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UNIVERSIDAD JUÁREZ
AUTÓNOMA DE TABASCO
"ESTUDIO EN LA DUDA. ACCIÓN EN LA FE"



INTERNATIONAL CONGRESS ON FOOD, AGRICULTURE AND ENVIRONMENT RESEARCHES IN GLOBAL WORLD -II

August 24-26, 2025 / New York, USA

PROCEEDINGS BOOK

EDITORS

Johannna Moscoso Pacheco

Rocio Romero Cruz

Jessica Esther Cruz Velazco

Maximiliano Martinez Ortiz



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International Congress on Food, Agriculture and Environment Researches in Global World -II



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10.09.2025

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August 24-26, 2025 / New York

CONGRESS ID

TITLE OF CONGRESS

INTERNATIONAL CONGRESS ON FOOD, AGRICULTURE AND
ENVIRONMENT RESEARCHES IN GLOBAL WORLD -II

PARTICIPATION

Face to Face & Online

DATE - PLACE

August 24-26, 2025 / New York

ORGANIZATION

İKSAD-Institute of Economic Development and Social Researches

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Assist. Prof. Dr. Alina AMANZHLOVA - Khoja Akhmet Yassawi International
Kazakh-Turkish University, Kazakhstan

PARTICIPATING COUNTRIES (12)

Türkiye, Vietnam, Pakistan, Brazil, Iran, Nigeria, India, Morocco,
Bangladesh, Lithuania, Romania, Egypt

TOTAL PAPERS: 35

The number of papers from foreign countries: **24**

The number of papers from Türkiye: **11**

LANGUAGES

Turkish, English

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PHOTO GALLERY



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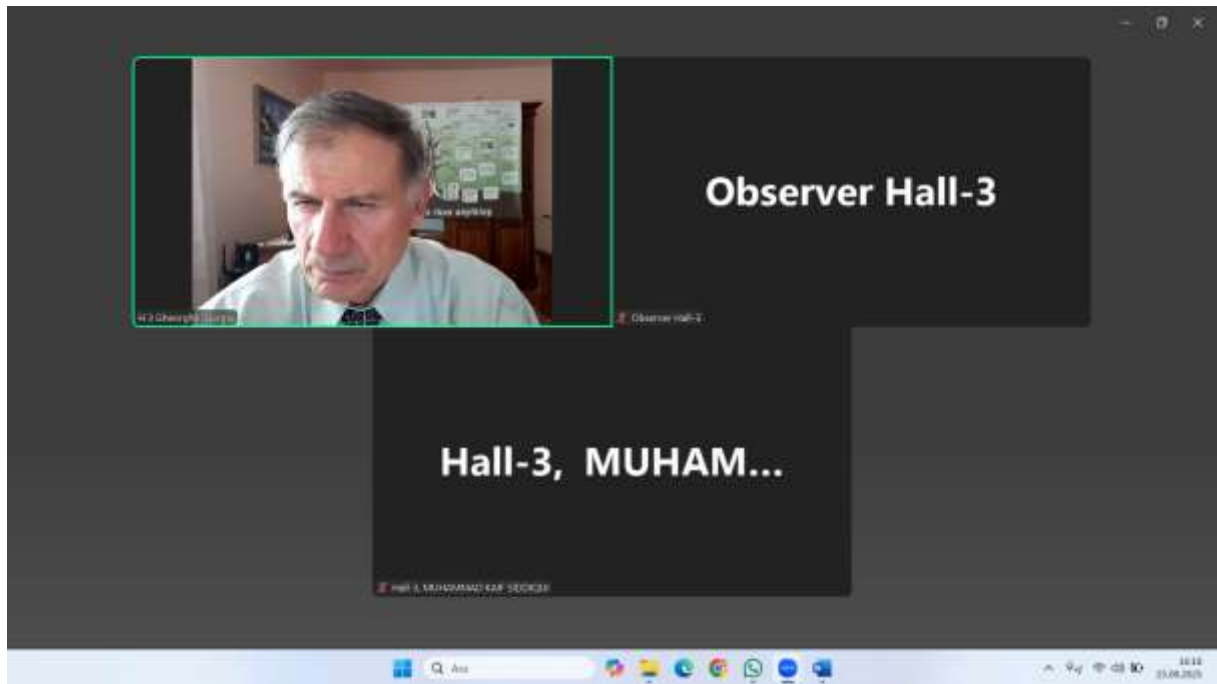
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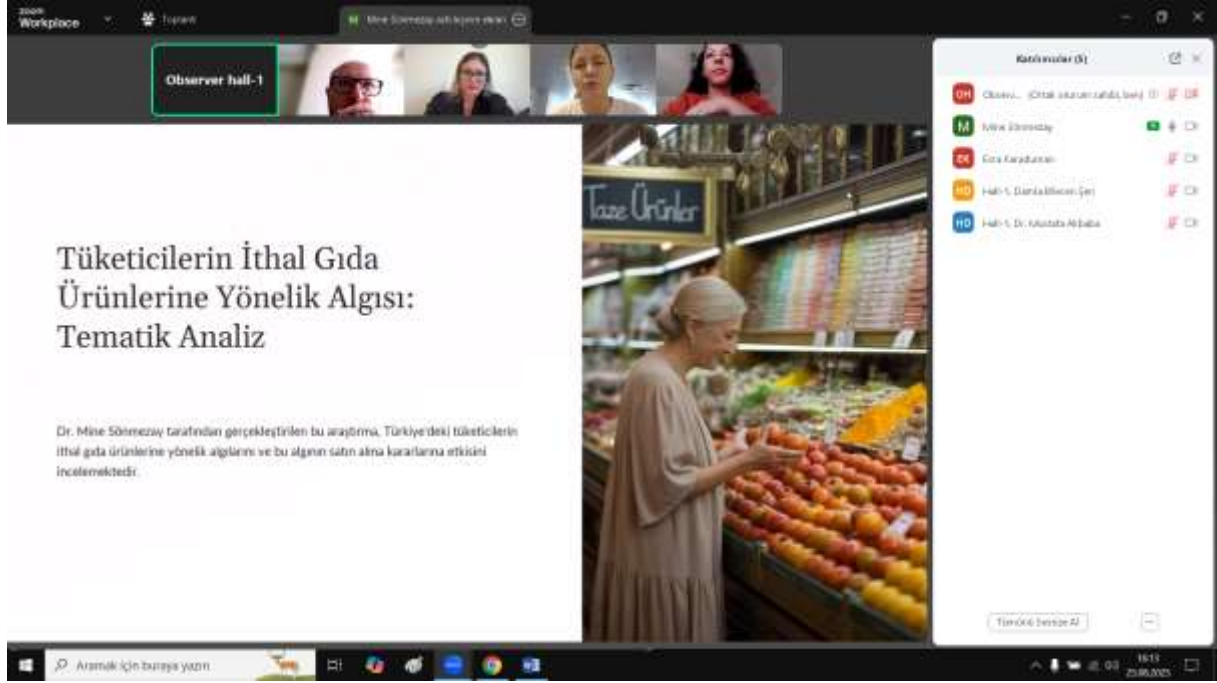
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International Congress on Food, Agriculture and Environment Researches in Global World -II

August 24-26, 2025

New York

CONGRESS PROGRAM



ONLINE PRESENTATIONS

Meeting ID: 870 6274 8180

Passcode: 242526

PARTICIPANT COUNTRIES (12):

Türkiye, Vietnam, Pakistan, Brazil, Iran, Nigeria, India, Morocco, Bangladesh, Lithuania,
Romania, Egypt

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FACE TO FACE PRESENTATIONS

Venue: Riu Plaza Times Square

23.08.2025



New York Local Time: 14:⁰⁰–16:⁰⁰

HEAD OF SESSION: Leslie R. Robinson

AUTHORS	AFFILIATION	TOPIC TITLE
Joris Vėžys Vytautas Ostaševičius Agnė Paulauskaitė Tarasevičienė Vytautas Jūrėnas Algimantas Bubulis Laura Kižauskienė Arnas Nakrošis Romas Gružasuskas Antanas Sederevičius Vaidas Oberauskas Ignas Šilinskas Juozas Žemaitis	Kaunas University of Technology, Lithuania Lithuanian University of Health Sciences	INNOVATIVE MONITORING SYSTEMS AND ARTIFICIAL INTELLIGENCE APPLICATION FOR ASSESSING DAIRY CATTLE HEALTH AND WELFARE

25.08.2025

Session-1 / Hall-1

New York Time: 09⁰⁰-11⁰⁰

Ankara Time: 16⁰⁰-18⁰⁰

HEAD OF SESSION: Lect. Dr. Mine SÖNMEZAY

TOPIC TITLE	AUTHORS	AFFILIATION
TÜKETİCİLERİN İTHAL GIDA ÜRÜNLERİNE YÖNELİK ALGISI: TEMATİK ANALİZ	Mine SÖNMEZAY	Mudanya University, Türkiye
GIDA ÜRÜNLERİNDE FİYAT, MENŞE VE GÜVENİLİRLİĞE YÖNELİK TÜKETİCİ ALGILARI: TEMATİK ANALİZ	Mine SÖNMEZAY	Mudanya University, Türkiye
BACTERIOPHAGES: A BIOCONTROL STRATEGY FOR BACTERIAL PLANT DISEASES	Mustafa AKBABA	Sivas Bilim ve Teknoloji University, Türkiye
ASSESSMENT OF THE ANTIOXIDANT CAPACITY IN LACTIC ACID BACTERIA ISOLATED FROM FOOD SOURCES	Damla BİLECEN ŞEN Pelin ERTÜRKMEN	Burdur Mehmet Akif Ersoy University, Türkiye
TECHNOLOGICAL TRANSFORMATION IN POULTRY PRODUCTION: ARTIFICIAL INTELLIGENCE-ASSISTED INDIVIDUAL BEHAVIOR MONITORING AND HOLISTIC EVALUATION OF SMART SYSTEMS	Esra KARADUMAN Doğan NARİNÇ	Akdeniz University, Türkiye
GROWTH CURVES IN POULTRY: MODELS, APPLICATIONS, AND CURRENT APPROACHES	Esra KARADUMAN Doğan NARİNÇ	Akdeniz University, Türkiye

25.08.2025

Session-1 / Hall-2

New York Time: 09⁰⁰-11⁰⁰

Ankara Time: 16⁰⁰-18⁰⁰

HEAD OF SESSION: Prof. Dr. Doğan NARİNÇ

TOPIC TITLE	AUTHORS	AFFILIATION
POSSIBILITIES OF USING BEE PRODUCTS IN ANIMAL NUTRITION	Pınar TATLI SEVEN Miray Sıla ÇİÇEK Seda İFLAZOĞLU MUTLU Usama Taha Mahmoud İsmail SEVEN	Fırat University, Türkiye Assiut University, Assiut, Egypt
TRANSCRIPTOME PROFILING AND SAMPLE CLUSTERING ANALYSIS OF CORIANDRUM SATIVUM USING DE NOVO RNA-Seq SEQUENCING	M. Alp FURAN Gülistan GENLİ	Van Yüzüncü Yıl University, Türkiye
EFFECTS OF ORGANIC AND CHEMICAL FERTILIZERS IN HEMP (Cannabis sativa L.) CULTIVATION	Levent YAZICI Muhammed Batuhan ERBAY	Yozgat Bozok University, Türkiye
CAN WE SAFELY EAT CHICKEN MEAT SOLD IN SUPERMARKETS?	Doğan NARİNÇ Esra KARADUMAN	Akdeniz University, Türkiye
THE IMPORTANCE OF CHICK QUALITY IN BROILER REARING	Doğan NARİNÇ Esra KARADUMAN	Akdeniz University, Türkiye

25.08.2025

Session-1 / Hall-3

New York Time: 09⁰⁰-11⁰⁰

Ankara Time: 16⁰⁰-18⁰⁰

HEAD OF SESSION: Major Gheorghe GIURGIU

TOPIC TITLE	AUTHORS	AFFILIATION
MICROBIOTA MODULATION AS THERAPEUTIC APPROACH IN THE NEUROPATHIC PAIN IN DOG WITH SPINAL CORD INJURY: IMPACT OF POLENOPLASMIN	Major Gheorghe GIURGIU, Prof. dr. med. Manole COJOCARU	Deniplant-Aide Sante Medical Center, Biomedicine, Bucharest, Romania Academy of Romanian Scientists Titu Maiorescu University, Faculty of Medicine, Bucharest, Romania
INTEGRATING CIRCULAR ECONOMY AND BEHAVIORAL INSIGHTS IN ROOFTOP AGRICULTURE: A SUSTAINABLE URBAN DEVELOPMENT PERSPECTIVE FROM BANGLADESH	Abid Hasan Md. Mehedi Hasan Md. Solaiman Chowdhury S M Shafeeul Islam Galib Safatul Huda	Khulna University, Bangladesh
PRODUCTION OF DESIGNER EGGS AND ITS IMPORTANCE IN HUMAN NUTRITION : A REVIEW	Ekanem Ndifreke John, Afolabi Kolawole Daniel, Muhammad Haroon Aslam, Agwu Ani Ekwe, Essien Kemfon Friday	University of Uyo, Uyo, Nigeria University of Agriculture Faisalabad, Faisalabad, Pakistan Federal Polytechnic Ngodo-Isuochi, Abia State, Nigeria Bayero University Kano, Kano State, Nigeria
EXPLORING THE BIOACTIVE COMPONENTS AND PHARMACOLOGICAL BENEFITS OF A NORTHERN MOROCCAN TRADITIONAL HERB	Nesrine Benkhaira, Saad Ibnsouda Koraichi, Kawtar Fikri-Benbrahim	Sidi Mohamed Ben Abdellah University, Fes, Morocco
AGRICULTURAL LAND ALLOCATION WITHIN ENERGY-FOOD NEXUS: PATHWAYS TO GLOBAL SUSTAINABLE DEVELOPMENT	Samane Ghazali	National Salinity Research Center (NSRC), Agricultural Research Education and Extension Organization (AREEO), Yazd, Iran.
PLANT-BASED SOLUTIONS FOR GLOBAL PATHOGEN RESISTANCE: ANTIMICROBIAL STUDY OF ALBIZIA LEBBECK	Muhammad Kaif Siddiqui Anushka Sharma	Aligarh Muslim University, U.P, India Chinmaya Degree College, Haridwar, U.K, India

25.08.2025

Session-1 / Hall-4

New York Time: 09⁰⁰-11⁰⁰

Ankara Time: 16⁰⁰-18⁰⁰

HEAD OF SESSION: Afshin Tavasoli Farsheh

TOPIC TITLE	AUTHORS	AFFILIATION
BIO PIGMENTS AS SUSTAINABLE ALTERNATIVES TO TRADITIONAL COLORANTS IN PLASTIC MASTERBATCH PRODUCTION: A REVIEW	Afshin Tavasoli Farsheh	Islamic Azad University, Mashhad, Iran
COMPARATIVE MORPHOLOGICAL, ANATOMICAL AND ECO-PHYSIOLOGICAL ASSESSMENT OF MORINGA OLIFERA LAM. ACROSS DIVERSE ECOLOGICAL REGIONS OF PUNJAB, PAKISTAN	Tanzeela Asad, Syed Mohsan Raza Shah, Iqra, Arshia Zia, Naila Hadayat, Muhammad Bedar Bekhat Naseem, Zaheer Abbas	University of Education, Lahore University of Agriculture, Faisalabad Government College University Faisalabad
ENVIRONMENTAL IMPACT ASSESSMENT OF THE ARTISANAL BAMBOO POLE (GUADUA ANGUSTIFOLIA) PRODUCTION IN THE BRAZILIAN AMAZON	Letícia Medeiros de Araujo, Gerson Araujo de Medeiros	São Paulo State University (Unesp), Brazil
LEAF STRUCTURAL AND FUNCTIONAL MODIFICATION OF IPOMOEA CARNEA JACQ. AN INVASIVE PLANT SPECIES, UNDER DIVERSE SALINITY GRADIENT	Saira Malik, Syed Mohsan Raza Shah, Uniza Fatima bukhari, Tasawar Fatima bukhari, Iqra	University of Education, Lahore, Pakistan
EVALUATION OF THE IN VITRO ANTIOXIDANT AND ANTIDIABETIC ACTIVITIES OF QUINOA (CHENOPODIUM QUINOA WILLD.) SEED EXTRACTS AND THE QUANTIFICATION OF THEIR BIOACTIVE COMPOUNDS	Zaina Idir, Rhizlane Abdnim, Ilham Abidi, Mohamed Bnouham, Fatima Aouinti, Nadia Gseyra	Mohammed First University, Oujda 60000, Morocco Hassan II Institute of Agronomy and Veterinary sciences, Morocco
DIATOM COMMUNITY STRUCTURE AS AN INDICATOR OF AQUACULTURE IMPACTS IN LAKE BULUAN, MAGUINDANAO, PHILIPPINES	Claudine Ann Nakila, Amera Malaco, Rodelyn Dalayap, Sharon Rose Tabugo	Mindanao State University-Iligan Institute of Technology (MSU-IIT), Philippines Sultan Kudarat State University, Philippines
IMMOBILIZATION OF PECTINASE ON ORANGE PEEL USING Luffa cylindrica FOR ENHANCED STABILITY AND APPLICATION IN JUICE CLARIFICATION	Lawal Atinuke Adenike	Federal Polytechnic, Ilaro, Nigeria
PLANT OILS AS REPLACEMENT OF DIETARY FISH OIL; EFFECT ON GROWTH PERFORMANCE, NUTRIENT DIGESTIBILITY AND BODY COMPOSITION OF LABEO ROHITA FINGERLINGS	Muhammad Amjad, Syed Makhdoom Hussain, Mahnoor Saleem, Adan Naeem, and Eman Naeem	Government College University, Faisalabad, Pakistan

