry's bioactive compounds to modulate cytokine production and immune cell activation.

#### **3.3 Cardiovascular Health**

Elderberry has been reported to have positive effects on cardiovascular health. The flavonoids and anthocyanins are thought to support cardiovascular health by reducing LDL cholesterol oxidation and improving endothelial function (Ciocoiu et al., 2012). Additionally, elderberry extracts have been observed to have hypotensive effects.

#### **3.4 Antidiabetic Effects**

Elderberry has shown potential in regulating blood sugar levels. In vitro and animal studies have demonstrated that elderberry extracts can inhibit  $\alpha$ -glucosidase and  $\alpha$ -amylase enzymes, potentially slowing carbohydrate absorption (Duymuş et al., 2014). These findings support the potential antidiabetic effects of elderberry.

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**Table 2:** Phenolic Compounds – Health Benefits, Stability, and Extraction Methods

Category	Details
🌿 <b>Chemical Structure</b>	Hydroxylated aromatic ring
🛡️ <b>Biological Activities</b>	<ul style="list-style-type: none"> <li>✓ Antioxidant</li> <li>✓ Immunostimulatory</li> <li>✓ Anti-inflammatory</li> <li>✓ Anti-allergic</li> <li>✓ Anticancer</li> </ul>
☐ <b>Antibacterial Compounds</b>	📄 Kaempferol, Apigenin, Ferulic Acid, Protocatechuic Acid, p-Coumaric Acid
☐ <b>Antiviral Compounds</b>	☐ Kaempferol 3-rutin, Isorhamnetin 3-rutin, Isorhamnetin 3-glucoside, Cyanidin derivatives
🍇 <b>Phenolic Compounds in Elderberries</b>	🌿 Anthocyanins: Cyanidin 3-glucoside (R-glucose), Cyanidin 3-sambubioside, Quercetin 3-rutinoside (R-rutinoside), Astragalin
<b>Factors Affecting Stability</b>	☁️ Oxygen, ☀️ Light, 🧪 Enzymatic activities, ⬇️ Temperature & pH, ⚗️ Metal ions, 💧 Water
🏭 <b>Extraction Methods for Bioactive Compounds</b>	<ul style="list-style-type: none"> <li>🧪 Conventional Solvent Extractions</li> <li>🔥 Soxhlet Extraction</li> <li>⇌ Pressurized Liquid Extraction</li> <li>📡 Microwave-Assisted Extraction</li> <li>🎵 Ultrasound-Assisted Extraction</li> <li>⚡ Supercritical Fluid Extraction</li> <li>⚡ Pulsed Electric Field Extraction</li> <li>⚗️ High Hydrostatic Pressure Extraction</li> <li>☐ Enzymatic Extraction</li> </ul>

### 3.5 Neuroprotective Effects

Studies on the neuroprotective effects of elderberry are promising. It has been suggested that anthocyanins and other polyphenols may have a protective effect against neurodegenerative diseases by reducing oxidative stress and suppressing neuroinflammation (Travica et al., 2020).

### 3.6 Antimicrobial Activity

Elderberry extracts have been reported to show antimicrobial activity against various pathogenic microorganisms. They have been observed to be particularly effective against influenza viruses, supporting the traditional use of elderberry (Krawitz et al., 2011) (Table 2).

## 4. Conclusion and Future Perspectives

Black elderberry emerges as an important functional food and potential therapeutic agent due to its rich nutritional composition and various health benefits. Its antioxidant, anti-inflammatory, immunomodulatory, and antimicrobial properties make it a valuable resource in the prevention and management of various health issues. However, more clinical research is needed to fully understand the health effects of elderberry. Future studies should focus on long-term consumption effects, optimal dosage, and potential drug interactions. The development of elderberry-based nutraceuticals and functional foods in the future could allow a wider population to benefit from the health advantages of this valuable plant. Furthermore, the

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isolation and characterization of elderberry's bioactive components could inform new drug development studies. In conclusion, black elderberry has a rich history from traditional use to modern scientific research and will continue to play an important role in health and nutrition in the future.



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**THE FUNCTION OF MICRORNAS IN CELL GENETIC REGULATION AND  
POSSIBLE THERAPEUTIC APPLICATIONS**

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**Abstract**

Fighting invasive infections requires an inflammatory response. In order to offer a data stream and eliminate pathogenic organisms including bacteria, fungi, viruses, and parasites, a variety of effector products and the dispersion of the reproductive product are involved. MicroRNAs (miRNAs), a rapidly expanding class of tiny RNAs, have become extended molecules with significant biodegradation potential and functional significance in recent years. Studies that link host miRNA regulation to infection retention, removal, or release have demonstrated the critical role miRNAs play in health status and responses. Through their permissiveness with the 3' untranslated regions of target mRNAs, miRNAs control genes at the post-transcriptional level, resulting in translational inhibition or mRNA instability and destruction. Consequently, miRNAs are separated into crucial biological components with invasive diseases, including cell death, signaling, development, dispersion, proliferation, and differentiation. The presence of disease, such as parasite infection, makes it simple to identify changes in miRNA biosynthesis and functions. In many pathological circumstances, this characteristic is significant.

**Keywords:** MicroRNA, Gene Expression, Toxoplasma, Trypanosoma, Leishmania

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## **Introduction**

Single-stranded RNAs with a length of around 22 nucleotides, known as microRNAs (miRNAs), are involved in the post-transcriptional control of gene expression (Lee et al., 1993). The length and cellular roles of RNA molecules vary (Wu et al., 2014). The genome contains miRNA genes, which are classified into intronic and intergenic subtypes according to where they are found (Olena and Patton, 2010). Intronic miRNA genes have distinct transcription units, do not overlap with other genes, are found in intronic or exonic regions of their host genes, and have promoter and terminator units that control their expression (Sundaram and Sampath, 2013). MicroRNAs target the majority of human genes (Friedman et al., 2009). Although a single microRNA can target many mRNAs and multiple microRNAs can target a single mRNA, the impact of a single microRNA on protein expression is rather small and results in production fine-tuning (Krek et al., 2005). Moreover, distinct genes engaged in a single biological activity can be targeted by a single microRNA, which may result in notable alterations in cell function (Loeb et al., 2012).

## **In host-parasite interactions, microRNAs**

By employing evasion strategies to circumvent and control host defensive mechanisms, parasites and their hosts have developed a complex co-evolutionary relationship that allows them to cause persistent infections (Andrade et al., 2014). Because miRNAs are non-immunogenic, can be carried and transferred from the pathogen to host cells in exocysts, and can quickly develop to target new transcripts, they are perfect tools for parasites to control gene expression in host cells in this situation (Manzano-Román and Siles-Lucas, 2012). MiRNAs are therefore essential for host-parasite interactions. For instance, miRNAs can help eliminate pathogens in host cells (Lemaire, 2013; Zhenk et al., 2013). In parasites, on the other hand, they can help the parasites' destructive strategy and survival by controlling various physiological processes, including sexual reproduction, developmental transition, antigenic molecule expression, and virulence factors (Hao et al., 2010).

## **miRNAs and Gene Expression Regulation**

Monocistronic or polycistronic (miRNA clusters) transcripts of miRNAs are produced from intergenic regions (Treiber et al., 2019). According to Lai et al. (2015), these sequences might have their own promoter regions or, if intragenic, might rely on host gene transcription. miRNAs have a significant biological influence by sequence-specifically controlling gene expression at the post-transcriptional level. Research has been focused on understanding the mechanisms of post-transcriptional regulation mediated by miRNAs, with studies being conducted in vitro, in vivo, and in cell-free extracts, as well as the use of bioinformatics prediction tools to demonstrate that miRNAs may regulate approximately 30% of all protein-coding genes in mammalian cells (Filipowicz et al., 2008). Furthermore, because extracellular miRNAs are secreted into vesicles, exosomes, or extracellular fluids and circulation, they may be involved in promoting intercellular communication and acting as biomarkers for various diseases, including infectious disorders (Makarova et al, 2016).

## **Expression of miRNA in Infectious Diseases**

### **Interaction of Toxoplasma with the Host**

A common parasite, *Toxoplasma gondii* can infect mice, people, pigs, birds, sheep, and cats, among other hosts. According to Hou et al. (2019), cats are the definitive hosts where sexual reproduction takes place. Depending on the host, its life cycle can be complicated. Eating raw contaminated meat or oocysts excreted in cat feces is the first step in infection in the major host area (Cannella et al., 2014). After that, the parasite sets out to infect and multiply as many cells

as it can. This parasite can change the host's miRNA profile to change how it reacts to infection, and almost all infections are quiet. Additionally, the parasite exhibits its own miRNAs and miRNA processing equipment (Jia et al., 2014). The miR-17-92 cluster has been linked in numerous studies to a number of cellular processes, such as inflammation, cancer, immunopathogenesis of autoimmunity, and even chronic illnesses (Kuo et al., 2019). The human host gene miR-17 encodes this cluster (Baumjohann, 2018). This miRNA cluster's activities are also linked to B and T cell differentiation and proliferation. It has been discovered that miR-17~92 controls the growth of immune cells.

#### **Leishmania-Host Interactions**

More than 20 distinct protozoan parasites can cause leishmaniasis in humans, a disease spread by vectors (Burza et al., 2018). By decreasing the efficacy of inflammation and the emergence of an adaptive immune response, the initial stages of the inflammatory reaction—which take place during the phagocytosis and localization of *Leishmania* within the phagolysosome—can control the immunological response. The microRNA profile of human, mouse, and canine macrophages and dendritic cells can be changed by infections with *L. amazonensis*, *L. infantum*, *L. major*, and *L. donovani*. This can affect the immune response's ability to recognize and activate the defenses against the parasites (Sacks and Kamhawi, 2001). According to Teixeira et al. (2013), several parasite virulence agents disrupt the miRNA machinery that regulates host mRNA expression. The fact that miRNAs that target genes implicated in inflammation and their expression can also govern interferon regulation shows how important *Leishmania* species are in affecting the course of an infection and miRNA profile (Tiwari et al., 2017). In general, a variety of miRNA profiles that are connected to target transcripts and host cell types can be produced by *Leishmania* species. This suggests that miRNA regulation is species specific and that host recognition of the pathogen directs miRNA-mRNA interactions during *Leishmania* infection (Muxel et al., 2017).

#### **Trypanosoma-Host Interactions**

Chagas disease is another neglected tropical disease caused by the parasite *Trypanosoma cruzi* (Bonney, 2014). Accidental ingestion, vertical transmission, organ transplantation, and blood transfusions are the main ways that the disease is transmitted. The illness is characterized by parasite penetration into the bloodstream, which infects different cell types in different organs, including cardiac muscle cells (Lidani et al., 2019). Animals with acute and chronic *T. cruzi* infections and humans with chronic Chagas disease have different gene expression patterns, according to myocardial tissue and heart gene expression profiling (Basso, 2013). Genes with variable expression are associated with immune response, energy and metabolism, and cell stress response. A complex relationship between miRNAs and mRNAs that affects pathogenesis and resistance to infection is represented by the interaction of cardiac tissue cells, such as cardiomyocytes, fibroblasts, endothelium, and infiltrating inflammatory cells, and the potential for miRNA transfer between these cells (Kratz et al., 2018). It has been reported that elevated levels of miR-208a in plasma samples from human chronic Chagas disease are linked to TGF- $\beta$  activation and the control of genes related to cardiac hypertrophy and fibrosis (Parker and Song, 2004). It has also been discovered that miRNAs play a role in the regulation of physiological and pathological variables' gene expression in Chagas disease (Zingales et al., 2009).

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## **Novel Views: MicroRNAs as Therapeutic Targets and Diagnostic Markers**

miRNAs are becoming useful therapeutic tools and indicators for a variety of illnesses. According to Chakraborty et al. (2017), there is still a significant gap in the development of treatment methods for neglected diseases. Despite the growing amount of studies on miRNA, translational research on miRNA is still difficult. Hanna et al. looked at the function of miRNAs in clinical research earlier this year (Hewson et al, 2016). According to Abel et al. (2001), they noted that the results of miRNA research are confined to academia, frequently fall short of phase 3 or 4 clinical trials, and there is a disconnect between basic science and clinical practice. Researchers have spent decades creating new medications and finding novel biomarkers of illness progression in relation to neglected diseases (Ferreira et al., 2014). Despite this, compared to hotspot diseases like cancer, heart and circulation diseases, and neurological disorders, the use of miRNAs as a biomarker and their therapeutic potential have not been thoroughly studied. Therefore, miRNAs are a very beneficial method to study as both biomarkers and medications for the treatment of diseases because of the many processes they regulate (Ferreira et al., 2017).

## **Conclusion**

The unique control of miRNA-mRNA interactions during host-pathogen interactions emphasizes how crucial a host's species identity, cell type, and genetic background are in figuring out the specifics of miRNA-mediated post-transcriptional regulation of gene expression. Nonetheless, the modulation of the same miRNAs, like miR-146a and/or miR-155, in host cells infected with cerebral malaria, *T. gondii* infection, and *L. major* infection, results in the specification of the host cell response to parasites and may aid in identifying shared characteristics involved in immune response perturbation (Frank et al., 2015).

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**THE BLUE ECONOMY: THE FUTURE OF THE ATLANTIC AFRICAN SEA  
FRONT INITIATIVE?**

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**Abstract**

This article describes the developmental dynamic that Morocco is leading on the Atlantic coast as part of its Atlantic Africa Initiative. The analysis focuses on the maritime economy as the backbone of this initiative and a serious avenue for implementation. The research takes stock of all areas of the blue economy in Africa with a focus on the immense potential it offers and the various obstacles that are hindering its growth. The contribution of the research consists of the outline of avenues of intervention for the take-off and sustainability of the initiative.

**Keywords:** Atlantic Africa Initiative, Atlantic African Sea front, Blue Economy, Morocco, Africa.

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**THE BLUE ECONOMY: THE FUTURE OF THE ATLANTIC AFRICAN SEA  
FRONT INITIATIVE?**

**Résumé**

Cet article décrit la dynamique développementiste que conduit le Maroc dans la façade Atlantique dans le cadre de son Initiative de l'Afrique Atlantique. L'analyse met le focus sur l'économie maritime comme l'épine dorsale de cette initiative et une piste sérieuse pour la mise en œuvre. La recherche dresse un état des lieux sur l'ensemble des domaines de l'économie bleue en Afrique avec un zoom sur l'immense potentiel qu'elle offre et les différents obstacles qui endiguent son essor. L'apport de la recherche consiste en l'esquisse de pistes d'intervention pour le décollage et la pérennisation de l'initiative.

**Mots clés :** Initiative de l'Afrique Atlantique, Façade Atlantique de l'Afrique, Économie bleue, Maroc, Afrique.

مبادرتة من كجزء الأطلسي المحيط ساحل على المغرب يفودها التي التتموية الديناميكية المقال هذا يصف- ملخص  
لتنفيذها جدية ووسيلة المبادرة لهذه الفقري العمود باعتباره البحري الاقتصاد على التحليل يركز. الأطلسية الإفريقية  
والعقبات يوفرها التي الهائلة الإمكانيات على التركيز مع أفريقيا في الأزرق الاقتصاد مجالات جميع البحث ويتناول  
واستدامتها المبادرة ديناميكية أجل من الاقتراحات بعض في البحث مساهمة تتكون. نموه تعيق التي المختلفة  
إفريقيا، المغرب، البحري الاقتصاد، إفريقيا الأطلسية الجبهة، الأطلسية إفريقيا مبادرة: المفاتيح الكلمات

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## Introduction

At a historic moment when the world is experiencing profound changes at the geopolitical, economic and environmental level, Morocco has chosen to strengthen South-South cooperation and anchor its orientation towards Africa through the establishment of a new regional strategy from its Atlantic coastline of Gibraltar to South Africa to the Cape of Good Hope. Morocco is moving towards its Atlantic coast to develop it into a true African economic locomotive and hub based on principles of co-development, win-win, non-interference and the promotion of security through development. Indeed, the coastal dimension has always been fundamental for Morocco in climatic, ecological, economic and historical terms. It is increasingly recognized as vital to its future and for its geostrategic configuration (Laouina, 2019). In general, coastlines are the seat of powerful dynamics, which variously reflect the expansion of the global economy and the processes of North- South or South-South regional integration (Ballouche & al., 2019). From this perspective, the Atlantic Africa initiative consists of the creation of a geoeconomic space conducive to cooperation and mobilized as a development lever for partner countries. This space brings together 23 Atlantic African states divided into two maritime sub-facades: the northern facade made up of 14 coastal countries from Morocco to Nigeria (belonging to North Africa and West Africa), and the southern facade includes 9 coastal countries from Cameroon to South Africa (belonging to Central Africa and Southern Africa) (Tobi, 2022). The Atlantic Africa initiative includes the Sahelo-Saharan region, West Africa and Central Africa. This involves allowing landlocked countries such as Mali, Burkina Faso, Niger and Chad to access the Atlantic via Moroccan ports and contributing through training to their economic integration and benefit of their natural resources.

The Atlantic Africa initiative includes the Sahelo-Saharan region, West Africa and Central Africa. This involves allowing landlocked countries such as Mali, Burkina Faso, Niger and Chad to access the Atlantic via Moroccan ports and contributing to their economic integration and benefit of their natural resources. Access to the Atlantic will allow them to no longer be totally dependent on the Gulf of Guinea, where most of their exports and imports transit, with a reduction in costs generated by high transport costs. The objective is to create a sharing economy around the blue economy, which relates to the exploitation of oceans and seas, paying particular attention to the sustainability of ecosystems and the environment. To this end, the initiative is based on a major infrastructural axis. It consists of upgrading the infrastructure of the Sahel States and connecting them to the transport and communication networks established in their regional environment and optimizing their logistical and commercial efficiency. The initiative essentially aims to streamline connectivity between Atlantic African countries through the development of infrastructure, the establishment of logistics hubs, allowing complementarity of value chains with other countries on the continent and ultimately creating growth. Injecting investments into this area could promote Africa to play an important role in international trade, which passes through sea routes. (El Maghrebi, 2016) believes that the African Atlantic initiative constitutes an opportunity for Morocco to participate in the implementation of projects in the areas of infrastructure, ports, airports and roads, energy security, port connectivity. This Atlantic facade also offers an opening towards the North and South American continent. By strengthening its relations with the United States, Brazil and Canada, Morocco can further assert its position as a geopolitical space on the Atlantic coast and capitalize on its positions to expand its influence in the region.

According to (Azirar, 2023), the objective of this approach consists of continuing for Morocco the dynamic of diversification of alliances and outlets for the greater West African region. (El

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Maghrebi, 2016; El Houdaigui, 2015; Tobi, 2022) agree on the fact that the establishment of a maritime power can only be advantageous for Morocco, both from a point of view of influence, security and economic development. (Tobi, 2022), asserts that the relative tranquility of the South Atlantic region in comparison to other regions, such as the Asia-Pacific or the strategic competition between the United States and China and the risks of Instability in comparison with the Mediterranean coast offers Morocco advantageous prospects. Added to this is the increase in operational flows from ports in the Africa Atlantic Maritime Area, particularly with the development of connectivity by road and rail between non-coastal countries and the Maritime Area. In addition to the fact that it is the scene of 90% of maritime incidents that occur in the world, the analysis of (EL Houdaigui, 2016) confirms that the problems of the African coast are essentially maritime, and can be managed more effectively on a more suitable scale. In general, Africa's contribution to global maritime trade remains low at only 6%. This initiative is taking place in a regional and international environment marked by major maritime issues. It involves for Morocco the mobilization of a numerous levers, which, in our opinion, revolve around the blue economy. To this end, the objective of this research is to answer the following question: How the blue economy can constitute a lever for accelerating regional and continental economic integration within the framework of the Atlantic Africa initiative? The targeted area represents 46% of the African population and generates 55% of the continent's GDP, carries out 57% of total inter-African trade and is home to enormous natural and maritime resources. Notwithstanding strong multiple security constraints (crime, maritime piracy, terrorism, trafficking, etc.), Morocco is committed to uniting the countries of the Atlantic coast around a vision that revolves around the blue economy able to enable the optimal exploitation of their potential and their wealth and to strengthen their positioning as a credible and strong regional grouping. Indeed, the blue economy constitutes the cornerstone of this initiative which envisages a more equitable and inclusive use of Atlantic resources. Several initiatives at the African level have been outlined around the promotion of the blue economy in Africa, notably the African Union Integrated Maritime Strategy (AIMS) 2050 adopted by the African Union in 2012 which provides for the establishment of a Africa's common maritime exclusive zone. The Agenda 2063 has placed the blue economy as the sixth pillar for accelerated African economic growth. The blue economy, as described in the African Union's Agenda 2063, "will contribute enormously to the transformation and growth of the continent". (EL Houdaigui, 2016) focuses on the fact that the Atlantic Africa project as a partnership area can in no way be in competition with the African Union and sub-regional organizations. This initiative should be seen as a complementary dynamic to the process of building governance, particularly with the African Free Trade Area (ZLECAF), through the improvement of logistical mechanisms facilitating trade between African countries and increased investments.

The initiative promotes in the sense of (Ogoulat, 1998) the return to the "creative womb", according to the expression of Alain Corbin. Already in 1998, Ogoulat noted that colonization led to the formation of many African states poorly prepared for things at sea. (Dahou, 2018) evokes this turning of Africans' backs towards the sea is due to the painful past relating to the Atlantic slave trade, between the 17th century and the mid-19th century. (Ogoulat, 1998) believes that the Convocation of the Third United Nations Conference on the Law of the Sea (1973-1982) aimed, among other things, to contain the nationalization of maritime areas. Faced with this new situation, Africa is barely heard, a spectator of the race for marine riches, even though its future is at stake. After the maritime dynamic of the 1970s, the following decade saw this process completely run out of steam in 1995. In theory, African fishing waters are

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protected by the 1982 United Nations Convention on the Law of the Sea (UNCLOS), which defines a 200 nautical mile zone off the coasts of coastal states, within which fishing and exploitation of other marine natural resources are regulated. However, African countries' efforts to exercise sovereignty within these limits are hampered by a lack of skills and capacity to enforce regulations, measure and monitor the vast maritime areas (African Progress Group, 2014). The vagueness surrounding the maritime borders of African states stimulates marine exploitation to the extent that it serves the exclusivity strategies of international private groups. The extension of State sovereignty over its maritime domains makes it possible to transform its maritime spaces and its inestimable wealth to the best of its political, strategic interests and its geo-economy (Nchare Nom, 2017). Power is “also” acquired through the exercise of State sovereignty at sea (maritime sovereignty) and control of the seas (Coutau-Begarie, 1995). (Ogoulat, 1998) insists on the fact that the interest of the sea for people today is therefore more than multiform, multidimensional. The African Atlantic facade initiative outlines the intention of overcoming the failure of the strategy initiated two decades ago. (Chauveau, 1986) asked the question «Is an African maritime history possible? ». (Nchare Nom, 2017) believes that this history is possible if African countries seek ways to redefine their relationships with their geography and if they adhere to the principles of the blue economy for sustainable exploitation of their maritime domains.

## **Methodology**

We based our research on the collection and analysis of documentary data produced by specialists in maritime issues in Africa. Data from governmental and non- governmental institutions that deal with the issue of the blue economy in Africa were also used. Given the recent issue of the Atlantic Front of Africa Initiative, we also based our research on particularly Moroccan press articles. We structured our research on three milestones. The first is dedicated to the conceptualization of the concept of “ocean facade” as a construct. Then we presented the Atlantic Africa Initiative undertaken by Morocco, its historical benchmarks and the institutional bodies for its management. This milestone also integrates Morocco's agenda for the operationalization of the initiative and explains how the blue economy is the keystone of this initiative. The second milestone addresses the state of play of the blue economy in the African Atlantic belt as well as the challenges facing this space. This inventory is a sort of diagnosis, which demonstrates the platform on which the Moroccan Initiative should be implemented. The different sectors of the blue economy are presented. The third and final part presents our contribution to the study, which consists of the outline of some avenues for reflection and suggestions, capable of mobilizing the potential of cooperation within the enlarged Atlantic area and could contribute to its success.

## **I. What about the Facade of Atlantic Africa?**

### **1. La The “Ocean façade” as a construct**

The concept of “façade” as a construct can be approached on two levels, the first is geographical, the second is economic. Geographically, (Sellier, 2015) defines ocean frontages as geographical entities corresponding to places of contact between continents and oceans. They share this property with the coastlines, but greatly surpass the latter in terms of their dimensions. An ocean coastline constitutes a major interface on a global scale, since it separates a continent and an ocean. Inspired by the vocabulary of maritime geographers, a facade is identified from a coastline, separating an oceanic foreland, which extends to an external limit,

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and a continental hinterland, which extends to an internal limit. Facades constitute attractive environments, as demonstrated by population density. They offer the opportunity to exploit the resources of several juxtaposed environments: coastal plains, oceanic climates, water potential, combined continental and marine food production (agricultural, fishing, shellfish), proximity to energy sources (tidal power installations, oil or offshore wind turbines), trading sites at the same time as industrial-port sites and above all opening up to the world, by sea. (Vigarié, 1970) defines a maritime facade, as a space whose economic development is linked to the sea bringing together a set of logistical and ports aligned along this coastline, serving an economically developed land territory, while allowing it to trade with other territories and the open sea. It is a functional space or a set of ports forming an interface or contact zone between a maritime foreland (foreland) and a terrestrial hinterland (hinterland). For (Mici & al., 2019), the seafront is an expression which refers to ports belonging to the same geographical area, and whose proximity represents a singularity. In this case, the maritime facade can be defined as a set of ports, whose integration of the respective hinterlands constitutes a competitive advantage. Ports play a key role in the land-sea interface of the facades and constitute essential nodal points for international and domestic trade. Their infrastructures have had to adapt, over time, to economic and technological developments. Their performance depends on the quality and extent of their forelands and hinterlands. The major maritime facades increasingly structure the logistics of global trade in goods. For (Nchare Nom, 2017), maritime facades constitute poles of attraction. They influence the organization of the world, the great flows of people, capital and goods. On their coastal plains, the emancipated strategic countries have developed an industrial, agropastoral and fish farming system, which allows them to dominate trade in basic products and capital goods. Sometimes braving the hostility of nature, they gain land from the sea, creating polders as in the Netherlands, dikes and drainage canals as in China and Japan, vast estates by the sea to aquaculture as in the EU and the Pacific area. The coastlines then become anchor points for gas pipelines, oil pipelines and optical fibers. The major world maritime facades are The Asian facade, dominated by Singapore and the Japanese and Chinese ports; the Northern Range, which extends from Hamburg to Le Havre; The Atlantic coast of North America, which extends from the St. Lawrence to the Gulf of Mexico; and the Pacific coast of the United States from Seattle to California.

However, it would be simplistic to see the maritime facade only as a reticular space dedicated to exchanges. It is also an urbanized space and a productive space (port, industrial, agri-food and tourist, etc.). The thickness of the hinterland varies from a few dozen to several hundred kilometers. The hinterland extends over the portion of territory, which is polarized by port and maritime activities. The future of ports therefore mainly depends on the level of structuring of the hinterlands. High- capacity corridors, inland terminals, as well as logistics, are all factors that favor this trend (Notteboom, Ducruet, de Langen, 2009). The limits of the port frontage are those of the influence exerted on the space in terms of employment and population dynamics in particular. However, (Mici & al., 2019) affirm that the concept of “seafront” is maturing. (El Houdaigui, 2016) confirms this statement by ensuring that it is difficult to make scientific use of the expression “Afro-Atlantic” (figure 1) in the absence of a common academic definition of the geographical perimeter concerned. Some researchers limit this space to countries located between Senegal and South Africa; others include Mauritania, while the third current considers the African Atlantic coast in its entirety between the Strait of Gibraltar and the Cape of Good Hope. The political factor is illustrated by the distrust of certain countries with regard to such a transregional initiative and by the need for a center of political impetus,

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regional power, sub-regional organization, or both. The transposition of this concept in the context of Atlantic Africa constitutes several definitional challenges, the latter while being in gestation or under construction (El Houdaigui, 2016). (Tobi, 2022) recommends an effort of conceptualization and theorization of this Afro-Atlantic space in order to be able to situate it as a geopolitical and geostrategic pole of opportunities and a field of academic study.



Figure 1: The outlines of the Atlantic Africa initiative (Source diplomatic Morocco, No. of November 29, 2023)

## 2. The historical benchmarks of the initiative

Interest in the Atlantic Ocean dates back to the 1980s when a conference of African maritime fisheries ministers was held. In 1989, the Ministerial Conference between the States bordering the Atlantic Ocean (COMHA FAT) was created at the initiative of Morocco. It brought together 22 countries and extended from Morocco to Namibia. It quickly became the subject of an ad hoc convention, adopted on July 5, 1991, setting out the areas and modalities of regional fisheries cooperation between the Member States. In 2009, Morocco joined the South Atlantic Initiative, which constitutes a cooperation framework driven by Lisbon and Madrid and supported by Paris as well as by countries in Latin America and Africa. In the same year, the Morocco launched the initiative to promote the Afro-Atlantic space. The Moroccan initiative to create the Ministerial Conference of African States bordering the Atlantic was born from the reflections carried out during the Tricontinental International Forum in Skhirat (May 29-30, 2009). The first ministerial session of the Conference was organized in Rabat in August 2009, during which the 22 participating States underlined the relevance of the concept of “Atlantic Africa” as a space of opportunity and development. The second Ministerial session was held in Rabat on November 14 and 15, 2010, during which the Rabat Declaration was adopted. The Declaration called for coordinating actions around themes specific to African realities, particularly in the sectors of transport, fishing, tourism, energy, management of metropolises and decentralized cooperation, maritime surveillance, global warming, biodiversity and coastal erosion. Thus, a first sectoral meeting of Ministers in charge of Maritime Transport was held in Libreville, Gabon, on May 11, 2011, adopted the Libreville Declaration, and decided to institutionalize this meeting on a biennial basis (Higher Planning Commission, 2012).

In 2012, the member countries of the Ministerial Conference of African Atlantic States began a series of negotiations for the institutionalization of this conference under the name of the

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“African Atlantic Initiative” (AAI). According to the texts, the member countries of this Conference are South Africa, Angola, Benin, Cameroon, Cape Verde, the Republic of Congo, the Democratic Republic of Congo, the Coast of Ivory, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Equatorial Guinea, Liberia, Morocco, Mauritania, Namibia, Nigeria, Democratic Republic of Sao Tome and Principe, Senegal, the Republic of Sierra Leone, Togo. These meetings show the usefulness of taking the Atlantic as an appropriate framework to meet the demands of social cohesion, mobility of people, sustainable development, climate change, biodiversity as well as maritime security, fight against violence and trafficking of all kinds. For (AL Maghrebi, 2016), these reflections will thus emphasize the need to see the emergence of a common will among the States bordering the Atlantic and to unite their efforts with a view to transforming the Atlantic area from a simple geographical concept to a space of political, economic and social cooperation. In this regard, proposals for concrete and immediate joint actions have been made for the valorization of the Atlantic area. They include the ocean itself, energy, agriculture and water, the fight against global warming and the defense of biodiversity, human mobility, the development of new technologies and education. The work of the first ministerial meeting of Atlantic African States, held in Morocco in 2022 with the participation of 21 countries on the Atlantic coast, is structured around three themes, "Political, Security and Safety Dialogue", "Blue Economy and Connectivity" and "Environment and Energy. This first ministerial meeting, held in Rabat on June 8, 2022, adopted the Rabat Declaration I, which underlined the political commitment of Atlantic African countries to implement their partnership aimed at strengthening ties cooperation and integration between African countries bordering the Atlantic Ocean, with a view to consolidating shared peace, stability and prosperity in the region.

After the establishment of the Atlantic African States Process (AASP), the second edition of the ministerial meeting took place in New York in September 2022. It launched work on the Action Program, which constitutes a roadmap to enable the member countries of this initiative to achieve their common objectives around three strategic priorities: Political dialogue and security, the Blue Economy, maritime connectivity and energy, and Protection and conservation of the environment marine. The work of the third ministerial meeting of the Atlantic African States Process (AASP) took place in July 2023 and saw the adoption of the Rabat Declaration II, which aims to invite the Permanent Secretariat and the Focal Points to begin the work of formulating the action plan on three strategic priorities. They are political and security dialogue on the fight against terrorism, transnational organized crime, maritime piracy and illegal migration; the blue economy, maritime connectivity and energy; sustainable development and the protection and conservation of the marine environment (African Business, 2023).