25.08.2025

Session-1 / Hall-5

New York Time: 09⁰⁰-11⁰⁰

Ankara Time: 16⁰⁰-18⁰⁰

HEAD OF SESSION: Dr. Nguyen Thi Bich Van

TOPIC TITLE	AUTHORS	AFFILIATION
THE EFFECTIVENESS OF NATURAL LIGHT IN MUSEUM DESIGN: THE CASE STUDY "THE HE ART MUSEUM"	Dr. Nguyen Thi Bich Van Nguyen Tran Thien Phuc	University of Architecture Hochiminh City, Vietnam
IMPACT OF COLOR ON PATIENT RECOVERY IN POST-OPERATIVE ROOM ENVIRONMENTS	Dr. Nguyen Thi Bich Van Vương Tôn Minh	University of Architecture Hochiminh City, Vietnam
THE ROLE OF INDIRECT LIGHTING IN CONTEMPORARY MUSEUM DESIGN	Dr. Nguyen Thi Bich Van Tong Hoang Bao Giang	University of Architecture Hochiminh City, Vietnam
DEAFSPACE IN EDUCATIONAL DESIGN: ACOUSTIC STRATEGIES AND SPATIAL ADAPTATIONS FOR THE HEARING-IMPAIRED	Dr. Nguyen Thi Bich Van Tran Nguyen Thao Nhi	University of Architecture Hochiminh City, Vietnam
POTENTIAL IMPACTS OF ACOUSTICS IN FACTORIES AND INDUSTRIAL ENTERPRISES ON WORKERS' HEALTH	Dr. Nguyen Thi Bich Van Hoang Trong Duc	University of Architecture Hochiminh City, Vietnam
EVALUATION OF COLOR APPLICATION AND TREATMENT IN EDUCATIONAL SPACES: THE CASE OF SCHOOLCRAFT ELEMENTARY SCHOOL	Dr. Nguyen Thi Bich Van Pham Thi Ngoc Ngan	University of Architecture Hochiminh City, Vietnam
THE ART OF STAGE LIGHTING: AN ANALYSIS OF HOW DYNAMIC LIGHTING DESIGN AND PERFORMANCE TECHNOLOGIES IMPACT AUDIENCE EMOTION AND ENERGY EFFICIENCY IN THEATRES	Dr. Nguyen Thi Bich Van Tran Gia Linh	University of Architecture Hochiminh City, Vietnam
THE ARCHITECTURE OF ILLUMINATION: ERGONOMIC LIGHTING STRATEGIES FOR TEMPORARY FASHION SPACES	Dr. Nguyễn Thị Bích Vân Quan Yến Mỹ	University of Architecture Hochiminh City, Vietnam
COLOR DESIGN FOR EMOTIONAL SUPPORT IN HEALTHCARE: THE TSURUMI CHILDREN'S HOSPICE CASE STUDY	Dr. Nguyen Thi Bich Van Tran Phuong Nghi	University of Architecture Hochiminh City, Vietnam

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Dr. Mine Sönmezay

Mudanya Üniversitesi, Meslek Yüksekokulu, Dış Ticaret Programı, Bursa

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ÖZET

Bu çalışmada, Türkiye’de 114 tüketicieye kolayda örnekleme yöntemiyle uygulanan çevrim içi anket sonucu elde edilen açık uçlu yanıtlar, manuel olarak gerçekleştirilen tematik analiz yöntemiyle incelenmiştir. Yanıtlar araştırmacı tarafından dikkatlice okunarak, tekrar eden örüntüler temelinde kodlanmış ve temalar oluşturulmuştur. Katılımcılara “Gıda ürünlerinde fiyat, ürün menşe (yerli/ithal) ve güvenilirlik arasında nasıl bir ilişki kuruyorsunuz? Bu üç unsurdan hangisi sizin için daha belirleyici olur, neden?” sorusu yöneltilmiştir. Tematik analiz sonucunda, cevaplar üç temel tema etrafında toplanmaktadır. Bunlar ürün menşe odaklı algıyı, güvenilirlik ve gıda güvenliğiyle ilgili yaklaşımları ve fiyat temelli değerlendirmeleri içermektedir. Elde edilen bulgulara göre katılımcıların yaklaşık %49’u ürün menşeni, %33’ü güvenilirliği ve %15’i fiyatı birincil belirleyici unsur olarak vurgulamıştır. Ürün menşe teması, özellikle yerli üretime yönelik tercihi ve etnik/ulusal sadakati yansıtırken; güvenilirlik teması, ürünün sağlık, hijyen ve içerik güvenliği gibi unsurlarına odaklanmıştır. Fiyat teması ise ekonomik durum ve bütçe kısıtlarıyla ilişkilendirilmiştir. Sonuçlar, literatürdeki benzer çalışmalarda da vurgulandığı gibi fiyatın genelde birinci etken olmasına rağmen, gıda güvenliği ve menşe bilgilerinin de tüketici güvenini etkileyen önemli faktörler olduğunu göstermektedir.

Anahtar Kelimeler: Tüketici davranışı, gıda menşe, güvenilirlik, fiyat algısı, tematik analiz

ABSTRACT

In this study, open-ended responses obtained from an online survey administered to 114 consumers in Turkey using a convenience sampling method were analyzed manually using thematic analysis. The researcher carefully read the responses, coded them based on recurring patterns, and created themes. Participants were asked, "What is the relationship between price, product origin (domestic/imported), and reliability in food products? Which of these three factors is more decisive for you, and why?" The thematic analysis revealed that the responses were grouped around three main themes. These included perceptions focused on product origin, approaches to reliability and food safety, and price-based evaluations. Findings indicated that approximately 49% of participants highlighted product origin, 33% reliability, and 15% price as the primary determining factor. The product origin theme reflects a preference for domestic production and ethnic/national loyalty, while the reliability theme focuses on product health, hygiene, and ingredient safety. The price theme was associated with economic status and budget constraints. The results indicate that, although price is generally the primary factor, as emphasized in similar studies in the literature, food safety and provenance information are also important factors affecting consumer trust.

Keywords: Consumer behavior, food provenance, reliability, price perception, thematic analysis

GİRİŞ

Küreselleşme sürecinin hız kazanmasıyla birlikte gıda tedarik zincirleri uluslararası bir boyut kazanmış, bu durum tüketicilerin gıda ürünlerini değerlendirme biçimlerinde önemli değişimlere yol açmıştır. Gıda tüketiminde geleneksel unsurlar olan tat, görüntü, alışkanlık gibi unsurların yanı sıra artık ürünün **menşe** (yerli/ithal oluşu), güvenilirliği (sağlığa uygunluk, hijyen, içerik) ve fiyatı gibi daha karmaşık ve çok boyutlu kriterler de karar alma süreçlerinde belirleyici hâle gelmiştir (Schrobbach et al., 2023). Bu

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bağlamda, gıda ürünleri için yapılan tercihlerin yalnızca ekonomik değil; aynı zamanda kültürel, psikolojik ve sağlıkla ilişkili boyutları da içeren karmaşık bir yapıya büründüğü görülmektedir. Özellikle “credence” olarak adlandırılan ve tüketici tarafından doğrudan değerlendirilemeyen ürün özellikleri (örneğin ürünün organik olup olmadığı, hangi tarım teknikleriyle üretildiği, ürün menşesi vb.), tüketicilerin güven oluşturma sürecinde merkezi rol oynamaktadır (Thomas & Feng, 2021).

Bu çerçevede, tüketiciler satın alma kararlarında güven oluşturmak amacıyla ürün etiketleri, ürün menşesi bilgisi, coğrafi işaretler, organik/iyi tarım sertifikaları gibi çeşitli işaretleyicileri dikkate almakta ve bu bilgileri ürünün güvenilirliği açısından bir tür sinyal olarak görmektedir (Bryła, 2021). Aynı zamanda, yerli üretim ürünlere duyulan bağlılık ve millî ekonomik değerlere katkı sağlama arzusu, tüketici tercihlerinde **tüketici etnosentrizmi** kavramını öne çıkarmaktadır. Bu eğilim, özellikle kriz dönemlerinde (örneğin pandemi sonrası gıda güvenliği tartışmaları) daha da güçlenmekte, tüketicilerin yabancı ürünlere olan temkinli yaklaşımını artırmaktadır (Onurlubaş & Altunışık, 2019). Bununla birlikte, Türkiye gibi gelişmekte olan ülkelerde ekonomik koşulların etkisiyle fiyat hâlâ güçlü bir belirleyici unsur olarak varlığını sürdürmektedir (Harris Interactive & Sodexo, 2024). Tüketicilerin önemli bir bölümü için ürünün uygun fiyatlı olması, erişilebilirlik açısından temel ön koşul olarak değerlendirilmektedir.

Tüm bu unsurlar, gıda tüketim tercihlerinde fiyat, ürün menşesi ve güvenilirlik gibi üç ana eksende şekillenen bir karar yapısını ortaya çıkarmaktadır. Ancak bu unsurların tüketici zihninde hangi sırayla ya da hangi öncelikte değerlendirildiği, kültürel bağlam, demografik yapı, ekonomik durum ve bilgi düzeyi gibi değişkenlere bağlı olarak farklılaşabilmektedir. Bu bağlamda, Türkiye örneğinde tüketicilerin bu üç unsur arasında nasıl bir bağ kurdukları ve hangisini daha öncelikli gördükleri sorusu, hem akademik hem de sektörel açıdan yanıtlanması gereken önemli bir araştırma problemidir.

Bu çalışmada, Türkiye’de farklı yaş, cinsiyet ve eğitim düzeylerinden bireylerin katılımıyla gerçekleştirilen bir anket aracılığıyla, tüketicilerin “fiyat, ürün menşesi ve güvenilirlik” ekseninde ürün tercihlerini nasıl temellendirdikleri analiz edilmiştir. Anketin açık uçlu yanıtları nitel veri analizi yöntemi olan tematik analiz tekniğiyle değerlendirilmiştir. Elde edilen temalar çerçevesinde, tüketici önceliklerinin yüzdesel dağılımı hesaplanarak bir bütünsel eğilim ortaya konmuştur.

Bu çalışma, hem tüketici davranışına ilişkin literatüre katkı sağlamayı hem de üretici, pazarlamacı ve politika yapıcılara gıda tercihlerinde etkili olan unsurlar konusunda yönlendirici bilgiler sunmayı amaçlamaktadır. Bu bağlamda, “fiyat mı, ürün menşesi mi, yoksa güvenilirlik mi daha belirleyicidir?” sorusuna saha verisine dayalı ampirik bir yanıt aranmaktadır.

YÖNTEM

Araştırmada nitel bir anket çalışması yapılmıştır. Çalışmaya Marmara bölgesinde yaşayan 114 yetişkin katılmıştır. Anket formunda demografik sorulara ek olarak bir açık uçlu soru yer almıştır: “**Gıda ürünlerinde fiyat, ürün menşesi (yerli/ithal) ve güvenilirlik arasında nasıl bir ilişki kuruyorsunuz? Bu üç unsurdan hangisi sizin için daha belirleyici olur, neden?**”. Katılımcıların demografik özellikleri Tablo 1’de özetlenmiştir.

Tablo 1. Katılımcıların demografik dağılımı (N = 110)

Değişken	Kategoriler	n	%
Cinsiyet	Kadın	54	47,4
	Erkek	60	52,6
Yaş Grubu	18–30	40	35,1
	31–50	50	43,9
	51+	24	21,0
Eğitim Düzeyi	İlköğretim veya altı	20	17,5
	Lise	30	26,3
	Üniversite	50	43,9
	Yüksek Lisans/Doktora	14	12,3

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Veri analizi sürecinde, açık uçlu sorulardan elde edilen metin verileri araştırmacı tarafından manuel tematik analizle kodlanmış; her bir katılımcı yanıtı içerdiği anlam ve anahtar kavramlar doğrultusunda “güvenilirlik (sağlık/hijyen/endişe)”, “ürün menşei (yerli/ithal tercih)” ve “fiyat” temalarından uygun olana atanmıştır. Kodlama aşamasında benzer içerikli ifadelerin sistematik biçimde gruplanması amacıyla yanıtlar birkaç kez okunmuş, öne çıkan örüntüler belirlenmiş ve temalar kesinleştirilmiştir. Tematik sınıflandırmanın ardından her tema altındaki yanıtların frekansları sayılmış, mutlak sayılar toplam katılımcı sayısına bölünerek yüzde değerleri hesaplanmıştır.

BULGULAR

Tematik analiz sonucunda yanıtlar üç ana temada toplanmıştır. Tablo 2’de her bir temanın yanıt sayısı ve yüzdesi verilmiştir.

Tablo 2. Katılımcı yanıtlarının tematik dağılımı.

Tema	Yanıt Sayısı (n)	Yüzde (%)
Menşe (yerli/ithal)	56	49
Güvenilirlik	37	32
Fiyat	17	15
Diğer	4	4
Toplam	114	100

Ürün Menşe Teması (%49)

Bu gruptaki katılımcılar, gıda ürünlerinin nerede/kim tarafından üretildiğinin (yerli mi ithal mi olduğunun) belirleyici olduğuna vurgu yapmıştır. Yerli üretime öncelik veren katılımcılar, hem ulusal ekonomi desteği açısından hem de kalite/güven endişesiyle yerli ürüne yönelmektedir. Örneğin, “Her zaman yerli ve milli ürünler tercihimdir” veya “Yerli olması önemli; üretimde GDO ve ilaçlama politikası güvenilirlik açısından kritik” gibi ifadeler bu tema altındadır. Araştırmamızda, bu temaya atfedilen katılımcıların yaklaşık yarısı (%49) menşe bilgisini en belirleyici unsur olarak görmüştür. Bu sonuç, Bryła’nın bulgularında da belirtildiği gibi çok sayıda tüketicinin ülke kökeni bilgisine önem verdiğini ve etnosentrik eğilimlerin (yerliliğe öncelik verme) satış niyetini etkilediğini doğrulamaktadır (Bryła, 2021). Ayrıca coğrafi işaretli ürünler bağlamında yapılan bir çalışmada da yerli etnik kaygı ve güven faktörleri öne çıkan kriterler arasında yer almıştır (Onurlubaş & Altunışık, 2019).

Güvenilirlik Teması (%32)

Bu temada yer alan cevaplar, ürünün sağlık, hijyen ve kalite güvencesi ile ilgili endişelere odaklanmaktadır. Katılımcılar genellikle “içerik temizliği, pestisit/GDO kullanılmaması, sertifikasyon/etiket bilgileri” gibi güven artırıcı unsurlara dikkat ettiklerini belirtmiştir. Örneğin “Güvenilirlik en önemli faktördür, sağlığımla doğrudan ilişkili” veya “Ürün içeriği, organik olması gibi kriterleri değerlendiririm” gibi yanıtlar bu gruptadır. Çalışmamızda %32 oranında katılımcı, ürünün güvenilirliğini ön planda tutmuştur. Bu sonuç, tüketicilerin gıda güvencesine büyük önem verdiğini gösteren önceki çalışmaları destekler niteliktedir (Taşdan ve ark., 2014; Kırmacı & Özçelik, 2021; Thomas & Feng, 2021). Örneğin Taşdan ve ark. (2014), Kırmacı ve Özçelik, (2021) gibi Türkiye’deki çalışmalar, tüketicilerin satın alma kararlarında ürünün hijyeni, sağlığa zararsızlığı ve gıda güvenliği bilgisine öncelik verdiğini ortaya koymuştur. Ayrıca tüketicilerin %87’sinin gıda güvenilirliği kavramını duyduğu ve bunu ürün tercihlerinde dikkate aldıkları bulgulanmıştır (Taşdan et al., 2014).