### **3. The governance structures of the Initiative**

The Conference of Ministers is the orientation and decision-making body of the Initiative. It is responsible for developing the general policy and approving its work program and examining the activity reports of the Conference. The Executive Council made up of a few member states is responsible for management. The Executive Secretariat, placed under the supervision of the Executive Council, is the body implementing the decisions of the Conference of Ministers of the organization. It is headed by an Executive Secretary appointed by the Conference of Ministers. The Permanent Secretariat is responsible for ensuring the coordination and implementation of the decisions adopted by the Conference of Ministers as well as the



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designation of a network of Focal Points with the aim of ensuring coordination and providing monitoring of multiple activities relevant to this initiative at the level of each country.

#### **4. Morocco's agenda for the operationalization of the initiative**

The operationalization of the Initiative is intended to be the result of participatory consultation work by the focal points, coordinated by the Permanent Secretariat of the Initiative. The Action Program must reflect the three pillars of this partnership, which are economic cooperation, infrastructural integration and regional security. A particular emphasis is put upon the opening of new trade routes and development for landlocked countries as well as the promotion of cooperation in the areas of the blue economy, maritime connectivity and energy; and the protection and conservation of the marine environment. The African Development Bank has stated that sub-Saharan Africa would need \$92 billion per year in infrastructure investment for roads, telecommunications networks and railways (Kaberuka, 2014). According to the texts of the Atlantic African States Process, cooperation in the field of the blue economy, support for development projects on the Afro-Atlantic coast, the fight against pollution of the Atlantic Ocean, in addition to strengthening coordination in security matters and the fight against piracy and smuggling networks constitute the keystone of this initiative. Its operationalization will be materialized through an upgrade of the coastline, including the Atlantic facade of the Moroccan Sahara, which is the subject of a structuring of African scope. To this end, the Southern Moroccan Provinces are being provided with infrastructure to ensure a fluid connection between the different components of the Atlantic coast, which we will break down in detail (see list of projects). The development program for the southern provinces launched in 2015 in Laâyoune and in Dakhla in 2016, with a total budget of 85 billion dirhams, achieved a project completion rate of 70%. This program includes the project to connect Dakhla and its region to the national electricity network, the strengthening of infrastructure, the Foum El Oued technopole, the strengthening of telecommunications networks and the launch or extension of seawater desalination stations, projects in the renewable energy sector and, soon, green hydrogen (Vedie, 2023).

The Initiative plans to upgrade the infrastructure of the Sahel states and connect them to the transport and communication networks established in their regional environment. Morocco will also provide the infrastructure, means of transport and logistics stations necessary to serve the initiative's partner countries. In addition to the extensive exploration of offshore natural resources, the economic integration of the initiative's member countries must be based on investment in maritime fishing sectors, the desalination of seawater for agricultural purposes, and support renewable energies and Atlantic tourism. For (Tobi, 2022), the operationalization of the initiative involves the establishment of Morocco as a port and logistics hub towards Africa through the intensification of efforts to modernize port logistics and the strengthening of the military fleet for securing the Atlantic routes of the future. For (Tobi, 2022), one of the development paths of the West African Atlantic coast is the establishment of a port network capable of operating, transporting and receiving the various commercial flows in the area. For (Tobi, 2022), the West African port potential is immense. These ports play the essential role of transporting and connecting landlocked countries with the rest of the world and can ultimately connect the Mediterranean and the Atlantic and between the South Atlantic and the North Atlantic. Thus, the projects that are in the pipeline for the operationalization of this Initiative are as follows:

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- **Dakhla Atlantique port:** Launched in 2015 for an amount of 12.4 billion DH, The Dakhla Atlantique port will be used for both fishing and trade. It will be built on the Ntirift site 70 km north of Dakhla and will have three components: a commercial port, the coastal and offshore fishing port and a platform dedicated to the naval industry. This port will, in the long term, support the development of the region, transform Dakhla into a regional economic hub and provide it with a modern logistical tool capable of promoting the area's fishing resources by boosting the sector and improving its competitiveness. It will connect Morocco with Africa and it will constitute a junction point between Europe and Africa and even an entry point to Africa for America, from both North and South. It will also connect Mali, Niger, Burkina Faso and Chad, which represents a distance by land of 7251 km. The port of Dakhla Atlantique aims to facilitate north-south trade; it will be connected to Casablanca by an expressway meeting international standards as well as a traditional railway line. The new land transport infrastructures will allow the port of Dakhla Atlantique to complement the neighboring ports of Laayoune and Nouakchott and thus contribute to further opening up the Sahel countries (Tobi, 2022). This port will also have services by container ships to the ports of Casablanca, Tangier Med, Las Palmas and ports in West Africa. (Azirar, 2023) believes that the region will also be an industrial platform because it will host Moroccan-Sahelian projects, which will develop products intended for the international market. For (Ghazi, Oualalou, 2021), the port of Dakhla Atlantique responds to this logic of the corridor focused on transport infrastructure and the industrial base. Indeed, the construction of the port of Dakhla Atlantique with the related connectivity infrastructures aims, among other things, the establishment of a fishing industrial activity park, the development of a new industrial and logistics zone near the port , and the increase in navigation opportunities to West Africa.

- **Nigeria-Morocco Gas Pipeline (NMGP):** According to (Ghazi and Oualalou, 2021), this gas pipeline must cover nearly 4,000 km and cross 14 countries to connect Nigeria to Morocco. It would transport Nigerian gas resources to West African countries and, ultimately, to Morocco, with the possibility of serving Europe. Coastal countries like Senegal, Mauritania and Ghana have found natural gas on their coast so this pipeline will reduce the costs of transporting natural gas, thus facilitating trade. Producing states will be able to inject their production there and importers will be able to meet their energy needs. Secondly, delivery could be done as far as Europe. It would thus constitute an economically structuring axis for all of West Africa. It is expected to strengthen the development of the energy sector throughout the region. It would also allow the development of related industries along the gas pipeline. Nigeria's Energy Minister Ekperikpe Ekpo announced that the construction of the mega energy project Nigeria-Morocco Gas Pipeline (NMGP) is scheduled to start in 2024 (Morocco World News, 2023)

\*1 This list is not exhaustive. It concerns the projects identified to date.

- **The Tiznit-Dakhla expressway:** Launched in 2017 and with a length of 1000 km, for an amount of more than 8.5 billion dhs, this expressway aims to provide the Southern Provinces with a road axis that meets international standards and a high degree of security (Vedie, 2023). This expressway aims to facilitate the transport of goods to and from cities in the South by improving their connection to the main national production and distribution centers. The overall Tiznit-Dakhla expressway project has reached a progress rate of 90%.

- **The Lamhiriz Port project:** located south of the city of Dakhla across the road leading to the Guerguerat border crossing, is considered one of the major projects on the level of the

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Dakhla-Oued Eddahab region. This port, located 300 kilometers south of Dakhla, and under the influence of the Birkandouz community in the Aousserd province, was built in order to create economic prosperity in the region, improve the working conditions and lifestyle of fishermen, as well as value and improve the quality of marine fishing products.

- **The creation of a national merchant marine fleet:** Following the liberalization of the sector in 2006, the national fleet decreased significantly. To this end, the Ministry of Transport and Logistics announced the launch of a feasibility study concerning the establishment of a national merchant marine fleet. This study will look into diagnosing the current situation of commercial shipping in order to adapt it to international best practices, with the aim of creating conditions conducive to encouraging investments in this sector. This fleet is called upon to contribute to the development of the southern provinces, by developing maritime links with the countries of West Africa. The same Ministry announced initiatives to encourage the sector through the revision of the specifications for obtaining licenses, the reduction of taxes as well as the possibility of reintegrating certain transporters into the formal sector.

- **The Marrakech-Agadir railway line project:** After the Al-Boraq line, inaugurated in 2018, Morocco aims to connect Tangier-Lagouira, will allow a high-speed commercial transport corridor between the shores of the western Mediterranean and the border of West Africa (source: Le Plan Rail Maroc 2040).

- **Offshore exploration and exploitation of the exclusive economic zone:** Morocco has undertaken oil-prospecting work 170 km from the Canary Island of Gracioso. Morocco supports the principle of the unity of waters from north to south to establish its “total sovereignty” over its seas. Morocco thus ratified, in May 2007, the Convention on the Law of the Sea (Montego Bay Convention of 1982) and presented a complete file to the United Nations on the new legislative framework now in force.

- **Green energy:** In 2015, four wind farms were operational: in Aftissat, Laâyoune, Akhfennir and Tarfaya. Between 2016 and 2020, it was planned to double the capacity of the Akhfennir wind farm, and to create two new wind farms in Boujdour and Tiskrad. Solar power was not forgotten, with the Noor Atlas program, via micropower plants like the 800 kw one in Assa (Vedie, 2023). Boujdour saw the creation of an irrigated area of 1,000 hectares thanks to the new seawater desalination station.

- **Investments in the production of fertilizers:** (Azirar & al., 2023) highlights the series of investments by the (OCP), in particular the construction of fertilizer factories in Nigeria and Togo. The first, already operational since the end of 2022, makes it possible to manufacture fertilizer from Nigerien ammonia (from gas) and phosphoric acid imported from Morocco. The second will allow Togolese phosphate to be directly transformed into fertilizer. (Ghazi, Oualalou, 2021) believe that through its investments in Africa, the OCP Group is a real player in agricultural transformation and the strengthening of regional value chains.

- **The seawater desalination station in Dakhla:** In addition to providing drinking water, the station will irrigate an agricultural area of 5,000 hectares and a wind farm in Dakhla.

- **Scientific exploration:** A scientific mission to study the marine ecosystem and assess the marine stocks of the coasts of the special economic zone of Liberia by the Moroccan research vessel Hassan Marrakchi. The scientific research initiative is part of the memorandum of understanding signed between the Moroccan Minister of Agriculture and the National Fisheries and Aquaculture Authority in Liberia, in January 2023. The exploration mission is part of the Blue Belt Initiative (BBI) project launched during the Conference of the Parties (COP22), a regional collaborative platform focused on improving ocean observation and

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fisheries sciences, with the clear aim of mitigate the effects of climate change and improve the resilience of marine ecosystems. This cooperative work took place at the request of the Liberian authorities and with the support of the Ministerial Conference on Cooperation in the Field of Marine Resources between African Countries Bordering the Atlantic Ocean (COMHAFAT).

- **The development of aquaculture in Sidi Ifni:** Sidi Ifni has a potential of more than 1,300 ha for the installation of aquaculture projects. This project will be carried out as part of the cooperation between the Department of Marine Fisheries, ANDA and FAO, with joint funding from the governments of Norway and the Netherlands.

- **The Fom El Oued technopole:** This project aims to be the backbone of knowledge and excellence in the region while taking into account the local Saharan environment. Finally, in the long term, this technology park aims for zero carbon and zero waste (Vedie, 2023).

- **The Dakhla fishing competitiveness cluster:** This project aims to increase the number of conservation factories and the numerous jobs associated with them, valuing catches on site at 80% and not 20% as was the case in 2016.

- **The industrial, agricultural and tourist competitiveness cluster:** According to (Vedie, 2023), the industrial competitiveness cluster concerns the exploitation of Phosboucraa phosphates, their valorization, with new industrial capacities of 0.5 M tonnes of acid phosphoric and 1 million tonnes of fertilizer produced each year. The aim is to make sub-Saharan Africa the main beneficiary, with reduced delivery times and transport costs. The agricultural competitiveness cluster mainly concerns two regions: Laâyoune, Sakia El Hamra and Dakhla Oued Eddahab. In the Laâyoune-Sakia El Hamra region, the implementation of a hydro-agricultural development project irrigating 1,000 hectares in the province of Boujdour is well advanced. The tourism competitiveness cluster brings together municipal micro-clusters, based on a Sea/Earth/Nature trilogy, specific to these territories with the obligation to respond to a dual priority, inclusiveness and sustainability. In the Laâyoune-Sakia El Hamra region alone, no less than 87 microprojects will be launched in 2015, for an amount of 2 billion dhs.

## II. The blue economy approach

According to (Noah Edzambi, 2018), the development of a blue economy is a condition for the exercise of sovereignty and the emergence of an African maritime power. (AU, 2015; ECA, 2016) consider the blue economy as a strategy to promote economic development as well as ecological conservation aimed at reducing poverty in Africa. (UNCTAD, 2018) affirms that the African Atlantic coast is full of economic opportunities thanks to natural energy, mining and agricultural resources, making this space an area of first-rate strategic interest. The (AfDB, 2023) estimates Africa's natural wealth at \$6.2 trillion in 2018. Africa is blessed with a vast network of aquatic resources and vast interconnected oceans. Africa's lake areas cover approximately 240,000 km<sup>2</sup>, while its transboundary river basins cover approximately 64% of the continent's land area (UNEP, 2010). The total length of the African coastline is approximately 26,000 km, making the African maritime domain extremely important for commercial, environmental, development and security reasons. There are more than 100 ports in Africa, 52 of which handle container and transnational trade.

The (African Natural Resources Management and Investment Centre, 2016) states that the total value added of Africa's fisheries and aquaculture is estimated at USD 24 billion, or 1.26% of the entire combined gross domestic product. African countries. The same source claims that Africa is also home to around 30% of the world's mineral reserves. Regarding oil and natural gas reserves, Africa had estimated its proven reserves at 125.3 billion barrels of oil in 2021 and

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natural gas accounted for about 7% of the world's total reserves. As a result, this rich heritage provides the necessary foundation for the deployment of a successful BE. For three-quarters of the African continent, the blue economy is the dominant economy and, if well implemented, could be a powerful engine of economic growth. The prospects of the BE were highlighted in the African Union Integrated Maritime Strategy (AIMS) 2050 adopted by the African Union in 2012. This strategy envisages the establishment of a Common African Maritime Exclusive Zone (CEMZA), which must be delimited and will constitute a barrier-free African maritime space. Then, the Lomé Charter and the Yaoundé Codes of Conduct were adopted. According to (Ghazi & Oualalou, 2021), the (AIMS 2050) called on African states to place the sea at the service of their development project and tends to stimulate intra-African trade, by eliminating or simplifying administrative procedures in the maritime transport. The CEMZA should contribute to the integration of the internal market for intra-AU maritime trade and services. The delay in its implementation has a negative impact on fisheries management, the defense of common economic and commercial interests, the protection of the marine environment as well as the security aspect. The vagueness surrounding the maritime borders of States stimulates marine exploitation to the extent that it serves the exclusivity strategies of international private groups (Frynas & al., 2003). The pooling of EEZs requires regional cooperation and the creation of a port free trade zone, facilitating intra-African trade, complementary to the land free trade zone, which is currently being implemented. The approach of “community maritimization” or “maritime regional integration” of which the common maritime exclusive zone of Africa is the first milestone. These initiatives are indicative of the progress of African governments on the issue of the blue economy.

Given the importance of the marine environment and its resources for the livelihood of Africans, one of the biggest challenges for a sustainable BE would be to safeguard its blue economy potential which some analysts believe is subject to waste by balancing inclusiveness, sustainability and economic development (De Graaf and Luca Garibaldi, 2014). Over the next 50 years, Africa will need to increase its food production amid chronic water shortages and rising costs of living. Its youth population is expected to reach 830 million by 2050, and more than 300 million of them will join the job market by 2035 (ADB, 2016). (Okafor-Yarwood, 2020), however, insists that blue growth in Africa remains largely inaccessible, as sustainable exploration of the sea is undermined by insufficient sustainable exploration of the sea is compromised by insufficient knowledge and technological capacity, combined with limited investments in environmental sectors. (Ogoulat, 1998) noted that the majority of African states remain particularly withdrawn from the sea and relied heavily on technology transfer following fishing agreements signed with developed countries.

This situation has generated the overexploitation of stocks by European industrial fleets, thus representing a significant danger, both for the renewal of species and for the supply of the regional market, in the long term. (Ogoulat, 1998) insisted on the creation of a regional pavilion better able to serve the interests of all. The prolonged control of the shipping sector by foreign interests is a parameter that can prove profoundly detrimental to the region, both from an independence and development perspective. (Machrouh, 2021) notes that this awareness of its maritime vocation is still lacking in Africa. This is the reason why recognition of the country's maritime vocation and the desire to make it a maritime power remain decisive. The analysis shows that very few African countries have really invested in the appropriation of their spaces and their resources, particularly maritime ones. According to a study by (Okafor-Yarwood, 2020), Africa's maritime resources have aroused the interest of the West and Asia and are

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overexploited to the detriment of locals, endangering their food security. For (Okafor-Yarwood 2020), in certain countries, foreign interests dominate, particularly in the sectors of oil prospecting, maritime transport, port infrastructure and industrial fishing. She cites the example of Angola's oil production which is dominated by large international companies including Total (France) with a market share of 41%, Chevron (United States) with 26%, Exxon Mobil (United States) with 19% and BP (United Kingdom) with 13%. (El Houdaigui, 2021) insists that African countries must find a balance between the practical management of foreign interference and membership in a South-South community of geoeconomic interests. The Atlantic Seafloor of Africa is becoming a major stake in this complex geopolitical game, involving various actors with multiple strategies (EU, United States, China, Russia as well as other African countries). For (Noah Edzambi, 2018), foreign powers are engaged in fierce competition in the construction and development of port infrastructure on the African Atlantic coast, in order to transform it for their benefit as a complementary maritime frontage for the their worldwide geo-economy. Observation supported by (EL Houdaigui, 2023), whom noted that the geopolitical status quo which favored the Europeans and the United States has evolved in favor of a new emerging dynamic in which China and Russia are challenging this pre-eminence. For (EL Houdaigui, 2023), a maritime refoundation of African States is necessary in order to better confront the problems that handicap the development of the continent. These problems concern the control of their territories, the definition of maritime borders, the underdevelopment of port infrastructures, the logistical weakness of the merchant navy and the security navy. (EL Houdaigui, 2023) adds that other issues that complicate the growth of the blue economy in Africa include territorial and maritime disputes, piracy, terrorism, and banditry).

According to the (African Union, 2019), the major challenges of the blue economy is IUU fishing in exclusive economic zones (EEZ), which causes losses estimated at 10 billion USD per year. Piracy at sea and illicit trafficking pose a real threat not only to the safety of ships and their crews, but also to the economies of affected countries, particularly in the Gulf of Guinea. Furthermore, pollution caused by the dumping of toxic waste, the indiscriminate disposal of single-use plastics and the random nature of the environment compromise the achievement of the growth of the blue economy in Africa. Furthermore, it is commonly recognized that climate change and variability are already having an impact on Africa's aquatic systems and overall food production. These challenges are compounded by significant institutional and governance issues that continue to constrain the capacity of AU Member States to effectively formulate and implement policies relating to the growth of the relatively new concept of the blue economy.

## 1) Overview of the blue economy sectors in Africa

### 1.1) Le The fishing sector

The (AfDB, 2023) estimated the annual production of capture fish in Africa at 10 million tonnes, of which approximately 7 million tonnes come from maritime fisheries and 3 million tonnes from inland fisheries. Approximately 90% of domestic fish protein consumption comes from landings by artisanal fleets. Around 13 million people are engaged in fishing, around 46% of whom are women. Fishing ensures food security for more than 200 million people in Africa and provides income for more than 10 million people (AMCEN, 2019). (UNCTAD, 2016) believes that the potential of BE has not yet been fully recognized. The West African coasts

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are among the richest waters in the world and represent economic growth potential for countries like Mauritania, Senegal and Guinea. However, the fishing sector in West Africa brings little to African countries considering the enormous potential. According to the Secretariat of the Convention on Biological Diversity (2020), the northwest and southeast regions of Atlantic Africa are home to the Canary Currents, which allow upwelling of deep, cold and nutrient-rich waters (upwelling) and Benguela off the coast of Namibia and Angola which raise the region to the rank of the most productive fishing areas in the world. According to the (AfDB, 2023), fish stocks in Africa are decreasing. The estimated value of fish stocks fell from \$59 billion in 2003 to \$20 billion in 2008, during which time Africa lost more than \$38 billion in fisheries capital. The main factors are attributed to fishing activities (IUU), overexploitation, insufficient knowledge and misperception of biophysical dynamics, and climatic conditions such as salinity, coastal upwelling and sea level rise. The prevalence of artisanal fishing (90% informal), also extremely important in terms of livelihoods for many coastal communities, the lack of respect for biological cycles and underinvestment in the sector lead to the under-exploitation of this financial windfall by West African countries (Tobi, 2022). For (Okafor-Yarwood, 2020), foreign fleets (EU, China, etc.) exploit African blue resources including (IUU). (De Graaf and Garibaldi, 2014) estimate that 25% of all marine catches on the continent are taken by non-African states, resulting in a loss of potential revenue of US\$3.3 billion, which could in turn impact on food and economic security. Managed correctly, BE is essential to ensure the sustainable development of African people by 2063.

### 1.2) **Maritime trade, port activities maritime, transport and maritime security**

According to (UNCTAD, 2020), around a third of African countries do not have a coastline, maritime transport remains the continent's main gateway to the global market. Africa's international trade is heavily dependent on ports. The (UNCTAD, 2018) indicated the weak integration of Africa into the global trading system with only 2.7% of global maritime traffic in 2017. African maritime trade is shaped by the continent's low diversification in particular sub-Saharan Africa with a global manufacturing value added (MAV), not exceeding 2%. Thus, in 2017, 40% of goods exported by sea were made up of crude oil, while more than two thirds of imports were made up of dry goods (dry bulk and containerized goods) and almost 20% of products oil and gas. For (Azirar & al., 2023), the ZLECAF free trade zone agreement is likely to boost this dynamic of maximizing continental benefit. Indeed, the lifting of customs tariff barriers between African economies for a wide range of goods allows African companies, particularly Moroccan ones, to continue the development of their regional value chains while remaining competitive.

Ports today constitute the major nodes in the construction of global networks (Steck, 2015). In Africa, maritime connectivity, which strongly influences transport costs, is below the global average. The best connected are the countries located at the ends of the continent, where international maritime routes connect hub ports, notably in Morocco, Egypt and South Africa. Apart from these four terminals, no African port appears on the 2016 list of the world's top 100 container ports. The African Atlantic coast is far from being an international hub. Without ports, it is difficult to develop other activities in the blue economy sector. (El Guerouani, 2020) established an inventory of maritime transport in the Atlantic coast of Africa which demonstrated the deficit in terms of infrastructure. The "Afro-Atlantic" maritime facade is made up of an alignment of 4 major ports: the port of Lomé in Togo; the port of Casablanca; the port of Tema in Ghana; the port of Lagos. (Tobi, 2022) estimates that West African

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countries are weakly connected to the global maritime network and weakly integrated at the regional level. This is evidenced by the maritime connectivity indices of (0.25) recorded in 2019, which reflects the low level of intra-regional trade. West African ports still require modernization, particularly around the connection between sea routes and road routes in order to be able to transport goods within the countries. Morocco stands out for its dynamism. In addition to the Port of Tangier Med, as well as other large ports under construction or expansion, such as the Port of Nador on the Mediterranean coast, the ports of Kenitra, Casablanca, Jorf Lasfar, Safi, Agadir and the future port Dakhla-Atlantique on the Atlantic coast, make Morocco a major player in the maritime trade of tomorrow. Improving port management is a prerequisite for the continued development of the maritime transport sector in West and Central Africa. However, Africa's need for maritime transport is growing, as reflected by the exponential growth of exports and imports surpassing that seen in the developing economies of America and Europe (El Guerouani, 2020). According to the same study, Morocco and Nigeria stand out for their weight in the total maritime traffic of the countries of the West African Atlantic coast because the two countries represent 64% of the total maritime traffic. Five countries: Ivory Coast, Ghana, Senegal, Togo and Benin contribute 29% to maritime traffic. Finally the group of countries contributing the least to maritime traffic which includes: Guinea, Liberia, Mauritania, Gambia, Sierra Leone, and Guinea Bissau, whose average traffic is less than 5MT over the period 2011-2015, and their total share is 7%. According to (UNCTAD, 2020), maritime transport in Africa faces challenges in the following areas: innovation and technology, quality of infrastructure, regulation and governance, human resources and skills, investment and sustainability.

The maritime fleet constitutes the Achilles heel of African maritime transport. According to (UNCTAD, 2018), the continent only holds a small part of the world fleet and no African country is among the 35 nations that have significant fleets. According to (El Guerouani, 2020), the size of the merchant fleet is West Africa's Achilles heel in maritime trade and transport. Same observation for Morocco, which disengaged from this sector during the 1990s. Participation in the supply of maritime transport services remains an objective that Africa has been aiming for a long time. The Liberian flag is the exception as a flag of convenience. It is the third in the world to register after Panama and the Marshall Islands (2018). Nigeria is among the top 35 ship-owning countries, with a share of 0.31% of deadweight tonnage as of January 1, 2020 (UNCTAD, 2018). According to (Elghormli, 2019), terrorism, illicit trafficking in arms, drugs or human beings are growing very quickly and threaten peace and development in the African Atlantic area. The threats posed by piracy harm the economic and commercial development prospects of countries in the region, estimating that the direct and indirect cost of piracy in the Gulf of Guinea would approach two billion dollars per year. Access to safe and secure maritime transit routes will be essential for the successful integration of these products into the global market.

### **1.3) The hydrocarbon sector**

The (AfDB, 2023) estimates mineral and fossil resources in Africa are estimated at \$290 billion and \$1,050 billion. The continent's proven oil reserves constitute 8% of the world stock and those of natural gas 7%. Indeed, the AfDB estimates that Africa's extractive resources could contribute more than \$30 billion per year in government revenue for the next 20 years. The Bank also estimates that revenues from newly discovered oil, gas and minerals could contribute between 9% and 31% of additional government revenue over the first ten years of production for countries such as Ghana, Liberia, Mozambique, Sierra Leone, Tanzania and Uganda.



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However, in Africa, international companies mainly extract hydrocarbons and most crude oil is refined outside the continent. As a result, benefits do not always stay in host communities and there is little respect for environmental sustainability (Okafor- Yarwood, 2018; 2020). The continent's producing countries import more than 80% of their fuel due to the lack of domestic refineries.

### 1.4) Seabed mining

Africa has significant mineral resources that are essential to the global transition to a carbon-free future (AfDB, 2023). The (AfDB African Center for Natural Resource Management and Investment 2016) estimates that approximately 30% of all global mineral reserves are in Africa. According to the United States Geological Survey (USGS), Africa is abundantly supplied with cobalt (52.4%), bauxite (24.7%), graphite (21.2%), manganese (46%) and vanadium (16%). Half of African countries possess at least one of the metals essential to the energy transition, putting the continent in a strategic position to influence the global transition to net zero emissions. Despite its vast natural resources, Africa participates in only small parts (10 %) of the total global value chain. Africa has not invested sufficiently in green minerals. Its mineral wealth is mainly for export with little or no local added value. Investments in green minerals and emerging energy storage using electrolysis to produce green hydrogen are also insufficient. Deepening the value chain of critical minerals in Africa requires, among other things, investments in infrastructure, new explorations, skills and digitalization. It is therefore important for African countries to break the vicious circle of excessive dependence on the export of natural resources by creating more value by strengthening production capacities and developing exports and intra-trade through the African Continental Free Trade Area (AfCFTA).

### 1.5) Renewable energies

Africa has strong potential in renewable energy and enormous assets in carbon sequestration with 25% of the world's natural biodiversity and 30% of the world's mineral resources such as lithium and rare earth metals needed to power the renewable energy revolution and 65% of the planet's uncultivated arable land. The continent has vast amounts of solar, wind and hydroelectric power, much of which will be essential for a green transition (ADB, 2023). However, Africa face the dilemma of its dependence on hydrocarbons, the reduction of which leads to the loss of a significant financial windfall. The innovative path to net zero lies in an appreciation of the continent's climate dilemma and the recognition that Africa is a potential global climate asset. Africa currently contributes only about 4 % of global GHG emissions, far lower than those of China (30.9 %), the United States (13.5 &), the European Union (7 .5 %) or in India (7.3 &). Despite all the potential, the transition to green growth has been slow. Between 2010 and 2021, Africa was among the least performing countries in achieving their green growth objectives, including in the production of blue electricity. The trend observed over the last quarter century shows a decline in the value of natural capital per capita. In the ocean energy sector, several obstacles must be overcome, such as the lack of evaluation and systematic inventory of these resources, the non-maturity of technologies linked to ocean energy, the still high cost of solutions, and lack of expertise and knowledge to design and operate offshore energy infrastructure (UNCTAD, 2016).

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## 1.6) Seaside tourism

The landscape is a form of natural capital, which is not fully measured and valued as part of the natural wealth of the African continent, as evidenced by its low share in global tourism with only 5% (AfDB, 2023). The tourism sector currently represents 8.1% of the continent's gross domestic product, valued at more than \$177 billion, and 6.5% of total employment, or more than 22 million jobs. Although it is already contributing, its potential is extremely underexploited. The bulk of the tourism sector falls into the blue or ocean economy category; with coastal countries accounting for over 95% of the continent total tourist arrivals and tourism revenue (UNCTAD, 2017). Coastal tourism in Africa suffers from a lack of strategies as well as the restriction of the range of tourism products associated with considerations of investment security and skills.

## 1.7) Environmental challenges

The (AfDB, 2023) believes that Africa's natural capital is under strain from climate change, biodiversity loss, land degradation, exports and excessive exploitation of raw materials and mismanagement. Future reporting on Africa's natural capital is needed to address these important sustainability challenges and the immediate and future well-being of the African population. These new reports integrate the principle of circularity, rationality, etc. Other issues, such as fishing and IUU fishing, industrial discharges or the consequences of other forms of maritime activities are all obstacles to productivity and sustainable exploitation of the seas and oceans. (Azirar & al, 2023) estimate that more than 25% of living species on the continent have disappeared or are seriously threatened with extinction. This deterioration in the quality of African natural ecosystems has serious consequences on the well-being of inhabitants: greater exposure to climatic risks, reduced soil fertility, deterioration in the quality of water and certain food products. For (Dahir & Willima 2023), the African continent is late in signing and ratifying the Biodiversity Treaty, which must be signed by September 20, 2025. The treaty constitutes the first binding international legal framework aimed at protecting the high seas and areas beyond national jurisdiction. It aims to conserve and sustainably exploit marine biodiversity in this area, which covers nearly two levels of the planet's oceans.

## III. Reflections for the operationalization and sustainability of the initiative based on the blue economy

The blue economy presents the idea of integrated management of marine spaces. It requires a lot of coordination and consultation and requires a holistic and participatory approach including the dimension of social progress in the sustainable use and management of maritime resources in a plural Africa (ECA, 2016). For Morocco, it is about implementing an overall blue strategy and translating it into a vision and an action program. We base ourselves on two conceptual frameworks: the first proposed by (Machrouh, 2021) which identified four particularly necessary levers, namely: recognition, knowledge, presence and alliances. The second we borrow from the reflection that we developed in our article on phronèsis on the basis of Aristotelian thought in Nicomachean ethics on phronèsis, epistemè and téchnè (Hanine, 2020). This conceptual framework seems appropriate to us to present the avenues that we suggest for accelerating the operationalization of the African Atlantic Initiative.

**Recognition:** In the sense of (Machrouh, 2021), recognition relates to an awareness of the maritime vocation. He believes that a country, which is not aware of its maritime vocation, can only turn its back on the sea. This is the reason why recognition of the maritime vocation of a

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country and the desire to make it a maritime power remain decisive. To this end, we underline the need for Morocco to consolidate its efforts deployed for the implementation of the blue economy strategy see (Hanine & al., 2023). For (Machrouh, 2021; Hanine & al., 2023), this recognition is also induced by the valorization of human capital dedicated to maritime affairs. Opinion that we share and that we have amply explained in our article on innovation in the blue economy in Morocco. (Machrouh, 2021) calls for the creation of a high authority for steering the blue economy in Morocco, which he calls the “Ministry of the Sea”. (Tobi, 2022) supports this suggestion and considers that it is necessary to set up a unified structure responsible for ensuring the coherence of public policies linked to the sea. For (Nchare Nom, 2017), this recognition of the sea remains a challenge to develop for African countries which are still oriented towards "continentality" without maritime anchorage and which should centralize the integrated management of the blue economy in the Morocco. (Nchare Nom, 2017) believes that a geographical awareness that allows Africans to no longer see space as a simple living environment, but as a life issue and a resource of power is essential. The big challenge is therefore to integrate the sea into the programmatic governance of African states because to put oneself on the margins of the sea is to cut oneself off from economic progress and lock oneself into poverty, subordination and economic extroversion. . For (Nchare Nom, 2017), the States, which master globalization, are those which are predominant in maritime trade and which are home to the largest port areas and the most important metropolises on their maritime facades. This question of recognition pushes us to link it to an important component, which is that of Afro-Atlantic identity. Many researchers believe that the two infrastructural and security components are not capable of consolidating the institutional anchoring of the Initiative on their own. (El Houdaigui, 2016) insists on the need to build an “Afro-Atlantic” identity and which, according to him, remains under construction and does not seem to impose itself in narratives, including African ones.

For the question of Afro-Atlantic identity (Saaf, 2012), defines it as a project of building a dynamic community with open issues which de facto moves away from “securitization” attitudes and automatisms. Building this identity will require very in-depth work by Moroccan soft power, which must involve all the driving forces of Moroccan society (Universities, Private Sector, and civil society). Moroccan soft power must transcend the construction of this transnational and geopolitical commercial space only from above, driven by diplomatic issues and speeches through a low-level approach, that is to say reaching the average African through dialogue enlargement and exchange. In our opinion, Moroccan soft power at the economic, diplomatic and cultural level has a role to play in this register. By drawing lessons from the European experience in Africa and more recently that operated by China, this soft power must be coupled with a phronesis with an axiological teleology on the true meaning of the values of sharing and win-win. This phronesis is defined as practical wisdom to achieve the good end (or telos) using the right means. That is to say, to reconsider one's way of doing things by considering the purposes and to act in one's own interest as well as in the general interest. The phronimos possesses the capacity for deliberation, judgment, and discernment in difficult moral situations about ends and goals worth pursuing and the means (good means) most likely to achieve those goals. Referring to Aristotle “It is not strictly speaking possible to be a good man without prudence any more than it is possible to be prudent without moral virtue”.

Knowledge, *épistémè* and *téchnē*: *Epistémè* concerns theoretical knowledge and science, logically constructed and teachable. *Téchnē*, for its part, designates technical expertise. In the sense of (Machrouh, 2021), knowledge is linked to the mastery of maritime matters implies

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skills and competencies in navigation, sea law, oceanographers, scientists and researchers specializing in the marine field, engineers equipped capacity for exploration and exploitation of offshore resources. Indeed, Morocco has considerable assets in terms of technology with its training institutes and the phronesis, which it demonstrates in terms of the audience it benefits from internationally. How can we link this knowledge to the promotion of the Moroccan initiative? In our opinion, the key word is technology transfer and capacity building of human capital for the benefit of African countries members of the Initiative in the field of fishing, aquaculture and ecosystem conservation. Indeed, Morocco has proven experience, particularly in territorial management, infrastructure, marine security and electrification. Morocco has a long tradition in the valorization of products and the exploitation by itself of its fishing resources, maritime navigation, transport and trade, the desalination of seawater, renewable energies, mineral extraction, innovative industries, climate change and Atlantic tourism. Technology transfer also integrates the legal, regulatory and institutional framework relating to the blue economy and the strengthening of maritime security in Africa. There is also room for cooperation in the prevention and fight against piracy and against illegal fishing.

**Presence:** In the sense of (Machrouh, 2021), it is not enough to possess a maritime space, but it is also necessary to be able to exercise all the elements of sovereignty there. However, maritime sovereignty involves many more resources than those deployed inland. This is more particularly true for States with long coastlines and an extensive (EEZ) as is the case of Morocco. The completion, in March 2020, of the national legal arsenal relating to the delimitation and regulation of all Moroccan maritime areas constitutes, in this regard, a prerequisite. The current context marked by conflicting regional and global maritime strategies makes possession of the means necessary for the effective exercise of national sovereignty over the entire Moroccan maritime space an essential issue. (Tobi, 2022) believes that to exploit the Exclusive Economic Zone (EEZ), Morocco should develop a clear and coherent geopolitical strategy to face competition from neighboring countries. Many researchers are unanimous on the fact that the creation of a national naval fleet is an initiative of major importance intended to redefine Morocco's position in the spheres of international maritime trade. It will contribute substantially to enriching the country's logistical assets, thus adding competitiveness in the maritime domain to the various constituent elements of the country's vast logistical competitiveness, such as port infrastructure, rail and road networks, among others. The creation of an African naval company promises to be a vector for establishing the sovereignty of African countries over their territorial waters. The presence is also strengthened by the provision of investments in the marine and aquatic areas of the continent. In our opinion, this objective can be achieved through several mechanisms: The Mohammed VI Fund for investment with initial capital of 1.5 billion dollars, which is the first model of its kind in sub-Saharan Africa and has the mission of promoting role of the State as an investor partner and complement to the private sector. The Mohammed VI Fund for Investment is able to offer innovative financing mechanisms to Moroccan companies in Morocco or Africa to invest in the different sectors of the Blue Economy. For each dollar invested by the Fund, a minimum of 2 dollars must come from private investors, (says Mr. Benchaâboun, the manager of this fund) and a dollar invested in the blue economy promotes a return on investment of 5 dollars. On the infrastructural level, the promotion of maritime transport through the construction and expansion of ports and maritime facilities in order to expand the maritime domain is a measure to anchor the presence. For his part, (El Guerouani, 2020) proposes the establishment of reinforced port and maritime cooperation favoring the pooling of human and technical resources, through the sharing of

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knowledge, expertise, and even infrastructure, to make benefit all countries in the region from the competitive advantages acquired in certain areas. She believes that this cooperation could result in the establishment of a regional maritime transport observatory, making the circulation of data and information on port activity fluid and transparent. Presence also includes visibility through celebrations for example; we suggest the establishment of a commemorative day of “The African and the Sea” which will be celebrated each year or the establishment of “The Year of Atlantic Africa.

**Alliances:** Multilateral development partners could support the construction of the Atlantic-African identity as a solid substrate for the Initiative project by driving and supporting initiatives on this register. This is an overall strategy, based on all-out diplomacy in this region, exchange of experts, mobility of people and traders, etc.) For (Machrouh, 2021), the sea could become the defining feature of essential union and the appropriate platform for amplified cooperation between Morocco and Atlantic Africa by strengthening development partnerships in the areas of the blue economy, maritime cooperation, as well as energy. Establishing an ecosystem requires identifying and surrounding yourself with the right partners (companies,

research and innovation centers, incubators, universities and schools, etc.). Increasing collaboration and coordination among stakeholders in Africa at all levels, including international and regional multilateral organizations, national governments and the private sector, can only strengthen the Initiative project. For example, the creation of a Cooperation Forum for Atlantic African countries whose objective will be to initiate consultations, deepen mutual knowledge, broaden consensus, and strengthen cooperation. This Forum may include thematic sub- forums, such as the blue economy sub-forum, the Security sub-forum, the sustainable development sub-forum, the poverty eradication sub-forum, etc. Likewise, there is a need to interact with the maritime initiatives adopted by the AU and the various instruments. The regional economic communities also constitute a scale of cooperation at the regional level. (Tobi, 2022) proposes expanding cooperation between States, towards more downward levels such as chambers of commerce and industry, making it possible to encourage relations between operators in this space (information on markets, export/import opportunities, commercial prospecting missions, etc.). We add to the list governmental and non-governmental organizations in the field of energy and infrastructure, environment.

## **Conclusion**

This article supports its analysis of the blue economy as a sector that offers enormous potential to support the developmental dynamic that Morocco is leading in the Atlantic coast of Africa. This Initiative, which is at the genesis stage presents an ambitious vision for dynamic cooperation in the African Atlantic aimed at promoting greater regional integration and south-south cooperation. Given the enormous potential that Africa presents in all sectors of the blue economy, the latter constitutes a very promising avenue for contributing to the development of the Initiative. This initiative underlines the strategic importance of the Atlantic for Morocco, which must seize this opportunity to strengthen its maritime character, anchor itself in Atlantic Africa, a space of “competition” and upgrade its national strategy of blue economy. However, the complexity of this regional space in formation and the interplay of actors at work in turn complicate this project. The Atlantic faces challenges that require enormous investments coupled with substantial soft power and political leadership. In this sense, the operationalization and sustainability of the Initiative should be achieved through major infrastructural efforts, investments but above all soft power, which ignites the effort to

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conceptualize the “Afro-Atlantic” space and the involvement of all the country's active forces for the success of the Initiative. We cannot conclude this research without asking pressing questions: how will the current geopolitical and geoeconomic movement marked by many uncertainties shape this Atlantic Africa Initiative project?

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**DIAGNOSTIC ASSESSMENT OF EDUCATION STUDENTS' AREAS OF  
DIFFICULTIES IN STATISTICS AT THE UNIVERSITY OF JOS, PLATEAU  
STATE, NIGERIA**

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**Abstract**

The study used diagnostic assessment to identify errors made by education students in statistics in the faculty of education at the University of Jos. The objectives of the study were to find out the performance profile of students in measures of central tendency in terms of mastery and non-mastery of the objectives covered by the diagnostic test items, identify the errors committed, find out the difference in the errors committed based on departments, and find out the perceived causes of errors and how these errors can be minimised. The study adopted a survey research design. The population comprised 2315 students in 300 level from the 2023/2024 academic session from all the departments in the faculty of education. Taro Yamane formula was used to determine the sample size of 341 students. A statistics diagnostic test and a questionnaire were developed and used for data collection. Cronbach Alpha method was used to estimate the reliability of the instruments and reliability coefficients of 0.92 and 0.88 were obtained. Percentages, mean, standard deviation and ANOVA were used for data analysis. The study revealed that most students make conceptual, computational, and procedural errors. It further revealed that the most common error in research statistics was computational error, followed by procedural and interpretational error, while the least common was conceptual error. It was discovered that students from the physical and health education department have the highest number of errors, followed by art education, special education, and educational foundations. It was recommended that teaching methods that include fewer lectures, more learner-directed classes, and more discussion be used by teachers. Statistics teachers should try to avoid skipping the scheme of work and should relate learners' daily activities to statistics as much as possible.

**Keywords: Statistics, Diagnostic assessment, Error and Students**

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## INTRODUCTION

Diagnostic assessment of students' academic performance is gaining ground in the higher institutions of learning in Nigeria. The difficulties and challenges being faced by the students are usually in disciplines or courses that are quantitatively inclined. Statistics is one of these disciplines. Statistics is the science of the collection, presentation, analysis, and interpretation of numerical data. It is a branch of mathematics that deals with the collection, analysis, interpretation, and presentation of analyzed numerical data (Achor, 2014). Statistics are important in research because they help researchers make sense of large amounts of data, draw conclusions, and make informed decisions. Statistics can also help researchers understand patterns and trends in data, and make predictions about future events (Subhabaha, 2023). Statistics is divided into descriptive and inferential statistics. Descriptive statistics are summary statistics that quantitatively describe or summarise features from a collection of information. It is classified into measures of central tendency and variability (spread). A measure of central tendency describes the center of a data set, while a measure of variability or spread describes the dispersion of data within the set. The measure of variability describes the dispersion of the calculated set of data. Statistics provide crucial guidance in determining what information is reliable and which predictions can be trusted. It often helps search for clues to the solution of a scientific mystery, and sometimes it keeps an investigator from being misled by false impressions. Statistics is unarguably one of the most important and basic courses students have to learn. Statistics is fundamental for both students and researchers in terms of the proper characterization, summarization, presentation, and interpretation of the results of research. Olusegum and Olushina (2013) viewed that the application of statistical knowledge has become imperative in virtually all areas of human endeavour. This is because decisions in many areas of modern society are based on the collection and empirical analysis of data. Generally, students have a phobia of computing and analyzing statistical data. Indeed, this has remained the problem with failing examinations. There has been a trend of poor performance in statistics in the Faculty of Education at the University of Jos. For instance, the first semester results of 300-level students in the Department of Educational Foundations in the 2019/2020 academic session showed that 47.5% passed and 52.5% failed. This dismal performance was worrisome to the Department of Educational Foundations, and since statistics is compulsory for all undergraduate students, quite a number of them have not graduated. Statistics is perceived as a difficult and complex course to learn, and most special education, social science and arts students have a phobia for statistics, unlike science students. The difficulties that are associated with solving statistical problems are described in the words of Antecol and Ozbeklik (2015), who say that learners have difficulties comprehending statistics because of two factors, which are cognitive and non-cognitive. It was further stated that cognitive factors deal with intellectuality such as intelligence and ageing, memory, and the learning process, while non-cognition factors have to do with attitude, perception, interest, expectation, and motivation. Collectively, Antoro Samosir, Kavling, and Indonesia (2015) said that attitudes towards statistics might impact the students' results. Difficulties in understanding or performing well in a statistics course are not only due to cognitive and non-cognitive factors but also to the mode of assessment, which could lead to poor student performance. Assessment is concerned with the processes through which students are evaluated. Assessment is the systematic collection of data to monitor the success of the program or course in achieving the intended learning outcomes. It is the process of documenting, in immeasurable terms, the knowledge, skills, attitudes, and beliefs of the learners. Olusegum and Olushina (2013) This could come in

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different forms, such as formative assessment, summative assessment, diagnostic assessment, confirmative assessment, norm-referenced assessment, criterion-referenced assessment, and impassive assessment. A diagnostic assessment is a pre-evaluation that allows a teacher to determine a student's strengths, weaknesses, knowledge, and skills before instruction. Ketterlin-Cieller and Yaranoff (2009) defined diagnostic assessment as the process adopted to locate and identify students' areas of learning difficulties, weaknesses, and errors in a subject or skill. Diagnostic assessment could be informed or standardized. Informed diagnostic assessment happens spontaneously. For instance, a teacher could call up a few students and ask them to share what they know about a specific course or subject. A standardized diagnostic assessment uses well-defined testing methods to evaluate a student's knowledge and identify any existing gaps. This assessment provides teachers with a more in-depth analysis of a student's learning weaknesses and strengths. It usually occurs when an informed assessment has been achieved. Diagnostic assessment tends to expand the student's knowledge and achievement. Its purpose is to assess the student's prior knowledge in addition to the type of learning problem the student may encounter; such problems can reduce the student's commitment to new learning if not diagnosed. The primary concern of diagnostic assessment is not to find out how much the student scores but to identify his or her areas of difficulty. Therefore, the a need for diagnostic assessment to assess areas students have mastered and areas that have not been mastered and to find out the errors made by the students, the causes of the errors, and how these errors can be minimised. An error is an inaccurate action. Norrish (1987) defined error as a systematic deviation when a learner has not learned something and consistently gets it wrong. It is a systematic deviation from the norms of the content being learned and instances where students hold incorrect concepts as true (Msomi & Bansilal, 2022). In statistics, error refers to the difference between the value that has been computed and the correct value, it is the sum of the deviations of each observation from the true value of a quality of interest. Errors can be classified into three types: procedural, factual, and conceptual. When a student has not followed the correct steps (or processes) to solve a problem, this is a procedural error (Simmons, Nelson & Simonsohn, 2011). Factual errors are mistakes that students make when they cannot recall a fact or formula required to solve a problem or have not mastered some basic facts. The difficulties that students face in statistics are indeed quite worrisome. The difficulties are identified as major problems that usually manifest as errors in calculations. The high rate of failure in statistics could be attributed to the errors that are made by students. Indeed, if a remedy is not proffered to address this problem, it will undermine the purpose for which statistics is being taught as a course. It is on this premise that this study is aimed at analyzing the diagnostic assessment of education students' areas of difficulty in statistics at the University of Jos, Plateau State, Nigeria.

## RESEARCH QUESTIONS

The following research questions were raised to guide the study:

1. What is the performance of students in measures of central tendency in terms of mastering and non-mastering of the objectives covered by the statistics diagnostic test items?
2. What are the errors committed by students in measures of central tendency as measured by the statistics diagnostic test items?
3. What is the difference in the errors committed by students in measures of central tendency based on departments?

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4. What are the causes of errors made by students in measures of central tendency in the university of Jos as measured by the statistics diagnostic test items?
5. How can errors committed by students in measures of central tendency be minimized?
- 6.

## **HYPOTHESIS**

There is no significant difference in the number of errors committed by students in measures of central tendency in the different departments at the University of Jos as measured by diagnostic test items.

## **METHODOLOGY**

The study used diagnostic assessment to identify errors made by 300-level students in statistics in the faculty of education at the University of Jos. The study adopted a survey research design. The study population comprised 2315 students in 300-level from the 2023/2024 academic session from all the departments in the faculty of education. Taro Yamane formula was used to determine the sample size of 341 students. A stratified sampling technique was used to select the students for the study. The stratification was based on departments in the faculty of education at the University of Jos. Within each department, students were divided into non-overlapping groups or categories called strata and a sample was selected using simple random sampling from each group. A Statistics Diagnostic Test (SDT) and a Diagnostic Assessment Questionnaire (DAQ) were used for data collection. The SDT consists of 13 essay items. The items were selected from the content, which includes the meaning of mean, median, and mode, computing the mean, computing median, and computing mode. In constructing the SDT, the researcher prepared a table of specifications to guide the test's development. The steps followed in the development of the DAQ were: identification of the objectives of the study, reading of literature and consultation of experts, generation of items, editing of the items and validation of the questionnaire. The Cronbach Alpha method were used to estimate the reliability of the instruments and reliability coefficients of 0.92 and 0.88 were obtained. Percentages, mean, standard deviation and ANOVA were used for data analysis. The errors committed by students in statistics diagnostic tests were identified and classified into different error patterns (conceptual, computation, procedural, plotting and interpretation errors) based on the various subtests (Mean, Median & Mode).

## **RESULTS**

### **Research Question One**

What is the performance of students in measures of central tendency in terms of mastering and non-mastering of the objectives covered by the diagnostic test items?

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**Table 1: Summary of the Achievement Profile of Students based on Mastery and Non- mastery of MCT Essay Items**

Item	Subtest	Mastery		Non-Mastery		Total	
		N	%	N	%	N	%
1	Mean	21	6.2	320	93.8	341	100
2	Mean	113	33.1	228	66.9	341	100
3	Mean	286	83.9	55	16.1	341	100
4	Mean	105	30.8	236	69.2	341	100
5	Mean	277	81.2	64	18.8	341	100
6	mean	124	36.4	217	63.6	341	100
7	Mean	271	79.5	70	20.5	341	100
8	Mode	291	85.3	50	14.7	341	100
9	Mode	196	57.5	145	42.5	341	100
10	Mode	293	85.9	48	14.1	341	100
11	Median	132	38.7	209	61.3	341	100
12	Median	149	43.7	192	56.3	341	100
13	Median	162	47.5	179	52.5	341	100

Table 1 shows a summary of a profile of mastery and non-mastery attributes for the 13 essay items. The result indicated that 286 (83.9%) of the 341 students have mastery of item 3 (mean), 277 (81.2%) have mastery of item 5 (mean), 271 (79.5%) have mastery of item 7 (mean), 291 (85.3%) have mastery of item 8 (mode), and 293 (87.2%) have mastery of item 10 (mode). This means that the majority of the students possess the necessary skills to perform well in those items. For non-mastery, 320 (93.8%) of the 341 students are classified under non-mastery of item 1 (mean), and 228 (66.9%) students have not mastered item 2 (mean). The majority of the students did not possess the skills needed to pass items on median. Also, Table 1 reveals that 236 (69.2%), 217 (63.6%), 209 (61.3%), 192 (56.3%), and 179 (52.5%) have not mastered items 4, 6, 11, 12, and 13, respectively. This means that more than half of the students do not possess the necessary skills to perform well in mean, mode, and median.

**Research Question Two**

What are the errors committed by students in measures of central tendency as measured by diagnostic test items?

Errors were classified into different patterns of error (conceptual errors, computation errors, procedural errors, and interpretation errors) based on the different subtests (mean, mode, and median). The number of times each identified error was committed by a student was recorded and later added, and a percentage was calculated based on the pattern of errors.

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**Table 2: Errors made by Students in measures of central tendency Diagnostic Test Items**

Subtest	Conceptual		Computation		Procedural		Interpretation		Total %
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	
Mean	312	8.6	2113	58.2	1105	30.4	103	2.8	3633(100)
Mode	250	13.1	892	46.7	673	35.2	96	5	1911(100)
Median	321	11.8	1203	44.3	1001	36.8	192	7.1	2717(100)
Total	883	10.7	4208	50.9	2779	33.7	391	4.7	8261(100)

The result in Table 2 reveals the most common errors made by students in measures of central tendency. diagnostic test was computation error with 50.9%, while procedural, conceptual, and interpretation errors had 33.7%, 10.7%, and 4.7%, respectively. On errors made by students in mean, Table 4 shows that computation errors are the most common with a frequency of 2113 (58.2%), closely followed by procedural errors at 1105 (30.4%), then conceptual errors at 312 (8.6%) in that order, and interpretation errors at 2.8%. This implies that the most common error made by students was a computation error and the least was an interpretation error. The result went further to present the frequency of errors committed by students in moderation. From the table, it was observed that 892 (46.7%) errors were computational errors, 673 (35.2%) procedural errors, 250 (13.1%) conceptual errors, and 96 (5%) interpretation errors in that order. This shows that the most common error in mode was computation error and the least was interpretation error. Lastly, the errors committed by students in the median, as indicated in Table 4, are conceptual errors, computation errors, procedural errors, and interpretation errors. However, the most common error was computation error with a frequency of 1203 (44.3%), while procedural error had a frequency of 1001 (36.8%), conceptual error had a frequency of 321 (11.8%), and interpretation error had a frequency of 192 (7.1). This shows that the most common error was a computational error, and the least common was an interpretation error. Generally, it was found that the most common error was computation error (37%), followed by conceptual error and then procedural error, while the least common was interpretation error.

**Research Question Three**

What is the difference in the errors committed by students in measures of central tendency based on departments?



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**Table 3 : Difference in the Errors Committed by Students in Measures of Central Tendency based on Departments**

<b>Department</b>	<b>N</b>	<b>Mean</b>	<b>Std. Deviation</b>
Special Education	43	23.26	8.819
Educational Foundations	77	22.44	7.308
Science Education	113	23.26	8.507
Arts Education	48	24.24	6.720
Social Science Education	47	23.19	7.586
Physical and Health Education	13	27.69	8.845
Total	341	23.36	7.969

Table 3 shows the difference in errors committed by faculty of education students based on departments. From the results, the department of special education has a mean score of 23.26 with a standard deviation of 8.82, and educational foundations has a mean score of 22.44 with a standard deviation of 7.31. Also, science education, arts education, social science education, and physical and health education have mean scores of 23.26, 24.24, 23.19, and 27.36, respectively. It means that physical and health education has the highest mean score, indicating a higher number of errors, followed by arts education, then special education, and educational foundations.

**Research Question Four**

What are the causes of errors made by students in measures of central tendency in the university of Jos as measured by diagnostic test items?

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**Table 4: The Responses of Students on the Causes of Errors made by Students in Measures of Central Tendency**

S/N	ITEMS	SA 5	A 4	U 3	D 2	SD 1	N	Mean	Std	DECISION
1	The unfriendly nature of some teachers makes students not to voice out their thought.	120	170		51	-	341	4.05	.98	Agree
2	Wrong application of calculation rules	144	137	-	60	-	341	4.07	1.07	Agree
3	Poor background in Basic mathematics at the secondary school level	138	144	-	40	19	341	3.99	1.18	Agree
4	inability of students to master the topics	134	128	-	51	28	341	3.83	1.31	Agree
5	Number of hours allocated to subject are not enough	122	144	-	72	3	341	3.89	1.13	Agree
6	The belief that anything calculation is difficult,	154	128	-	59	-	341	4.09	1.07	Agree
7	Students forget the procedures taught due to lack of practicing.	128	118	-	95	-	341	3.81	1.22	Agree
8	Some students do not read instructions during examinations.	144	110	-	87	-	341	3.91	1.21	Agree
9	Students lack of concentration in class	150	124	-	39	28	341	3.95	1.28	Agree
10	Poor teaching of key concepts by teachers	80	20	114	118	9	341	3.12	1.21	Agree

Table 4 shows the result of the analysis of the causes of errors made by students in the faculty of education. The result reveals that all the items have mean scores above the criterion mean of 3.00, indicating that the causes of errors in MCT are the unfriendly nature of some teachers,

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which makes students not voice out their thoughts, the wrong application of calculation rules, a poor background in basic mathematics at the secondary school level, the inability of students to master the topics, the fact that the number of hours allocated to each subject is not enough, the belief that any calculation is difficult, Students forget the procedures taught due to a lack of practice. Some students do not read instructions during examinations, and students' lack of concentration in class can lead to errors.

**Research Question Five**

How can errors committed by students in measures of central tendency be minimized?

**Table 5: Responses of Students on the Possible Solutions to Causes of Errors made by Students in MCT**

S/N	ITEMS	SA 5	A 4	U 3	D 2	SD 1	N	X	Std	DECISION
1	Teachers should teach key concepts before starting a lesson and should start from simple to complex	126	206	-	9	-	341	4.30	.612	Agree
2	students should find time to read and practice what have been taught at home	150	128	--	40	23	341	3.99	1.24	Agree
3	Students should think positively toward calculation	138	124	-	60	19	341	3.87	1.27	Agree
4	students should read and understand instruction during examinations	128	118	44	51	-	341	3.95	1.06	Agree
5	teacher should teach only the topics they are specialized in, for effective mastery of content areas	116	170	-	52	3	341	4.01	1.03	Agree
6	Teachers should vary their teaching methods	154	104	-	83	-	341	3.95	1.19	Agree
7	Teacher should motivate their students through giving prizes and being friendly with them	149	110	-	82	-	341	3.96	1.19	Agree

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Table 5 shows the result of the analysis on the possible solutions to the causes of errors made by faculty of education students in MCT. The result reveals that all the items have mean scores above the criterion mean of 3.00, indicating that the possible solutions to the causes of errors are that teachers should teach key concepts before starting a new lesson and should start from simple to complex; students should find time to read and practice what has been taught at home; students should think positively toward calculation; teachers should teach only the subjects they are specialized in for effective mastery of content areas; teachers should vary their teaching methods; and teachers should motivate their students through giving prizes and being friendly with them.

## Hypothesis

There is no significant difference in the number of errors committed by students' in measures of central tendency in the different departments in Faculty of Education, university of Jos as measured by the statistics diagnostic test items.

**Table 6: ANOVA Result on the Difference in the Number of Errors Committed by Students in MCT based on Departments**

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	344.333	5	68.867	1.086	.368
Within Groups	20868.395	335	63.430		
Total	21212.728	340			

Table 6 shows the ANOVA result on the significant difference in the number of errors committed by students in measures of central tendency in the different departments in the Faculty of Education, University of Jos, as measured by statistics diagnostic test items. The result yielded  $F(5,335) = 1.09$ ,  $P > 0.05$ , and since the p-value of 0.368 is greater than the 0.05 level of significance, the null hypothesis was retained. It was concluded that there is no significant difference in the errors made by students in MCT, in the faculty of education based on departments.

## 4.1 DISCUSSION

The findings on the achievement profiles of students in terms of mastery and non-mastery of the skills covered by Measures of Central Tendency diagnostic test items revealed that students show higher mastery of three items that measure attributes in mean, three items in mode and non in median. This contradicts the Chief Examiners' Report (WAEC and NECO, 2010, 2013, and 2018) and Bulus (2018), which state that students have weaknesses in items that measure attributes in median. It further revealed that students show low mastery of four items that measure attributes in mean and all the three items which measured skills in median.

The findings on errors in the Measures of Central Tendency Diagnostic Test (MCTDT) showed that errors were classified into error patterns, which include conceptual, procedural, computation, and interpretation errors. The result showed the most common errors to be computation and procedural errors. This implies that students lack conceptual and computation skills, which are in line with the findings of Hansen (2006), Aderomu and Nte (2012), and

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Bulus (2018) that computation, conceptual, and procedural errors are the most common errors made by students. This is contrary to the findings of Omosewo and Akanbi (2013), who found operational errors, algorithm errors, and communication errors to be the most common errors in their studies on errors committed by students in physics. This could be a result of poor teaching of key concepts by teachers, prior knowledge students come into the class with, a lack of preparedness, a lack of concentration on the part of students, a lack of practicing, the unfriendly nature of some teachers, and poor assessment techniques, among others.

Again, the findings on the causes of errors made by students in MCT indicated that the causes of errors are the unfriendly nature of some teachers, which makes students not voice out their thoughts; poor background in basic mathematics at the school level; inability of students to master the topics; the number of hours allocated to the course is not enough; the belief that any calculation is difficult; students forget the procedures taught due to a lack of practice; some students do not read instructions during examinations; and a lack of concentration on the part of students can lead to errors. This is in line with the work of Bulus (2018) and Abok (2022), who found errors to be caused by teachers' poor knowledge of the subject matter, not teaching concepts before starting new lessons, and a lack of practicing at home after school hours.

The findings on possible solutions to causes of errors made by secondary school students in quantitative economics indicate that the possible solutions to the causes of errors are that teachers should teach key concepts before starting a new lesson and should start from simple to complex, students should find time to read and practice what has been taught at home, Students should think positively toward calculation; teachers should teach only the subjects they are specialized in for effective mastery of content areas; and teachers should motivate their students through giving prizes and being friendly with them.

Furthermore, the findings on the differences in the errors made by students in MCT based on departments revealed that PHE students make more errors in the faculty of education, followed by arts education, special education, and science education; the least is educational foundations students and that there is no significant difference in the errors made by faculty of education students in MCT at the University of Jos. This confirms the findings of Ndifon, Umoinyang, and Ndiku (2015) and Bulus (2018), who found items to function differently among students in their studies on the differential item functioning of economic and mathematical items.

## CONCLUSION

From the findings of the study, it is clear that students do not have a good understanding of statistics. This means that more than half of the students do not possess the necessary skills to perform well in measures of central tendency. The findings further show the results of the causes of errors made by students in the faculty of education and how these errors can be minimized. They also reveal that there is no significant difference in the errors committed by students in MCT in the faculty of education based on different departments.

## RECOMMENDATIONS

The following recommendations are drawn based on the findings of the study:

1. There is a need for more emphasis on teaching methods that include less lecture, more learner-directed classes, and more discussion in the classroom.
2. Incorrect responses from the learners must be handled in a positive way to encourage their participation and enhance their confidence to be active instead of passive learners.

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3. that lecturers should teach key concepts before starting a new lesson and should start from simple to complex,
4. The learners should work hard and know that statistics is for everybody and can be learned through constant practice.

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**KURŞUN (II)'NİN ERGANİ CEVİZİ KABUĞU İLE ADSORPSİYON KİNETİĞİNİN  
İNCELENMESİ**

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**Özet**

Dünyamız daha önce hiç olmadığı kadar kirlenmiş durumdadır. Ülkeler arası kalkınma yarışı, tüketim alışkanlıkları derken geldiğimiz nokta, dünyanın sonuna ramak kalmış olmasıdır. Kurşun, başta atmosfer olmak üzere toprak ve suları kirleten bir ağır metaldir. Canlı ve cansız doğaya zarar veren bu elementi gidermek için çeşitli yöntemler kullanılmaktadır. Adsorpsiyon, alternatif seçenek olarak karşımıza çıkmaktadır. Adsorpsiyon hızı etkin bir adsorpsiyonun temel taşlarından. Mekanizmasının anlaşılması doğayı anlamamıza fayda sağlamaktadır. Biyoadsorplayıcılar ucuz, kolay bulunabilmeleri ve çevre dostu olmaları nedeniyle son yıllarda üzerinde çok çalışma yapılan malzemelerdir. Bu çalışmada Kurşun (II)'nin Türkiye'nin Diyarbakır iline bağlı Ergani ilçesinden elde edilen cevizin kabuğu ile adsorpsiyonu sonucu elde edilen kinetik veriler modellendi. Çalışma 303, 313 ve 323 K sıcaklığında gerçekleştirildi. Regresyon analizi en küçük kareler yöntemine göre çalışmada, deneysel verilerin izoterm modellerine uyum sırası Elovich < Partiküller Arası Difüzyon Modeli (Weber-Morris) < Yalancı-İkinci dereceli Kinetik Model olarak belirlendi.  $R^2$  değeri 0,9555, 0,9870 ve 0,9581 olarak belirlendi.  $q_e$  değerleri 8,143, 8,375 ve 8,373 mgg-1 olarak belirlendi.  $k_2$  değerleri 0,0091, 0,0062 ve 0,0373 olarak bulundu. Sonuçlar Ergani cevzine ait kabuğun adsorplayıcı olarak kullanılabileceğini gösterdi.