Fiyat Teması (%15)

Bu grup, gıda ürünlerinde bütçe ve ekonomik durumu ön plana çıkarmıştır. Cevaplar genellikle “gelir durumu nedeniyle fiyat belirleyici” veya “uygun fiyat/kalite dengesi” gibi ifadelerdir. Örneğin “Ekonomik durumum nedeniyle fiyat daha belirleyici” veya “Aynı kalitedeki yerli ürünler pahalıysa, ithal daha uygun olabilir” türü ifadeler kaydedilmiştir. Çalışmamızda katılımcıların yaklaşık %15’i fiyatı birincil unsur olarak göstermiştir. Bu bulgu, küresel ölçekte yapılan araştırmalarla uyumludur; zira yapılan uluslararası araştırmalarda tüketicilerin çoğu için gıda seçerken fiyatın en önemli etken olmaya

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devam ettiği ve %73'ünün çevresel kaygılardan daha çok fiyata önem verdiği raporlanmıştır (Harris Interactive & Sodexo, 2024). Bu nedenle, katılımcılar genellikle fiyatı diğer faktörlerden bağımsız değerlendirmese de, ekonomik kaygıları belirgin şekilde dile getirmiştir.

Diğer Temalar (≈%4)

Çok az sayıdaki yanıt (4 kişi, %4) üç faktörü eşit derecede önemli gördüğünü veya temalar arasında belirgin ayırım yapmadığını belirtmiştir (“Üçü arasında dengeli olmalı” gibi ifadeler). Bu katılımcılar, fiyat, ürün menşe ve güvenilirlik unsurlarını birbiriyle bağlantılı olarak değerlendirmiştir.

TARTIŞMA

Araştırma bulguları, Türkiye’deki tüketicilerin gıda tercihlerinde ürün **menşe** ve **güvenilirliğe** yönelik hassasiyetin belirgin olduğunu ortaya koymuştur. Ürün menşe temasının ön plana çıkması, tüketicilerin yerli ürüne karşı olumlu tutumlarını ve ulusal kaynaklara güvenlerini yansıtmaktadır; bu durum, literatürde “tüketici etnosentrizmi” olarak da tanımlanır (Bryła, 2021). Öte yandan, güvenilirlik temasındaki güçlü vurgu, gıda güvenliğinin tüketicilerin sağlığına olan doğrudan etkisinin bilincinin yüksek olduğunu göstermektedir (Kırmacı & Özçelik, 2021; Taşdan et al., 2014). Bu durum, Taşdan ve ark. (2014) ile Madenci ve ark. (2019) gibi Türkiye çalışmalarındaki sonuçlarla paraleldir; söz konusu çalışmalar, Türkiye’de tüketicilerin satın alma önceliklerini ürünün hijyeni ve sağlığa etkisi üzerine kurduklarını bildirmiştir.

Fiyatın görece olarak daha düşük oranda tercih edilmesi ise ekonomik gerçeklerle uyumludur: Çalışmaya katılanların önemli bir kısmı için hâlâ “uygun fiyat” temel bir kriterdir (Harris Interactive & Sodexo, 2024). Ancak Türkiye bağlamında yapılan analizlerde fiyat genellikle yüksek ağırlıkta bulunurken (Onurlubaş & Altunışık, 2019), bu çalışmada tüketicilerin yarıdan fazlasının fiyatı birincil unsur olarak görmemesi dikkat çekicidir. Bu durum, güvenlik endişelerinin ve yerli üretime yönelik duyarlılığın gittikçe arttığı bir dönem analizine denk gelmektedir. Ayrıca sürdürülebilir gıda tüketimi gibi alanlarda yapılan çalışmalar da, tüketicilerin karar verirken tat ve sağlıkla birlikte fiyatı göz önünde bulundurduklarını göstermektedir (Harris Interactive & Sodexo, 2024).

Sonuç olarak, elde edilen bulgular fiyattan ziyade **güven** ve ürün **menşe** bilgilerine yönelik tüketici ilgisinin arttığını göstermektedir. Bu durum, üreticiler ve pazarlamacılar için ürün etiketlerinde menşe ve kalite güvence bilgisine vurgu yapmanın önemini ortaya koymaktadır (Thomas & Feng, 2021; Kırmacı & Özçelik, 2021). Ayrıca politika yapıcılar, yerli üretimi teşvik ederken tüketicinin güvenlik algısını güçlendirecek denetim ve sertifikasyon mekanizmaları geliştirebilir.

SONUÇ

Bu araştırma, Türkiye’deki tüketicilerin gıda ürünlerini satın alırken fiyat, menşe ve güvenilirlik unsurlarına verdikleri görece önemi nitel veriye dayalı tematik analiz yoluyla ortaya koymuştur. Toplam 114 katılımcının açık uçlu yanıtları, tüketici davranışının giderek karmaşıklaştığı küresel gıda piyasasında, özellikle ürün menşe ve güvenilirlik temalarının öne çıktığını göstermiştir. Katılımcıların yaklaşık yarısının (%49) menşeyi, üçte birinin (%32) güvenilirliği ve daha küçük bir bölümünün (%15) fiyatı birincil faktör olarak vurgulaması, Türkiye’de yerli üretime yönelik artan bilinç ve gıda güvenliği endişesinin somut bir göstergesidir. Bulgular, “tüketici etnosentrizmi” olgusunun yerel ekonomiyi koruma motivasyonu ve algılanan kalite güvencesi ile birleşerek satın alma niyetini şekillendirebildiğini ortaya koyan çalışmaları destekler niteliktedir (Bryła, 2021; Onurlubaş & Altunışık, 2019).

Özellikle pandemi sonrası dönemde gıda kaynaklı sağlık risklerine ilişkin duyarlılık artmış, tüketiciler güvenilirlik göstergesi olarak sertifikasyonlara, içerik şeffaflığına ve menşe bilgisine daha fazla odaklanmıştır (Kırmacı & Özçelik, 2021; Taşdan et al., 2014; Thomas & Feng, 2021). Bununla birlikte ekonomik belirsizliklerin sürmesi, fiyat faktörünü tamamen geri plana itmemiştir. Ankete katılanların önemli bir kısmı “uygun fiyat” arayışını sürdürmekle birlikte, bulgular fiyatın artık tek başına belirleyici olmadığını, tüketicilerin fiyat–kalite dengesi içinde güven ve menşe bilgilerini daha bilinçli tarttığını göstermektedir (Harris Interactive & Sodexo, 2024).

Üreticiler ve perakendeciler, tüketicinin menşe hassasiyetini karşılamak için ürün etiketlerinde “yerli üretim” ifadesini sadece vurgulamakla kalmamalı, aynı zamanda coğrafi işaret, organik sertifika ve gıda güvenliği yönetim sistemleri (HACCP, ISO 22000 vb.) gibi güven artırıcı işaretleri görünür kılmalıdır.

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Tedarik zinciri boyunca izlenebilirlik çözümlerinin (ör. blokzincir tabanlı izlenebilirlik) yaygınlaştırılması, tüketicinin güven algısını daha da güçlendirebilir. Pazarlama mesajlarında fiyat odaklı indirimler ile kalite ve güvence söylemlerinin dengelenmesi, fiyat duyarlılığını koruyan fakat menşe ve güvenilirliğe de önem veren bir tüketici profilini etkili biçimde hedefleyebilir.

Bulgular, yerli üretimi destekleyen teşviklerin yanı sıra gıda denetimlerinin sıklaştırılması ve şeffaf raporlama mekanizmalarının geliştirilmesinin, tüketici güvenini yükselteceğini göstermektedir. Tarım ve Orman Bakanlığı ile Ticaret Bakanlığı, gıda güvenliği ve menşe etiketleme standartlarını uyumlu hâle getirerek üreticiye net kurallar, tüketiciye ise kolay anlaşılır bilgi sunmalıdır. Ayrıca, kamuoyunu bilinçlendirmeye yönelik ulusal medya kampanyaları ve okul temelli eğitim programları ile güvenilirlik algısı daha erken yaşlarda pekiştirilebilir.

Çalışma, açık uçlu verilerin tematik analizinin Türk tüketici bağlamında fiyat–menşe–güvenilirlik üçlüsüne dair anlamlı farkındalıklar sunduğunu göstermiştir. Gelecek araştırmalar, farklı bölge ve gelir gruplarında daha geniş örneklemeler kullanarak bulguların genellenebilirliğini test edebilir; nicel yaklaşımla yapısal eşitlik modellemesi (SEM) veya çoklu regresyon analizleri, faktörler arasındaki nedensel ilişkileri daha derinlemesine inceleyebilir. Ayrıca sürdürülebilirlik ve çevresel etki gibi yeni kriterlerin bu üç unsurla etkileşimi de gelecekteki çalışmalar için verimli bir alan sunmaktadır.

Genel olarak bu araştırma, Türk tüketicisinin gıda tercihlerinde duygusal (etnosentrik) ve rasyonel (güven–fiyat dengesi) motivasyonların birlikte işlediğini ortaya koymuş; üretici, pazarlamacı ve politika yapımcılar için uygulanabilir stratejik öneriler geliştirmiştir. Giderek rekabetçi hâle gelen gıda pazarında, ürünün menşe ve güvenilirliği konusunda şeffaf, kanıta dayalı iletişim stratejileri tasarlamak, fiyat hassasiyetini gözetirken tüketici sadakatini artırmanın temel anahtarı olarak görünmektedir.

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TÜKETİCİLERİN İTHAL GIDA ÜRÜNLERİNE YÖNELİK ALGISI: TEMATİK ANALİZ

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ÖZET

Bu çalışma, Türkiye'deki tüketicilerin ithal menşeli gıda ürünleri algısını ve bunun satın alma kararlarına etkisini nitel bir yaklaşımla incelemiştir. Toplam 110 katılımcıya çevrim içi anket yöntemiyle "Bir gıda ürününün ithal olması, satın alma kararınızı nasıl etkiler?" sorusu yöneltilmiş ve yanıtlar tematik analiz yöntemi ile analiz edilmiştir. Analiz sonucunda altı ana tema belirlenmiştir. Bu temalar yerli ürün tercihi (%40), kalite ve sağlık önceliği (%19), zorunlu durumda ithal kabulü (%16), güven ve kuşku (%10), etkisiz tutum (%13) ve fiyat-ekonomik değerlendirme (%2) temaları olmuştur. Katılımcıların büyük çoğunluğu (%40) yerli ürünü öncelikli tercih ettiklerini belirtirken, %19'luk kesim kalite-sağlık koşulları sağlandığında ithal ürüne açık olduklarını vurgulamıştır. Bu bulgular, tüketicilerin menşe bilgisini tek başına belirleyici görmediklerini; kalite, sağlık, güven ve millî bilinç gibi faktörlerin birlikte etkili olduğunu ortaya koymaktadır. Sonuçlar, tüketici davranışları literatürüne katkı sunmakta ve özellikle yerli üretim politikaları ile pazarlama stratejileri açısından önemli çıkarımlar içermektedir.

Anahtar Kelimeler: İthal gıda ürünleri, tüketici algısı, tematik analiz, yerli ürün tercihi, tüketici etnosentrizmi

ABSTRACT

This study examined consumers' perceptions of imported food products in Turkey and their impact on purchasing decisions using a qualitative approach. A total of 110 participants were asked, "How does the import of a food product affect your purchasing decision?" via an online survey, and the responses were analyzed using thematic analysis. The analysis identified six main themes: preference for domestic products (40%), priority for quality and health (19%), acceptance of imports under compulsion (16%), trust and doubt (10%), ineffective attitude (13%), and price-economic evaluation (2%). The majority of participants (40%) stated that they prioritize domestic products, while 19% emphasized that they are open to imported products if quality and health conditions are met. These findings demonstrate that consumers do not consider origin information a sole determinant; rather, factors such as quality, health, trust, and national awareness play a role in their overall decision-making. The results contribute to the consumer behavior literature and have important implications, particularly for domestic production policies and marketing strategies.

Keywords: Imported food products, consumer perception, thematic analysis, domestic product preference, consumer ethnocentrism

GİRİŞ

Küreselleşme ve dijitalleşmenin etkisiyle birlikte, tüketici tercihleri ürünün fiyatı, tadı ve erişilebilirliği gibi geleneksel faktörlerle şekillendirmekle birlikte, ürünün menşe bilgisi, üretim koşulları, çevresel etkileri, etik boyutu ve ülke ekonomisine katkısı gibi çok boyutlu unsurları da etkileyebilmektedir. Özellikle tarım ve gıda gibi doğrudan insan sağlığını etkileyen sektörlerde bu çok boyutluluk daha da belirgin hâle gelmiştir. Gıda ürünlerinin ithal olup olmaması, yalnızca bir lojistik ya da ticaret meselesi değil; aynı zamanda tüketicinin güven duygusu, sağlık algısı, millî bilinç düzeyi ve ekonomik tercihlerinin bir yansımasıdır.

Tüketicinin bir ürünün menşeni dikkate alarak karar vermesi, literatürde menşe etkisi (country-of-origin effect, COO) olarak tanımlanır. Bu etki, ürünün ait olduğu ülkeye duyulan güven, o ülkenin üretim

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standartları ve genel itibarı gibi unsurlarla şekillenir (Shankarmahesh, 2006). Örneğin, bir tüketici Almanya'dan gelen bir gıda ürününü teknoloji ve kaliteyle özdeşleştirerek olumlu değerlendirirken; aynı ürün farklı bir ülke menşeli olduğunda daha şüpheci yaklaşabilir. Thøgersen ve arkadaşlarının (2023) sistematik derlemesi, özellikle gelişmekte olan ülkelerde menşe bilgisinin tüketiciler açısından önemli bir değerlendirme kriteri olduğunu ortaya koymuştur.

Türkiye gibi tarımsal üretim kapasitesi yüksek bir ülkede dahi ithal gıda ürünlerinin market raflarında yoğun şekilde yer alması, tüketiciler açısından dikkat çekici bir çelişki yaratmaktadır. Bir yanda yerli üretimin desteklenmesi gerektiği yönündeki toplumsal farkındalık, diğer yanda ithal ürünlerin cazip ambalajları, tanıtım gücü ve markalaşma kabiliyetiyle oluşturduğu talep, tüketicii karar verme aşamasında ikileme sürüklemektedir. Bu bağlamda, yerli ve ithal ürün algıları sadece ekonomik tercihlerle değil, aynı zamanda tüketicinin duygusal ve bilişsel değerlendirmeleriyle de şekillenmektedir.

Tüketici etnosentrizmi kavramı, tüketicilerin yabancı ürünleri satın almanın ülke ekonomisine zarar vereceği inancı temelinde yerli ürünleri tercih etme eğilimini açıklar (Bryła, 2021). Bu bağlamda, ithal gıdalara yönelik olumsuz tutumlar, yalnızca sağlık veya kalite kaygısıyla değil, millî duygularla da ilişkilendirilebilir. Nitekim Türkiye örneğinde, yerli tarımsal üretimin korunması, döviz kaybının önlenmesi ve kırsal kalkınmanın desteklenmesi gibi gerekçelerle ithal ürünlere temkinli yaklaşım yaygındır. Kılıç ve Aydın'ın (2020) Samsun örneklemiyle gerçekleştirdiği araştırma, tüketicilerin ithal ürünler yerine yerli tarım ürünlerine yönelmesinde millî bilinç, güven ve kalite algısının belirleyici olduğunu göstermektedir.

Ancak bu eğilim homojen değildir. Bazı tüketiciler için menşe bilgisi yalnızca ikincil bir etkidir; ürünün kalitesi, sağlık açısından uygunluğu, fiyat-performans dengesi gibi diğer unsurlar daha baskın olabilmektedir. Özellikle pandemi sonrası dönemde sağlık bilincinin artmasıyla birlikte, ürünün geldiği ülke kadar üretim koşulları, katkı maddesi içerip içermediği ve sertifika bilgileri gibi detaylar da önem kazanmıştır (Miran & Thomas, 2024). Bu nedenle, tüketici kararlarını yalnızca menşe bilgisi üzerinden açıklamak yeterli değildir; menşe ile birlikte etkileşimde olan başka faktörlerin de analiz edilmesi gerekmektedir.