**Anahtar Kelimeler:** Yalancı-İkinci Dereceli Kinetik Model, Adsorpsiyon Kinetiği, Kurşun, Ceviz, Biyoadsorplayıcı.

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**Abstract**

Our world is polluted like never before. The point we have reached with the development race between countries and consumption habits is that the world is on the verge of ending. Lead is a heavy metal that pollutes the atmosphere, soil and water. Various methods are used to remove this element that harms living and non-living nature. Adsorption is an alternative option. Adsorption speed is one of the cornerstones of effective adsorption. Understanding its mechanism helps us understand nature. Bioadsorbents are materials that have been studied a lot in recent years because they are cheap, easily available and environmentally friendly. In this study, the kinetic data obtained from the adsorption of Lead (II) with walnut shells obtained from Ergani district of Diyarbakır province, Turkey were modeled. The study was carried out at 303, 313 and 323 K. In the study, according to the least squares method of regression analysis, the order of fit of the experimental data to the isotherm models was determined as Elovich < Interparticle Diffusion Model (Weber-Morris) < Pseudo-Second-order Kinetic Model. R<sup>2</sup> values were determined as 0.9555, 0.9870 and 0.9581. q<sub>e</sub> values were determined as 8.143, 8.375 and 8.373 mgg<sup>-1</sup>. k<sub>2</sub> values were found as 0.0091, 0.0062 and 0.0373. The results showed that Ergani walnut shell can be used as adsorbent.

**Keywords:** Pseudo-Second Order Kinetic Model, Adsorption Kinetics, Lead, Walnut, Bioadsorbent.

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## Giriş

Günümüzde, çevreye karşı olan duyarsızlık, volkanik olaylar, aşırı fosil yakıt tüketimi, eksoz gazları, atık sular, tarım alanlarında kullanılan ilaçlar ve gübreler, maden yatakları gibi etmenler hem toprak ve su kaynakları üzerinde hem de tüm canlılarda olumsuz etkiye neden olan ağır metal kirliliğine yol açmaktadırlar (Yerli, Çakmakçı, Şahin, & Tüfenkçi, 2020). Ağır metaller aşırı toksik ve yüksek yoğunluklu olduklarından çok düşük konsantrasyonlar da dahi zehirleyici etkileri oluşabilmektedir. Amerika Birleşik Devletleri Koruma ajansı verilerine göre 2011 yılında yayınlamış olduğu listeye göre; 650 tane toksik etkili ve kirletici kimyasal içerisinde 129 tanesinin öncelikli kirleticiler olduğu yönündedir (Batır, 2014). Kurşun en çok kullanılan elementlerden biri olmakla beraber, insanların faaliyetleri sonucunda da doğaya zarar veren son derece önemli ağır metallerden biridir. Bunun dışında, bazı ağır metaller düşük dozlarda bitkiler için oldukça önemli mikro elementler olarak ifade edilmektedirler (Okçu, Tozlu, Kumlay, & Pehlivan, 2009). Bu ağır metallerin sucul ortamlardan giderimi için pek çok yöntem mevcuttur. Bu yöntemlerden biri de adsorpsiyondur. Adsorpsiyon prosesi farklı fazlarda bulunan sıvı veya gaz moleküllerinin katı veya sıvı halde bulunan maddelerin yüzeyine tutunması olarak tanımlanmaktadır. Adsorpsiyon uygun adsorplayıcılar sayesinde hem düşük maliyetli hem de kolay uygulanabilir olmaları nedeniyle son derece tercih sebebidir. (Altunkaynak & Canpolat, 2022), (Dal, Onursal, Arıca, & Yavuz, 2021). Bu adsorbanlar arasında tarımsal atık malzemeler ön plana çıkmaktadır. Bunlar arasında; fındık, pirinç, badem, fıstık, nar, muz, kestane, ceviz kabuğu sayılabilir. Bu çalışmada ceviz kabuğu adsorplayıcı olarak kullanılacaktır. Cevizler Kuzey Afrika, Asya ve Avrupa'da yaygın olarak bulunan, basit ifadeyle ceviz ağacı olarak tabir edilen Juglans Regia L olarak bilinen bir ağaçtan üretilmektedir (Albatrni, Qiblawey, & J. Al-Marri, 2022).

## Ağır Metaller

Açık renk ve metalik özelliğe sahip tüm elementlere verilen isimdir. Ağır metaller için fiziksel olarak yapılan tanım  $5 \text{ g/cm}^3$  'den büyük özgül ağırlığa ve 20'den büyük atom numarasına sahip metaller olarak ifade edilmektedirler. Ancak biyolojik olarak ise, çevre üzerinde kirlilik oluşturan ve toksisite etkisi oldukça yüksek olan kirleticilere verilen isimdir (Duffus, 2002). Bu metaller geçiş elementleri olarak periyodik cetvelde oldukça geniş yer tutmaktadırlar. Ağır metallerin sayısı 60-70 arasında olup; Kurşun, bakır, kadmiyum, nikel, kobalt, demir ve mangan bunlardan bazılarıdır (Onursal, Dal, Kul, & Yavuz, 2020).

## Ceviz Kabuğu

Ceviz üretimi 2019 verilerine göre küresel ölçekte 3,7 milyon tondan fazladır. En büyük üretici olarak Çin yılda 1,06 milyon ton ile liderdir. İkinci sırada İse 600 ton ile ABD akabinde 405 tonluk üretimle İran gelmektedir. Ceviz içinin ağırlığı toplam ağırlığın %67'si kadardır. Bu da demektir ki cevizin %33'lük kabuk kısmı birçok alanda kullanılabilir.

## Adsorpsiyon Kinetik Modelleri

Adsorpsiyon kinetik modelleri hem adsorpsiyon mekanizmasını hem de hızını daha iyi modellemek ve açıklamak için tasarlanmış modellerdir. Bu modellere uyarlanmış adsorpsiyondaki çözeltiden katı maddenin alım hızı hesaplanabilir (Dalaran, 2009).

Adsorpsiyon kinetiğinin anlaşılması açısından deneysel çalışmadan elde edilen veriler; Pseudo Second – Order (Ho-Mac Kay), Elovich, ve Weber-Morris (parçacık içi difüzyon) kinetik modellerine uygulanmıştır.

***Pseudo - Second Order Kinetik Modeli***

Bu model Ho tarafından 1995 yılında geliştirilmiş olup, bu denklemden hızın adsorbat konsantrasyonundan bağımsız olarak katı fazdaki adsorpsiyon kapasitesine ve zamana bağlı olduğu ifade edilmiştir. Bu modele ait denklem aşağıdaki gibidir. ( Balcı & Erkurt, 2015).

$$\frac{t}{q_e} = \frac{t}{q_e} + \frac{1}{k^2 q_e^2}$$

Burada  $k_2$ , Yalancı ikinci dereceden adsorpsiyonun hız sabitidir (g/mg.dk)

***Elovich Kinetik Modeli***

Elovich kinetik modelinde temel amaç, katı yüzeyler üzerine çeşitli inorganik adsorplayıcıların adsorpsiyon hem adsorpsiyon hem de desorpsiyon kinetiklerini belirlemektir. Bu modele ait lineer bağıntı aşağıda verildiği şekildedir (Sparks, 2002).

$$q_t = \frac{1}{\beta} \ln(\alpha\beta) \frac{1}{\beta} \ln t$$

Bu bağıntıdaki  $\alpha$ , adsorpsiyon hızını  $\text{mg} \cdot (\text{gmin}^{-1})$ ,  $\beta$  ( $\text{gmg}^{-1}$ ) kimyasal sorpsiyon için aktivasyon enerjisini ve yüzey kapsamayı genişletmek ile ilgili sabitlerdir.

***Parçacık İçi Difüzyon (Weber-Morris) Kinetik Modeli***

Adsorpsiyon prosesinde  $q_t$  · nin  $\sqrt{t}$ ' ye karşı grafiğe geçirilmesi ile parçacık içi difüzyonun etkisi tespit edilebilmektedir. Burada hız sabiti eğimden bulunmaktadır. Bu modele ait bağıntı ise aşağıda verilmiştir (Waranusantigul, Pokethitiyook, Kruatrachue, & Upatham, 2003).

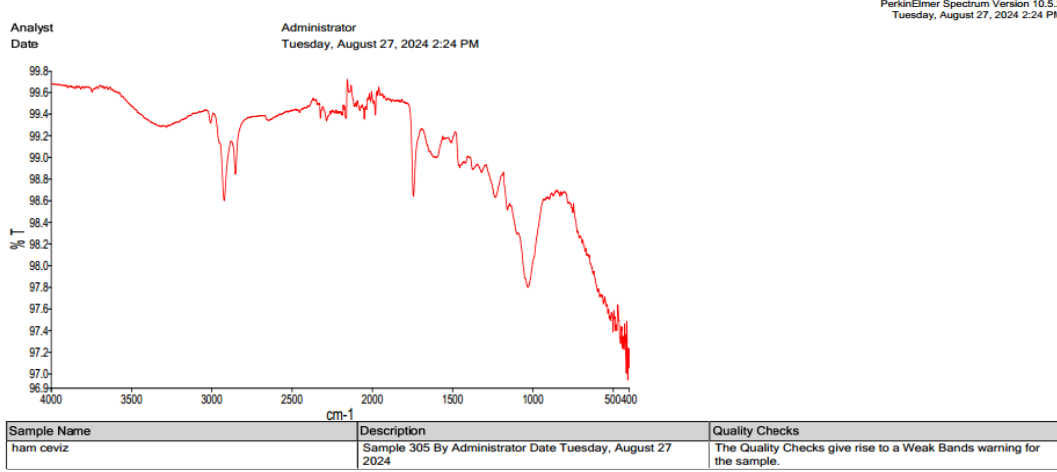
$$q_t = k_i \sqrt{t} + C$$

Bağıntıda verilen;  $q_t$  : t zamanında birim adsorbent üzerine adsorplanan madde miktarını ( $\text{mgg}^{-1}$ ), t: zamanı (dk)  $k_i$ : Parçacık içi difüzyon hız sabitini ( $\text{mg} (\text{g dk}^{1/2})^{-1}$ ) ifade etmektedir.

***Materyal ve Yöntem***

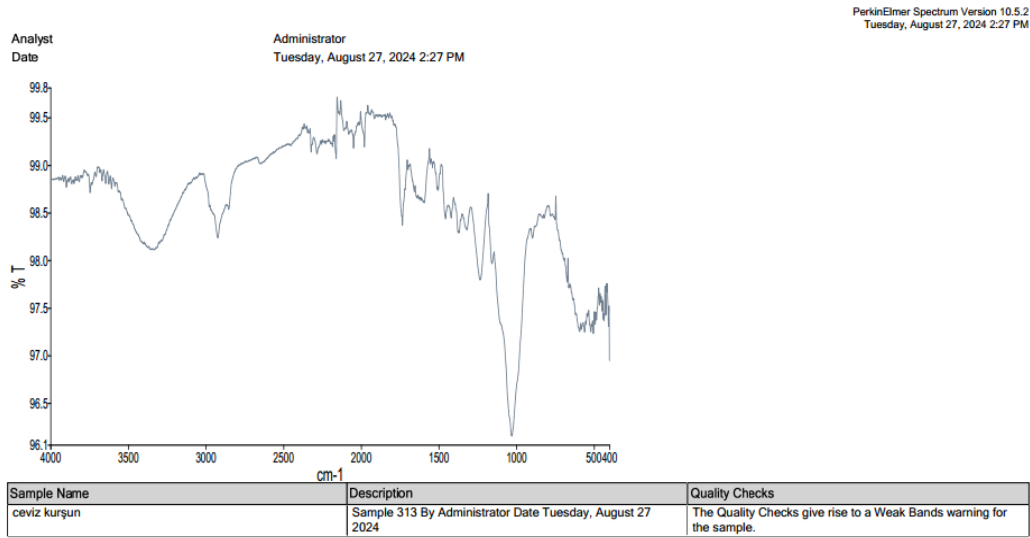
Diyarbakır ili Ergani ilçesine bağlı Gözekaya (Ayneto) köyünden temin edilen cevizler, önce yıkanıp kurutulduktan sonra kabukları çıkartılmıştır. Kurutulan numune Three Beans marka öğütücüde öğütülüp kullanıma hazır hale getirilmiştir. 303,313 ve 323 K sıcaklıklarında yapılan ön çalışmalar sonucu adsorpsiyon süresinin 4 saat olarak uygulanmasına karar verilmiştir. Deneylerden elde edilen; Pseudo Second – Order (Ho-Mac Kay), Elovich, ve Weber-Morris (parçacık içi difüzyon) kinetik modellerine uygulanmıştır.

## Bulgular FT-IR Analizi



Şekil 1. Doğal cevize ait FT-IR diyagramı

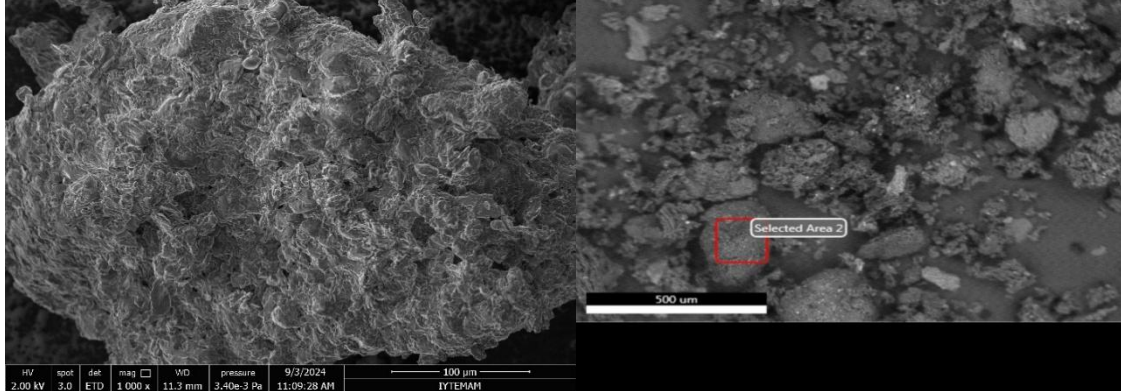
Diyagramdaki  $1700\text{ cm}^{-1}$  civarındaki kuvvetli pik tipik C=O bağı göstermektedir,  $2990$  ile  $2850\text{ cm}^{-1}$  arasındaki kuvvetli iki pik ise C-H tekli bağı göstermektedir. En sağdaki  $100\text{ cm}^{-1}$  civarındaki pik ise parmak izi bölgesi olarak bilinen bölgede bulunmaktadır. Bu bölge genellikle çok bant göstermekte olup sıklıkla birbirleriyle örtüşen karmaşık alandır



Şekil 2. Kurşun ile muamele edilmiş cevize ait FT-IR diyagramı

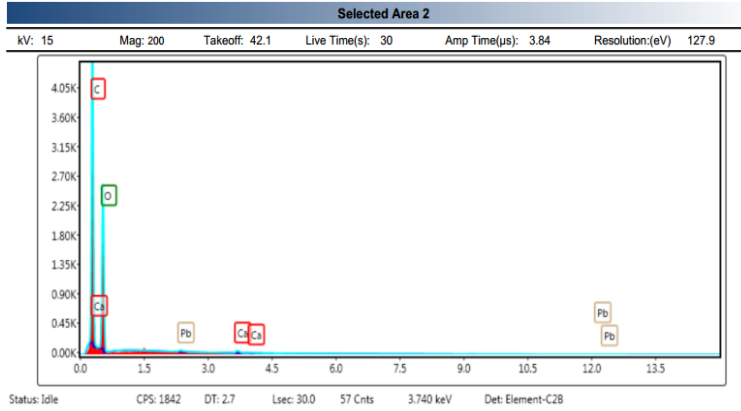
Diyagramda  $3400\text{ cm}^{-1}$  dalga sayısı civarında bulunan pik O-H varlığını gösterir.  $2900\text{ cm}^{-1}$  dolaylarında bulunan kuvvetli pik tipik C=O bağı göstermektedir.  $1250$  ve  $1050\text{ cm}^{-1}$  dalga sayısındaki pikler parmak izi bölgesine ait karmaşık yapıdaki piklere tekabül etmektedir.

### SEM-EDAX Analizi



Şekil 3. (a) Ham ceviz kabuğuna ait SEM görüntüsü

(b) Kurşun ile işlem görmüş ceviz kabuğu SEM görüntüsü



### eZAF Smart Quant Results

Element	Weight %	Atomic %	Net Int.
C K	48.94	56.77	807.03
O K	49.11	42.77	476.09
PbM	0.76	0.05	6.74
CaK	1.18	0.41	11.99

Şekil 4. SEM'e ait Edax diyagramı ile veri tablosu

Adsorpsiyon sonrası yapılan SEM analizine göre; adsorplayıcı olarak kullanılan ceviz kabuğunun dağınık irili ufaklı amorf yapıda olduğu görülmektedir. 1 adet kurşun piki EDAX grafiğinde görülmektedir. Yüzde olarak kurşun oranı toplam kütleinin 0,76'sının kurşun elementi olduğu görülmektedir.

### BET Analizi

BET analizinde elde edilen veriler ışığında BET yüzey alanının 0.8119 m<sup>2</sup>/g olduğu, tek noktadan gözenek hacminin ise 6.10<sup>-4</sup> m<sup>3</sup>/g gram olduğu ayrıca ortalama gözenek çapının (ebatının) 29. 5577 10<sup>-8</sup> cm olduğu tespit edilmiştir.

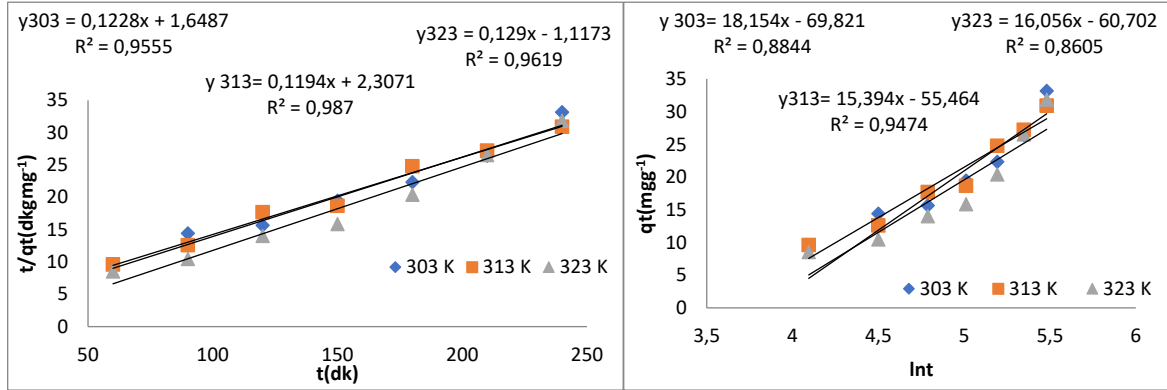
### Deneysel Çalışmalar

#### *Pb (II)'nin Ceviz kabuğu üzerine Kinetik Çalışmaları*

Ceviz kabuğunun kurşun adsorpsiyonuna sürenin ve sıcaklığın etkisi incelendi veriler şekil ve tablolarda da verildiği gibidir.

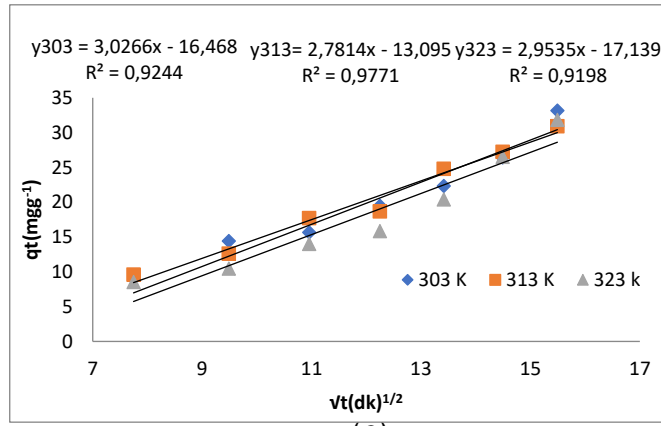
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(a)

(b)



(c)

Şekil 5. 303, 313 ve 323 K'deki Pb (II)' nin Ceviz kabuğu üzerindeki (a) PSO, (b) Elovich ve (c) Weber-Morris grafikleri.

Table 1. Pb (II) iyonlarının Ceviz kabuğu üzerindeki adsorpsiyon Kinetik verileri

Sıcaklık K	PSO			Elovich			Weber-Morris		
	$q_e$	$K_2$	$R^2$	$\alpha$	$\beta$	$R^2$	$K_{WM}$	C	$R^2$
303 K	8,143322	0,009147	0,9555	0,02136	18,154	0,8844	3,0266	-16,468	0,9244
313 K	8,375209	0,006179	0,987	0,02724	15,394	0,9474	2,7814	-13,095	0,9771
323 K	8,873114	0,037324	0,9581	0,02281	16,056	0,8605	2,9535	-17,139	0,9198

### Tartışma ve Sonuç

Ağır metaller içerisinde kurşun metalinin özgün biryeri vardır. Verdiği ciddi zararlar nedeni ile bu metali çevreden uzaklaştırmak çevreye insan sağlığı açısından hayati önem taşımaktadır. Kurşun giderimi konusunda çeşitli yöntemler kullanılmakla beraber, adsorpsiyon yöntemi araştırmacılar tarafından rağbet gösterilmektedir.

Adsorplanan ile adsorplayıcı arasındaki ilişkiyi belirlediği için adsorplayıcının nitelikleri

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önemlidir. Biyoadsorplayıcılar çevre dostu olmaları, adsorptiv özellikleri, ucuz olmaları, kolay ve bol bulunmaları nedeniyle araştırmacılar tarafından artan şekilde rağbet görmektedir.

Bu çalışmada Kurşun (II) iyonunun ceviz ile adsorpsiyonu araştırıldı. Adsorplayıcı olarak Türkiye'nin Diyarbakır iline bağlı Ergani ilçesinden elde edilen cevizin kabuğu kullanıldı. Çalışma 303313 ve 323 K olmak üzere 3 sıcaklıkta çalkalayıcılı su banyosu ortamında gerçekleştirildi.

Regresyon analizi en küçük kareler yöntemine göre çalışmada, deneysel verilerin izoterm modellerine uyum sırası Elovich < Partiküller Arası Difüzyon Modeli (Weber-Morris) < Yalancı-İkinci dereceli Kinetik Model olarak belirlendi.  $R^2$  değeri 0,9555, 0,9870 ve 0,9581 olarak belirlendi.  $q_e$  değerleri 8,143, 8,375 ve 8,373  $mgg^{-1}$  olarak belirlendi. Sonuçlar  $q_e$  değerlerinin sıcaklıktan az etkilendiği yönündedir.  $k_2$  değerleri 0,0091, 0,0062 ve 0,0373 olarak bulundu. Sonuçlar Ergani cevizine ait kabuğun adsorplayıcı olarak kullanılabileceğini gösterdi.



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KURŞUN (II)'NİN ERGANİ CEVİZİ KABUĞU İLE ADSORPSİYON  
İZOTERMLERİNİN KARŞILAŞTIRMALI ANALİZİ

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**Özet**

Biyoadsorplayıcılar ucuz, kolay bulunabilmeleri ve çevre dostu olmaları nedeniyle son yıllarda üzerinde çok çalışma yapılan malzemelerdir. Kurşun metali dünyamızı kirleten ağırmetallerin başında gelmektedir. Zararlarının azaltılması, ancak çevreden giderilmesi ile mümkündür. Bu çalışmada Kurşun (II)'nin Türkiye'nin Diyarbakır iline bağlı Ergani ilçesinden elde edilen Biyoadsorplayıcılar ucuz, kolay bulunabilmeleri ve çevre dostu olmaları nedeniyle son yıllarda üzerinde çok çalışma yapılan malzemelerdir. Kurşun metali dünyamızı kirleten ağır metallerin başında gelmektedir. Zararlarının azaltılması, ancak çevreden giderilmesi ile mümkündür. Bu çalışmada Kurşun (II)'nin Türkiye'nin Diyarbakır iline bağlı Ergani ilçesinden elde edilen cevizin kabuğu ile adsorpsiyonu sonucu elde edilen izotermler modellendi. Çalışma 303 K sıcaklığında gerçekleştirildi. Regresyon analizi en küçük kareler yöntemine göre çalışmada, deneysel verilerin izoterm modellerine uyum sırası Harkins-Jura-Oursal-Dal (HJOD) > Temkin > Freundlich > Harkins-Jura (HJ) > Elovich > Langmuir. En yüksek uyumu 0,9922 R<sup>2</sup> değeri ile HJOD izoterm modeli gösterdi. HJOD ve Elovich izoterm modelleri güven seviyesi içinde (p<0.05) kaldı. q<sub>max</sub> değeri Elovich modeli baz alınarak 5,8106 mgg<sup>-1</sup> olarak belirlendi. Sonuçlar Ergani cevzine ait kabuğun adsorplayıcı olarak kullanılabileceğini gösterdi.

**Anahtar Kelimeler:** Adsorpsiyon, Kurşun, Ceviz Kabuğu, Adsorpsiyon İzotermleri, Harkins-Jura-Onursal-Dal İzoterm Modeli, HJOD İzoterm Modeli.

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**COMPARATIVE ANALYSIS OF ADSORPTION ISOTHERMS OF LEAD (II) WITH  
PURPLE NUT SHELL**

**Abstract**

Bioadsorbents are materials that have been studied a lot in recent years because they are cheap, easily available and environmentally friendly. Lead metal is one of the main heavy metals that pollute our world. Reducing its harms is only possible by removing it from the environment. In this study, isotherms obtained as a result of the adsorption of Lead (II) with walnut shells obtained from Ergani district of Diyarbakır province in Turkey were modeled. The study was carried out at 303 K. In the study according to the least squares method of regression analysis, the order of fit of the experimental data to the isotherm models was Harkins-Jura-Oursal-Dal (HJOD) > Temkin > Freundlich > Harkins-Jura (HJ) > Elovich > Langmuir. The HJOD isotherm model showed the highest fit with an R<sup>2</sup> value of 0.9922. HJOD and Elovich isotherm models remained within the confidence level ( $p < 0.05$ ). The  $q_{max}$  value was determined as 5.8106 mgg<sup>-1</sup> based on the Elovich model. The results showed that the shell of Ergani walnut can be used as an adsorbent. **Keywords:** Adsorption, Lead, Walnut Shell, Adsorption Isotherms, Harkins-Jura-Onursal-Dal Isotherm Model, HJOD Isotherm Model.

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## Giriş

Boya ve ağır metal iyonları gibi bazı kirleticilerle çevre ve su kirliliği giderek artmaktadır (Teimouri, Nasab, Habibollahi, Fazel-Najafabadi, & Chermahini, 2015.). Bunları ortadan kaldırmak için acil ve çok etkili çözümlere ihtiyaç en büyük sorunlarımız arasındadır. (Kalantar & Ghanavati Nasab, 2022). Bu kirleticilerin canlı organizmalar üzerindeki zararlı etkileri, sistein glutatyon ve homosistein gibi biyomoleküllerle seçici olarak etkileşime girerek bağlandıklarında, enzimlerin aktivitesini, protein sentezini ve metabolizmayı bozdukları zaman ortaya çıkmaktadır (Sadat Kiamarzi, Abrishamkar , & Maleki, Afsaneh, 2023). Bazı adsorbanların özellikle tarımsal bazlı olması tercih nedenidir. Bu adsorbanlara ilgi artmakta ve özellikle adsorpsiyon alanında ve su arıtma endüstrisinde yoğun şekilde kullanılmaktadır (Safinejad, Arab Chamjangali, Goudarzi, & Bagherian, 2017). Buna bağlı olarak eşsiz fiziko-kimyasal özellikleri ağır metal iyonlarından tutun organik bileşiklere kadar çok çeşitli bileşenlere karşı, yüksek afiniteleri nedeniyle yeni nesil adsorbanlar olarak yaygın bir şekilde araştırılmaya başlanmışlardır. Tarımsal bazlı adsorplayıcılar, yenilenemeyen ve maliyeti yüksek olan petrol kalıntıları, kömür ve polimerlerin aksine hem daha ucuz hem de yenilenebilmektedirler. Çeşitli tarımsal atıklar arasında, fındık, fıstık, badem, muz, portakal ve ceviz kabukları hem ham olarak hem de aktif karbon öncüsü olarak oldukça büyük potansiyele sahiptirler ( Albatrni, Qiblawey, & J. Al-Marri, 2022).

Ayrıca atık suların ağır metallerin uzaklaştırılması, biyolojik olarak parçalanamaması oldukça düşük konsantrasyonlarda dahi ciddi toksisiteye sahip olması nedeniyle giderek artan önem kazanmıştır ( Mansoor, Kazem , & Sanaz , 2015). Suyun kurşun ile kirlenmesinin en temel nedenleri arasında, işleme endüstrisi, elektro kaplamacılık, pil imalatı, mühimmat ve tetraetil kurşun imalatı, çevre temizleme hizmetleri ile seramik ve cam endüstrisi sayılabilir (Rais & Shaziya , 2015), ( Qian, Zeng, Xue, & Guo, 2015). Kurşun, oldukça yoğun bir zehirdir ve canlı organizmalar üzerinde son derece ciddi zararlarıyla fizyolojik etkilere neden olabilmektedir (Leandro , Rossimiriam, & Laurent , 2008). Özellikle kurşun tehlikelerine maruz kalan çocuklarda zihinsel geriliğe ve öğrenme güçlüklerine neden olabilir (Flora, Gupta , & Tiwari , 2012). Bunun dışında kurşunun, vücut fonksiyonlarına müdahale ederek merkezi sinir sistemi, hepatik, kardiyovasküler ve böbrek sistemlerini etkileyerek ciddi bozukluklara neden olduğu bilinmektedir (Rahman & Haseen, 2014). Endüstriyel ve belediye atık sularından ağır metal ve özellikle kurşun giderimi için etkili olan bazı metodolojiler, iyon değişimi, elektro kaplamacılık, kimyasal çökeltme, membran filtrasyonu, çimentolama, ters ozmoz ve adsorpsiyon şeklinde sıralanabilir (Altunkaynak, Canpolat, & Yavuz, 2021), ( Liu, Bai , & San Ly, 2008), (Wong, Lee, Low, & Haron, 2003),

## Ağır Metaller

Ağır metaller, toksik olmaları, atmosferde uzun süre kalmaları ve biyolojik açıdan birikimleri vasıtasıyla insan vücudunda birikme yetenekleri sebebiyle en iyi çevre kirleticileri arasında sayılmaktadırlar (Mitra, ve diğerleri, 2022). Bunların üretim faaliyetlerinden kaynaklı atık ya da ürünler hem çevre kirliliği hem de insan sağlığı hastalıkları üzerinde oldukça fazla öneme sahiptirler. Bu sebeple insanların sağlık ve ekolojik kaygıları da en üst seviyeye çıkmaktadır. Bu metallerden kurşun, ikinci en toksik metaldir ve Dünya kabuğunun sadece % 0,002 sini oluşturmaktadır. Bu bağlamda doğada çok az bulunmasına rağmen oldukça fazla alanda kullanılmaktadır. Bunlar arasında; otomobiller, piller, çeşitli endüstriler sayılabilir (Raj & Das, 2023).

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## Adsorpsiyon

Adsorpsiyon olayı, oldukça büyük çevresel ve teknolojik önemi olan ve bir dizi sürecin altında yatan önemli bir vakadır. Bunun dışında, şüphesiz ki adsorpsiyonun endüstri ve çevreyi korumada ki hayati önemi açıkça bellidir (Azizian & Eris, 2021). Adsorpsiyon prosesi, molekülün bir akışkan kütlelerinin (gaz veya sıvı olabilir) katı bir yüzeye gönderilerek burada arayüz tabakası oluşturup, farklı iki faz arasındaki etkileşmeyi ifade eden bir olgudur. Bu tabakalar fiziksel veya kimyasal etkileşim olarak tanımlanır (Alaqrbeh, 2021).

## Adsorpsiyon Modelleri

Adsorpsiyon izoterm modellerinin, bir yüzeye adsorplanan adsorplayıcı miktarı ile, sabit sıcaklıktaki basıncı veya konsantrasyonu arasındaki ilişkiyi tanımlayan matematiksel bir ilişki olarak tanımlanması mümkündür. Bunlar arasında HJOD (Harkins-Jura-Onursal-Dal), Temkin, Freundlich, Harkins-Jura, Elovich ve Langmuir gibi modeller vardır. Bu modeller sayesinde adsorpsiyonun doğası hakkında gerekli olan yüzey özellikleri, adsorpsiyonun kapasitesi ve çeşitli koşullar altında adsorplayıcı ile adsorplanan arasındaki etkileşimlerin karakterizasyonuna ait bilgiler elde edilmektedir.

## Freundlich İzoterm Modeli

Ampirik bir model olan Freundlich modelinin lineer olmayan ilk biçimi aşağıdaki gibidir. Bu formun iki tarafının logaritması alınarak Lineer hali elde edilir.

$$q_e = K_F C_e^{1/n}$$

$$\log q_e = \log K_F + \frac{1}{n} \log C_e$$

Burada;  $q_e$ ; dengede adsorplanan madde miktarını ( $\text{mgg}^{-1}$ ),  $C_e$ ; denge halindeki derişimi ( $\text{mgL}^{-1}$ ),  $K_F$ ; Freundlich sabitini ( $\text{mgg}^{-1}$ ) ve  $n$  ise; adsorpsiyon şiddeti değerini ifade etmektedir. (Onursal, 2023).

## Langmuir İzoterm Modeli

Langmuir izoterm modeli, tek tabaka sorpsiyonunun özdeş adsorpsiyon bölgelerine sahip homojen bir yüzeyde gerçekleştiğini ifade etmektedir. Langmuir izoterm denklemi aşağıda verildiği şekilde gösterilmektedir:

$$\frac{1}{q_e} = \left(\frac{1}{q_{max} k_L}\right) \left(\frac{1}{C_e}\right) + \frac{1}{q_{max}}$$

Burada;

$q_e$ : dengede adsorpsiyon kapasitesidir,

$q_{max}$ : maksimum adsorpsiyon kapasitesidir ( $\text{mgg}^{-1}$ ),

$k_L$ : Langmuir adsorpsiyon sabitidir ( $\text{Lmg}^{-1}$ ) ve

$C_e$ : adsorbatın denge konsantrasyonudur ( $\text{mgL}^{-1}$ ) (Mansoori, ve diğerleri, 2022).

## HJOD (Harkins-Jura-Onursal-Dal) İzoterm Modeli

Bu model Onursal ve Dal'ın, Harkins-Jura'ya ait olan lineer denklemden türettikleri bir modeldir. Buna bağlı olarak ta HJ postulatlarını da kabul etmektedir. Heterojen dağılımlı yüzeylere, dolayısıyla fiziksel adsorpsiyona uyduğu söylenebilir. Bu model de lineer olup aşağıdaki şekilde ifade edilmektedir.

$$q_e^2 = \frac{A}{B} + \frac{1}{B} q_e^2 \log C_e$$

$\log C_e q_e^2 \cdot q_e^2$ 'ye göre çizildiğinde elde edilen doğrunun eğimi  $1/A$ 'yı, kayması ise  $A/B$

'yi vermektedir (Onursal, Dal, 2023).

### Temkin İzoterm Modeli

Temkin izoterm denklemleri genelde aşağıdaki biçimde uygulanmaktadır.

$$q_e = \frac{RT}{b_T} \ln(A_T P_e)$$

Bu ifadenin lineer formu ise;

$$q_e = B_T \ln A_T + B_T \ln P_e$$

Şeklinde. Ancak burada;

$$B_T = \frac{RT}{b_T} \text{ şeklindedir.}$$

İfadelere ait değerler ise;

T mutlak sıcaklık R evrensel gaz sabiti,  $A_T$  maksimum bağlanma enerjisine karşılık gelen denge bağlanma sabiti,  $b_T$  Temkin izoterm sabiti ve sabit  $B_T$  adsorpsiyon ısıyla ilişkilidir (Mabuza, Premlall, & Daramola, 2022).

### Freundlich İzoterm Modeli

Ampirik bir model olan Freundlich modelinin lineer olmayan ilk biçimi aşağıdaki gibidir. Bu formun iki tarafının logaritması alınarak Lineer hali elde edilir.

$$q_e = K_F C_e^{1/n}$$

$$\log q_e = \log K_F + \frac{1}{n} \log C_e$$

Burada;  $q_e$ ; dengede adsorplanan madde miktarını ( $\text{mgg}^{-1}$ ),  $C_e$ ; denge halindeki derişimi ( $\text{mgL}^{-1}$ ),  $K_F$ ; Freundlich sabitini ( $\text{mgg}^{-1}$ ) ve  $n$  ise; adsorpsiyon şiddeti değerini ifade etmektedir. (Onursal, 2023).

### Harkins-Jura İzoterm Modeli

Bu modelin izotermi çok katmanlı izotermidir. Bu modele göre heterojen gözenek dağılımı mevcutsa çok katmanlı adsorpsiyonun oluşabileceği şeklindedir.

Harkins-Jura izoterminin doğrusal biçimi aşağıdaki gibidir.

$$\frac{1}{q_e^2} = \frac{B_{HJ}}{A_{HJ}} - \left( \frac{1}{A_{HJ}} \right) \log C_e$$

Burada verilen  $B_{HJ}$  ve  $A_{HJ}$  değerleri Harkins Jura izoterm sabitleridir (Onursal, Dal, 2023).

### Elovich İzoterm Modeli

Bu modelde temel amaç katı yüzeyinde gerçekleşen adsorpsiyon prosesinin nasıl oluştuğunu açıklamaktır. Literatürde bu modelin aynı zamanda Zeldovich ve Roginsky'nin geliştirdiği model olarak ta ifade edildiği bilinmektedir. Modele ait denklemler aşağıda ki gibidir (Salem, Alshoukry, Ismae, & Imayo, 2020)

$$\ln \frac{q_e}{C_e} = \ln K_e q_m - \frac{q_e}{q_m}$$

Burada;

$q_m$ ; Gram adsorpsiyon başına adsorplanan maksimum miktarı,

$K_e$ ; Elovich denge sabitini simgelemektedir.

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## Langmuir İzoterm Modeli

Langmuir izoterm modeli, tek tabaka sorpsiyonunun özdeş adsorpsiyon bölgelerine sahip homojen bir yüzeyde gerçekleştiğini ifade etmektedir. Langmuir izoterm denklemi aşağıda verildiği şekilde gösterilmektedir:

$$\frac{1}{q_e} = \left(\frac{1}{q_{max}k_L}\right)\left(\frac{1}{C_e}\right) + \frac{1}{q_{max}}$$

Burada;

$q_e$ : dengede adsorpsiyon kapasitesidir,

$q_{max}$ : maksimum adsorpsiyon kapasitesidir ( $mg\ g^{-1}$ ),

$k_L$ : Langmuir adsorpsiyon sabitidir ( $Lmg^{-1}$ ) ve

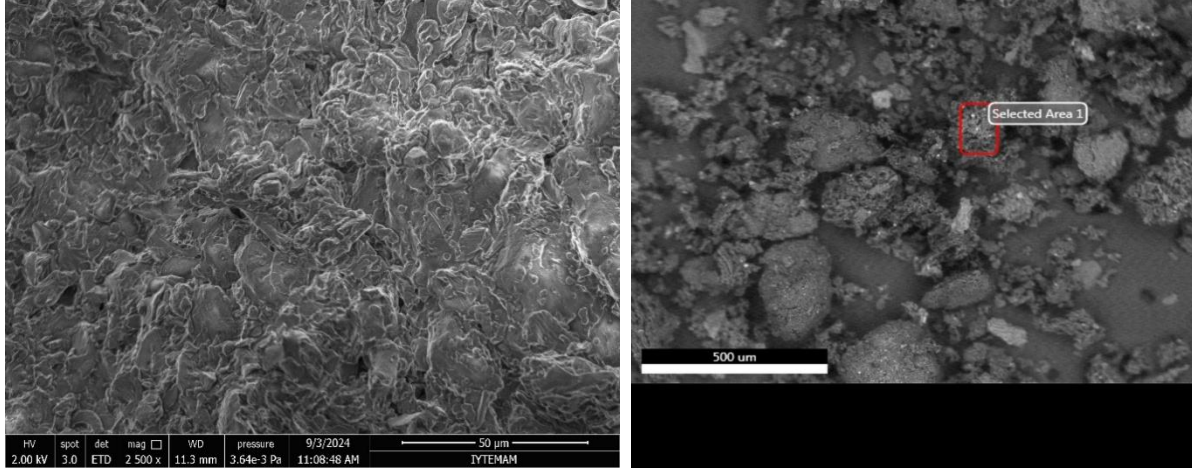
$C_e$ : adsorbatın denge konsantrasyonudur ( $mgL^{-1}$ ) ( Mansoori, ve diğerleri, 2022).

## Materyal ve Yöntem

Cevizler, Diyarbakır ili Ergani ilçesine bağlı Gözekaya köyünden temin edilmiştir. Yıkanan cevizlerin kabuğu çıkarıldıktan sonra, Memmert UN55 marka etüv de kurutuldu ve desikatörde soğutulmuştur. Kurutulan numune Three Beans marka öğütücüde öğütülüp kullanıma hazır hale getirildi. Deneyler için Merck marka  $Pb(NO_3)$  çözeltisi % 99 saflıkta temin edilmiştir. Deneyler Memmert (WNB14) marka Isıtmalı çalkalayıcı (shaker), cihazda 303 K sıcaklığında çalışılmıştır. Yapılan çalışmalar sonucu adsorpsiyon süresi 4 saat olarak belirlenmiştir. Deneylerden elde edilen sonuçlar Harkins-Jura-Oursal-Dal (HJOD) > Temkin > Freundlich > Harkins-Jura (HJ) > Elovich > Langmuir modellerine uygulanmıştır. Hesaplamalar ise Microsoft excel ® 2010 programında yapılmıştır.

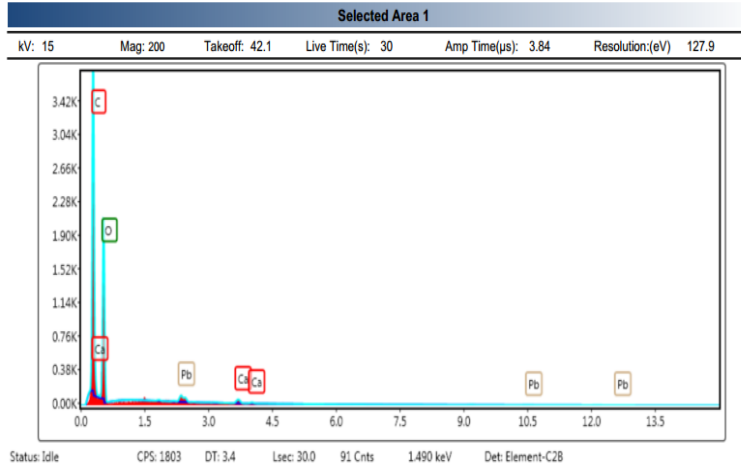


**Bulgular**  
**SEM-EDAX Analizi**



**Şekil 1.** (a) Ham ceviz kabuğuna ait SEM görüntüsü

(b) Kurşun ile işlem görmüş ceviz kabuğu SEM görüntüsü



**eZAF Smart Quant Results**

Element	Weight %	Atomic %	Net Int.
C K	47.97	57.09	678.16
O K	47.05	42.04	386.31
PbM	3.16	0.22	21.47
CaK	1.82	0.65	15.74

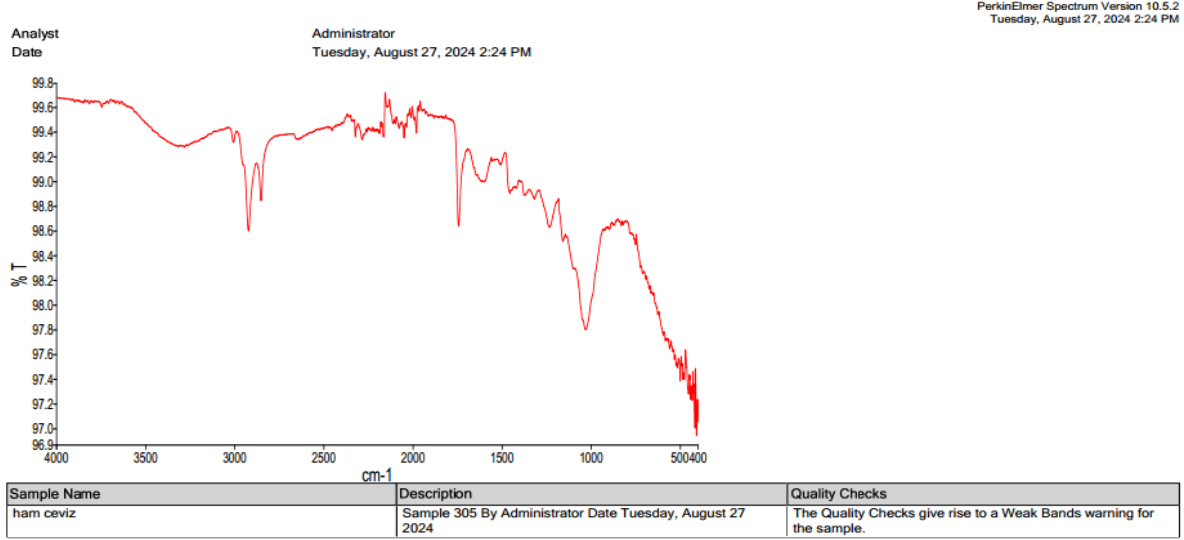
**Şekil 2.** SEM'e ait Edax diyagramı ve veri tablosu

Adsorpsiyon sonrası yapılan SEM analizine göre; adsorplayıcı olarak kullanılan ceviz kabuğunun dağınık irili ufaklı amorf yapıda olduğu görülmektedir. Üç adet kurşun piki EDAX grafiğinde görülmektedir. Yüzde olarak kurşun oranı toplam kütleinin 3,16'sına tekabül etmektedir.

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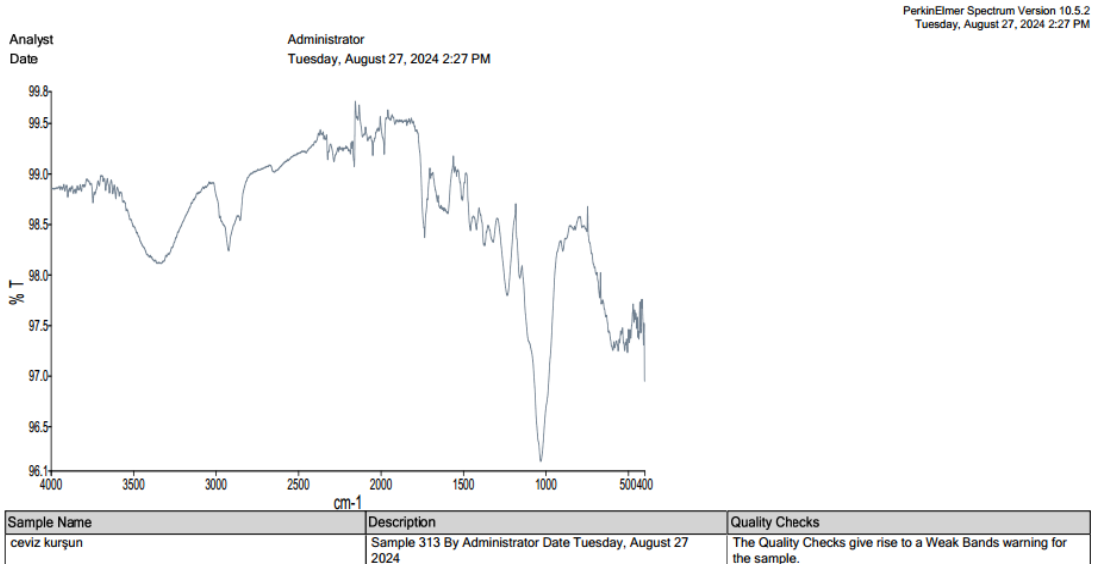
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## FT-IR Analizi



Şekil 3. Ham cevize ait FT-IR diyagramı

Diyagram da görüldüğü üzere  $1700\text{ cm}^{-1}$  civarındaki kuvvetli pik C=O bağı,  $2900\text{ ile }2850\text{ cm}^{-1}$  arasındaki kuvvetli iki pik ise C-H tekli bağı, diyagramın en sağında bulunan  $100\text{ cm}^{-1}$  civarındaki pik ise parmak izi bölgesi olarak bilinen bölgede bulunmaktadır. Bu bölge genellikle çok bant göstermekte olup sıklıkla birbirleriyle örtüşen karmaşık alandır.



Şekil 4. Kurşun ile işlem görmüş cevize ait FT-IR diyagramı

Bu diyagram incelendiğinde,  $3400\text{ cm}^{-1}$  civarında bulunan pik O-H varlığını,  $2900\text{ cm}^{-1}$  dolaylarında bulunan kuvvetli pik C=O bağı göstermektedir.  $1250$  ve  $1050\text{ cm}^{-1}$  dalga

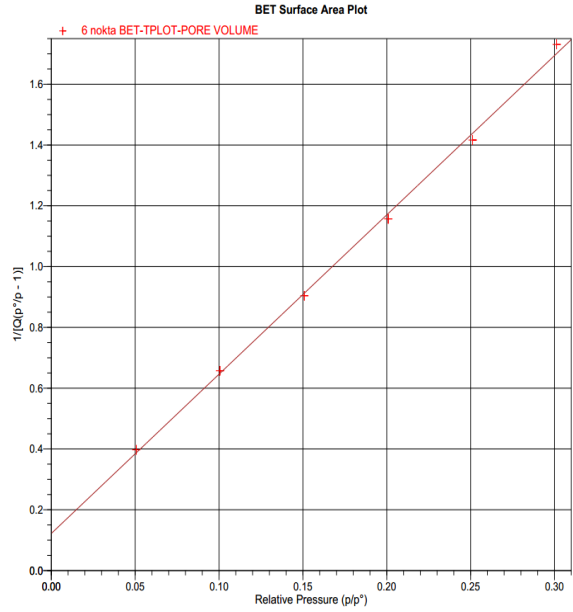
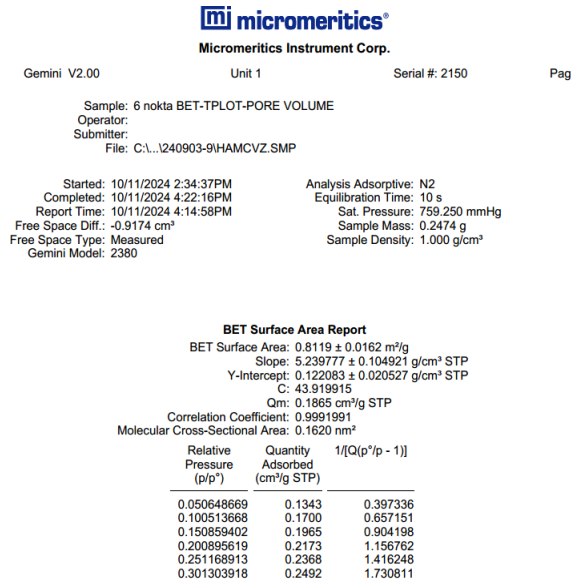
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sayısındaki pikler parmak izi bölgesine ait karmaşık yapıdaki pikler tekabül etmektedir.

## BET Analizi

BET analizinde elde edilen veriler ışığında BET yüzey alanının  $0.8119 \text{ m}^2/\text{g}$  olduğu, tek noktadan gözenek hacminin ise  $6.10^{-4} \text{ m}^3/\text{g}$  gram olduğu ayrıca ortalama gözenek çapının (ebatının)  $29.5577 \cdot 10^{-8} \text{ m}$  olduğu tespit edilmiştir. Bunun dışında aşağıda numuneye ait 6 nokta BET yüzey alanı grafiği verilmiştir.

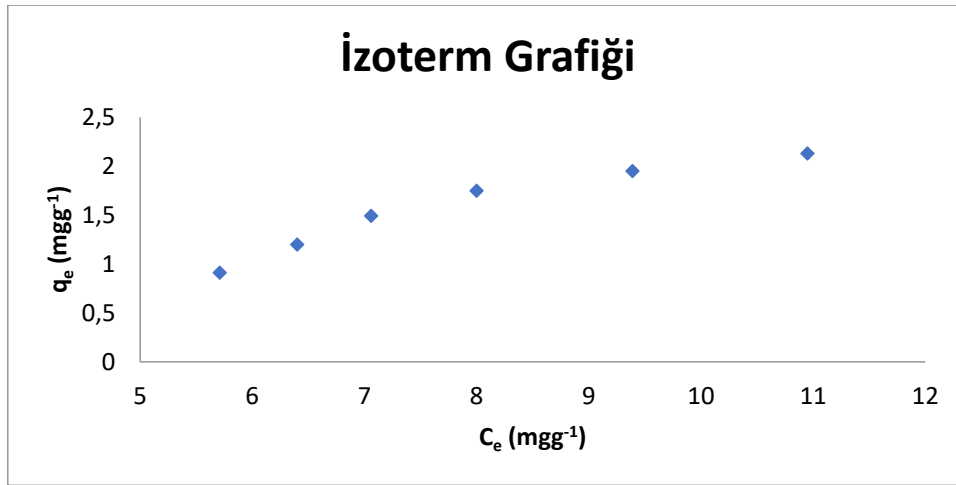


Şekil 5. Nokta BET yüzey alanı verileri ve 6 nokta grafiği

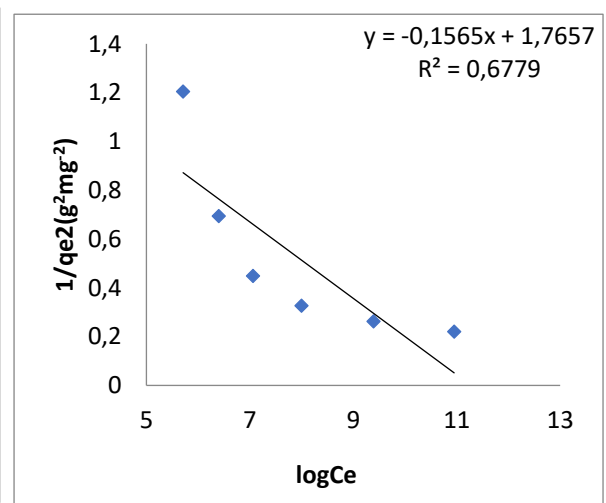
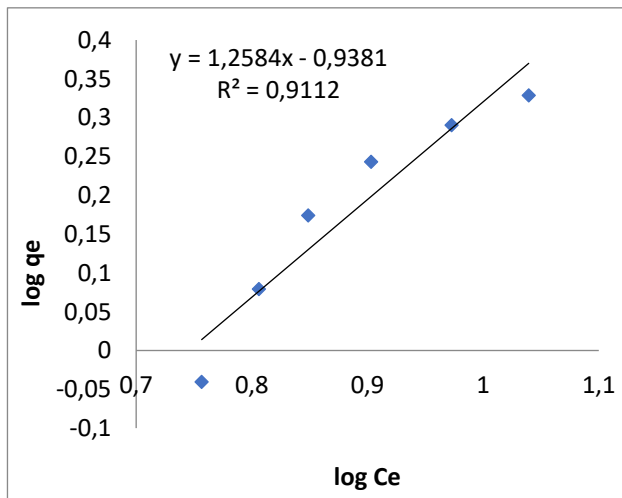
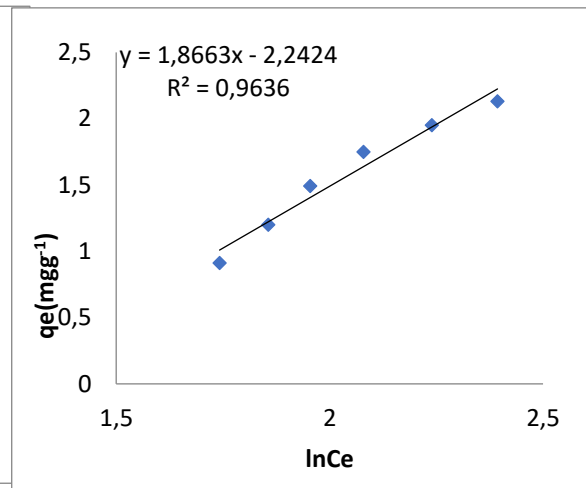
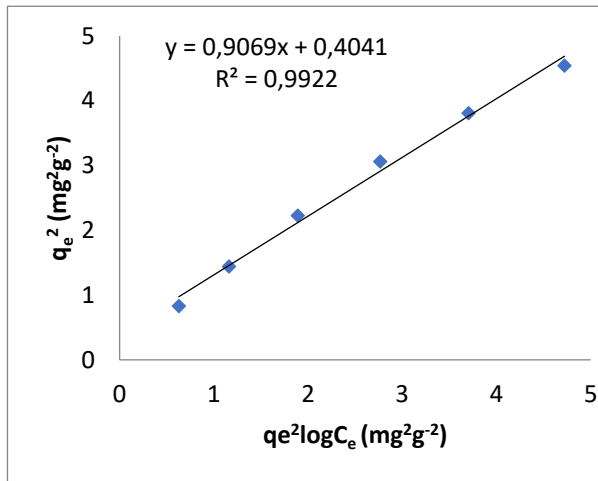
## Deneysel Çalışmalar

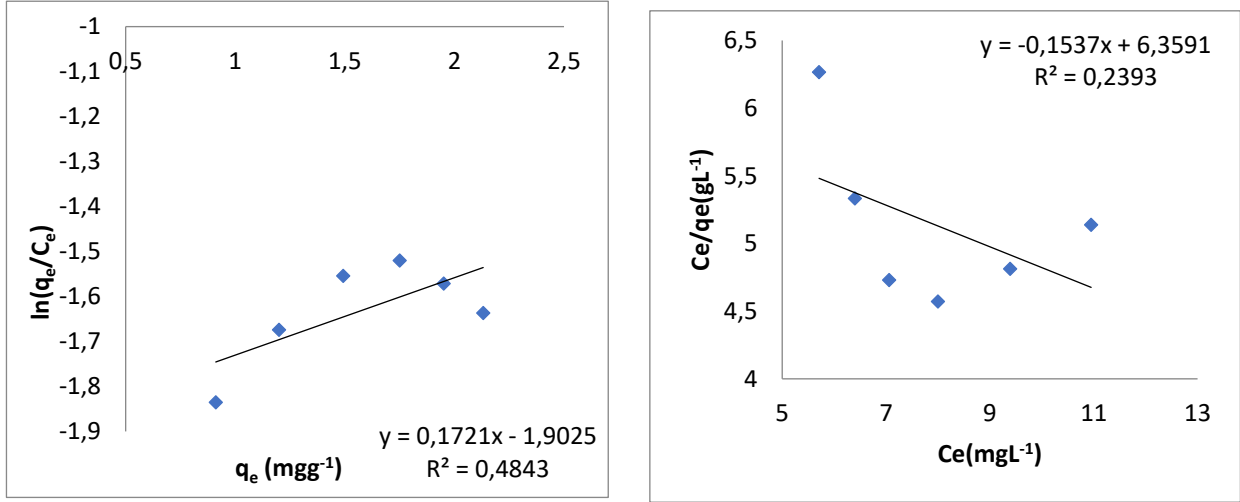
### Pb (II)'nin İzoterm Çalışmaları

Ceviz kabuğunun kurşun adsorpsiyonuna sıcaklığın etkisi incelenmiş olup veriler grafik ve tablolarda verilmiştir.



Şekil 6. 303 K'deki Pb(II)' nin Ceviz kabuğu üzerindeki İzoterm grafiği.





Şekil 7. 303 K'deki Pb (II)' nin Ceviz kabuğu üzerindeki (a) HJOD, (b) Temkin, (c) Freundlich, (d) HJ, (e) Elovich ve (f) Langmuir grafikleri.

Table 1. Pb (II) iyonlarının Ceviz kabuğu üzerindeki adsorpsiyon verileri

Sıcaklık K	HJOD			Temkin			Freundlich			HJ			Elovich			Langmuir		
	A	B	R <sup>2</sup>	K <sub>T</sub>	B	R <sup>2</sup>	K <sub>F</sub>	n	R <sup>2</sup>	A	B	R <sup>2</sup>	q <sub>m</sub>	K <sub>E</sub>	R <sup>2</sup>	q <sub>Fm</sub>	K <sub>L</sub>	R <sup>2</sup>
308 K	0,445 6	1,102 7	0,992 2	0,300 7	1,866 3	0,963 6	0,115 3	0,794 7	0,911 2	6,389 8	11,28 2	0,677 9	5,810 6	6323 5	0,484 3	6,506 2	0,024 2	0,239 3

### Tartışma ve Sonuç

Biyoadsorplayıcılar ucuz, kolay bulunabilmeleri ve çevre dostu olmaları nedeniyle son yıllarda üzerinde çok çalışma yapılan malzemelerdir. Kurşun metali dünyamızı kirleten ağır metallerin başında gelmektedir. Zararlarının azaltılması, ancak çevreden giderilmesi ile mümkündür. Adsorpsiyon metodu kökeni eski mısır uygarlığına dayanan bir ayırma yöntemidir. Ucuz ve etkili olması nedeniyle adsorpsiyon yöntemi dünya genelinde sayısız araştırmacı tarafından kullanılmaktadır.

Bu çalışmada Kurşun (II)'nin Türkiye'nin Diyarbakır iline bağlı Ergani ilçesinden elde edilen cevizin kabuğu adsorplayıcı olarak kullanılmıştır. Adsorplayıcının teşhis edilebilmesi için SEM-EDAX, BET ve FT-IR analizleri yapıldı. Adsorpsiyon sonucunda analizi yapılan ceviz numunesinin SEM-EDAX sonucu, numunenin % 3,16'sının kurşun olduğu, böylece adsorpsiyonun gerçekleştiği tespit edildi. BET analizi sonucu ham ceviz kabuğunun yüzey alanının 0,8119 m<sup>2</sup>/g, gözenek hacminin 6,10<sup>-4</sup> cm<sup>3</sup>g<sup>-1</sup> ve gözenek çapının 29,5577 10<sup>-8</sup> cm olduğu tespit edildi. Adsorpsiyon deneyi sonucu elde edilen izoterm modelleri. Çalışma 313 K sıcaklığında gerçekleştirildi. Regresyon analizi en küçük kareler yöntemine göre çalışmada, deneysel verilerin izoterm modellerine uyum sırası Freundlich<Temkin<Harkins-Jura (HJ) < Harkins-Jura-Onursal-Dal (HJOD) < Langmuir. En yüksek uyumu 0,9767 R<sup>2</sup>

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deęeri ile Langmuir modeli gosterdi. Langmuir ve HJOD modelleri guven seviyesi iinde ( $p < 0.05$ ) kaldı.  $q_{\max}$  4,545  $\text{mgg}^{-1}$  olarak belirlendi.  $k_2$  deęeri 0,266  $\text{Lmg}^{-1}$  olarak bulundu. Sonular Ergani cevzine ait kabuęun adsorplayıcı olarak kullanılabileceęini gosterdi.