Bu çalışmada, Türkiye'deki tüketicilere yöneltilen açık uçlu bir soruya verilen yanıtlar üzerinden, ithal gıda ürünlerine yönelik tutumlar ve bu tutumların ardındaki gerekçeler tematik analiz yöntemiyle incelenmiştir. Böylece tüketici davranışlarını şekillendiren duygusal, bilişsel ve ekonomik dinamikler bütüncül bir biçimde değerlendirilmiş; elde edilen bulgular, hem akademik literatüre katkı sunmayı hem de tarım politikaları ve pazarlama stratejileri açısından yol gösterici olmayı amaçlamıştır.

YÖNTEM

Araştırma, betimsel nitel bir tasarıma sahiptir. Veri toplama sürecinde katılımcılara çevrim içi form yoluyla şu açık uçlu "Bir gıda ürününün ithal olması, satın alma kararınızı nasıl etkiler? Lütfen nedenleriyle birlikte açıklayınız." sorusu yöneltilmiştir.

Elde edilen toplam 110 açık uçlu yanıt, Braun ve Clarke'ın (2006) geliştirdiği tematik analiz yaklaşımı doğrultusunda analiz edilmiştir. Analiz süreci beş temel aşamadan oluşmuştur: (1) veriye aşinalık, (2) ilk kodların oluşturulması, (3) temaların belirlenmesi, (4) temaların gözden geçirilmesi ve (5) temaların tanımlanması ve raporlanması (Braun & Clarke, 2006). Bu aşamalarda veriler satır satır kodlanmış, benzer içerikler gruplanarak alt temalar oluşturulmuş ve nihai olarak altı ana tema belirlenmiştir.

Tematik analiz, özellikle psikoloji ve sosyal bilimlerde, nitel verilerde tekrar eden örüntülerin sistematik olarak ortaya konması ve yorumlanmasında sıkça tercih edilen esnek bir analiz yöntemidir (Braun & Clarke, 2006). Bu yöntem sayesinde, katılımcıların ithal ürünlere ilişkin duygu, düşünce ve motivasyonları detaylı biçimde sınıflandırılmış; analiz süreci, katılımcı ifadelerinden örneklerle zenginleştirilerek çalışmanın derinliği artırılmıştır.

Katılımcıların Demografik Özellikleri

Araştırmaya katılan 110 tüketiciye ait temel demografik bilgiler Tablo 1'de özetlenmiştir. Katılımcı dağılımı, Türkiye'deki genel tüketici profilini temsil edecek şekilde çeşitlendirilmiştir. Katılımcılar yaş, cinsiyet, eğitim düzeyi ve gelir grubu açısından dengeli bir şekilde örnekleme dahil edilmiştir.

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Tablo 1. Katılımcıların demografik dağılımı (N = 110)

Değişken	Kategori	f	%
Cinsiyet	Kadın	66	60,0
	Erkek	44	40,0
Yaş Grubu	18-25	28	25,5
	26-35	33	30,0
	36-50	33	30,0
	51 ve üzeri	16	14,5
Eğitim Düzeyi	Lise ve altı	44	40,0
	Üniversite	44	40,0
	Lisansüstü	22	20,0
Gelir Düzeyi	Düşük	30	27,3
	Orta	58	52,7
	Yüksek	22	20,0

Bu çalışmaya katılan bireylerin büyük çoğunluğu kadınlardan (%60) oluşmaktadır. Bu dağılım, Türkiye’de gıda alışverişlerinde kadınların daha aktif rol almasıyla uyumludur. Yaş aralığına göre, 26–50 yaş grubunun %60’lık bir oranla ağırlıkta olduğu görülmektedir. Bu yaş grubu, hem ekonomik karar verme hem de ev içi gıda tercihleri açısından aktif tüketici profiline karşılık gelmektedir.

Eğitim düzeyi açısından ise katılımcıların %40’ı lise ve altı, %40’ı üniversite mezunudur. Bu dağılım, tüketici profili içinde farklı bilgi ve farkındalık düzeylerine sahip bireylerin analizde yer almasını sağlamaktadır. Lisansüstü düzeydeki bireylerin oranı ise %20’dir. Bu durum, karar alma süreçlerinde sezgisel yaklaşımların akademik bilgiyle dengelendiğini düşündürmektedir.

Gelir düzeyi açısından, katılımcıların çoğunluğu (%52,7) orta gelir grubunda yer almaktadır. Bu bulgu, tüketici tercihlerinde fiyat faktörünün neden çoğu katılımcı için belirleyici olmadığını açıklamaya yardımcı olabilir. Ancak düşük gelir grubundaki katılımcılar için fiyat duyarlılığının, özellikle ithal ürünlerde daha etkili olabileceği değerlendirilmiştir.

BULGULAR

Yerli Ürün Tercihi (%40): Katılımcıların %40’ı, millî duygularını ve yerel üretimi destekleme arzusunu dile getirmiştir. Örneğin bir katılımcı, “Yerli olanı ithal olana genellikle tercih ederim, daha güvenilir olduğu için” demiştir. Bu grup “*öncelikle yerli*” yaklaşımına sahiptir; yerli üretimin güçlendirilmesi, ülke tarımına katkı ve millî kalkınma ön plandadır. Literatürde de tüketicilerin yabancı menşeli yerine yerli ürünü tercih etme eğiliminin sıkça raporlandığı görülmektedir (Thøgersen, Pedersen, & Aschemann-Witzel, 2023). Thøgersen ve arkadaşları, ABD başta olmak üzere çeşitli ülkelerde tüketicilerin genellikle ithal ürünlere kıyasla yerli gıda tüketmeyi tercih ettiğini belirtmiştir (Thøgersen et al., 2023). Bryła (2021) da etnosentrik eğilimlerin yerli ürün satın alma isteğini belirgin biçimde artırdığını göstermiştir. Türkiye’de yapılan çalışmalar da yerli ürünlerin kalite ve güvenilirliğinin vurgulandığını, yerliye fiyat primi ödendiğini bulgulamaktadır (Kılıç & Aydın, 2020). Kılıç ve Aydın’ın Samsun örnekleminde, yerli tarım ürünü tercih edenlerin başlıca gerekçesinin “yerli üretimi ve yerli gıda sanayini korumak” olduğu; ithal ürünü tercih edenlerin ise “yüksek teknolojiyle üretilme” algısını öne çıkardığı saptanmıştır. Bu bulgular, katılımcılarımızın milliyetçi duygularla yerli ürünü destekleme eğilimini doğrulamaktadır.

Zorunlu Durumda İthal Kabulü (%16): Katılımcıların yaklaşık %16’sı, “yerli eşdeğer ürün yoksa veya acil ihtiyaç varsa ithal ürünü alırım” şeklinde yanıt vermiştir. Bu grup, yerli alternatif bulunmadığında ithal ürünü dışlamamakta ancak önceliği yerli ürüne vermektedir. Literatürde de benzer biçimde, Avrupalı tüketicilerin yerli ürün bulunmadığında ithal ikamesine yönelebildiği rapor edilmiştir

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(Kılıç & Aydın, 2020). Bu tema, tüketici tercihlerinde yerli ürün yokluğu hâlinde taviz verilebileceğini göstermektedir.

Kalite ve Sağlık Önceliği (%19): Katılımcıların %19'u için ürünün kalitesi, tazeliği ve sağlık güvenilirliği esas belirleyicidir; menşe ikincil konumdur. Bu katılımcılar, “Ürün gerçekten sağlıklı, katkısız ve uygun fiyatlı ise nereden geldiği önemli değil” görüşünü paylaşmıştır. Literatürde, özellikle organik veya sağlık odaklı ürünlerde menşe bilgisinin geri plana atılabildiği belirtilmektedir (Thøgersen et al., 2023; Miran & Thomas, 2024). Miran ve Thomas'ın (2024) Türkiye örneğinde, tüketicilerin gıda seçiminde en yüksek önceliği “sağlıklılık” ve “tazelik”e verdiği gösterilmiştir. Thøgersen ve ark. ise pandemi sonrası dönemde tüketicilerin menşe yerine üretim koşulları ve kalite işaretlerine odaklandığını; organik ya da taze ürün etiketlerinin önem kazandığını vurgulamıştır (Thøgersen et al., 2023). Bu temada katılımcılar, “Kaliteli, sağlıklı, katkısız olursa menşe beni ilgilendirmez” söylemiyle ürünü sağlık kriterlerine göre değerlendirmiştir.

Güven ve Kuşku (%10): Yaklaşık %10'luk bir grup, ithal ürünlere karşı temkinlidir. Bir katılımcı, “Menşe ülke güvenim için önemli, bazen yabancı ürünün içeriğinden emin değilim” demiştir. Thøgersen ve ark. (2023), birçok tüketicinin belirli ülkelerin gıda ürünlerini daha güvenli kabul ettiğini, diğerlerine karşı kuşku duyduğunu bildirmiştir. Benzer şekilde Bryła (2021), etnik kimlik ve millî gururun yabancı ürünlere duyulan güvensizliği tetikleyebileceğini belirtmiştir.

Etkisiz/Nötr Tutum (%13): Katılımcıların %13'ü, ürünün ithal olmasının kararlarını “olumlu ya da olumsuz etkilemediğini” belirtmiştir. Örneğin bir katılımcı, “Fikrimi çok değiştirmez, içeriği temiz ise yine alırım” demiştir. Literatürde de bir kısım tüketicinin menşe bilgisini ikincil gördüğü; tat, kalite ve ihtiyaç durumunun menşe kadar belirleyici olabileceği ifade edilmiştir (Thøgersen et al., 2023). Özellikle bilgili veya deneyimli tüketicilerin, ürünün organik olması veya içerik bilgisi gibi özelliklere menşeden daha fazla önem verdiği vurgulanmaktadır.

Fiyat ve Ekonomik Değerlendirme (%2): Çok küçük bir grup (%2), satın alma kararını “öncelikle fiyat/ekonomi” kriterine dayandırmıştır. “İthal ürünler pahalıysa tercih etmem, fiyat/performansı iyiye bakarım” ifadesi bu tutumu yansıtır. Literatürde de fiyatın menşe bilgisini gölgede bırakabildiği; özellikle kısıtlı bütçelerde tüketicilerin maliyet-fayda analizine yöneldiği raporlanmıştır (Miran & Thomas, 2024). Çalışmamızda da fiyat odaklı bu küçük grup, pratik gerekçelerle menşeyi ikinci plana atmıştır.

Tablo 2. Tematik analiz sonuçlarına göre katılımcı yanıtlarının dağılımı (N = 110)

Tema	f	%	Açıklama
Yerli Ürün Tercihi	44	40,0	Millî üretimi destekleme, ülke ekonomisine katkı, güven temelli tercih
Kalite ve Sağlık Önceliği	21	19,1	Ürünün içeriği, katkısızlığı, sağlığa uygunluğu
Zorunlu Durumda İthal Kabulü	18	16,4	Yerli ürün bulunmadığında veya ihtiyaç hâlinde ithal ürün alımı
Etkisiz Tutum	14	12,7	Menşe bilgisinin tercihte etkili olmaması
Güven ve Kuşku	11	10,0	İthal ürünlere karşı şüphe, menşe ülkeye duyulan güvensizlik
Fiyat ve Ekonomik Değerlendirme	2	1,8	Fiyat/performans karşılaştırması, bütçe odaklı yaklaşım

Tablo 2’de görüldüğü üzere, katılımcıların en yaygın yanıtı yerli ürünlere yönelik tercih eğilimidir (%40). Kalite ve sağlık faktörleri ise ikinci sıradadır (%19,1). Bu sonuç, sadece millî duyguların değil; sağlık ve kalite hassasiyetlerinin de tüketici kararlarında güçlü bir etken olduğunu göstermektedir. Menşe bilgisinin etkisiz olduğu veya ikincil sayıldığı durumlar da (%12,7) dikkate değerdir. En düşük oran ise fiyat odaklı tercihlere aittir (%1,8); bu da genel olarak çalışmada menşe algısının fiyattan daha güçlü bir etki oluşturduğunu ortaya koymaktadır.

TARTIŞMA VE SONUÇ

Elde edilen bulgular, tüketicilerin ithal gıda ürünlerine yönelik tutumlarının çoklu faktörlerle şekillendiğini göstermektedir. Bir yandan literatürde yaygın olarak rapor edildiği üzere etnosentrik eğilim sonucu, katılımcıların önemli bir bölümü yerli üretimi destekleme eğilimindedir (Thøgersen, Pedersen, & Aschemann-Witzel, 2023; Bryła, 2021). Bu durumda milli bilinç, yerli tarımın korunması ve ulusal ekonomiye katkı vurguları öne çıkmaktadır. Öte yandan kalite ve sağlık beklentisi yüksek olan tüketiciler için menşe tek başına belirleyici olmamış, ürünün öz nitelikleri (tazelik, katkısız içerik vb.) daha baskın çıkmıştır; bu bulgu, “menşe bilgisi bir kalite ipucudur ancak organik ya da taze etiketleri menşeyi gölgede bırakabilir” sonucunu desteklemektedir (Thøgersen et al., 2023; Miran & Thomas, 2024). Güven konusundaki kaygılar ise ithal ürünlere karşı temkinli bir tutumu yansıtmış, bu durum kurumsal güvenle doğrudan ilişkilidir. Özellikle içerik şeffaflığının düşük olduğu düşünülen ürünlerde tercih tereddüdünün arttığı görülmüştür (Thøgersen et al., 2023). Sonuçlar ayrıca demografik değişkenlerin etkisine de işaret etmektedir; önceki araştırmalar, yaş, gelir ve eğitim düzeyine göre etnosentrizm düzeyinin değişebildiğini göstermiştir (Bryła, 2021). Bu çalışmada kadın-erkek veya yaş grupları arasında belirgin bir fark gözlemlenmemişse de, benzer profilde genç tüketicilerin ithal ürünler konusunda zaman zaman kararsızlık yaşadığı ve tutarsız tutumlar sergilediği rapor edilmiştir (Thøgersen et al., 2023).

Bu çalışma, Türkiye’deki tüketicilerin ithal gıda ürünlerine yönelik tutumlarını anlamaya yönelik olarak gerçekleştirilmiş ve elde edilen bulgular, tüketici davranışlarının oldukça katmanlı, duygusal, bilişsel ve ekonomik faktörlerin etkileşimiyle şekillendiğini ortaya koymuştur. Tematik analiz sonuçlarına göre, katılımcıların yaklaşık %40’ı yerli ürünleri milli bilinç, üretici desteği ve güven duygusu temelinde öncelikli olarak tercih ettiğini ifade etmiştir. %19’luk bir kesim kalite ve sağlık kriterlerini menşe bilgisinin önüne koyarken, %16’lık bir grup yerli alternatifin bulunmadığı durumlarda ithal ürünü tercih edebileceğini belirtmiştir. Geri kalan katılımcılar arasında %13’ü ithal menşenin kararlarını etkilemediğini söylerken, %10’u ithal ürünlere karşı kuşkucu yaklaşmakta, %2’lik küçük bir grup ise kararını fiyat ve ekonomik gerekçelere dayandırmaktadır.

- Bulgular, tüketici davranışları literatürünü desteklerken tarım politikaları ve pazarlama stratejileri için de önemli çıkarımlar sunmaktadır. Örneğin:
- Yerli ürün tercihinin yüksek önem veren tüketiciler için güven artırıcı sertifikalar (organik, coğrafi işaret vb.) güçlendirilebilir.
- Tarım destek programları, “ülke içinde kalacak döviz” vurgusuyla milli bilinci pekiştirecek biçimde revize edilebilir.
- Kalite-sağlık odaklı segmentte, yerli üretimin “sağlıklı ve katkısız” olduğu mesajı öne çıkarılmalı; markalar menşeden çok sağlık temalarını vurgulamalıdır.
- Güven eksikliği yaşayan tüketicilerde, “menşe değil kalite” odaklı bilgilendirme kampanyaları yürütülebilir.

Bu bulgular, ithal ürünlere yönelik tek yönlü bir algı olmadığını, aksine tüketici segmentlerinin oldukça farklılaşmış tutumlara sahip olduğunu göstermektedir. Yerli ürünlere duyulan güven ve milliyetçi tercihlerle şekillenen etnosentrik yaklaşım, Türkiye’deki tüketicilerin önemli bir bölümünde baskın durumdadır. Ancak sağlık, kalite ve güvenilirlik gibi niteliksel kriterler, menşe bilgisini çoğu zaman gölgede bırakabilmekte ve tüketiciler arasında daha rasyonel değerlendirme biçimlerinin öne çıkmasına neden olabilmektedir. Bu durum, tüketicilerin yalnızca milli ya da politik motivasyonlarla değil; aynı zamanda sağlık ve güven kriterleriyle de hareket ettiğini göstermektedir.