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**ENVIRONMENTAL ASSESSMENT OF NATURAL RANGELANDS AND THEIR  
MANAGEMENT POTENTIAL**

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**Abstract**

The lands of the world covered with grass or fodder crops that are used to feed the animal in any way of feeding without exploiting that land in the cultivation of other crops for humans because the cultivation of this land with field crops requires soil service operations to be prepared for cultivation and that such a process leads to the gradual eradication of natural plants, pasture grasses and grasses growing in that land. Rangelands are the main source of the necessary fodder resources for livestock, which in turn convert unpalatable materials by man into animal products of high nutritional value with their amino acids necessary for the human body. These rangelands may be cultivated fields or lands covered with mostly green plants belonging to the falconry and legumes and used in grazing animals or feeding them in any of the different feeding methods. It is known that each pasture has an energy called the pasture load, which is the ability of the pasture to support the largest number of animals so that we get the largest animal yield without damage or degradation of the pasture's plants or soil. The United Nations at the Desertification Conference has developed critical numbers to identify the extent of animal pressure on the land. These numbers are an animal unit (29) per five hectares in dry areas and an animal unit per hectare in semi-arid areas. Otherwise, the pasture and its soil will be degraded, and the load of the pasture is affected by many factors

**Keywords:** Natural pastures, Soil degradation Desertification, Sustainable livestock, Biodiversity conservation, Climate impact

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## **Introduction**

Rangelands are considered one of the main land use patterns in the world, where 11% of the land area is used for agriculture, 24% is considered sustainable pastures, 31% is considered forest, 34% is considered deserts, frozen areas, high mountain peaks, and civil and industrial facilities. Natural rangelands that vary in their vegetation and area according to different geographical conditions, especially those related to climatic conditions. Before we enter into the discussion of rangelands, we must address the definition of grazing because natural rangelands derive their name from grazing, which is: Domesticated and wild animals consume plants (both) suitable for consumption and are thus divided into natural pasture lands and industrial pastures. Industrial pastures are the pastures in which humans enter by planting desirable plants that serve as a basis for grazing. In this lecture, we will focus on pastures only.

## **The problem of the study**

- 1- What is the geographical distribution of rangelands in the world
- 2- What are the main factors causing degradation of natural rangelands
- 3- How natural resources can be managed and maintained

## **Hypothesis of the Study**

- 1- There is a disparity in the distribution of rangelands in the world
- 2- There are natural and human factors affecting rangelands
- 3- There are many ways to maintain rangelands in the world

## **Purpose of the Study**

The study aims to reveal the importance of rangelands and their types with the data of their geographical distribution and the factors affecting them, indicating the methods and methods used to maintain rangelands

Structure of the study:

## **The research was divided into four sections:**

1. The concept of rangelands and their importance
2. Geographical distribution of rangelands in the world
3. Main factors causing degradation of natural rangelands
4. Management and maintenance of natural rangelands

## **The first topic: The concept of rangelands and their importance**

These are those lands of the world covered with grass or fodder crops that are used to feed the animal in any way of feeding without exploiting that land in the cultivation of other crops for humans because the cultivation of this land with field crops requires soil service operations to be prepared for cultivation and that such a process leads to the gradual eradication of natural plants, pasture grasses and grasses growing in that land, and there are several types of pastures that can be limited to two groups:

## **Natural pastures:**

Artificial rangelands

We will focus only on the study of natural rangelands:

It includes all lands (pastures) that man did not interfere with their service or construction, but mainly contain endemic plants suitable for grazing. These pastures depend on rainfall because there is no fixed irrigation system and the following patterns fall under these pastures: -

1-Lawns (wide open pastures), which are very wide pasture lands that humans may resort to

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fencing to protect and control them.<sup>1</sup>

2-Forest pastures: These are the lands covered by coarse short grasses and small shrubs.

3-Forest land pastures: in which weeds and dry plants suitable for grazing grow.

4-Logged forest pastures: These are lands that have been cut down and still have some green plants after logging.

## **Rangeland Management Science**

Rangeland management can be defined as: -

The science and art of exploiting rangelands as a renewable natural resource to obtain the highest and best products and services (the highest economic return). This is without negatively affecting these resources. Rangeland management deals with humans, plants, soil and animals together. So that the vegetation remains well distributed and suitable and keeps the soil from eroding. And the concepts built me one of the most important of them.

(Rangelands are a renewable natural resource)<sup>2</sup>

Natural pastures are of great importance, the most important of which are the following:

Rangelands play a major role in providing humans with animal products in all parts of the world except those areas covered with ice. In some countries, 80-90% of the food comes from livestock meat and dairy, for example, the countries of Africa. These animals are also used as a cash crop to buy other types of food. The large size of the pieces helps to ensure its reconstruction from the remaining animals after the expiry of the periods of barrenness.

## **Feral animals**

Rangelands are the main habitat for all high value wild animals as a source of meat, hunting and enjoying aesthetics. The economic importance of wild animals in rangelands is receiving increasing attention in developed developing countries.

Wild pasture animals are of great importance as a source of meat for human consumption in a number of African countries.

## **Trekking**

The increase in population in the countries of the world has given pastures greater importance as places frequented by people to spend time in hiking. Climbing, setting up camps, driving bicycles and trips, fishing, fishing and picking stones are the most important hiking activities in pastures.

## **Agricultural Products**

Rangelands produce a large number of different plants that can contribute significantly to meeting our future needs, such as medicinal and nutritional herbs that humans can benefit from. Potential salinity shrubs have high production capabilities of both that qualify them to be suitable types for areas that are going through long periods of drought and that contain a large amount of salinity. A number of rangeland shrubs appeared to be used for coordination purposes and used as ornamental plants.

Its importance in holding the soil and preserving it from erosion and erosion in wet and dry areas, as the process of water erosion is active in wet areas with a steep slope, and wind erosion processes are active in dry and semi-arid areas.

The importance of vegetation cover in influencing climatic characteristics and the role it plays in the processes of exchange, balancing, freedom and reduction in dry and semi-arid areas.

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<sup>1</sup> Grazing, web search <http://www.factuly.com>

<sup>2</sup>Grazing Research published on the Internet <http://www.factuly.com>

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## **The second topic: The geographical distribution of rangelands in the world**

Grasses: They are the areas where many herbaceous plant communities grow and are overcome by the grassy family, and they are one of the richest pastures, where they are found, including:

### **Savannah Areas**

The savannah makes up most of the grass areas in the tropical or tropical climate, and its vegetation consists of tall or medium grasses distributed among individual trees or in groups. In general, the extent of these grasses extends around the ranges of tropical forests to the extent of hot deserts, and rain falls in the savannah region in the hot season of the year, so the growth of grasses flourishes, and when the dry season comes, they dry and die, and the height and density of savannah grasses depend on the amount of rainfall. They may reach a height of two meters and sometimes up to (4) meters, but they are usually shorter than that. It is noted from Figure (1) that the area of the savannah region is small in the continent of Asia, due to the abundance of seasonal rainfall that leads to the growth of tropical forests, and in the continent of Australia, they spread in a large area extending south of tropical forests in the north of the continent, while in Africa the savanna reaches its maximum breadth, as it covers one third of the continent's area and extends between tropical and tropical forests and between the desert.

### **Tall grass areas (prairies)**

The prairie areas occupy areas with light to flat terrain and are covered with long grasses that are usually more than (1-2) m long. These grasses grow in temperate areas between two latitudes (25-50), that is, in the transitional area between forest areas and stubble grass. These grasses are characterized by their ability<sup>3</sup> to resist drought. The prairies are found in the continent of Asia in northern China on the side between Machoria and northwestern China. They are found in North America in the central plains region and extend to the eastern slopes of the Rocky Mountains. In South America, the Brazilian region extends in the form of a crescent known as the Pampas region between two latitudes (30-40) in the south, while in Africa it is located in the Field region in the south of the continent, and in Europe, it is represented in a small range that extends from Romania in the north and then east through Ukraine to the southern end of the Ural Mountains.<sup>4</sup>

Prairie grass is one of the best areas used for grazing because of its moderate climate and its suitability for the growth of grasses and its high suitability for feeding livestock and sheep, as well as the presence of these pastures in mostly developed countries that can improve their exploitation. The proximity of the pastures of Europe and North America to the centers of industry and the overcrowding of the population on the two continents resulted in the transformation of large areas into agricultural fields, so the areas that were allocated for grazing in contrast and budgeted in North America towards the west and settled in the Estes range in the western part of the central plains and on the semi-arid plateaus to the east of the Rocky Mountains. Since these pastures are relatively poor, the snitch in which they are raised is often meager. Therefore, it is transported to the agricultural areas in the east where it feeds on corn to fatten and slaughter it. As for the continent of Europe, the grazing areas have also shifted towards the east and become concentrated in the pastures of Central and Western Asia. As for

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<sup>3</sup>Fathi Abdel Aziz Abu Radi, Climatic and Botanical Geography, Dar Al-Maaref for Publishing, Alexandria, 1983, p. 558.

<sup>4</sup>Abdulaziz Tareh Sharaf, Climatic and Vegetarian Geography, previous source, p. 388.

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South America, Africa and Australia, the percentage of what has been transferred from weed areas to agricultural lands is still less, and the grazing craft remains dominant in each of them.

<sup>5</sup>

### **Short grass areas (steppe – estebes)**

These wide areas are occupied by light to flat terrain covered with short grass (usually less than 60 cm in length) or medium height grass (60-100 cm).

It means the areas covered by relatively poor weeds that receive less rain from the prairie regions, as the rain ranges between (250-500) mm. Stubbs may be present in the same widths of prairie weeds and their height reaches between one and two meters and their density varies from one region to another. In some parts they appear as continuous grass cover and in other parts they appear as distant grass clusters, especially in the adjacent parts of deserts. Stubbs generally<sup>6</sup> appear in the dry regions of Eurasia from the Black Sea to the Manchuria border in China.

This region is the widest range of stubbornness in the world.<sup>7</sup> There is also a specific area of stubble in the continent of Africa near the desert sides. It is also found in the south of the continent in the east of the entire desert, irrigation, and some parts of the plateau in the south. It is also found in the central plains of North America, between the prairie region in the east and the semi-arid region in the east of the Rocky in the west, extending from Canada in the north to near the Gulf of Mexico in the south. In the southern African continent, stubble is found in the middle of the Petaconia plateau in Argentina, and in the continent of Australia, it is found in the central plains of the Marri and Darling rivers basins.

Desert plants: The most important feature of the desert climate is that its rainfall is very low, so that it does not exceed 250 mm per year, and that the daily, annual and seasonal range of temperatures is very high, and the sunlight is shed on the surface of the earth throughout the day without being obscured by anything. This has resulted in the emergence of poor plant life.<sup>8</sup>

There are two types of desert plants in terms of their suitability for climatic characteristics, a sustainable type such as the plants of aloe, acacia and limb, and this type fits itself with drought conditions, and the second type represents plants that avoid drought and have no resistance properties:

Herbaceous plants: - This species grows immediately after rainfall and its life cycle does not exceed a few weeks and consists of grasses whose seeds remain dry in the dry season lurking in the soil, until rain falls, so it germinates, grows and blooms quickly, as this species consists of (50-60%) of desert plants.<sup>9</sup> Desert plants are generally used economically for grazing goats and camels, which do not need rich pastures as they can feed on short grassy plants, shrubs and desert thorns.

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<sup>5</sup>Ali Hussein Shalash and Abdul Ali Al-Khafaf, Geography of Life 1982 , p. 118 .

<sup>6</sup>Fathi Abdel Aziz Abu Radi, Climatic and Vegetarian Geography, previous source, p. 562.

<sup>7</sup>Wafik Hussein Al-Khashab et al., Climatic and Vegetarian Geography, op. Cit., P. 79.

<sup>8</sup>Khalis Hosni Al-Ashab and Anwar Mahdi Saleh, Natural Resources and their Maintenance, Dar Al-Kutub , Mosul University, 1988, p. 127 .

<sup>9</sup>Fathi Abdel Aziz Abu Radi, Climatic and Vegetarian Geography, previous source, p. 563.

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## **Shrubs**

It is one of the largest pasture areas in the world and is characterized by a dry climate (less than 25 cm of rain per year) and poor soil. Vegetation cover is characterized by the sovereignty of small shrubs (their height is less than two meters) and can be divided into two parts:

### **Hot desert shrub areas**

They are prevalent in tropical and subtropical regions, such as the Arabian Desert, the Sonora Desert in the United States, and the Sahara Desert.

### **Cold desert shrub areas**

The deserts of Russia, Mongolia and Iran are spread in the temperate areas.

### **Tundra Areas**

These are areas covered by herbaceous plants and characterized by a short growing season. It is either Arctic or high (3000-4000) meters above the surface of the earth (called Alpine). The first is deployed in the Arctic regions and wildlife lives on it. The second is used for grazing in summer.

The third topic is the main factors causing the deterioration of natural rangelands

## **Permissible and early grazing**

It is known that each pasture has an energy called the pasture load, which is the ability of the pasture to support the largest number of animals so that we get the largest animal yield without damage or degradation of the pasture's plants or soil. The United Nations at the Desertification Conference has developed critical figures to identify the extent of animal pressure on the land. These figures are an animal unit (29) per five hectares in dry areas and an animal unit per hectare in semi-arid areas. Otherwise, the pasture and its soil will be subjected to degradation. The load of the pasture is affected by many factors, the most important of which are.<sup>10</sup>

### **The type of pasture, the fodder crop and its ability to produce vegetables.**

Animal type and its feeding type.

### **Pasture topography.**

The prevailing climate in the region.

The main purpose of the pasture.

### **Grazing season**

The grazing system followed.

Degree of pasture protection (fencing)

Availability, quality and places of drinking.

## **Reclamation of pasture land for agriculture**

It is to intensify agricultural use or load the soil beyond its biological capacity, especially since the expansion of rain-fed agriculture is often at the expense of pasture land, and then the pastoralists retreat towards less wet areas or pasture poverty, and the result is rapid deterioration and imbalance in the environmental balance in both pasture land and agriculture.<sup>11</sup>

**Changing the animal structure of the pasture:** Each pasture must have its own animals that the pasture can support without changing the quality of the animal, which may cause the depletion of the plant. Increasing the movement of machinery and unregulated means

<sup>10</sup>Ramadan Ahmed Al-Tikriti et al., Fodder and Pasture Crops, Faculty of Agriculture, University of Baghdad, 1999, p. 157.

<sup>11</sup>Zayn al-Din Abd al-Maqsud, Environment and Human Relations and Problems

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of transport in pastures, which leads to the dismantling of the rank and thus affects its vegetation.

Failure of legislation to address violations and protect rangelands:

Negative effects of degradation of natural rangelands.

The decay of vegetation cover, the disappearance of good grazing plants and the prevalence of unpalatable species. Low grazing capacity of grazing lands and their inability to support large animals. Increasing the dryness of rangeland lands, as a result of shrinking vegetation cover, which allows the disintegration of the soil and exposes it to the risk of erosion or erosion. Degradation of soil properties, and low fertility. The problem of overgrazing is exacerbated by the lack of vegetation cover and low productivity.

Lack and low productivity of the animal unit.

Increased resource demands

Lack of numbers of wild animals as a result of the loss of the appropriate environment and food.

The spread of the phenomenon of desertification.

Some of the measures taken to reduce this deterioration and provoke the bad establishment of natural reserves and give an opportunity for vegetation to reproduce and spread.

Introducing the cultivation of some grazing shrubs suitable for the region to raise the productivity of the pasture and secure the micro-environment that helps the flowering of plant life.

Proposed plans for the development and reconstruction of degraded pastoral resources:

## **Attention to grazing management.**

It is the art of planning and directing the exploitation of pasture lands to obtain the highest economic production of pasture animals while preserving natural resources (plants, soil and wildlife) in a continuous and renewable production situation.

Reviewing the grazing systems used to choose their genealogies.

In order to determine the most appropriate ways to exploit rangelands, it is necessary to have full knowledge of grazing systems, which are<sup>12</sup>

1-Continuous grazing. This method is characterized by allowing animals to graze all year round in the same pasture or graze during a certain season and then move to another pasture. One of its advantages is that it allows the animal to select palatable parts of the grass continuously. As for its damage, it is an abuse of the natural pasture condition for the continuity of grazing and the deterioration of vegetation cover.

2- Deferred grazing: It is the postponement of grazing until the formation and dropping of seeds to allow plants to continue to grow as well as allowing old plants to be active if the postponement period is appropriate. This method is characterized by the fact that plants are not at the peak of their nutritional value during grazing, while animal production is the least that can be obtained from continuous grazing.<sup>13</sup>

3- Periodic grazing: This method includes alternating between periods of grazing and periods of evaporation without emphasizing the production of seeds. The purpose of this method is to transfer animals from one piece to another so as to ensure that the same section is not grazed

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<sup>12</sup>Hussein Mohammed Al-Qahtani, Almarai Multi Exploitation Department [http// web cache. googleusercontent.com/search](http://web.cache.googleusercontent.com/search).

<sup>13</sup>Ramadan Ahmed Al-Tikriti et al., Fodder and Pasture Crops, Faculty of Agriculture, University of Baghdad, 1999, p. 180.



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on the same date year after year. Alternate grazing may be called rotating grazing. One of the characteristics of this method is that it helps to preserve fodder vegetation well, but does not help to restore seeds naturally.

4- Deferred periodic grazing: It is the transfer of the postponement period of grazing from one plot to another and periodically similar to what is followed in agricultural cycles, but in this case the succession is in the postponement period, and the number of plots and the number of years can be controlled according to the quality of crops.

5- The method of periodic evaporation: This method includes the evaporation of part of the pasture for a full year and the most common for five years, where the pasture is divided into five fenced pieces that prevent grazing for each piece and successively. Experiments have shown that the response of animals in terms of weight gain in this method is less than the method of continuous grazing, while fodder plants respond better to this method, and the purpose of this method remains, and the purpose of this method is to improve vegetation cover by allowing plants to reproduce in addition to maintaining a layer of straw on the surface of the soil to reduce erosion and help water leakage into the soil.<sup>14</sup>

Main factors causing degradation of natural rangelands

overgrazing

Reclamation of pasture land for agriculture

Logging of bushes

Changing the Animal Structure of the Pasture

Failure of legislation to address violations and protect rangelands

Increasing the movement of vehicles and unregulated means of transport in rangelands.

Ignorance of the methods and methods of rangeland maintenance.

Employing large capital in the service of livestock

Negative effects of degradation of natural rangelands

Decay of vegetation cover, and loss of good pastoral vegetation.

Low grazing capacity of rangelands.

Low quality and productivity of vegetation.

Increasing the dryness of rangeland lands, as a result of shrinking vegetation cover.

The occurrence of water and air erosion, and the disintegration of soil grains.

Degradation of soil properties, and low fertility.

The problem of overgrazing is exacerbated by the lack of vegetation cover and low productivity.

Lack and low productivity of the animal unit.

Increased resource demands

Lack of numbers of wild animals, as a result of the loss of the appropriate environment and food.

The spread of the phenomenon of desertification.

## **Fourth topic: Management and maintenance of natural rangelands**

Rangelands are the main source of the necessary fodder resources for livestock, which in turn convert unpalatable materials by man into animal products of high nutritional value with their amino acids necessary for the human body. These rangelands may be cultivated fields or lands

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<sup>14</sup> Ramadan Ahmed Al-Tikriti et al., Fodder and Pasture Crops, Faculty of Agriculture, University of Baghdad, 1999, p. 180.

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covered with mostly green plants belonging to the falconry and legumes and used in grazing animals or feeding them in any of the different feeding methods [15-17].

### **Good rangeland qualities**

The qualities of a good pasture can be summarized in the following points:

- 1-The pasture should be young
- 2-It should be of high vegetation density and within reasonable limits.
- 3- Pastoral plants must be at an appropriate stage of growth and of appropriate length.
4. The quality and digestibility of green food determines how much a pastoral animal can eat.
- 5- Pasture location.
- 6- The pasture must have clean sources for watering animals.

The importance of natural rangelands and their relationship to livestock

Despite the large number of livestock, and the low per capita consumption of vital protein. Production is still not keeping pace with consumption needs, due to the low productivity of livestock, which is due to a number of reasons, the most important of which is the lack of fodder resources and their inability to cover the food needs of livestock.

### **Natural pastures:**

Natural rangelands contribute to the provision of the necessary fodder resources for livestock, and since most of the area of natural rangelands is between the lines of 50-200 mm/ year, most rangelands are poor, characterized by low productivity and fluctuation from year to year [18-20]. The most important functions of natural rangeland plants are the following points:

A major source of livestock food.

Soil and Water Maintenance.

Soil stabilization and stopping desertification

Wildlife Conservation

Tourism, Hunting and Recreation

Medical and industrial uses.

### **Establishing the measures taken to reduce this deterioration and its bad effects**

1-Attention to grazing management:

It is the art of planning and directing the exploitation of pasture lands to obtain the highest economic production of pasture animals while preserving natural resources (plants, soil and wildlife). In a continuous and renewable mode of production.

2-Reviewing the grazing systems used to choose the most appropriate ones:

In order to determine the most appropriate ways to exploit rangelands, it is necessary to have full knowledge of grazing systems, namely:

1-Continuous grazing.

2-Deferred Grazing

3. Periodic grazing

4-Deferred Periodic Shepherding

5-Grazingwith periodic rest

3-Reviewing the pastoral policies in force in the past to follow the righteous, including:

Pastoral policy is the investment system developed by countries to share the benefit between the earth's resources and its investors.

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Rangeland management for multiple exploitation

Multiple exploitation is the harmonized framework for exploiting for more than one purpose

## **Rangeland Hydrology:**

Water is the main determinant of plant production in most of the world's rangelands. All water used in pastures comes from rain. Part of the rain moves above the surface into streams, ponds, lakes, dams, and oceans. This part is referred to as the water running above the surface and the gradient above the ground. Another part is preserved in the place of its precipitation through the leakage process (the transfer of water within the soil) and becomes available for plant growth, and part of the moisture moves to the depths of the soil to reach the water. Rangelands are the main source of water for domestic use, farm irrigation and industrial needs in dry areas. Failure to implement proper rangeland management procedures in the past has resulted in severe economic losses and human suffering [21].

## **Leakage**

When the raindrop reaches the surface of the soil, it seeps into the soil, evaporates, or becomes part of the water flowing above the ground.

The main factor affecting soil infiltration is vegetation and it can be controlled. When raindrops fall on unprotected soil, they mix soil grains and wash away its surface. The lower the vegetation cover, the less leakage, and this reduces the soil moisture available to produce both. This leads to the desertification of dry areas.

## **Runoff flow**

Runoff begins when the amount of rain exceeds the leakage rate and storage soil capacity. The most important factor affecting runoff is the amount of vegetation cover available to impede the movement of water above the soil surface and runoff decreases when vegetation coverage increases [22]. Erosion and sediment accumulation are important problems caused by surface runoff, and sediments are economically important, because they cover land and vegetation, reduce the storage capacity of dams, increase the risk of flooding, and pollute water sources [23]. Rapid erosion is the most severe consequence of overgrazing, because replacing lost soil is a slow process. Soil loss leads to almost no grazing load [24].

The best way to protect against erosion is to establish and maintain good vegetation cover. Rapid erosion can be overcome in its early stages by making adjustments in rangeland management [25].

## **Traces of grazing in waterfalls**

Livestock affect the properties of waterfalls by removing vegetation and by the physical influence of their hooves and shadows. The decrease in vegetation coverage increases the impact of rain drops, reduces organic matter and composite soil grains, and increases cracks in the soil surface. The most important occurrence of livestock hooves is the compaction of the soil surface. Devegetation and soil compaction reduce the leakage rate and increase runoff. The riparian areas (the sides of the rivers) constitute a small percentage of the pasture, but they are difficult to manage, and these areas and their fish are negatively affected by grazing.

## **Wildlife Status**

Many wildlife abandon pasture when overexploited

Heavy grazing harms birds with ground nests

The excessive increase of fungal species has a negative impact and changes the status of pasture (donkey horses, prairie dogs, loans, rabbits ... etc.) were targeted by people of domesticated species [26-28]. When there are no grazing plants, wildlife is exposed to physiological stress,

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disease, and possibly death. Exploiting pasture to graze domesticated animals increases the risk of transmitting diseases to non-domesticated (fungal) species. The system of continuous grazing of the entire pasture leads to the aversion of fungal species. Insects have an effect on plants no less than that of pastoral animals, as their grazing is deep and may reach the roots. Research suggests that wildlife diversity was highest under moderate grazing (smith at el. 1996).

## Hiking & Recreation

1-The use of pesticides to expel and kill insects for the convenience of tourists, led to environmental and vital problems for those areas.

2- The fencing of natural parks harmed fungal animals and their freedom of movement led to their decline.

3-Means of transportation (especially cars and motorcycles) cause great damage to plants and their small and large living creatures, as well as damage to the soil, which led to its compression and poor fertility.

4- Human activity, especially around water resources, causes disturbance to the animal's performance and its transition to areas of lower pastoralism.

As for the types of pasture exploitation for hiking, tourism and recreation, it can be limited to the following:

Activities with limited impact on rangelands, including:

- |            |   |
|------------|---|
| 1-Walking  | 2-Setting up camps                        |
| 3- Fishing | 4- Snowboarding                           |
| 5- Boating | 6- Rowing in inflatable boats mountaineer |

Activities with a significant impact on rangelands:

- |                  |                     |
|------------------|---------------------|
| 1- Hunting       | 2- Horseback riding |
| 3- Riding Cycles | 4- Riding SUV       |

Knowing all this, we can use natural pastures for hiking, medical uses and grazing after studying the circumstances. These circumstances determine the nature of use, that is, if we have a pasture with few plants, it is used in hiking and medical uses under specific controls, so as not to affect vegetation cover. Table 1 shows some data and results from literature studies.

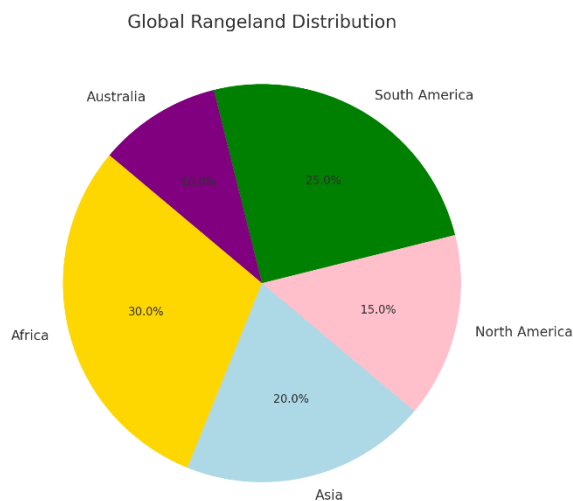
**Table 1** Comparative for some studies

Aspect	Savannah	Prairies	Steppes	Deserts
Geographical Location	Africa, South America, Australia	North America, Asia, South America	Eurasia, North America, Australia	Africa, Middle East, Central Asia
Rainfall(mm/year)	250-1000	500-1000	250-500	<250
Vegetation Type	Tall grasses, scattered trees	Long grasses	Short grasses	Shrubs, xerophytic plants
Grazing Capacity	Moderate to high	High	Moderate	Low
Main Threats	Overgrazing, deforestation	Conversion to agriculture	Overgrazing, soil erosion	Climate change, low water availability
Management Practices	Rotational grazing, reforestation	Intensive grazing management	Deferred grazing	Shrub planting, water conservation
Economic Importance	Livestock, biodiversity conservation	Livestock, agriculture	Livestock	Medicinal plants, grazing for camels

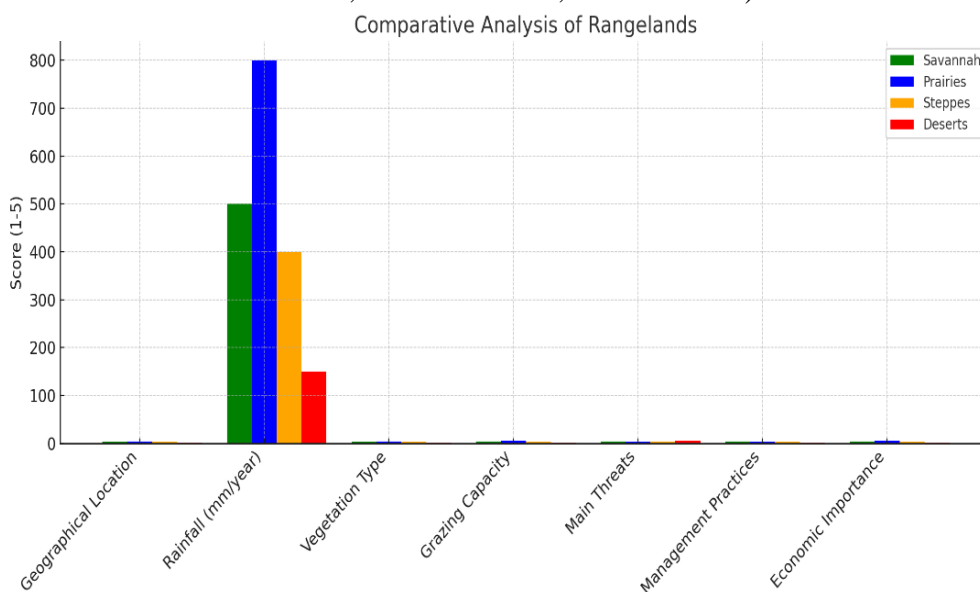
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Figure 1 shows the Pie Chart for hypothetical global distribution of rangelands by region (Africa, Asia, North America, South America, and Australia). Figure 2 shows the Bar Plot for a comparative analysis of key rangeland features (grazing capacity, rainfall, and economic importance) across Savannah, Prairies, Steppes, and Deserts.



**Figure 1.** Hypothetical global distribution of rangelands by region (Africa, Asia, North America, South America, and Australia).



**Figure 2.** A comparative analysis of key rangeland features (e.g., grazing capacity, rainfall, and economic importance) across Savannah, Prairies, Steppes, and Deserts

## Conclusions

The natural pastures in Iraq are essential for sustaining livestock and maintaining biodiversity, yet they are under threat due to overgrazing, climate changes, and improper land management. The study highlights the significant degradation of rangelands, resulting in a decrease in soil fertility and biodiversity. The findings reveal that overgrazing and early grazing have severely

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impacted pasture productivity, leading to desertification and the decline of high-quality grazing species. The research suggests the need for improved management practices, such as rotational grazing, reforestation efforts, and stricter regulations to prevent overuse of rangelands. By adopting sustainable land management practices, Iraq can preserve its pastures and ensure long-term agricultural productivity and environmental health.

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ÇİFTLİK GÜBRESİNİN BİTKİ GELİŞİMİ ÜZERİNDEKİ ETKİSİ

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**Özet**

Ülke topraklarımız organik madde yönünden son derece fakirdir. Organik madde yetersizliği, toprağın küme yapıdan teksel yapıya geçişini hızlandırır ve toprağın havalanmasını, ısınmasını, su tutma kapasitesini olumsuz yönde etkiler. Tarım alanında doğal gübre olarak kullanılan ahır gübresi toprağın fiziksel, kimyasal ve biyolojik yapısını düzenler ve toprak verimliliğini artırır. Aynı zamanda bitki beslenmesi ve gelişimi açısından gerekli besin maddelerini sağlar ve sürdürülebilir tarım uygulamalarının desteklenmesi açısından önemli bir kaynak oluşturur. Kimyasal gübre kullanımını azaltan çiftlik gübresi, çevre üzerindeki olumlu etkisiyle doğal döngüyü sürdürmeye katkı sağlar. Ayrıca sürdürülebilir organik tarım ve iyi tarım uygulamalarının yaygınlaşması açısından da çiftlik gübrelerinin kullanımı büyük önem taşımaktadır.

**Anahtar Kelimeler:** Çiftlik gübresi, İçeriği, Kullanım yöntemleri, Organik madde.

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**EFFECT OF FARM MANURE ON PLANT DEVELOPMENT**

**Abstract**

Our country's soil is extremely poor in terms of organic matter. Insufficient organic matter accelerates the transition of the soil from a clustered structure to a single structure and negatively affects the aeration, warming and water holding capacity of the soil. Farm manure, which is used as a natural fertilizer in the agricultural field, regulates the physical, chemical and biological structure of the soil and increases soil fertility. It also provides the nutrients necessary for plant nutrition and development and is an important source in terms of supporting sustainable agricultural practices. Farm manure, which reduces the use of chemical fertilizers, contributes to the maintenance of the natural cycle with its positive effect on the environment. In addition, the use of farm manure is of great importance in terms of the spread of sustainable organic agriculture and good agricultural practices.

**Key Words:** Farm manure, Content, Usage methods, Organic matter.

### Giriş

Ülkemiz topraklarının organik madde oranlarının düşük olması nedeniyle bu gübrelerin uygulanması ile topraklarda organik madde miktarının artmasını sağlar ve organik madde topraklarda yaşayan mikroorganizma faaliyetlerin artmasına, katyon değiştirme, su tutma, havalandırma kapasitesinin artmasına, bitki besin elementlerinin çözünürlüğünü azaltarak ortama vermesi ile element kayıplarının azalmasına vb avantajlar sağlamaktadır (Öner ve Öner, 2022). Toprağa ilave edilen organik maddenin içinde bulunan bitki besin elementleri ve organik bileşikler toprakta flora ve fauna faaliyetini arttırmakta, bitkilerin çimlenme oranını, kök büyümesini, toprağın işlemeye uygunluğunu, yüksek katyon değişim kapasitesi arttırması üzerine olumlu etki nedeniyle toprak verimliliğinin sürekli olmasını sağlamaktadır (İlbaş, 2009). Bitki için gerekli olan besin maddelerini toprağa salan aynı zamanda toprağın yapısı üzerine de olumlu etkiler yapan ahır gübresi bu yönüyle dikkat çekmektedir (Çakmakçı ve Erdoğan, 2005). Toprağı bitki besinlerince zenginleştirmesi yanında, çözünen bitki besinlerinin depolanmasını da sağlamaktadır (Aydeniz ve Brohi, 1991). Çiftlik gübresi ile yapılan çalışmalarda; Özel (1989), Çukurova koşullarında ekim zamanının tek yıllık çim (*Lolium multiflorum* L.)'in yeşil ot verimini 3379.63- 8943.51 kg/da, tohum verimini ise 98.14-164.29 kg/da olarak saptamıştır. Serin ve ark. (1996), Erzurum koşullarında tek yıllık çimin ham protein verimini 41.3-133.4 kg/da arasında tespit etmişlerdir. Kutluay (2003), tek yıllık çim'in ortalama yaş ot verimini 3375 kg/da ve ham protein verimini ise 76.9-162.4 kg/da arasında saptamıştır. Kızıl (2004), 1. ürün sorgum-sudanotu melezinde en yüksek selüloz ve lignin (ADF) oranın 2. biçimden, en düşük selüloz ve lignin (ADF) oranının ise 1. biçimden elde edildiğini bildirmiştir. Kuşvuran ve Tansı (2005), tek yıllık çimde ortalama yaş ot verimini 2769.84-3244.90 kg/da, ortalama protein verimini 105.86-115.15 kg/da, tohum verimini ise 20.02-36.46 kg/da arasında tespit etmişlerdir.

Bu derleme çalışmasında, çiftlik gübresinin bitki gelişimi üzerindeki etkisi incelenmiştir.

### Çiftlik Gübresinin Faydaları

1- Ahırda beslenen hayvanların sıvı ve katı dışkıları ile yataklık olarak kullanılan materyallerin (sap, saman, talaş, ot gibi) karışımından oluşan ve bitki büyümesi ve gelişmesi üzerine olumlu etkisi olan çiftlik gübresi, bitkilerin daha güçlü ve sağlıklı büyümesini sağlar, verimi artırır, hastalık ve zararlılara karşı daha dirençli hale gelmesine yardımcı olur.

2- Çiftlik gübresi toprağın fiziksel, kimyasal ve biyolojik yapısını düzenler. İçerdiği organik maddenin toprakta yarattığı biyolojik etkileri sayesinde bitki enzimlerini uyarır, mikrobiyal faaliyeti teşvik eder, biyolojik süreçte katalizör görevi yapar, bitki köklerinin büyümesini destekler, kök hücre zarlarının geçirgenliğini artırır ve bitkilerin topraktan daha fazla besin maddesinden faydalanmasını sağlar.

3- Çiftlik gübresi, toprak rengini iyileştirerek daha fazla güneş enerjisi emilimini sağlar ve toprak ısını bitki gelişimi için uygun hale getirir.

4- Çiftlik gübresi, ince yapılı toprakların parça bağlılığını gevşetir, hava boşluklarını artırır ve toprağa bitki gelişimi için uygun bir yapı kazandırır. Böylece toprağın gevşekliğini artırarak daha iyi havalanmasını ve tava gelmesini sağlayarak işlenebilirliğini kolaylaştırır.

5- Ahır gübresinin toprakta bozulması sonucu elde edilen humus, toprak verimliliğini artırır ve su tutma kapasitesini yükseltir. Toprağın geçirgenliğini olumlu yönde etkiler, suyun toprak yüzeyinden bağımsızca akmasına, buharlaşmasına engel olur. Böylece toprak erozyonunda azaltıcı rol oynar ve kurak dönemlerde bitkilerin susuzluğa karşı daha dayanıklı olmalarını sağlar.

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6- Ahır gübrelere önemli özelliklerinden biri de zengin mikroorganizma kaynağı olmasıdır. Mikroorganizmalar için iyi bir gelişme ortamı oluşturur, topraktaki mikroorganizma sayısını ve etkinliğini artırarak biyolojik değişimlerin hızlandırmasını sağlar.

7- Hayvan gübresi, toprağın pH değerini düzenler ve zararlı mikroorganizmaların sayısını azaltarak bitkilerin hastalıklara karşı dirençlerini artırır.

**Çiftlik Gübresinin İçeriği**

Hayvan atıklarının parçalanması ve ayrıştırılması sonucu elde edilen organik gübre olan çiftlik gübresi önemli miktarlarda da azot (N), fosfor (P) ve potasyum (K) içermektedir (Çizelge 1, Çizelge 2). Bunun yanı sıra, kireç, magnezyum, kükürt, sodyum, demir ve bakır gibi bitki besin maddeleri de içermektedir. Hayvan gübrelere bileşimi, özellikle hayvanın türüne ve diyetine bağlı olarak değişiklik gösterebilir. Örneğin; inek gübresi genellikle %1-3 arası azot, %1-2 arası fosfor, %1-3 arası potasyum içermektedir. Tavuk gübresi ise daha yüksek oranda azot içermekte olup, aynı zamanda kalsiyum ve magnezyum açısından da zengindir.

**Çizelge 1.** Bazı Hayvanların İdrarlarının Gübre Değeri Yönünden Kimyasal Yapısı (Sezen, 1984)

Cinsi	H <sub>2</sub> O (%)	Kuru Madde (%)	N (%)	P <sub>2</sub> O <sub>5</sub> (%)	K <sub>2</sub> O (%)	Ca (%)
Sığır	93.8	6.2	0.58	0.00	0.49	0.01
At	90.1	9.9	1.55	0.00	1.50	0.45
Koyun	87.2	12.8	1.95	0.01	2.26	0.16

Bitkilerin büyüme dönemlerinde besin ihtiyaçlarını karşılamak, toprak verimliliğini ve hastalıklara karşı bitki dirençlerini artırmak amacıyla çiftlik gübresinin doğru miktarlarda ve doğru zamanda kullanılması oldukça önemlidir.

**Çizelge 2.** Bazı Hayvansal Gübrelere Kimyasal Yapıları (Sezen, 1984)

Cinsi	H <sub>2</sub> O (%)	Kuru Madde (%)	N (%)	P <sub>2</sub> O <sub>5</sub> (%)	K <sub>2</sub> O (%)	CaO
Sığır	83.2	16.2	0.29	0.17	0.10	0.34
At	75.7	24.3	0.44	0.35	0.35	0.15
Koyun	65.5	34.8	0.55	0.31	0.15	0.46
Kaz, Ördek	75.0	25.0	0.80	1.00	0.80	1.30
Güvercin, Tavuk	62.0	38.0	1.70	1.60	0.90	2.00

**Çiftlik Gübresi Depolama Yöntemleri**

Çiftlik gübresinin bitkiye ve toprağa faydalı hale gelebilmesi için depolama ve bekletme işlemi mutlaka yapılmalıdır. Depolama ve saklama yöntemlerinin doğru bir şekilde yapılması, çiftçilik faaliyetlerinin sürdürülebilirliği açısından oldukça önemlidir. Doğru depolama ve saklama teknikleri ile çevreye ve insan sağlığına zarar verici etkiler azaltılabilir. Depolama alanları kuru ve havadar bir ortam olacak şekilde titizlikle seçilmeli ve çevreye zarar vermeyecek şekilde planlanmalıdır. Yanlış depolama ve saklama yöntemleri kötü kokuya, yer altı suların kirlenmesine ve çevre kirliliğine yol açabilir. Açık havada depolama yapılıyorsa

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düzgün bir drenaj sistemi ile çevreye yayılan kötü koku ve gazların etkisi azaltılmalıdır. Kapalı alanlarda depolama yapıyorsa depoların kapalı ve sızdırmaz olması önemlidir. Her ihtimale karşı sızıntıları engellemek için sızıntı önleyici tabanlar ve yanal duvarlar kullanılmalıdır.

Taze olarak kullanımı sakıncalı olan hayvan gübrelerinin uygun şekilde olgunlaştırılması yani fermente edilerek yakılması gerekir. Bu nedenle 3 ila 6 ay arasında bekletilerek iyice yanması sağlanmalıdır. İyi bir fermentasyon olabilmesi için yığın yüksekliği 1-1.5 m'den yüksek olmamalıdır. Olgunlaşmada yığının havalanması, sıcaklığı ve nemi oldukça önemlidir. Havalanma ortamı iyi olursa yanma işlemi çabuklaşır. Yığın içerisinde havasız koşullarda mikroorganizma faaliyeti ile gübre ısınır ve yanma işlemi hızlanır. Kuru bir gübrede yanma işlemi olmaz ve özellikle kurak mevsimlerde yığının ıslatılması gerekebilir. Aşırı rutubetli ortamlarda depolama, mikrobiyal aktiviteyi artırabilir ve zararlı gazların salınımına neden olabilir. Bu nedenle gübre depolama alanlarında rutubet kontrolü düzenli aralıklarla yapılmalıdır. Normal koşullarda yeterli nem, kış ve bahar yağışları ile sağlanabilmektedir. Fermente olmayan çiftlik gübresinin olumsuz etkiler aşağıda sıralanmıştır.

1. Ayırışma daha uzun sürer.
2. Ayırışmamış gübredeki benin maddelerinden bitkiler yararlanamaz.
3. Taze gübre bazı hastalık etmenlerini ve zararlıları içerir.
4. Bünyesinde yabancı ot tohumları bulunur ve uygulandıkları alanda yabancı ot popülasyonu artar.
5. Parçalanırken bitkiye zararlı toksik bileşikler oluşur.
6. Taze gübrenin parçalanması sırasında topraktaki azot mikroorganizmalar tarafından tüketilir.

### Çiftlik Gübresinin Kullanılması

Çiftlik gübresinin doğru uygulama yöntemlerini bilmek, gübrenin doğal yapısı ve içeriği hakkında bilgi sahibi olmak oldukça önemlidir. Hayvan gübresinin doğru kullanımı için ilk olarak dikkat edilmesi gereken konu, toprağa atılacak miktarın doğru bir şekilde belirlenmesidir. Bunun için de toprak analizi yapılmalı ve analiz sonucunda belirlenen miktar doğrultusunda kullanılmalıdır. Gübrenin içerdiği bileşenler ve besin değerleri göz önünde bulundurularak doğru oranda uygulama yapılmalıdır.

Dikkat edilmesi gereken bir diğer önemli nokta ise çiftlik gübresi tarlada uzun süre bekletilmemelidir. Gübrenin tarlada bekletilme süresine bağlı olarak içerdiği bitki besin maddelerinde kayıplar meydana gelebilir. Bu nedenle tarlaya taşınan gübrenin içerdiği organik madde ve bitki besin maddelerinin kaybını önlemek için tarlaya serildikten sonra pullukla veya ikileme aletleriyle toprakla karıştırılmalı ve toprak altına gömülmelidir. Gübrenin toprakla iyice karıştırılması ve kök bölgesine doğrudan uygulanmasıyla bitki besin elementlerinin dengeli bir şekilde toprağa salınması sağlanmış olur. Böylece bitkiler, besin maddelerinden azami düzeyde faydalanmış olur.

Çiftlik gübresinin uygulama zamanı da önemlidir. Bitkilerin büyüme dönemlerine göre uygun zamanda gübre uygulaması yapılmalıdır. Gübrenin yağış öncesinde uygulanması da toprağa daha iyi nüfuz etmesi açısından yararlı olacaktır. Taze hayvan gübresi kullanımından kaçınılmalı ve iyice yanmış gübre kullanımına özen gösterilmelidir. Yanmamış hayvan gübresi bitkilerin köklerine zarar verebilir, yabancı ot artışına neden olabilir ve çeşitli hastalıklara yol açabilir. Sıvı hayvan gübresi daha kolay uygulanır ve hızlıca bitkilere ulaşırken, katı hayvan gübresi toprakta uzun süre kalır ve toprağın organik madde miktarını artırır.

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Çiftlik gübresinin kullanımı sırasında kişisel hijyen kurallarına da dikkat edilmelidir. Gübrelerle temas etmeden önce eldiven ve maske gibi koruyucu ekipmanların kullanılması önerilir.

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CADALUZ MİZAH GAZETESİNDE HAYVANLARA DAİR KARİKATÜR VE  
MİZANSENLERİN TANZİMAT PARADİGMASI İLE TESPİTİ VE TENKİDİ

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**Özet**

II. Meşrutiyet Dönemi'nde Haydar Rüştü ve Nurettin Rüştü önderliğinde yayın hayatına başlayan Cadaloz mizah gazetesinin ömrü yaklaşık olarak altı ay kadar sürmüştür. Bir mizah gazetesi olmasına rağmen Cadaloz mizah gazetesi gerek iç siyaset gerekse dış siyaset hakkında yapmış olduğu karikatürler ve mizansenler açısından dikkatimizi çekmektedir.(E.Gün Canik;2020:7.)Cadaloz mizah gazetesinin mizansenleri ve karikatürleri incelendiğinde Tanzimat döneminin getirilerini anlamamız açısından büyük önem taşır. Fransız İhtilali'nin sonrasında gelişen milliyetçilik akımının etkisiyle Balkan ulusları Osmanlı Devleti'ne karşı ayaklanmaya başlamışlardır. Osmanlı Devleti ise bu ayaklanmalara karşı çok uluslu ve dinli imparatorluk yapısını korumaya çalışarak parçalanma sürecini geciktirmeye çalışmıştır. Osmanlı Devleti'nin parçalanmamak adına vermiş olduğu bu tavizler çoğu kez basın eleştirilerinin odak noktası olmuş olsa da geneli itibariyle takdir toplamıştır. Osmanlı Devleti'nden kopma girişimleri Osmanlı mizah gazetelerinin uzun süre gündemini meşgul etmişti. Bu karikatürlerin içeriğinde Osmanlı Devleti'ne karşı isyan başlatmış olan Balkan devletleri, çeşitli hayvan imgeleri kullanılarak aşağılanmışlardır. Balkan devletlerini temsilen kullanılan hayvan figürleri genellikle kurnaz, sadakatsiz ve tırsak karakterli olarak seçilmiş olması da bir tesadüf eseri değildir. Cadaloz mizah gazetesindeki karikatürlerin ve mizansenlerin içerisinde geçen bazı hayvan isimler dikkatimizi çeker. Osmanlı münevverleri tarafından takip edilen mizah basını içeriğinde yer alan bu hayvan figürleriyle hangi devletlerin temsil edildiği okurların malumudur. Yapmış olduğumuz bu çalışmada II. Meşrutiyet döneminde yayın hayatına başlamış olan Cadaloz mizah gazetesi üzerinden Tanzimat ve Meşrutiyet ekseninde bu mizah basını içeriğinde yer alan hayvan figürlerinin siyasal ve sosyo-politik yansımaları değerlendirilmiştir.

**Anahtar Kelimeler: Mizah, Osmanlı Basını, Tanzimat, II. Meşrutiyet,**



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**THE DETECTION AND EVALUATION OF ANIMALS IN THE HUMORE AND  
CARTOONS WITHIN THE CADALUZ HUMORE MAGAZINE ACCORDING WITH  
THE TANZİMAT APROACH**

**Abstract**

The Cadaloz humor magazine, which began released under the leadership of Haydar Rüştü and Nurettin Rüştü during the Second Ottoman Constitutional Era, lasted approximately six months. Despite being a humor magazine, the Cadaloz draws our attention with its cartoons and satires about both domestic and foreign politics. When the lampoon and cartoons of the Cadaloz are examined, they are of great importance in terms of understanding the outcomes of the Tanzimat period. Under the influence of the nationalist movement that developed after the French Revolution, the Balkan nations began to revolt against the Ottoman Empire. The Ottoman Empire, on the other hand, tried to delay the disintegration process by trying to protect its multinational and religious imperial structure against those revolts. Although those concessions made by the Ottoman Empire in order not to disintegrate were often the focus of criticism in the press, they were generally appreciated. Attempts to break away from the Ottoman Empire occupied the agenda of Ottoman humor magazines for a long time. In the content of these cartoons, the Balkan states that had started a rebellion against the Ottoman Empire were humiliated by using various animal images. It is not a coincidence that the animal figures used to represent the Balkan states were generally chosen as cunning, disloyal and sly referring to their reprehensive regarding within the Turkic culture. Some animal names in the cartoons and scenes in the Cadaloz attract our attention. It is known to the readers which states are represented by these animal figures in the humor press content followed by Ottoman intellectuals. In this study, we evaluated the political and socio-political reflections of the animal figures in the humor press content in the context of Tanzimat and Constitutional Era through the Cadaloz, which started its publication life during the Second Constitutional Era in 1911.

## GİRİŞ

Osmanlı Devleti'nde radikal değişimleri konu alan Tanzimat süreci devletin bekasını temin için yasal bir zemin oluşturmayı hedeflemişti. Bu yasal zemin Osmanlı geleneksel devlet yönetim tarzından emareler taşımakla beraber özünde Avrupalı devletlerin hukuk nizamına dair veriler üzerine inşa edilmişti. Evrensel olarak kabul edilen insan hakları Tanzimat ile birlikte güvence altına alınırken bireylerin kısmen de olsa fikri ve mülki bağımsızlıkları devlet garantisi altına alınmaktaydı. Osmanlı Devleti'nde fikri bağımsızlıktan kasıt manen mensup olduğu dine ait fikirleri özgürce beyan etme sınırının ötesine gidemiyordu. Devleti ve saltanatı eleştirmek Tanzimat reformlarına rağmen sansür ve hatta cezai yaptırımlara tabi idi. Bu arada Avrupa'daki gelişmelere paralel olarak Osmanlı topraklarında yaşayan hayvanlara dair de bazı devletin müdahil olduğu uygulamalar tezahür etmişti. Bu uygulamalar hayvan haklarının savunulmasının çok daha gerisinde kalan hükümler içermekteydi. Hayvanları merkeze alan bu yasal uygulamaların temelinde insan sağlığı yer almaktaydı. XIX. yüzyılda kuduz, tifüs, kolera ve dizanteri gibi hastalıkların konakçı hayvanlar üzerinden bulaş risklerinin arttığı anlaşıldığından bu türden hayvanların karantina kapsamında ıtlafı hukuken mubah görülmüştü. Halbuki Osmanlı geleneksel yaşantısında ıtlafına icaz verilen bazı hayvanlar masundu ve insan korumasına muhtaçtı. Avrupa merkezli Tanzimat'ta yer bulan bulaş riski olan ve karantina kapsamında katledilmesine icazet verilen hayvanlardan köpekler, atlar, koyunlar, inekler, eşekler vb Osmanlı kültür hayatında yer bulan canlıların katledilmesi kamu nezdinde olumlu karşılanmamıştır. Bu ikilem yani gelenekler ve devletin başlattığı reform çabaları arasında her daim sorun oluşturmuştur. Çalışmamız kapsamında incelediğimiz Osmanlı mizah basınından Cadaloz içeriğinde yer alan hayvan figürleri üzerinde de Osmanlı geleneksel yaşam tarzında yer alan hayvan figürleri üzerinden değerlendirmeler yapıldığı anlaşılmaktadır. Cadaloz içeriğinde tespit etmiş olduğumuz bu hayvan figürleri Osmanlı gündelik yaşamında yer alan hayvan içerikli jargonları kapsar. Bu hayvanlardan önemli bir kısmı ise Osmanlı gündelik yaşamında insan unsuru ile birlikte iktisadi ve sosyal süreçleri paylaşan canlılardır. Bu canlılar ihtiva ettikleri mizahi unsur ile birlikte harf sırasına göre tespit, tahlil ve analiz edilmiştir.

## ASLAN FİĞÜRÜ VE BOZ AYI;

Osmanlı mizah gazetelerinde çoğunlukla aslan figürü kullanılmıştır. Genellikle güç, kuvvet, cesaret ve asaletin sembolize edildiği hususlarda Aslan imgesi kullanılmıştır. Osmanlı basınında genellikle aslan figürü Osmanlı Devleti için ve düşmanla mücadeleden korkmayan Osmanlı askerleri için kullanılır. Gerçekte Osmanlı geleneksel gündelik jargonda aslan asaleti ve cesareti sembolize eder. Halbuki Tanzimat ile tanımlanan batılılaşma konseptinde aslan sömürüyü temsil etmektedir. İncelediğimiz mizah gazetesinde geleneksel bir yaklaşımla aslan figürünün asalet ve cesaret yönüyle Osmanlıyı temsilde kullanıldığı anlaşılır. Osmanlı geleneksel yaşantısında ayı ise gücün, kudretin sembolü olduğu kadar aslan kadar saygı duyulan bir varlık olarak kabul görmez. Kaba kuvveti ve asaletsiz bir varlığı sembolize eder. Bu yüzden ki kaba kuvvetiyle savaş meydanlarında Osmanlı devletine galip gelen devletler basite indirgenmek için soysuz kabul edilen bu canlı ile özdeşleştirilir. İncelediğimiz hayvan figürleri içerisinde ister kutup ayısı ister bozayı olsun tamamen Rus çarlığı ile özleştirilmiştir. Konuya dair Cadaloz mizah gazetesinden bazı örnekler vermek mümkündür. Cadaloz numara 18, 6 Cemaziyülahır 1329 tarihli nüshada bir aslanın karşısındaki ayı ve köpeğe karşı cesurca saldırdığı görülür. (Cadaloz 18, R-1329:4) Bu karikatürde aslanın üstünde bulunan Türk bayrağı ile Osmanlı Devleti tasvir edilmiştir. Cadaloz kadın ise araya girerek ayıya şu sözleri söyler: "*Aslan zaten bu küçük mahluku tepelemeye tenezzül etmez ama mübarek hayvan sana ne oldu?!*". Osmanlı Devletinden ayrılmak isteyen isyancı bir devlet köpek figürü ile

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aşağılanırken onu kaba kuvvetiyle destekleyen dış mihrak olarak ayı figürü ile Rus Çarlığı sembolize edilmiştir. Osmanlı Devleti'nden ayrılmak isteyen ve köpek figürü ile aşağılanan devletin Balkan devletlerinden biri olduğunu tahmin etmekteyiz. Köpek figürü ile muhtemelen sınırları küçük bir devlet tanımlanmış olmalıdır. Bu kapsamda sınırları küçük ve her zaman Rusya tarafından desteklenen yegâne Balkan devleti 1911 yılının şartlarında Karadağ ya da Bulgaristan olma ihtimali yüksektir. Aslan figürünün İngiltere'yi de temsil ettiğini bilen Osmanlı münevverleri arasında karışıklığa sebebiyet verilmemesi adına Aslan figürünün üzerine Türk bayrağı çizilerek herhangi bir yanlış anlaşılmanın önüne geçilmek istenmiştir.

### **TILKI ;**

Gerek batıda gerekse Osmanlı Devleti'nde tilki figürü metafor olarak aşağı yukarı benzer anlamlar içerir. Kırsal alanda köylülerin tavuklarına dadanıp onları yiyen tilki, Osmanlı toplumu tarafından kurnaz bir canlı olarak geleneksel kültür hayatında yer edinmiştir. Tanzimatın merkezine aldığı Avrupalı devletlerde ise Tilki Kraliyet mensuplarının av partilerinde avlanarak ciğeri yenilen avanak bir canlı olarak tanımlanır. Her ne kadar Avrupa'nın son demlerinde Hindistan merkezli hikâyeleri Fransız toplumuna aktaran La Fontende Tilki kurnaz olarak tanımlanmakla beraber hilekar yönü daha çok öne çıkarılır. İncelediğimiz mizah gazetesi içeriğinde Tilki unsuruna da rastlanılmıştır. Cadaloz mizah gazetesinin 28 cemaziyel evvel 1329 tarihli nüshasında "Ooo demek ki tilkinin tavuk masalı gibi hep siyaset hee!!" (Cadaloz 16, R-1329:2). cümlesinin yer aldığını görmekteyiz. İlgili cümle içeriğinde Osmanlı geleneksel kültüründe yer alan Tavuk ve Tilki arasındaki bir fıkraya gönderme yapılır. Tilkinin kurnazlığına dayandırılan bu fıkra ile Osmanlı siyaseti tespit ettiğimiz mizansen içeriğinde özdeşleştirilmiştir. Dolaylı yollardan Osmanlı siyasetçileri Tilkiye benzetilirken onların sözlerine kanan Osmanlı vatandaşları işe tavuk olarak tanımlanmışlardır.

### **HİNT HOROZU,**

Diğer kümes hayvanlarından farklı olarak hırçınlığı ve kavgacı yapısıyla nam salan Hint Horozu Osmanlı mizahına da yansımıştır. Genellikle politik anlamda darbe yemiş umduğunu bulamamış Osmanlı siyasetçileri için kullanılan bir imge olmuştur. Ancak Tanzimat paradigmasından bakıldığında horoz Fransızların milli sembolüdür. Özetle geleneksel yapıdaki horoz algısı ile batılı anlamdaki horoz sembolü incelediğimiz mizah gazetesinde harmanlanmıştır. Bir taraftan yorgun siyasetçiler tanımlanırken diğer taraftan Fransız yanlısı politikalar takip eden Osmanlı siyasetçilerine göndermeler yapılmıştır. Genellikle Osmanlı Devleti yerleşkelerinde mahalle aralarında bulunan ringlerde Hint horozları dövüştürülmekteydi. Osmanlı gündelik yaşamında geleneksel bir uğraş, bir eğlence ve hatta bir kazanç kaynağı olan horoz dövüşleri bütün kamunun malumu bir vaka idi. Bu ringlerde dövüştürülen Hint Horozları, dövüşlerinin ardından tüylerinin bir kısmı dökülmüş ve kanlar içerisinde kalmakta idiler. Bu durum Cadaloz mizah gazetesi içeriğinde bazı siyasetçilerin tanımlanması için bir mizansen figür olarak tanımlanır. Örneğin "Tüyleri dökülmüş Hint horozu" şeklindeki cümlede bir Osmanlı siyasetçisine göndermede bulunulmuştur. (Cadaloz 11,R-1329:2.)

### **KOYUN;**

Osmanlı toplumu içerisinde hayvancılıkla geçimini sağlayan kırsal kesim Osmanlı mizahına da yansımıştır. Kırsalda hayvancılıkla uğraşan kişilerin bazı hayvan davranışlarını insan davranışlarına benzetmeleri genelin anlayabileceği bir türden mizahın oluşmasına zemin hazırlamıştır. Hayvan olarak koyun genellikle sürü psikolojisiyle hareket eden bir tür olduğu için Osmanlı mizahında yerini bularak daha çok bilinçsizce düşünmeden hareket eden ve sonucuna

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katlanmak durumunda kalan kitleleri imgeler. Buna bir örnek vermek gerekirse Cadaloz 22 Cemaziyelahir 1329 tarihli 23.nüşhada şöyle bir göndermeye rastlanılmaktadır: “Hürriyetimizi ve hatta insaniyetimizi bile unuttur ve sonra beş sene evvelki gibi nereye sevk edildiğini bilmez bir sürü koyun asâ körü körüne gideriz” (Cadaloz 23,R-1329:2). Cadaloz mizah gazetesinde kullanılan başka bir hicivde ise “yerine koyun başımı takayım” ifadesi tepkisiz yurttaşları tanımlamak için kullanılmıştır. (Cadaloz 9, R-1329:2)Koyun ile ilgili ayrıca bir karikatürü örnek vermek gerekirse 27 Cemaziyelahir 1329 tarihli 27 . nüsha yer alan bir koç figürü ile Müslüman Arnavutların Osmanlı Devletine olan sadakatleri tanımlanır.(Cadaloz 27,R-1329:2) İlgili karikatür içeriğinde yer alan ve Osmanlı geleneksel yaşantısında asil bir hayvan olarak tanımlanan ve mağrur duruşlu bir at Osmanlı saltanatını sembolize eder. Karikatürün içeriğindeki açıklamada ise “*Hamiyetli Arnavud: padişahımızın uğrunda bu koyunların yerine ben kurban olayım. Cadaloz : bende senin gibi vatanına ,vatanperver padişahına kurban olanlara kurban olayım.*” ifadeleri yer almaktadır.

### **KARTAL;**

Osmanlı mizahında “Kartal” figürü genellikle Roma İmparatorluğu ile özdeşleştirilen devletleri tanımlamada kullanılmıştır. Roma İmparatorluğu çift başlı kartalla sembolize edilir. Doğal olarak kutsal Roma Germen İmparatorluğu sınırları içerisinde yer alan bütün devletler Kartal figürü ile tanımlanır. Bu ülkeler İtalya, Avusturya –Macaristan ve Prusya olarak incelediğimiz mizah gazetesinde dikkat çeker. Konuya dair elde ettiğimiz karikatürde iki tane çift başlı kartal çok uluslu Avusturya-Macaristan İmparatorluğu ve site devletlerinden müteşekkil İtalya devletini sembolize ederken tek başlı kartal figürü ise bir ulus devlet olan Prusya’yı tanımlar. Bu figürler esasen geleneksel Osmanlı kültüründe Selçuklu özdeşleşmiş olsa da sıklıkla kullanılan motifler arasında yer almaz. Ancak Tanzimat sonrası batılı devletlerin yönetsel kurallarıyla tanışan Osmanlı kartal figürünü de batılı devletlerden Roma ile iltisaklı olanları tanımlamada kullanmıştır. Bu durum haddi zatında kartal figürü ile bu ülkelerin kendilerini sembolize etmesinden kaynaklanmaktadır. Cadaloz mizah gazetesinin 22 Cemaziyel ahir 1329 tarihli 23. nüshasında kartal figürlerinin yer aldığı bir karikatür dikkat çeker. İlgili karikatürde Osmanlı topraklarındaki ayaklanmalarla mücadele eden Osmanlı askerlerinin vatanlarını savunmalarını temaşa eden devletler karikatürize edilmiştir.