Sonuç olarak, hem kamu politikaları hem de pazarlama stratejileri açısından: (i) yerli üretimin teşvik edilmesi geniş toplumsal destek bulacak; (ii) ithal ürünlerin tercih edilebilirliğini artırmak isteyen paydaşlar için içerik şeffaflığı ve güven sertifikaları vazgeçilmez olacaktır; (iii) kampanyaların hedef kitleye göre ayrıştırılması, tüketiciyle daha etkili iletişim kurulmasını sağlayacaktır. Gelecek çalışmalarda bu bulguların daha geniş ve farklı sosyoekonomik profillere uygulanarak test edilmesi, nicel analizlerle desteklenmesi ve özellikle ürün grubu bazında (örneğin süt ürünleri, kuru gıda, organik ürünler vb.) ayrıştırılmış şekilde değerlendirilmesi önerilmektedir. Ayrıca tüketici kararlarında etkili

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olan psikolojik unsurlar (örneğin risk algısı, güvensizlik düzeyi, bilişsel çelişki) da ileri analizlerle derinleştirilebilir. Böylece ithal gıda ürünlerinin pazardaki konumu ve tüketici zihnindeki yeri daha bütünsel şekilde anlaşılabilir hale gelecektir.

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MICROBIOTA MODULATION AS THERAPEUTIC APPROACH IN THE NEUROPATHIC PAIN IN DOG WITH SPINAL CORD INJURY: IMPACT OF POLENOPLASMIN

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Background Studies have demonstrated the presence of gut dysbiosis (alterations in gut bacterial homeostasis) secondary to spinal cord injury in dogs. The dysbiosis is thought to impair recovery by decreasing the production of short-chain fatty acids which play a role in suppressing inflammation within the central nervous system.

Objective Therefore, targeting gut dysbiosis could have significant therapeutic value in the management of spinal cord injury. The purpose of this study is to determine if gut dysbiosis occurs in dogs with spinal cord injury. Another area of potential intervention interest is in situations of spinal injury where there is an urgent need to generate new neurons. To arrive at these observations, the authors examined how Polenoplasmin and diet solve paralysis in dogs.

Materials and methods The most common cause of spinal problems in dogs is trauma. We are currently assessing whether indoles can also stimulate formation of neurons in dogs with paralysis.

Results We found that gut microbes that metabolize tryptophan-an essential amino acid-secrete small molecules called indoles, which stimulate the development of new brain cells in dogs, also demonstrated that the indole-mediated signals elicit key regulatory factors known to be important for the formation of new neurons.

Conclusion This study is another intriguing piece of the puzzle highlighting the importance of lifestyle factors and diet. The link between the health of the microbiome and the health of the brain shows how microorganisms in the gut solve paralysis, gut microbe secreted molecule linked to formation of new nerve cells in paralyzed dogs.

Keywords: gut dysbiosis, indole, paralyzed dog, Polenoplasmin.

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HEALTH AND WELFARE

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ABSTRACT

The dairy sector continually seeks technological advancements for sustainability and efficiency. Modern technologies offer significant opportunities to optimize production, enhance animal welfare, and promptly identify health issues [1]. Intensive livestock farming, with large populations, inherently increases disease risk and complicates individual monitoring [2]. Thus, advanced animal monitoring methods are becoming essential for efficient farm operations and maintaining high animal welfare standards [3]. Early disease diagnosis, precise physiological monitoring, and detailed behavioral analysis are crucial. These approaches mitigate economic losses from illness and reduced productivity, promoting more responsible farming [4]. Growing public awareness of animal welfare and food safety further encourages farms to adopt innovations that boost production while aligning with ethical considerations. Continuous oversight of animal health and welfare helps optimize feed use, minimize medication (especially antibiotic) reliance [5], and improve dairy product quality.

Extensive research was conducted at the Lithuanian University of Health Sciences Practical Testing Center, housing over 100 dairy cows and two DeLaval milking robots. This research focused on developing and validating innovative animal monitoring systems. The primary aim was to integrate and apply cutting-edge technologies: thermography, remote pulsometric monitoring, exhaled breath analysis, and visual behavior analysis, specifically for dairy cow health and welfare assessment. The overarching objective was to create a comprehensive system that, by seamlessly combining various data streams and leveraging artificial intelligence (AI), could provide real-time, actionable information to farm managers [11]. This system would facilitate informed decision-making and enable prompt responses to herd issues. Each of the four distinct experiments addressed a specific problem, testing novel data collection. The synergistic integration of these experiments led to a sophisticated, multi-faceted platform for animal health and welfare assessment, readily applicable in practical farming, equipping farmers with reliable tools for efficient and responsible herd management [12].

Application of Thermography for Subclinical Mastitis and Hoof Disease Diagnosis

The first experiment utilized thermography technology for measuring dairy cows' udder and leg temperatures. Subclinical mastitis is a prevalent and economically detrimental dairy farm disease. Often unnoticed due to absent clinical signs, it degrades milk quality, reduces yield, and elevates somatic cell count, negatively impacting milk processing. Early diagnosis is critical to avert substantial losses, reduce the antibiotic usage, and maintain superior milk quality. Similarly, hoof diseases induce lameness, diminish activity, and alter natural behaviors, adversely affecting cow productivity, welfare, and reproduction. Conventional diagnostic approaches are often invasive, time-consuming, and stress-inducing for animals, complicating routine large-herd examinations. Thermography offers a non-invasive, rapid alternative for mass screenings.

During the study, an Android phone with an attachable, cost-effective thermal camera was employed, chosen for its accessibility, convenience, and sufficient accuracy for initial screening. The thermal camera captured skin surface temperature, directly correlating with blood flow and inflammatory processes. Measurements systematically recorded temperatures of udder teats/quarters, leg joints, and hoof coronet. Thermographic images were analyzed with specialized software to visualize temperature distribution and identify "hot spots" signaling inflammation. In subclinical mastitis, inflammation causes

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localized udder tissue temperature increases due to heightened blood supply, clearly visible thermographically. For hoof diseases (e.g., abscesses, joint inflammations), a localized temperature increase at the lesion site is also observed, enabling early detection before visible lameness. Collected thermographic data were rigorously correlated with other diagnostics like somatic cell count in milk and visual lameness scores to confirm thermography's accuracy. Findings demonstrated thermography as an effective tool for early diagnosis of both conditions, facilitating rapid, stress-free screening, minimizing human error and time. This empowers farmers to implement preventive measures or early treatment, mitigating disease progression and adverse impacts.

Remote Pulse and Heart Rate Monitoring

The second experiment focused on developing and testing a remote pulse and heart rate monitoring system. Animal pulse and heart rate changes are vital physiological indicators signaling stress, pain, fever, infections, or other health disorders. Elevated heart rate may indicate fever, pain, or fear; irregular rhythm could point to cardiac issues. Traditional pulse measurement is challenging in large farms, inducing animal stress and demanding continuous staff involvement. The innovative system aimed to overcome these limitations with non-invasive, continuous monitoring. The system operated remotely, employing specially adapted non-contact sensors capable of detecting pulse waves or electrical heart signals without direct skin contact. Sensors were integrated near milking robots. The newly developed system operated remotely, employing a DFRobot SEN0623 C1001 mmWave Human Detection Sensor. This high-precision 60GHz millimeter-wave radar was utilized for its ability to non-invasively detect vital signs. Unlike traditional contact-based methods, this sensor emitted millimeter waves, which penetrated the animal's hide, allowing for the detection of subtle internal movements caused by blood flow and heart contractions. By analyzing these reflected waves, the sensor could accurately determine the animal's pulse rate and heart rhythm without any physical contact or disturbance.

Collected pulse and heart rhythm data were transmitted real-time to a central server via wireless connection (e.g., Wi-Fi, Bluetooth Low Energy) for analysis. Server software performed sophisticated data processing, noise filtering, and visualization, enabling individual physiological parameter monitoring. Specialized algorithms were developed and trained to identify unusual pulse/heart rhythm fluctuations signaling disease onset or stress. For example, sustained pulse rate increase above a cow's baseline might indicate fever, inflammation, or systemic infection. Rhythm disturbances could suggest cardiac or metabolic problems. The system underwent extensive testing for reliability and accuracy in a dynamic farm environment. This system opens new avenues for early disease diagnosis and animal stress assessment, empowering farmers to respond swiftly to changing animal conditions without additional animal stress or personnel requirements. Remote data transmission ensures continuous monitoring, optimizing farm management and resource allocation.

Exhaled Breath Analysis for Acidosis Detection

The third experiment aimed at an innovative acidosis diagnosis method via exhaled breath analysis. Acidosis, especially subclinical, is a widespread issue in dairy cows, arising from improper nutrition (e.g., excessive rapidly fermentable carbohydrates) and impaired digestive function. It causes rumen dysfunction, reducing milk productivity, degrading quality (decreased fat/protein), and increasing risk of lameness, mastitis, or laminitis. Traditional acidosis detection methods are invasive, demanding specialized equipment and personnel, and impractical for regular application across large animal populations.

For this study, a custom device using an Arduino microcontroller and IoT sensors was developed for cow exhaled breath gas analysis. The primary focus was accurately recording changes in acetone concentration, in percentages (%) and parts per million (ppm), in exhaled air. Acetone level fluctuations directly indicate a cow's metabolic status. In acidosis, the body intensifies fat breakdown, producing ketone bodies like acetone, which is expelled via the respiratory system. Elevated acetone concentration serves as a reliable early indicator of acidosis and ketosis (another metabolic disease linked to negative energy balance post-calving).

Sensors underwent thorough calibration and testing for precise measurements. The device was installed to automatically collect exhaled air samples when a cow approached a designated point (e.g., feeding trough). Collected acetone data were transmitted real-time to a central server wirelessly. Server software

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performed sophisticated data analysis, employing advanced machine learning algorithms. These algorithms identified specific acetone concentration patterns correlating with acidosis or ketosis risk. Dynamic thresholds were established, considering individual cow characteristics and diurnal cycles, to minimize false alarms. This non-contact, non-invasive method provides continuous monitoring of the cow's digestive and metabolic state, enabling early detection of acidosis/ketosis risk. This proactive approach empowers farmers to timely adjust nutrition or implement preventive measures, averting severe health issues and sustaining optimal productivity. The system's seamless integration into existing farm infrastructure ensures automated data collection, eliminating manual labor. Such a system has potential to significantly reduce veterinary expenses and improve animal health.

Monitoring Cow Head and Ear Position for Welfare Assessment

The fourth and final experiment focused on assessing cow welfare by observing head and ear positions. Animal behavior is a critical indicator reflecting physical and psychological well-being. Behavioral alterations can signal stress, pain, discomfort, illness, or herd social dynamics. Head and ear position, while subtle, are highly informative behavioral cues revealing comfort, stress, pain, or early disease symptoms (e.g., drooped ears/head, unnatural tilt, unusual movements). Traditional observation is often human-intensive, subjective, and inefficient for large farms.

For this study, a high-resolution video camera continuously recorded cow behavior near the feeding area, 24/7. This location was chosen due to consistent cow presence and behavior. Individual cows were precisely identified using RFID systems, enabling tracking of behavioral changes and correlation with other data. Specifically developed computer vision algorithms, underpinned by deep learning and neural networks, meticulously analyzed head and ear positions and movements. Algorithms were trained to recognize various postures (e.g., drooped/raised ears, specific head turns/angles). For instance, consistently drooped ears or a lowered head might indicate stress, pain, apathy, or fever. Conversely, a vigilant, dynamically moving head and ears generally signify a healthy, active animal.

Behavioral models were established to differentiate normal behavior from deviations indicating health issues or discomfort. This encompassed monitoring head tilt angle, ear position symmetry, and movement frequency/nature. For instance, a painful cow might consistently hold its head atypically or exhibit reduced movement. This methodology provides objective, continuous welfare information, empowering farmers to swiftly respond to unusual changes. Furthermore, the system aids in optimizing the farm environment by pinpointing stress factors (e.g., noise, inadequate lighting, cramped spaces, social tension). This contributes to improved animal welfare and enhanced productivity by mitigating stress's negative impact on immunity and milk production. The technology facilitates identifying individual animals needing attention and assesses overall herd welfare, enabling systemic farm management adjustments.

Integrated Decision-Making System and Artificial Intelligence Application

Each described experiment's true potential emerged when their data streams were comprehensively integrated and analyzed. For this, a complex, integrated system was developed. It seamlessly combined data from all four experiments (thermography, pulse, exhaled breath, behavior) with crucial information from DeLaval milking robots (milk yield, frequency, composition, conductivity) and Bolus devices (rumination, body temperature, rumen pH). This extensive data integration created a comprehensive, dynamic, real-time health and welfare profile for each cow.

For instance, if thermography indicates elevated udder temperature, correlated by the milking robot's reduced milk yield, altered conductivity, and increased somatic cell count, this strongly signals a high risk of mastitis or active inflammation. Similarly, altered pulse, increased exhaled acetone, diminished rumination, and unusual head posture can collectively point to cow discomfort, metabolic disorders, or early disease onset like acidosis or ketosis. This integrated diagnostic approach enables much earlier disease detection.

To process this data, advanced artificial intelligence (AI) analysis methods were employed. Machine learning algorithms, including neural networks, decision trees, support vector machines, and clustering, were rigorously trained. They recognized intricate data patterns and correlations, predicting disease risk before visible symptoms. For example, the AI system identified specific exhaled acetone patterns

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combined with minor pulse/rumination deviations signaling heightened acidosis risk, even without overt behavioral changes. Algorithms underwent continuous refinement and testing with real-world data for maximal accuracy and minimal false alarms.

The system's output was based on a "traffic light principle," providing farm managers clear, intuitive, and immediate information about herd and individual animal status. This enables rapid situational assessment and informed decision-making, significantly reducing complex data interpretation:

- * Green light: Optimal state; no significant deviations. Cows are healthy, productive, welfare assured.
- * Yellow light: Cautionary signal. Minor deviations or potential risks detected. Allows proactive steps (e.g., dietary adjustments, increased monitoring) before major problems arise.
- * Red light: Urgent action needed. Significant, potentially dangerous deviations indicating acute illness, severe disorder, or profound stress. Demands prompt veterinary examination and treatment.

This AI-powered integrated system transforms traditional farm management from reactive to proactive and preventative. Real-time data and automated analysis minimize human error, optimize labor, and significantly contribute to farm sustainability. Continuous monitoring and early diagnosis crucially reduce antibiotic usage, supporting antimicrobial resistance mitigation and the "One Health" concept. The system also improves animal welfare by facilitating rapid identification and resolution of discomfort or pain issues.

Conclusions and Future Perspectives

In conclusion, research at the Lithuanian University of Health Sciences Practical Testing Center demonstrated the immense potential of advanced monitoring and AI in the dairy sector. Integrating four distinct experimental systems—thermography, remote pulse monitoring, exhaled breath acetone analysis for acidosis, and cow behavior observation—creates a comprehensive health and welfare database for each cow. Data integration from DeLaval milking robots and Bolus devices, combined with sophisticated AI, leads to an advanced, practical decision-making system. The traffic light principle provides clear, immediate information, enabling efficient herd management, prompt responses, and high animal welfare.

This research paves the way for dairy farms to transition towards smarter, more sustainable operational models. Future plans involve continuous refinement to enhance accuracy, reliability, and robustness. This includes improved sensor calibration, optimized data filtering, and iterative AI model updates with larger datasets. Furthermore, plans include integrating additional data sources, such as animal weight changes, automatic feeding system data, and environmental monitoring, for even more precise animal condition analysis. Such supplementary data will empower AI algorithms to identify subtle shifts and predict risks with greater precision.

Moreover, future research will explore AI model applicability for forecasting disease outbreaks across the entire farm, enabling more effective preventative measures. Efforts will also focus on reducing system implementation and maintenance costs for broader accessibility. The commercialization and widespread adoption of these systems could significantly improve animal health, reduce production costs through early diagnosis/prevention, and profoundly contribute to dairy sector sustainability. Our research represents a pivotal step in developing advanced animal health and welfare monitoring systems, made to empower farmers to make superior, data-driven decisions for prosperous, responsible farming. These innovations are crucial for addressing contemporary agricultural challenges and ensuring global food safety/quality, particularly given increasing demands and stricter regulations.

Keywords: animal, welfare, AI-systems, technologies.

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BAKTERİYOFAJLAR: BAKTERİYEL BİTKİ HASTALIKLARINA KARŞI BİR BİYOLOJİK MÜCADELE STRATEJİSİ

BACTERIOPHAGES: A BIOCONTROL STRATEGY FOR BACTERIAL PLANT DISEASES

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ÖZET

Bitkisel üretimde verim ve kalite kayıplarına yol açan temel sorunlardan biri, çeşitli tarım ürünlerinde hastalıklara neden olan bitki patojeni bakterilerdir. Yaygın olarak bu hastalık etmenleriyle mücadelede bakırlı bileşikler ve antibiyotikler kullanılmaktadır. Ancak, bu kimyasalların kullanımı insan ve çevre sağlığı için potansiyel riskler taşımaktadır. Antibiyotiklerin ve bakırın aşırı kullanımı, patojen bakterilerin bu maddelere karşı direnç geliştirmesine neden olabilmektedir. Bu tehlike nedeniyle, birçok ülke son yıllarda tarımsal üretimde antibiyotik kullanımını yasaklamıştır. Bakırlı bileşikler de sınırlı sistemik etki, zorlu uygulama zamanlaması, dirençli suşların ortaya çıkışı ve fitotoksosite gibi çeşitli dezavantajlara sahiptir. Bitkilerdeki bakteriyel hastalıklarla mücadelede, güvenli, etkili ve bitkilere zarar vermeyen kimyasal çözümlerin yetersizliği, son yıllarda yeni stratejilere olan ilgiyi artırdı. Bu durum, araştırmacıları bitki hastalıklarını doğal yollarla kontrol etmeyi amaçlayan alternatif yöntemlere yöneltti. Son yıllarda yapılan birçok çalışma, bitki bakteriyel hastalıklarının kontrolünde hem çevreye hem de üreticiye dost bir dizi umut verici biyolojik mücadele stratejisini test etti. Bu stratejiler arasında antagonist mikroorganizmalar, bitki sistemik direncini artıran uyarıcılar, patojene dirençli transgenik bitkiler, patojenin avirulent suşları, bitki özleri ve uçucu yağlar yer almaktadır. Bu stratejilerden farklı olarak, bakteriyofajların bitki bakteri hastalıklarını kontrol etmek için kullanılması son yıllarda hızla gelişen ve dikkat çeken etkili bir biyolojik mücadele yöntemi olarak öne çıkmaktadır. Bakteriyofajlar, geleneksel kontrol önlemlerin alternatif olarak bitki korumada büyük bir potansiyele sahiptir. Bu çalışma, bitki bakteri hastalıklarıyla mücadelede bakteriyofajların kullanımına yönelik son gelişmelere odaklanmaktadır.

Anahtar Kelimeler: Bakteriyofajlar, fitobakteriyoloji, biyolojik mücadele, bitki bakteri hastalıkları.

ABSTRACT

One of the main problems causing yield and quality losses in agricultural production is plant pathogenic bacteria, which lead to diseases in various crops. Copper compounds and antibiotics have been widely used to control these pathogens. However, these chemicals have potential risks on human health and the environment. Overuse of antibiotics and copper can lead to antibiotic and copper resistance in pathogenic bacteria. Due to this threat, many countries have banned the use of antibiotics in agricultural production in recent years. Copper compounds have several disadvantages, including limited systemic effects, difficulty in application, emergence of resistant strains, and phytotoxicity. The lack of safe, effective and plant-safe chemical solutions to control of bacterial diseases in plants has increased interest in new strategies in recent years. This has led researchers to alternative methods to control of plant diseases naturally. In recent years, many studies have tested a number of promising biological control strategies that are both environmentally and farmer-friendly in controlling plant bacterial diseases. These strategies include antagonistic microorganisms, stimulants of plant systemic resistance, pathogen-resistant transgenic plants, avirulent strains of the pathogen, plant extracts, and essential oils. Distinct from these strategies, the use of bacteriophages for controlling bacterial plant diseases has emerged as a rapidly developing and noteworthy effective biological control method in recent years. Bacteriophages have great potential in plant protection as an alternative to traditional control measures. This study focused on the latest developments in the use of bacteriophages for the control of plant bacterial diseases.

Keywords: Bacteriophages, phytobacteriology, biocontrol, plant bacterial disease.

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ASSESSMENT OF THE ANTIOXIDANT CAPACITY IN LACTIC ACID BACTERIA ISOLATED FROM FOOD SOURCES

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ABSTRACT

Lactic acid bacteria (LAB) are widely recognized for their probiotic properties and potential health benefits, including antioxidative activity. In this study, 20 LAB strains previously isolated from various food sources, such as fermented dairy products and colostrum, were evaluated for their antioxidant capacities using two complementary assays: the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay and the Ferric Reducing Antioxidant Power (FRAP). Results revealed significant variability among the LAB strains ($P < 0.05$). DPPH radical scavenging activity ranged from $25.75 \pm 0.03\%$ to $41.34 \pm 0.03\%$, while FRAP values ranged between 2.20 ± 0.03 and 2.53 ± 0.05 mmol Fe²⁺/L. DPPH and FRAP analyses revealed significant strain-specific differences in antioxidant capacity among the tested LAB isolates ($P < 0.05$). The highest DPPH activity was observed in *Enterococcus faecium* BS11 (41.34%), while the lowest was found in *Lactobacillus acidophilus* BS1 (25.75%). In the FRAP assay, the strongest reducing power was recorded for *E. faecium* BS6 (2.53 ± 0.05 mmol Fe²⁺/L), which also demonstrated high DPPH activity, indicating a consistent antioxidant potential. Overall, strains isolated from colostrum samples exhibited promising potential for use in functional food applications. These findings suggest that certain LAB strains possess notable antioxidant properties and may be suitable for functional food or nutraceutical development. This study contributes to the growing body of research supporting the health-promoting potential of LAB and highlights the importance of strain-specific screening for identifying probiotic candidates with enhanced functional characteristics.

Keywords: Lactic acid bacteria, antioxidant activity, FRAP, DPPH, functional foods, probiotic

INTRODUCTION

Lactic acid bacteria (LAB) have long been recognized for their probiotic characteristics, offering a variety of health-promoting effects, including antimicrobial activity, immunomodulation, and the improvement of intestinal microbiota composition (Hill et al., 2014; Akbal et al., 2025; Ertürkmen, 2025). Recently, their antioxidant potential has gained increased attention, especially in the context of oxidative stress-related diseases. Oxidative stress, caused by an imbalance between free radicals and antioxidant defenses, is a major contributor to various chronic conditions such as cardiovascular diseases, cancer, and neurodegeneration (Singh et al., 2022).

The antioxidant effects of LAB are believed to be mediated by several mechanisms, including scavenging of reactive oxygen species (ROS), metal ion chelation, and the modulation of antioxidant enzyme activity. These functions are influenced by strain-specific genetic and metabolic characteristics (Alam et al., 2023). Therefore, comprehensive *in vitro* assessment using reliable methods are essential for identifying probiotic candidates with potential antioxidant capacity.

In this study, we aimed to evaluate the antioxidant potential of 20 LAB strains previously isolated from food sources, including fermented dairy products and colostrum. To compare and quantify their

antioxidative capacity, two widely used assays were employed: the DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging assay and the Ferric Reducing Antioxidant Power (FRAP) assay.

MATERIAL AND METHODS

Bacterial strains and culture conditions

Twenty LAB strains were selected from the strain collection of the Food Technology Laboratory at Burdur Mehmet Akif Ersoy University. These strains were originally isolated from traditional Turkish fermented foods, such as cheese, and from bovine colostrum samples. Species-level identification was previously confirmed using Matrix-Assisted Laser Desorption/Ionization Time-of-Flight Mass Spectrometry (MALDI-TOF MS). The selected strains belonged to the genera *Lactobacillaceae* and *Enterococcus*. The collection included 7 *Lactobacillus acidophilus*, 3 *Lactiplantibacillus plantarum*, 5 *Enterococcus faecium*, 4 *Lacticaseibacillus paracasei*, and 1 *Lactobacillus bulgaricus* strains.

Each strain was cultured twice in de Man, Rogosa, and Sharpe (MRS) broth (Merck, Germany) and incubated at 37 °C for 18–24 hours under anaerobic conditions using an AnaeroGen gas generation system. Following incubation, the cultures were vortexed, transferred to polypropylene tubes, and centrifuged at $10000 \times g$ for 10 minutes at 4 °C. The obtained supernatants were used to determine the antioxidant capacity.



Figure 1. Preparation of lactic acid bacteria supernatants

Determination of antioxidant capacity

The antioxidant capacities of 20 LAB strains were determined using both the DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging activity assay and the Ferric Reducing Antioxidant Power (FRAP) assay.

DPPH radical scavenging activity

The antioxidant capacity of LAB strains was determined with some modifications based on the method described by Shang et al. (2019). A 40 μ L aliquot of the supernatant was mixed with 100 μ L of DPPH solution, and the samples were incubated at room temperature in the dark for 30 minutes (40 μ L of ethanol was used as the blank). After incubation, absorbance readings were taken at 515 nm against ethanol using a spectrophotometer, and the DPPH radical scavenging activity (%) or percent inhibition was calculated using the following formula:

$$\text{DPPH radical scavenging activity (\%)} \text{ or } \% \text{ inhibition} = \left[\frac{(\text{Absorbance of blank} - \text{Absorbance of sample})}{\text{Absorbance of blank}} \right] \times 100.$$

Ferric Reducing Antioxidant Power (FRAP) assay

The antioxidant capacity was determined with some modifications based on the method described by Zhao and Shah (2016). The FRAP reagent was prepared by mixing 300 mmol/L acetate buffer (pH 3.6), 10 mmol/L TPTZ (2,4,6-Tri(2-pyridyl)-s-triazine) dissolved in 40 mmol/L HCl, and 20 mmol/L ferric

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chloride hexahydrate in a 10:1:1 ratio. For the analysis, 10 μL of supernatant was mixed with 150 μL of the FRAP reagent. The mixture was incubated at 25 °C for 30 minutes and the absorbance was measured at 593 nm against a blank prepared with distilled water. The obtained absorbance values were converted to mmol Fe^{2+}/L using a standard calibration curve prepared with ferrous sulfate heptahydrate ($\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$).

Statistical analysis

All measurements were performed in triplicate. Data are presented as mean $\pm$ standard error. Statistical analysis was conducted using one-way ANOVA followed by Duncan's post-hoc test with SPSS version 25 (IBM Corp., Armonk, NY, USA). A P value of less than 0.05 was considered statistically significant.

RESULTS AND DISCUSSION

DPPH radical scavenging activity

The antioxidant activity of 20 LAB strains was assessed using the DPPH radical scavenging method, with results ranging from $25.75 \pm 0.03\%$ to $41.34 \pm 0.03\%$ (Table 1). The highest DPPH inhibition was exhibited in *E. faecium* BS11, whereas the lowest activity was recorded for *L. acidophilus* BS1. These findings highlight considerable strain-dependent variability in free radical scavenging capacity, consistent with previous studies (Kim et al., 2020).

The observed variation in DPPH activity may be attributed to multiple factors, including the synthesis of antioxidant metabolites (e.g., exopolysaccharides, short-chain fatty acids, and enzymatic antioxidants such as superoxide dismutase), as well as cell wall properties that influence interactions with lipophilic radicals (Liu et al., 2020).

Interestingly, among the *L. acidophilus* strains isolated from colostrum, a broad range of antioxidant activity was observed (25.75%–40.11%), indicating potential variability within the same species and source. Similarly, *Lbs. paracasei* isolates showed a comparable broad activity range (26.69%–40.87%). In contrast, *Lpb. plantarum* strains exhibited more stable antioxidant capacities, ranging from 26.46% to 36.58%.

The overall results confirm that DPPH activity is not strictly species-specific but is highly influenced by strain-level differences and environmental adaptation. These findings support the notion that antioxidant potential should be evaluated individually for each strain.

Table 1. DPPH radical scavenging activity (%) of lactic acid bacteria

Isolation material	Bacteria strains	Inhibition %
Colostrum	<i>L. acidophilus</i> BS1	25.75 ± 0.03^c
Colostrum	<i>L. acidophilus</i> BS2	33.52 ± 0.07^{abc}
Colostrum	<i>L. acidophilus</i> BS3	40.11 ± 0.04^{abc}
Colostrum	<i>L. acidophilus</i> BS4	33.38 ± 0.04^{abc}
Colostrum	<i>L. acidophilus</i> BS5	39.50 ± 0.04^{abc}
Colostrum	<i>L. acidophilus</i> BS9	35.59 ± 0.02^{abc}
Colostrum	<i>L. acidophilus</i> BS10	37.81 ± 0.01^{abc}
Colostrum	<i>Lpb. plantarum</i> BS 8	36.58 ± 0.06^{abc}
White Cheese	<i>Lpb. plantarum</i> BS19	26.46 ± 0.07^{bc}
White Cheese	<i>Lpb. plantarum</i> BS20	27.54 ± 0.02^{abc}
Colostrum	<i>E. faecium</i> BS11	41.34 ± 0.03^a
Colostrum	<i>E. faecium</i> BS6	33.90 ± 0.01^{abc}
Colostrum	<i>E. faecium</i> BS7	31.12 ± 0.05^{abc}
White Cheese	<i>E. faecium</i> BS17	34.23 ± 0.04^{abc}
White Cheese	<i>E. faecium</i> BS18	26.74 ± 0.01^{bc}

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Colostrum	<i>Lbs. paracasei</i> BS12	35.03±0.05 ^{abc}
White Cheese	<i>Lbs. paracasei</i> BS14	40.87±0.02 ^{ab}
Tulum Cheese	<i>Lbs. paracasei</i> BS15	26.84±0.07 ^{bc}
Tulum Cheese	<i>Lbs. paracasei</i> BS16	26.69±0.04 ^{bc}
Colostrum	<i>L. bulgaricus</i> BS13	38.23±0.02 ^{abc}

Means with different letters in a column differ statistically significantly at *P*-value; **P* < 0.05. The results are presented as mean ± standard error.



Figure 2. Absorbance measurement at 515 nm for the DPPH assay using a microplate reader

Ferric Reducing Antioxidant Power (FRAP) activity

The FRAP assay revealed values ranging from 2.20 ± 0.03 mmol Fe²⁺/L and 2.53 ± 0.05 mmol Fe²⁺/L across the tested LAB strains (Table 2). The highest FRAP value was observed in *E. faecium* BS6, which was also among the strains exhibiting the strongest DPPH inhibition, suggesting a consistent and robust antioxidant profile.

However, notable differences were observed between the DPPH and FRAP results. For instance, while *L. acidophilus* BS3 exhibited relatively high DPPH activity (40.11%), it showed the lowest FRAP value (2.20 mmol Fe²⁺/L). This discrepancy highlights the complementary nature of antioxidant assays, as DPPH measures radical scavenging ability, whereas FRAP reflects reducing power. Therefore, reliance on a single assay may lead to an incomplete assessment of antioxidant potential.

Strain origin also influenced the results. Colostrum-derived isolates, particularly *L. acidophilus* and *E. faecium*, tended to exhibit consistent antioxidant activity in both assays. In contrast, strains isolated from different cheese types (*white cheese* and *tulum cheese*) displayed a wider range of FRAP values, suggesting that the source matrix may affect the functional attributes of LAB strains.

In agreement with Alam et al. (2023), who reported high reducing power in *E. faecium* strains isolated from fermented foods, the strong antioxidant potential of this species observed in the current study further supports its potential application in functional food formulations.