### **SALYANGOZ**

Fransız mutfağında yer alan Salyangoz Tanzimat ile birlikte gelişen Batıya ait kültürel transferlerden birisidir. Halbu ki Osmanlı toplumu içerisinde Salyangoz, bağı bahçeye musallat olan iğrenç bir canlı olarak tanımlanır ve yenilmez. Ancak Fransızlar açısından kıtlık yıllarında gıda olarak tüketildiğinden Fransız mutfağında yer bulmuş bir unsurdur. Tanzimat ile birlikte Osmanlı münevverlerinin Fransız kültür hayatına olan ilgileri Fransız toplumu açısından salyangozun tanımını öğrenmelerine vesile teşkil etmiştir. Osmanlı gündelik jargonunda Tanzimat sonrasında Osmanlı geleneklerine uygunsuz olan bir gelişme “Müslüman mahallesinde salyangoz satmak” tabiri ile özdeşleştirilmiştir. Yani Fransızlar için normal olan bir şey Osmanlı Müslümanları için mekruh raddesinde değerlendirilebilmektedir. Bu nedenledir ki Tanzimat merkezli Osmanlı idari reformlarında halkın hoşuna gitmeyen dayatmalar salyangoz figürü ile hiciv edilmiştir. Örneğin; “*Ben Salı pazarı diye gelmiştim salyangoz pazarı çıktı. Kabahat bende mi?*”<sup>15</sup> ifadesinde Osmanlı yönetiminin reformlarına yönelik bir hiciv içeriğinde Osmanlı geleneksel yapısına uygun olmayan bir durum değerlendirilmesi yapılmıştır.Bu hicivde “*Salı pazarı*” Osmanlı geleneksel ticaret hayatında

<sup>15</sup>Cadaloz No 43, 9 ramazan 1329

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alışıla geldik uygulamaları tanımlarken “*Salyangoz pazarı*” Osmanlı geleneklerine aykırı devletin dayatmasıyla topluma dikte edilen batılı uygulamaları tanımlar.

### **KAZ;**

Cadaloz mizah gazetesinde kaz figürü, Osmanlı geleneksel yaşantısında olduğu gibi saflığın ve velveciliğin habercisi olarak kullanıldığını görmekteyiz. Kaz figürü ile ilgili olarak Cadaloz mizah gazetesinde 2 Rebiülahir 1329 tarihli ikinci nüshasında Karadağ’ın eteklerinin dibinde Cadaloz ’un elindeki asa ile kaz sürüsünü dağıtmaya çalıştığı görülmektedir. Cadaloz bu karikatürde kazlara seslenerek “ bütün kış o Karadağ’dan beslendiniz şimdide bizim tarlaya tecavüz haa” şeklinde bir hitapta bulunur. Bu karikatürden anlaşılacağı üzere tahminimizce Osmanlı topraklarında isyan edip takibata uğradıklarında Karadağ’a sığınan Hristiyan Arnavut isyancılar tanımlanmıştır.(Cadaloz 2,R-1329:2) Bu isyancıların kaz suretinde figürüze edilmeleri onların saflıklarına ve kolay kandırılabilirdiklerine yönelik geleneksel motiflerden beslenen bir göndermedir.

### **SONUÇ**

Çalışmamız kapsamında değerlendirdiğimiz Cadaloz mizah gazetesi içeriğindeki hayvan figürlerinin önemli oranda Osmanlı geleneksel yaşantısı içerisinde kamu algısında kabul gördüğü şekliyle değerlendirildiği tespit edilmiştir. Ancak kartal,salyangoz,horoz ve maymun figürleri Tanzimat ile başlayan batılılaşma sürecinde Osmanlı kültür hayatına ithal edilen batı menşei değerleri sembolize etmektedir. İncelediğimiz mizah gazetesi içeriğinde batı menşei reformlara yönelik muhalif karikatür ve hiciv unsurları batıdan transfer edilen ve batı değerlerini içeren bu hayvan figürleriyle tasvir edilmiştir. Ayrıca Avrupalı devletlerin kendilerine sembolize ettikleri hayvan figürleri de karikatür içeriklerinde değerlendirilmiştir. Örneğin Fransızların horozu, Prusya,İtalya ve Avusturya- Macaristan’ın kartal figürleri sıklıkla müracaat edilen semboller arasındadır. Bizce dikkat çeken husus batı kültüründe yer alan bu figürlerin Osmanlı kamusu tarafından da biliniyor olmasıdır. Bu durum Tanzimat ile birlikte başlayan batılılaşma reform ve uygulamalarının salt idari ve hukuki zeminde kalmadığı aynı zamanda Osmanlı kültür hayatına da bazı sembollerin dahil olmasına yol açtığını iddia etmemize sebep olur. Aksi taktirde bir Fransız için milli bir sembol olan horoz figürü Fransız ekolünü takipte ısrarcı bir Osmanlı siyasetçisini tanımlamakta tercih edilmezdi. Benzer şekilde kendisini kartal ile figüre eden batılı devletlerin bir Osmanlı mizah gazetesindeki karikatürde kendi ulusal sembollerine tanımlanmaları mümkün olamazdı. Tanzimat ve beraberinde getirdiği değer yargıları Osmanlı kültür hayatındaki tanımlanan hayvan figürlerine yeni bir paradigma getirmiş olmalıdır.

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Ek 1.



Ek 2.

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EK 3.

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ANTIOXIDANT ACTIVITY OF *SMILAX EXCELSA* L. STEM EXTRACT

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**Abstract**

In this study, the effects of ultrasonic-assisted extraction with different solvents, including ethanol, methanol and water, on the DPPH radical scavenging activity of *Smilax excelsa* L. were determined. For this purpose, extraction was performed with different ratios of solvents (100% and 50%) from the stems of the plant. All groups were kept in an ultrasonic bath at 35-45 ° C for 60 min. At the end of this time, the liquid extracts obtained were filtered through filter paper. Then, the solvents were removed in a water bath at 45 ° C, and solid extracts were obtained from the stem parts of the plant. Stock solutions were prepared from the solid extracts using appropriate solvents, and the DPPH radical scavenging activity was determined as %. Variance analysis of the data obtained from this study was determined with the One-Way ANOVA module; the differences between the groups were determined with Duncan's multiple comparison test. The effect of ultrasonic-assisted extraction with different solvents on the antioxidant level of *Smilax excelsa* L. stems was significant ( $P < 0.001$ ). It was determined that the highest DPPH radical scavenging activity (51.91%) was in the extraction process with ethanol. The lowest DPPH radical scavenging activity (20.16%) was in the extraction process with water. As a result, according to the data obtained from the study, the solvent used to extract *Smilax excelsa* L. plant stems could increase the antioxidant capacity.

**Keywords:** *Smilax excelsa* L., ultrasonic-assisted extraction, antioxidant, DPPH

**SMILAX EXCELSA L. SAP EKSTRAKTININ ANTIOKSİDAN AKTİVİTESİ**

**Özet**

Bu çalışmada etanol, metanol ve su olmak üzere farklı çözücülerle ultrasonik destekli yapılan ekstraksiyon işleminin *Smilax excelsa* L. bitkisinin DPPH radikal giderim aktivitesi üzerine etkileri belirlendi. Bu amaçla, bitki saplarından farklı oranlarda (%100 ve %50) 3 farklı solvent ile ekstraksiyon yapıldı. Tüm gruplar, 35-45°C sıcaklıkta 60 dk süreyle ultrasonik banyoda bekletildi. Bu süre sonunda elde edilen sıvı ekstraktlar, kaba filtre kağıdından süzüldü. Ardından 45°C sıcaklıktaki su banyosunda solventler uzaklaştırılarak bitkinin sap kısımlarından katı ekstraktlar elde edildi. Katı ekstraktlardan uygun solventler kullanılarak stok çözeltiler hazırlandı ve DPPH radikal giderim aktivitesi % olarak belirlendi. Bu çalışmadan elde edilen datanın varyans analizi One-Way ANOVA modülüyle; gruplar arasındaki farklılıklar Duncan çoklu karşılaştırma testiyle belirlendi. Farklı solventlerle ultrasonik destekli yapılan ekstraksiyonun *Smilax excelsa* L. bitki saplarının antioksidan düzeyine etkisi önemli oldu ( $P<0.001$ ). En yüksek DPPH radikal giderim aktivitesinin (%51.91) etanol ile yapılan ekstraksiyon işleminde olduğu tespit edildi. En düşük DPPH radikal giderim aktivitesinin (%20.16) ise su ile yapılan ekstraksiyonda olduğu belirlendi. Sonuç olarak, çalışmadan elde edilen verilere göre *Smilax excelsa* L. bitki saplarının ekstraksiyonunda kullanılan solvent türünün antioksidan kapasitesini arttırabileceği ortaya konuldu.

**Anahtar kelimeler:** *Smilax excelsa* L., ultrasonik destekli ekstraksiyon, antioksidan, DPPH

## GİRİŞ

*Smilax excelsa*, *Smilacaceae* familyasında yer almaktadır (Topdas ve ark., 2021). *Smilax excelsa* L., Türkiye'nin özellikle Karadeniz Bölgesi'nde yetişmektedir (Yıldız ve ark., 2018). Halk arasında melocan, silcan, diken ucu, kırçan gibi isimlerle adlandırılmaktadır (Ozsoy ve ark., 2013). Bu bitki sürgünlerinin immünomodülatör, antifungal, antitümör, antibakteriyel, antioksidan ve anti-inflamatuar olmak üzere çeşitli aktivitelere sahip olduğu bilinmektedir (Atar ve ark., 2020).

Yapılan çalışmalarda (Ozsoy ve ark., 2008; Sarıaltın ve ark., 2023; Topkara ve ark., 2024), *Smilax excelsa* L. bitkisinin antioksidan özelliğinin yüksek olduğu bildirilmiştir.

Bu çalışma, *Smilax excelsa* L. bitki sapının ultrasonik yöntemle yapılan ekstraksiyonunda kullanılan solvent türünün DPPH radikal giderim aktivitesi üzerine etkilerinin belirlenmesi amacıyla yürütüldü.

## MATERYAL VE METOD

Bu çalışmada, *Smilax excelsa* bitki saplarının antioksidan aktivitesi (DPPH radikal giderim aktivitesi) belirlendi.

### *Smilax excelsa* L. Bitkisi

Çalışmada kullanılan bitki, Mayıs ayında Samsun İlinden toplandı ve tür teşhisi yapıldı. Bitkinin sap kısımları etüvde 45°C sıcaklıkta kurutuldu. Kurutulmuş bitki sapları Resim 1'de verildi.



Resim 1. Kurutulmuş *Smilax excelsa* sapları

### Bitkinin Ekstraksiyonu

*Smilax excelsa* bitki saplarının ekstraksiyonu için su, etanol ve metanol olmak üzere üç farklı çözücü kullanıldı (Resim 2).



Resim 2. Farklı çözücülerle ekstraksiyona hazırlık

Ekstraktlar, ultrasonik banyo (Çalışkan Ultrasonic Cleaner) kullanılarak 35-45°C'de 1 saat

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sürede hazırlandı (Resim 3).



**Resim 3.** Ultrasonik banyoda ekstraksiyon

Ultrasonik destekli ekstraksiyon işlemi sonrasında elde edilen sıvı ekstraktlar kaba filtre kağıdından 2 defa süzüldü (Resim 5). Daha sonra 45°C su banyosunda (Wisd, Wise Bath) solvent maddeler uzaklaştırıldı. Böylece katı ekstraktlar elde edilmiş oldu.



**Resim 5.** Süzme işlemi ve elde edilen sıvı ekstraktlar

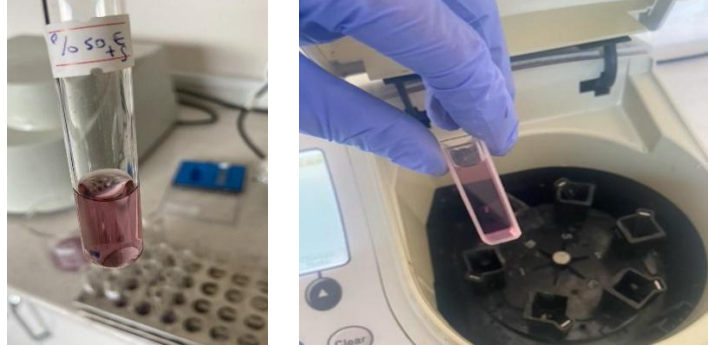
**DPPH Radikal Giderim Aktivitesinin Belirlenmesi**

Bitki sap ekstraktlarında DPPH radikal giderim aktivitesinin belirlenebilmesi için %50 ve %100 oranlarında farklı solventler (su, etanol ve metanol) ile stok çözeltiler (1000 ppm) hazırlandı. Ekstraktların DPPH (2,2-difenil-1-pikrilhidrazil) radikal giderim aktiviteleri Singh ve ark. (2002) tarafından geliştirilen metod kullanılarak her bir gruptan 3'er paralel (tekerrür) olarak belirlendi. Hazırlanan stok çözeltilerden cam tüplere 200 µL alınarak üzerlerine metanol ile hazırlanmış DPPH çözeltisi (3.8 mL) eklendi. DPPH-numune karışımları voltex (IKA Vortex 4 Basic) yardımıyla 7-10 sn karıştırıldı. Vortex sonrası tüpler laboratuvar ortam sıcaklığında (1 saat) bekletildi. Bu sürenin sonunda numunelerin absorbansları spektrofotometre (Therma Scientific, Genesys 10S UV-VIS) kullanılarak (Resim 6) DPPH radikal giderim aktivitesi formülü kullanılarak (%) örneklerin antioksidan düzeyleri belirlendi (Sudha ve ark., 2011).

DPPH radikal giderim aktivitesi =  $(\text{Kontrol absorbansı} - \text{Örnek absorbansı}) / \text{Kontrol absorbansı} \times 100$   
(Kontrol tüpü: ekstraksız, numunesiz)

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Resim 6. Spektrofotometrede absorbanların belirlenmesi

### İstatistik Analiz

Çalışma kapsamında elde edilen datanın istatistiksel analizi için SPSS 21.0 paket programında One-Way- ANOVA modülü ve Duncan çoklu karşılaştırma testi kullanıldı (IBM Corp., 2012).

### BULGULAR VE TARTIŞMA

#### *Smilax excelsa* L. Bitki Saplarının DPPH Radikal Giderim Aktivitesi

*Smilax excelsa* L. bitki saplarının DPPH radikal giderim aktivitesi (%) Tablo 1’de sunuldu.

Tablo 1. Farklı Solventlerin *Smilax excelsa* L. Bitki Saplarının Antioksidan Düzeyine Etkisi

Gruplar	DPPH (%)
35-45°C, 60 dk, E	51.91 <sup>a</sup>
35-45°C, 60 dk, M	26.35 <sup>d</sup>
35-45°C, 60 dk, S	20.16 <sup>e</sup>
35-45°C, 60 dk, %50 E-S	45.71 <sup>b</sup>
35-45°C, 60 dk, %50 M-S	35.71 <sup>c</sup>
35-45°C, 60 dk, %50 E-M	44.17 <sup>b</sup>
SEM	2.717
P	<0.001

a,b,c,d,e: Aynı sütundaki farklı harflerle gösterilen ortalamalar arasındaki farklılıklar önemlidir (P<0.05).

DPPH: 2,2-difenil-1 -pikrilhidrazil. S: Su, E: Etanol, M: Metanol.

*Smilax excelsa* saplarının ultrasonik destekli ekstraksiyonda kullanılan farklı çözücülerin (su, etanol ve metanol) DPPH radikal giderim aktivitesi üzerine etkisinin önemli olduğu tespit edildi (P<0.001). DPPH radikal giderim aktivitesi bakımından en yüksek değer (%51.91) %100 etanol ekstraksiyonunda tespit edildi. İkinci en yüksek değer (%45.71) etanol-su ekstraksiyonunda olduğu belirlendi. En düşük antioksidan değeri ise (%20.16) bitki sapının sulu ekstraksiyonunda olduğu tespit edildi.

Yapılan bazı çalışmalarda da (Sultana ve ark., 2009; Lezoul ve ark., 2020; Seyrekoğlu ve Temiz, 2020; Mehmood ve ark., 2022; Sataei Mokhtari ve ark., 2022) farklı çözücüler

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kullanılarak yapılan bitki ekstraksiyonlarının DPPH radikal giderim aktivitesi üzerine etkileri araştırılmıştır.

Yapılan bir çalışmada (Ozsoy ve ark., 2008), *Smilax excelsa* L. yapraklarının farklı çözücüler ile (su, etanol ve etil asetat) ekstraksiyonunun antioksidan kapasitesi üzerine etkileri araştırılmıştır. Çalışmada, tüm ekstraktların önemli bir antioksidan etkiye sahip olduğu ve bitki yapraklarının doğal bir antioksidan olarak kullanılabileceği bildirilmiştir.

Başka bir çalışmada (Sarıaltın ve ark., 2023), *Smilax excelsa* ve *Aegopodium podagraria* bitkilerinin sitotoksik etkisi ve antioksidan kapasitesi belirlenmiştir. *Smilax excelsa* metanol ekstraktının en yüksek DPPH radikal giderim aktivitesi değerine sahip olduğu bildirilmiştir. Yine aynı çalışmada en yüksek toplam fenolik ve flavonoid miktarlarının da metanol ekstraktında olduğu tespit edilmiştir.

Diğer bir çalışmada (Topkara ve ark., 2024), *Smilax excelsa* bitkisinden farklı solventlerle (su, etanol ve metanol) yapılan ekstraksiyonun antioksidan ve antimikrobiyal aktivite üzerine etkileri değerlendirilmiştir. Çalışmada, bitkinin fenolik madde içeriğinin en yüksek etanol ve metanol ekstraktlarında olduğu; sulu ekstraktın daha düşük fenolik madde ihtiva ettiği tespit edilmiştir.

#### **SONUÇ**

Bu çalışmada, *Smilax excelsa* bitki sap ekstraktında kullanılan farklı solventlerin (su, etanol ve metanol) DPPH radikal giderim aktivitesi üzerine etkisi önemli bulundu. En yüksek DPPH radikal giderim aktivitesinin etanol ekstraksiyonunda olduğu; en düşük DPPH radikal giderim aktivitesinin ise su ekstraksiyonunda olduğu belirlendi. Sonuç olarak, çalışmadan elde edilen verilere göre *Smilax excelsa* L. bitki saplarının ekstraksiyonunda kullanılan solventin antioksidan kapasitesini arttırabileceği ortaya konuldu.

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**PROBIOTICS AND EVALUATION OF POTENTIAL ANTIOXIDANT FEATURES**

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**Abstract**

Reactive oxygen species (ROS) are formed as a by-product of normal metabolic processes and are associated with oxidative stress. An increase in ROS levels disrupts the intracellular oxidant-antioxidant balance, causing oxidative stress. This can lead to molecular changes such as lipid peroxidation, protein oxidation, and DNA damage. Oxidative stress may play a role in the pathogenesis of pathological conditions such as cardiovascular diseases, neurodegenerative disorders, and cancer. Antioxidants prevent or delay oxidation, thus protecting cells from damage caused by free radicals. These substances can be natural or synthetic. However, due to the potential toxic effects of synthetic antioxidants, interest in natural antioxidants has increased. Recent studies have shown that probiotics play a very important role in gastrointestinal health and in reducing oxidative stress with their antioxidant properties. Probiotics are live microorganisms that provide health benefits, including antioxidant properties that help reduce oxidative stress, which is linked to various diseases, especially cardiovascular diseases, cancer, and obesity. Probiotics can neutralize free radicals by producing various antioxidant enzymes and metabolites, support the antioxidant capacity of the host, and minimize oxidative damage. In this review, probiotics and their potential antioxidant effects are discussed.

**Keywords:** Probiotic, antioxidant, oxidation, oxidative stress



### PROBİYOTİKLER VE POTANSİYEL ANTIOKSİDAN ÖZELLİKLERİ

#### Özet

Reaktif oksijen türleri (ROS), normal metabolik süreçlerin bir yan ürünü olarak oluşur ve oksidatif stresle ilişkilidir. ROS seviyelerindeki artış, hücre içi oksidan-antioksidan dengesini bozarak oksidatif strese neden olur. Bu durum, lipid peroksidasyonu, protein oksidasyonu ve DNA hasarı gibi moleküler değişikliklere yol açabilir. Oksidatif stres kardiyovasküler hastalıklar, nörodejeneratif bozukluklar ve kanser gibi patolojik durumların patogenezinde rol oynayabilir. Antioksidanlar, oksidasyonu önleyen veya geciktiren, böylece serbest radikallerin neden olduğu hasardan hücreleri koruyan maddelerdir. Bu maddeler, doğal veya sentetik olabilir. Ancak sentetik antioksidanların potansiyel toksik etkileri nedeniyle doğal antioksidanlara olan ilgi artmıştır. Son yıllarda yapılan araştırmalar, probiyotiklerin yalnızca gastrointestinal sağlık üzerinde değil aynı zamanda antioksidan özellikleri ile oksidatif stresin azaltılmasında da çok önemli rol oynadığını göstermektedir. Probiyotikler başta kardiyovasküler hastalıklar, kanser ve obezite olmak üzere çeşitli hastalıklarla bağlantılı olan oksidatif stresi azaltmaya yardımcı olan antioksidan özellikler de dahil olmak üzere sağlık yararları sağlayan canlı mikroorganizmalardır. Probiyotikler, çeşitli antioksidan enzimler ve metabolitler üreterek serbest radikallerin nötralizasyonunu sağlayabilir; konakçının antioksidan kapasitesini destekleyebilir ve oksidatif hasarı en aza indirebilir. Bu derlemede, probiyotikler ve onların potansiyel antioksidan etkileri ele alınmıştır.

**Anahtar kelimeler:** Probiyotik, antioksidan, oksidasyon, oksidatif stres

### **Antioksidanlar ve Etki mekanizmaları**

Çevresel faktörler ve kimyasallar, organizmaları oksidatif strese maruz bırakabilir (Halliwell ve Cross, 1994). Bu stres, hücrel homeostazı bozarak çeşitli patolojik durumların gelişimine katkıda bulunabilir. Reaktif oksijen türleri (ROS), normal metabolik süreçlerin bir yan ürünü olarak oluşur ve oksidatif strese ilişkilidir (Arı, 2017; Unluguzel Ustun ve ark., 2021; Keskin ve Karul, 2022). ROS seviyelerindeki artış, hücre içi oksidan-antioksidan dengesini bozarak oksidatif strese neden olur. Bu durum lipid peroksidasyonu, protein oksidasyonu ve DNA hasarı gibi moleküler değişikliklere yol açabilir. Uzun süreli oksidatif stres kardiyovasküler hastalıklar, nörodejeneratif bozukluklar ve kanser gibi patolojik durumların patogenezinde rol oynayabilir (Eftekharzadeh ve ark., 2010).

Antioksidanlar, hücrel bileşenlerin oksidasyonunu önleyen veya geciktiren, böylece hücreleri serbest radikallerin neden olduğu hasardan koruyan maddelerdir. Başta reaktif oksijen türleri (ROS) ve reaktif nitrojen türleri olan bu serbest radikaller, çeşitli kronik hastalıklarda rol oynayan oksidatif strese yol açabilir. Antioksidanlar, meyvelerde, sebzelerde ve kepekli tahıllarda bulunan vitaminler, mineraller ve fitokimyasallar dahil olmak üzere diyet kaynakları ile endojen olarak üretilebilir veya diyet yoluyla elde edilebilir (Tyagi ve ark., 2022; Myhrstad ve Wolke, 2023).

Antioksidanlar çeşitli etki mekanizmaları bulunmaktadır. Bunlar, indirgeyici etkileri yoluyla serbest radikal oluşumunu engelleyebilir, radikal temizleyiciler olarak serbest radikalleri yakalayabilir ve prooksidatif süreçleri katalize eden karmaşık geçiş metali iyonlarını yakalayabilirler. (Li, 2023). Ayrıca literatürde etki mekanizmaları arasında antioksidan enzimlerin aktive edilmesi, metal katalizörlerinin şelatlandırılması ve oksidazların inhibe edilmesi yer almaktadır (Sundaram Sanjay, ve Shukla, 2021). Bazı antioksidanlar, vücudun oksidatif strese karşı birincil savunmasının bir parçası olan süperoksit dismutaz ve katalaz gibi endojen antioksidan enzimlerin aktivitesini artırır (Li, 2023)

Doğal ve sentetik antioksidanlar, serbest radikalleri nötralize ederek oksidatif strese mücadelede çok önemli roller oynarlar, ancak kaynakları, mekanizmaları ve uygulamaları bakımından farklılık gösterirler. Doğal antioksidanlar öncelikle meyveler, sebzeler ve şifalı bitkiler gibi diyet kaynaklarından elde edilirken, sentetik antioksidanlar sentetik olarak üretilir. Bitkilerden elde edilen doğal antioksidanlar flavonoidler, vitaminler ve karotenoidleri içerir. Bunlar, anti-kanser ve anti-enflamatuar olmak üzere çeşitli farmakolojik özellikler sergiler. Enzimatik ve enzimatik olmayan mekanizmalar yoluyla hücrel düzeyde serbest radikal hasarına karşı koruma sağlar. Buna karşılık, sentetik antioksidanlar sağlık riskleri oluşturabilir (Alamzeb ve ark., 2024).

Doğal ve sentetik antioksidanlar, reaktif oksijen türleri (ROS) ve reaktif nitrojen türleri (RNS) gibi serbest radikallerin neden olduğu oksidatif stres önlemede önemli rol oynayan bileşiklerdir. Doğal antioksidanlar flavonoidler, karotenoidler ve vitaminler gibi biyolojik olarak aktif bileşenler içeren bitkisel kaynaklardan elde edilir ve genellikle düşük toksisite ve ek sağlık faydaları nedeniyle tercih edilir. Bu bileşikler, serbest radikalleri doğrudan temizleme, antioksidan enzimlerin ekspresyonunu artırma ve iltihaplanmayı azaltma gibi çeşitli mekanizmalarla oksidatif hasarı önler (Abeyrathne ve ark., 2022; Li, 2023; Alamzeb ve ark., 2024). Buna karşılık sentetik antioksidanlar, gıda endüstrisinde lipid oksidasyonunu önlemek ve raf ömrünü uzatmak amacıyla kullanılan bütillenmiş hidroksitoluen (BHT) ve bütillenmiş hidroksianisol (BHA) gibi bileşenlerden oluşur. Ancak, bazı sentetik antioksidanların uzun vadeli sağlık riskleri taşıyabileceği yönündeki endişeler, doğal kaynaklı bileşiklere olan ilgiyi artırmıştır (Losada-Barreiro ve ark., 2022; Li, 2023).

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Doğal ve sentetik antioksidanlar, oksidatif stresle mücadelede farklı etki mekanizmalarına sahiptir. Doğal antioksidanlar, fenolik bileşiklerin radikal temizleme etkisi ve metal şelasyonu gibi biyokimyasal süreçler yoluyla oksidasyonu önlerken, sentetik antioksidanlar genellikle mitokondriyal elektron taşınması sırasında oksijen radikallerinin oluşumunu engeller. Bununla birlikte, doğal antioksidanlar serbest radikallerle sinerjik bir şekilde çalışan kompleks biyoaktif bileşikler içerirken, sentetik antioksidanlar daha spesifik bir etki gösterir ancak yüksek dozlarda pro-oksidan aktivite sergileyebilir (Metaxas ve Kourti, 2023). Ayrıca, bitkisel antioksidanlar genellikle aromatik halkalar ve hidrosil grupları içerirken, hayvansal kaynaklı antioksidanlar belirli amino asit içeren peptitlerden oluşur (Losada-Barreiro vd., 2022). Bu farklılıklar, doğal ve sentetik antioksidanların sağlık ve endüstri açısından farklı kullanım alanlarına sahip olmasına neden olmakta olup, her iki türün avantaj ve sınırlamalarının dikkatlice değerlendirilmesi gerekmektedir.

## **Probiyotiklerin Antioksidan Özellikleri**

Probiyotikler, bağırsak mikrobiyotasını düzenleyerek konakçı sağlığını iyileştiren canlı mikroorganizmalardır. Son yıllarda yapılan araştırmalar, probiyotiklerin yalnızca gastrointestinal sağlık üzerinde değil aynı zamanda antioksidan özellikler sergileyerek oksidatif stresin azaltılmasında da önemli rol oynadığını göstermektedir (Boyajian ve ark., 2024). Oksidatif stres, serbest radikallerin hücrel sistemlerde birikmesi sonucu ortaya çıkan bir durum olup; kardiyovasküler hastalıklar, kanser, nörodejeneratif bozukluklar ve obezite gibi çeşitli kronik hastalıklarla ilişkilidir (Kavyani ve ark., 2024). Probiyotikler kardiyovasküler hastalıklar, kanser ve obezite gibi çeşitli hastalıklarla bağlantılı olan oksidatif stresi azaltmaya yardımcı olan antioksidan özellikler de dahil olmak üzere sağlık yararları sağlayan canlı mikroorganizmalardır. Probiyotikler, antioksidan enzimler ve metabolitler üreterek serbest radikallerin nötralizasyonunu sağlayabilir; konakçının antioksidan kapasitesini artırabilir ve oksidatif hasarı en aza indirebilir. Özellikle *Lactobacillus gasseri* A237, *Lactobacillus plantarum* WCFS1 ve *Lactobacillus fermentum* NCIMB 5221 gibi belirli probiyotik suşlarının, bilinen güçlü bir antioksidan olan quercetin ile karşılaştırılabilir DPPH radikal süpürücü aktivite sergilediği belirlenmiştir (Boyajian vd., 2024). Bu bulgular, probiyotiklerin sadece bağırsak sağlığını desteklemekle kalmayıp, aynı zamanda oksidatif strese bağlı hastalıkların yönetiminde de önemli bir rol oynayabileceğini göstermektedir.

Probiyotiklerin antioksidan etkileri, birden fazla mekanizma ile gerçekleşmektedir. Bazı suşlar doğrudan serbest radikalleri temizleyerek oksidatif hasarı azaltırken, diğerleri antioksidan enzim ekspresyonunu artırarak hücrel savunma sistemlerini güçlendirmektedir. Örneğin, *Lactiplantibacillus plantarum* ZJ316, hidrojen peroksite karşı yüksek tolerans gösterirken, antioksidan gen ekspresyonunu düzenleyerek redoks homeostazını koruma kapasitesine sahiptir (Wu ve ark., 2023). Benzer şekilde, *Limosilactobacillus fermentum* USM 4189 (LF 4189), reaktif metabolitler üreterek oksidatif stresle mücadele eder ve D-galaktoz kaynaklı yaşlanma modelinde plazma antioksidan aktivitesini artırırken lipid peroksidasyonunu azaltır (Lee ve ark., 2023). Ayrıca, probiyotikler bağırsak mikrobiyotasını modüle ederek yararlı bakteri popülasyonlarını artırabilir ve böylece bağırsak sağlığını koruyucu etkiler sağlayabilir (Yang ve ark., 2023). Bağırsakta üretilen kısa zincirli yağ asitleri, antioksidan özellik göstererek inflamatuvar süreçleri baskılayabilir ve hücrel hasarı önleyebilir. Bu mikrobiyal bileşikler, özellikle prebiyotiklerle birleştirildiğinde sinerjik etki göstererek antioksidan kapasitelerini artırabilir ve oksidatif strese bağlı hastalıkların önlenmesine katkıda bulunabilir (Mounir ve ark., 2022). *Lacticaseibacillus paracasei* TDM-2 ve *Pediococcus pentosaceus* TCM-3 gibi probiyotikler, yüksek toplam antioksidan kapasitesi (T-AOC) göstererek oksidatif

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hasarı azaltıcı etkiler sergilemiştir (Yang ve ark., 2023). Probiyotikler, yalnızca serbest radikalleri temizlemekle kalmaz, aynı zamanda bağışıklık sistemini düzenleyerek oksidatif stresle ilişkili hücresel süreçleri iyileştirme potansiyeline de sahiptir. Yapılan çalışmalar, spesifik probiyotik suşlarının tüketiminin bağışıklık tepkilerini artırarak inflamasyonu baskıladığını ve oksidatif hasarı azalttığını ortaya koymuştur (Moghdam, 2024). Tüm bu bulgular, probiyotiklerin sadece sindirim sağlığına değil, genel vücut sağlığına da önemli katkılar sunduğunu ve özellikle kardiyovasküler hastalıklar, kanser ve yaşlanma gibi oksidatif stresle ilişkili durumların yönetiminde potansiyel bir biyoterapötik ajan olarak değerlendirilebileceğini göstermektedir. Ancak, probiyotiklerin antioksidan etkilerinin mekanizmalarının daha iyi anlaşılması ve insan sağlığı üzerindeki klinik öneminin belirlenmesi için ileri araştırmalara ihtiyaç duyulmaktadır.

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