Table 2. FRAP value (mmol Fe²⁺/L) of lactic acid bacteria

Isolation material	Bacteria strains	FRAP (mmol Fe ²⁺ /L)
Colostrum	<i>L. acidophilus</i> BS1	2.41±0.01 ^{abc}
Colostrum	<i>L. acidophilus</i> BS2	2.33±0.03 ^{abc}
Colostrum	<i>L. acidophilus</i> BS3	2.20±0.03 ^c
Colostrum	<i>L. acidophilus</i> BS4	2.37±0.06 ^{abc}
Colostrum	<i>L. acidophilus</i> BS5	2.45±0.04 ^{ab}
Colostrum	<i>L. acidophilus</i> BS9	2.46±0.02 ^{ab}

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Colostrum	<i>L. acidophilus</i> BS10	2.36±0.11 ^{abc}
Colostrum	<i>Lpb. plantarum</i> BS 8	2.27±0.03 ^{bc}
White Cheese	<i>Lpb. plantarum</i> BS19	2.42±0.07 ^{abc}
White Cheese	<i>Lpb. plantarum</i> BS20	2.34±0.02 ^{abc}
Colostrum	<i>E. faecium</i> BS11	2.29±0.09 ^{abc}
Colostrum	<i>E. faecium</i> BS6	2.53±0.05 ^a
Colostrum	<i>E. faecium</i> BS7	2.27±0.01 ^{bc}
White Cheese	<i>E faecium</i> BS17	2.28±0.14 ^{bc}
White Cheese	<i>E faecium</i> BS18	2.47±0.06 ^{ab}
Colostrum	<i>Lbs. paracasei</i> BS12	2.47±0.06 ^{ab}
White Cheese	<i>Lbs. paracasei</i> BS14	2.50±0.11 ^{ab}
Tulum Cheese	<i>Lbs. paracasei</i> BS15	2.39±0.02 ^{abc}
Tulum Cheese	<i>Lbs. paracasei</i> BS16	2.38±0.02 ^{abc}
Colostrum	<i>L. bulgaricus</i> BS13	2.31±0.15 ^{abc}

Means with different letters in a column differ statistically significantly at *P*-value; **P* < 0.05. The results are presented as mean ± standard error.



Figure 3. Measurement of FRAP activity at 593 nm following incubation

Functional applications and implications

LAB strains with high antioxidant activity are valuable candidates for the development of functional dairy and plant-based products. The use of such strains can not only improve the nutritional profile of foods but also enhance shelf life and stability by mitigating lipid oxidation. Furthermore, these strains have potential applications in nutraceutical formulations aimed at reducing oxidative stress in specific population groups, such as the elderly, athletes, or individuals with chronic diseases (Zhou et al., 2022; Ghoneim et al., 2024). The comprehensive evaluation of antioxidant activity using both DPPH and FRAP assays confirmed the significant functional potential of certain LAB strains, particularly *E. faecium*. While some species, such as *L. acidophilus* and *Lbs. paracasei* exhibited strain-level variability, their consistent antioxidant properties indicate a promising role in health-promoting food applications.

The differences observed among strains, even within the same species or from identical sources, emphasize the importance of **strain-specific screening** in the selection of probiotic or bioprotective candidates for industrial applications.

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CONCLUSION

This study demonstrated significant variability in the antioxidant capacities of LAB strains isolated from traditional food sources. Results from both DPPH and FRAP assays consistently indicated that *Enterococcus faecium* exhibited superior antioxidant potential compared to other strains, particularly *Lactobacillus acidophilus*. These findings highlight the importance of strain-level screening for identifying LAB with high functional potential.

The incorporation of such potent strains into functional food products may confer health benefits beyond basic nutrition. Future *in vivo* studies and molecular investigations will be essential to elucidate the mechanisms underlying LAB-derived antioxidant activity and to validate their physiological relevance in humans.

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HAYVAN BESLEMEDE ARI ÜRÜNLERİNİN KULLANILMA OLANAKLARI POSSIBILITIES OF USING BEE PRODUCTS IN ANIMAL NUTRITION

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ÖZET

Arı ürünleri, hayvan besleme ve sağlık alanında doğal ve sürdürülebilir katkı maddeleri olarak öne çıkmakta olup, biyolojik açıdan aktif bileşenleri sayesinde hayvanların büyüme, bağışıklık, üreme ve metabolik fonksiyonlarını desteklemektedir. Bal, içeriğinde bulunan antioksidanlar, enzimler ve temel besin maddeleri sayesinde büyüme performansını artırmakta, sindirim sağlığını desteklemekte ve bağışıklık sisteminin güçlenmesine katkıda bulunmaktadır. Ayrıca, stres kaynaklı hematolojik ve biyokimyasal parametreler üzerine iyileştirici etkiye sahiptir. Apilarnil, testosteron seviyelerini yükselterek üreme sağlığını iyileştirmekte, antioksidan özellikleri ile oksidatif stresi azaltarak metabolik sağlığı olumlu yönde etkilemektedir. Flavonoidler ve fenolik asitler bakımından zengin bir bileşime sahip olan propolis, bağışıklık sistemini güçlendirmenin yanı sıra yemden yararlanma oranını ve üreme verimliliğini artırmaktadır. Arı poleni, büyüme ve üreme performansını desteklemekte ayrıca karkas kalitesi üzerinde de olumlu etkiler göstermektedir. Balmumu, antimikrobiyal ve antioksidan özellikleri sayesinde besin madde sindirilebilirliği ve biyokimyasal parametreler üzerinde olumlu etkilere sahiptir. Arı sütü, yüksek ve kaliteli besin madde içeriği ile büyüme ve üreme sağlığına katkıda bulunurken, bağışıklık sistemi üzerine destekleyici etkiler göstermektedir. Arı ekmeği, besleyici ve prebiyotik özelliklere sahip fermente bir arı ürünü olup; protein, vitamin, mineral ve antioksidan içeriği sayesinde bağışıklık sistemini güçlendirmekte, oksidatif stresi azaltmakta ve üreme performansını iyileştirmektedir. Arı zehri ise melittin ve apamin gibi aktif bileşenleri ile hayvan sağlığını güçlendirerek üretim verimliliğini artırmaktadır. Sonuç olarak, arı ürünleri, hayvancılık sektöründe doğal, yenilikçi ve çevre dostu çözümler sunmakta olup, bu bileşenlerin tam potansiyellerinin ortaya konulabilmesi için daha fazla bilimsel araştırmaya ihtiyaç duyulmaktadır. Arı ürünlerinin etkin ve bilinçli kullanımı, sürdürülebilir hayvansal üretim hedeflerine önemli katkılar sunmaktadır.

Anahtar Kelimeler: *Apis mellifera*, arı ürünleri, hayvan besleme.

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ABSTRACT

Bee products stand out as natural and sustainable additives in the field of animal nutrition and health, supporting the growth, immune, reproductive and metabolic functions of animals thanks to their biologically active components. Thanks to its antioxidants, enzymes and essential nutrients, honey improves growth performance, supports digestive health and contributes to strengthening the immune system. It also has a healing effect on stress-induced hematological and biochemical parameters. Apilarnil improves reproductive health by increasing testosterone levels and positively affects metabolic health by reducing oxidative stress with its antioxidant properties. Propolis, rich in flavonoids and phenolic acids, strengthens the immune system and increases feed utilization and production efficiency. Bee pollen supports growth and reproductive performance and has positive effects on carcass quality. Beeswax has positive effects on nutrient digestibility and biochemical parameters thanks to its antimicrobial and antioxidant properties. Royal jelly, with its high and high quality nutrient content, contributes to growth and reproductive health and has supportive effects on the immune system. Bee bread, a fermented bee product with nutritional and prebiotic properties, strengthens the immune system, reduces oxidative stress and improves reproductive performance thanks to its protein, vitamin, mineral and antioxidant content. Bee venom, with its active components such as melittin and apamin, strengthens animal health and increases production efficiency. In conclusion, bee products offer natural, innovative and environmentally friendly solutions in the livestock sector, and more scientific research is needed to reveal the full potential of these components. Effective and conscious use of bee products makes significant contributions to sustainable animal production goals.

Keywords: *Apis mellifera*, bee products, animal nutrition.

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INTEGRATING CIRCULAR ECONOMY AND BEHAVIORAL INSIGHTS IN ROOFTOP AGRICULTURE: A SUSTAINABLE URBAN DEVELOPMENT PERSPECTIVE FROM BANGLADESH

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ABSTRACT

Purpose

This study investigates the adoption of rooftop agriculture (RA) in urban Bangladesh, with a focus on its alignment with circular economy principles and its contributions to sustainable urban development. It aims to understand the behavioral and structural determinants influencing RA adoption within a resource-constrained and densely populated urban environment.

Theoretical Framework

Grounded in the Theory of Planned Behavior (TPB), the study integrates pro-environmental orientation, autonomous motivation, and structural constraints to develop a comprehensive framework for understanding RA adoption.

Design/Methodology/Approach

A positivist research paradigm guided the study, adopting a quantitative approach with a deductive research strategy. A conclusive descriptive survey design was employed. Due to the unknown population size of potential RA practitioners, a multistage sampling method was adopted involving purposive, quota, and stratified random sampling. The final sample size was 640. Data were collected using a structured questionnaire adapted from validated scales and analyzed using SmartPLS 4 for Partial Least Squares Structural Equation Modeling (PLS-SEM).

Findings

Results indicate that attitudes, subjective norms, and perceived behavioral control significantly predict the intention to adopt RA. Circular economy practices such as organic waste composting and resource reuse enhance the environmental, economic, and social value of RA. However, barriers including financial limitations, lack of technical expertise, and inadequate policy support impede widespread adoption.

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Originality/Value

This study contributes to filling a research gap by offering empirical insights into the behavioral and structural drivers of RA in the context of a developing country. It provides a holistic understanding of how circular economy principles intersect with individual behavior and systemic constraints in fostering sustainable urban practices.

Practical Implications

The study offers actionable policy recommendations including financial incentives, public awareness initiatives, and institutional support mechanisms to promote RA. The findings are instrumental for urban planners, policymakers, and sustainability advocates aiming to scale up RA practices in Bangladesh and comparable contexts.

Limitations and Future Research

While the study presents robust findings, its scope is limited to urban Bangladesh, restricting generalizability. Future research should explore longitudinal effects of RA adoption and conduct cross-regional comparative analyses.

Keywords: Rooftop Agriculture, Circular Economy, Sustainable Urban Development, Theory of Planned Behavior, Partial Least Squares SEM, Urban Bangladesh

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PRODUCTION OF DESIGNER EGGS AND ITS IMPORTANCE IN HUMAN NUTRITION: A REVIEW

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ABSTRACT

Designer eggs are one of the significant developments in poultry egg production, driven by the increasing need for nutritionally dense foods. They are enriched eggs that are produced by modifying the diet of laying hens to improve the nutritional profile of eggs with superior makeup/composition to their original. As designer eggs are laid by hens whose diets have been infused with certain feed additives which includes antioxidants, vitamins, minerals, omega-3-rich sources, and the likes, they can also be considered as nutritionally enhanced eggs. By means of genetic selection and beneficial modifications, designer eggs can also be produced to provide advantageous health benefits. This review explores the different techniques of producing designer eggs, with an emphasis on feed-based approaches including adding flaxseed, fish oil, microalgae, selenium, and carotenoids as additives. These dietary changes produce eggs that are highly metabolized. The paper further examines the use of designer eggs to prevent chronic diseases, such as cardiovascular ailments, cognitive decline, and vitamin deficiencies, in addition to detailing compositional enhancements. Within the larger framework of nutrition-sensitive agriculture, the function of designer eggs to promote public health is assessed with a focus on alleviating undetected malnutrition and non-communicable diseases in both industrialized and developing nations. Even though, there are still issues with production costs, safety standards, and nutritional stability, designer eggs present a viable pathway for the development of functional foods. They offer a practical, long-term approach to enhancing population health by combining focused dietary modifications with farming methods.

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EXPLORING THE BIOACTIVE COMPONENTS AND PHARMACOLOGICAL BENEFITS OF A NORTHERN MOROCCAN TRADITIONAL HERB

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ABSTRACT

Ruta montana L., a medicinal herb in Moroccan folk medicine, has been used to treat infections, hyperglycemia, spasms, and fever. This study uses GC-MS to examine the bioactive constituents of RMEO and analyzes its antibacterial, antioxidant, and antidiabetic actions *in vitro* and using molecular docking approaches.

GC-MS identified 2-undecanone as the main compound of the essential oil. RMEO inhibited α -amylase ($IC_{50} = 0.365 \pm 0.11$ mg/mL) and α -glucosidase ($IC_{50} = 0.311$ mg/mL), had significant antioxidant potential (FRAP $EC_{50} = 188.61 \pm 1.12$ μ g/mL; beta-carotene $IC_{50} = 149.21 \pm 1.12$ μ g/mL), and had potent antibacterial effects, particularly against *Micrococcus luteus* and *Staphylococcus aureus* (20.05 ± 0.98 and 18.11 ± 1.11 mm).

It demonstrated modest efficacy against *Candida albicans* (13.05 ± 0.5 mm), with MIC/MBC values ranging from 0.25 to 8% (v/v). Molecular docking and ADME tests confirmed these findings. Overall, DVEO exhibits remarkable antioxidant, antibacterial, anticandidal, and antidiabetic effects, indicating a potential for natural therapeutic uses.

Keywords: volatile oil, *Dittrichia viscosa*, GC-MS, antibacterial, antiradical.

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AGRICULTURAL LAND ALLOCATION WITHIN ENERGY-FOOD NEXUS: PATHWAYS TO GLOBAL SUSTAINABLE DEVELOPMENT

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ABSTRACT

Due to the scarcity of land and a corresponding rise in demand for food and energy, there should be a global concern about agricultural land allocation to produce energy. Considering sustainable development goals (SDGs), decision-making in the supply of both energy and food (clean energy (Goal 7) and zero hunger (Goal 2)) is essential for achieving global sustainable development. The association between clean energy and zero hunger requires addressing energy and food nexus. As a result, this study aimed to look globally into the impact of allocating agricultural land within the energy and food nexus on environmental and economic benefits. Accordingly, 72 primary articles were reviewed and analyzed using meta-analysis based on available databases from 1950 to 2023. The results of meta-regression showed that geographical location affects decreased environmental quality but increases economic growth at the global level. Moreover, the crop rotation between energy and food products affected all environmental (from 6% to 67%) and economic (from 11% to 23%) benefits. The most important result of the current review indicated that increasing agricultural land allocated within the energy and food nexus globally increased sustainable development of improving the environment (from 56% to 86%) and growing economy (from 14% to 42%). According to the results, it should be noted that high demand for bioenergy can have implications such as competition with food products. Therefore, it is recommended that countries with large agricultural lands apply crop rotation within the energy and food nexus as an opportunity for achieving sustainable development.

Keywords: Bioenergy; Environmental and economic benefits; Land allocation; Meta-regression; Rotation system.

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DE NOVO RNA-SEQ DİZİNLEME İLE *CORIANDRUM SATIVUM*'UN TRANSKRİPTOM PROFİLLEMESİ VE ÖRNEK KÜMELEME ANALİZİ

TRANSCRIPTOME PROFILING AND SAMPLE CLUSTERING ANALYSIS OF *CORIANDRUM SATIVUM* USING DE NOVO RNA-SEQ SEQUENCING

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ÖZET

Coriandrum sativum, mutfak ve geleneksel tıpta yaygın olarak kullanılan, ekonomik ve tıbbi açıdan önemli bir bitkidir. Bu çalışmada, kamuya açık RNA-Seq verileri kullanılarak de novo transkriptom dizilimi ve gen ifade profillemesi gerçekleştirilmiştir. Kalite kontrolü ve kırpma işlemleri sonrası veriler Trinity yazılımı ile birleştirilmiş, transkript bolluğu Salmon aracı ile hesaplanmıştır. İfade verilerine dayalı olarak yapılan Temel Bileşenler Analizi (PCA) ve ısı haritası görselleştirmesi, örnekler arasında belirgin kümeleşme desenleri ortaya koymuştur. Bu analizler, *C. sativum*'un işlevsel gen ekspresyonu ve diferansiyel gen analizi gibi ileri düzey biyoinformatik çalışmalar için sağlam bir temel oluşturmaktadır.

Anahtar Kelimeler: *Coriandrum sativum*, RNA-Seq, Transkriptom.

ABSTRACT

Coriandrum sativum is an economically and medicinally important plant widely used in culinary practices and traditional medicine. In this study, de novo transcriptome assembly and gene expression profiling were conducted using publicly available RNA-Seq data. After quality control and trimming, the reads were assembled using the Trinity software, and transcript abundance was estimated with Salmon. Principal Component Analysis (PCA) and heatmap visualization based on expression data revealed distinct clustering patterns among the samples. These analyses provide a robust foundation for advanced bioinformatics investigations such as functional gene expression studies and differential expression analysis in *C. sativum*.

Keywords: *Coriandrum sativum*, RNA sequencing, Transcriptome.

GİRİŞ

Coriandrum sativum L. (kişniş), Apiaceae (maydanozgiller) familyasına ait, çok yönlü kullanım alanlarına sahip bir bitkidir. Gıda endüstrisinde özellikle yaprakları ve tohumları taze ya da kurutulmuş olarak baharat amacıyla kullanılmakta; geleneksel tıpta ise antimikrobiyal, antienflamatuvar, sindirim düzenleyici ve hipoglisemik etkilerinden dolayı yaygın olarak tercih edilmektedir (Sahib et al., 2013; Laribi et al., 2015). Kişniş, içerdiği uçucu yağlar (örn. linalool), flavonoidler, fenolik bileşikler ve diğer sekonder metabolitler bakımından zengin kimyasal profiliyle de dikkat çekmektedir. Ancak bu biyolojik etkilerin moleküler temelini oluşturan genetik düzenekler büyük ölçüde bilinmemektedir.

Bitkilerde gen ekspresyonu profillerinin çözülmesi, hücresel süreçlerin ve fizyolojik tepkilerin anlaşılması açısından kritik öneme sahiptir. Özellikle sekonder metabolit biyosentez yolları, çevresel stres yanıtları ve dokuya özgü genetik mekanizmaların çözülmesi hem temel biyoloji hem de tarımsal

uygulamalar açısından değerlidir. *C. sativum* gibi model organizma olmayan türlerde bu tür analizlerin gerçekleştirilmesi, referans genomların olmaması nedeniyle teknik zorluklar içerebilir. Ancak, son yıllarda yaygınlaşan yüksek verimli RNA dizileme (RNA-Seq) teknolojisi, referans genom gerektirmeksizin ifade analizi ve transkript keşfine olanak sağlamaktadır (Wang et al., 2009).

RNA-Seq, özellikle bitki biyoteknolojisinde giderek artan bir şekilde kullanılmaktadır. Bu teknoloji sayesinde, model olmayan bitkilerde de novo transkriptom montajı yapılarak ifade edilen genlerin belirlenmesi ve karşılaştırmalı analizler yoluyla biyolojik süreçlerin incelenmesi mümkün hale gelmiştir (Grabherr et al., 2011). Bu bağlamda, kişniş gibi henüz genomik düzeyde yeterince çalışılmamış türlerin moleküler biyolojisini anlamak için RNA-Seq büyük bir fırsat sunmaktadır. Ayrıca, gen ekspresyonu verilerine dayalı olarak yapılan istatistiksel analizler (ör. PCA, heatmap, diferansiyel ifade analizi), biyolojik örneklerin kümeleme desenlerini ortaya koymakta ve hangi genlerin hangi koşullarda aktif olduğunu belirlemede önemli rol oynamaktadır (Love et al., 2014).

Bu çalışmada, *C. sativum*'a ait kamuya açık RNA-Seq verileri kullanılarak de novo transkriptom montajı gerçekleştirilmiş, gen ifade düzeyleri Salmon yazılımı ile miktarlandırılmış ve örnekler arası ilişkiler PCA ve ısı haritaları aracılığıyla görselleştirilmiştir. Bu analizlerin temel amacı, kişniş örnekleri arasındaki ifade farklılıklarını anlamak ve ileri düzey genetik/fonksiyonel analizler için başlangıç verisi sunmaktır. Çalışma, kişniş bitkisinin transkriptomik düzeyde daha iyi anlaşılmasına katkı sağlayarak sekonder metabolit biyosentezi, çevresel stres tepkileri ve biyoteknolojik uygulamalara yönelik araştırmalara zemin hazırlamaktadır.

MATERYAL ve YÖNTEMLER

RNA-Seq Veri Setlerinin Elde Edilmesi

Bu çalışmada, *Coriandrum sativum*'a ait kamuya açık üç adet çift uçlu (paired-end) RNA-Seq veri seti kullanılmıştır: SRR6242013, SRR6242014 ve SRR6242015. Bu veriler, National Center for Biotechnology Information (NCBI) Sequence Read Archive (SRA) veri tabanından (<https://www.ncbi.nlm.nih.gov/sra>) FASTQ formatında indirilmiştir. Her bir örnek, farklı biyolojik koşulları temsil etmektedir ve transkriptom profillemeye amacıyla kullanılmıştır.

Kalite Kontrolü ve Ön İşlem Adımları

Ham RNA-Seq verilerinin kalitesi öncelikle FastQC (v0.12.1) aracı ile değerlendirilmiştir (Andrews, 2010). Ardından, düşük kaliteli bazlar ve adaptor sekanslarının temizlenmesi için fastp (v0.23.4) yazılımı kullanılmıştır (Chen et al., 2018). Bu aşamada Phred kalitesi düşük (<Q30) olan uçlar kırılmış ve 35 bp altı kısa diziler dışlanmıştır. Elde edilen veriler FASTQ formatında, analizlere hazır hale getirilmiştir.

De novo Transkriptom Montajı

Temizlenmiş okuma dizileri, referans genom kullanılmadan **Trinity (v2.15.1)** yazılımı ile de novo olarak birleştirilmiştir (Grabherr et al., 2011). Trinity, üç aşamalı bir montaj süreci olan Inchworm, Chrysalis ve Butterfly algoritmalarını kullanarak yüksek kaliteli transkript kümeleri oluşturmuştur. Montaj kalitesi, montaj uzunlukları ve N50 gibi metriklerle değerlendirilmiştir.

Transkript Düzeyinde İfade Miktarlandırması

Elde edilen transkript kümelerine karşı örneklerin ifade düzeyleri Salmon (v1.10.3) yazılımı kullanılarak hesaplanmıştır (Patro et al., 2017). Salmon, referans transkriptlere yarı hizalanma (quasi-mapping) yaklaşımı ile hızlı ve doğru miktarlandırma yapmaktadır. Bu analiz sonucunda transkript düzeyinde TPM (Transcripts Per Million) ve raw count değerleri elde edilmiştir.

Normalizasyon ve İfade Matrisi Oluşturulması

Salmon çıktıları Trinity'nin "abundance_estimates_to_matrix.pl" komutu ile gen ve izoform seviyesinde ifade matrisine dönüştürülmüştür. Genel karşılaştırmalarda kullanmak üzere TMM (Trimmed Mean of M-values) normalizasyon yöntemi ile ifade değerleri normalize edilmiştir (Robinson & Oshlack, 2010). Normalizasyon işlemleri ve veri analizi R (v4.3.1) ortamında gerçekleştirilmiştir.

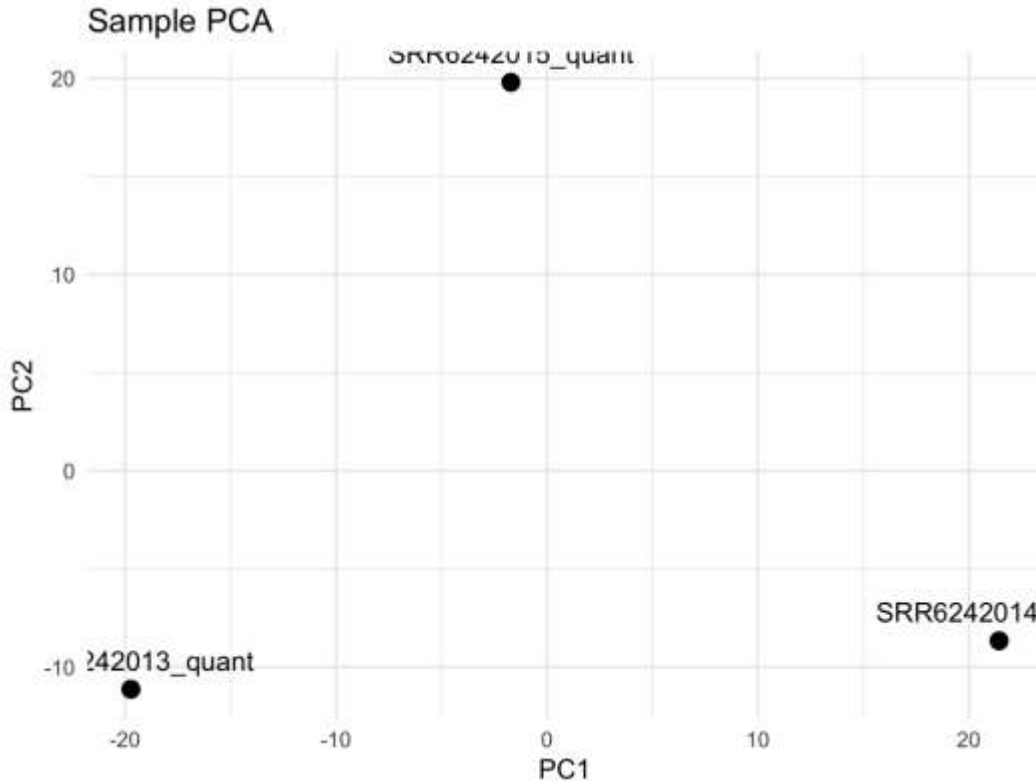
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Kümeleme ve Görselleştirme

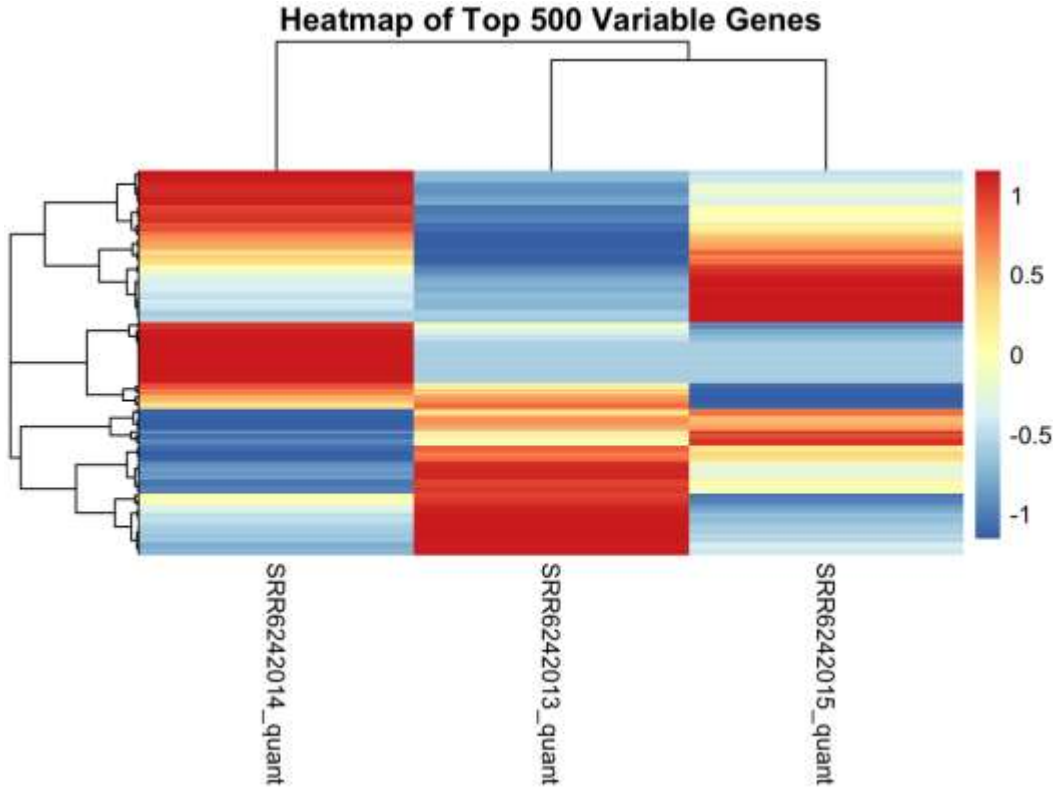
Verilerin genel yapısını incelemek amacıyla Temel Bileşenler Analizi (Principal Component Analysis-PCA) uygulanmıştır. PCA, R'de prcomp() fonksiyonu kullanılarak gerçekleştirilmiş ve örnekler arasındaki varyansın ilk iki bileşeni görselleştirilmiştir. Ayrıca, gen ifadesindeki varyasyonu daha detaylı incelemek amacıyla en değişken 500 gen kullanılarak ısı haritası (heatmap) oluşturulmuştur. Bu işlem pheatmap paketi ile satır bazında ölçeklendirilerek gerçekleştirilmiştir. Bu analizler örnekler arasında gen ekspresyonuna dayalı kümeleşmeleri açıkça göstermektedir.

BULGULAR

Bu çalışmada, *Coriandrum sativum*'a ait üç farklı RNA-Seq örneği (SRR6242013, SRR6242014, SRR6242015) üzerinden yürütülen transkriptom analizleri sonucunda örnekler arasında belirgin gen ekspresyon farklılıkları tespit edilmiştir. İlk olarak, Temel Bileşenler Analizi (PCA) uygulanarak örneklerin genel varyasyon düzeyine göre konumları görselleştirilmiştir. Şekil 1'de görüldüğü üzere, PCA sonuçlarına göre birinci bileşen (PC1) toplam varyansın büyük bir kısmını açıklarken, ikinci bileşen (PC2) örnekler arasındaki ikincil farklılıkları göstermiştir. Üç örnek PCA uzayında birbirlerinden açıkça ayrılmıştır; bu durum örnekler arasında biyolojik veya teknik farklılıkların varlığına işaret etmektedir.



Şekil 1. TMM-normalize edilmiş TPM değerlerine dayalı numunelerin PCA çizimi.



Şekil 2. En çok değişkenlik gösteren 500 genin ısı haritası.

Özellikle SRR6242014 örneği, PCA düzleminde diğer iki örnekten uzak konumlanarak gen ekspresyon profili bakımından ayırt edici bir özellik göstermiştir. Bu durum, örneklerin ya biyolojik koşulları ya da RNA izolasyon/dizileme süreçlerindeki teknik değişkenlikten kaynaklanabileceğini düşündürmektedir.

PCA analizinin desteklenmesi amacıyla, varyasyon düzeyi en yüksek 500 gen seçilerek ısı haritası (heatmap) oluşturulmuştur. Şekil 2’de sunulan bu görselleştirme, örneklerin gen bazında kümeleme desenlerini daha detaylı ortaya koymuştur. Isı haritası analizinde, örnekler arasında geniş çapta farklılık gösteren gen kümeleri belirlenmiş ve örnekler, bu ekspresyon profillerine göre iki ana kümeye ayrılmıştır. SRR6242013 ve SRR6242015 benzer ekspresyon desenleri sergilerken, SRR6242014 örneği bu kümelerden farklı bir şekilde ayrılmıştır. Bu sonuçlar, Şekil 1’deki PCA analizinde elde edilen örnek ayrımının Şekil 2 ile tutarlı olduğunu göstermektedir.

Ayrıca, örnekler arasında farklı ifade düzeylerine sahip genlerin genel dağılımı ve örnek bazlı ekspresyon paternleri hem genel biyolojik varyasyonu hem de potansiyel olarak durum-ya-da-hücre-tipi-spesifik genlerin ayırt edilmesine olanak tanımaktadır. Bu ilk ifade profillemesi adımı, diferansiyel gen analizi ve fonksiyonel açıklamalar için sağlam bir zemin oluşturmaktadır.

TARTIŞMA ve SONUÇ

Bu çalışmada, *Coriandrum sativum* için ilk defa de novo RNA dizilemesine dayalı kapsamlı bir transkriptomik analiz gerçekleştirilmiş ve bu sayede bitkiye ait temel gen ifade profilleri ortaya konulmuştur. Montaj ve ifade miktarlandırma süreçleri başarılı bir şekilde tamamlanmış, elde edilen veri setleri üzerinden yapılan kümeleme analizleri (PCA ve ısı haritası) örnekler arasında belirgin biyolojik veya teknik ayrımlar olduğunu göstermiştir. Bu ayrımlar, bitkinin moleküler düzeydeki farklı fizyolojik durumlarını veya stres yanıtlarını yansıtıyor olabilir.

Bu analizler, özellikle referans genomu bulunmayan model dışı bitki türlerinde RNA-Seq’in sağladığı avantajları açıkça ortaya koymaktadır. De novo montaj ile transkript kümesi oluşturulması hem ifade analizleri hem de ilerleyen aşamalarda yapılabilecek fonksiyonel anotasyon ve yolak analizleri açısından kritik bir adımdır (Grabherr et al., 2011). PCA ve heatmap gibi istatistiksel ve görsel analiz yöntemleri

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ise örnekler arasındaki benzerlik ve farkların biyoinformatik düzlemde yorumlanmasını kolaylaştırmaktadır (Conesa et al., 2016).

Çalışmada elde edilen bulgular, özellikle farklı ifade desenleri sergileyen gen kümelerinin varlığını ortaya koyarak ileride yapılacak diferansiyel ifade analizlerine temel oluşturmaktadır. Ayrıca bu gen kümeleri; sekonder metabolit biyosentezi, sinyal iletimi, stres yanıtı ve dokuya özgü fizyolojik süreçler gibi önemli biyolojik mekanizmaların aydınlatılmasına katkı sağlayabilecek potansiyele sahiptir. Bu durum, kişniş bitkisinin tarımsal ıslahı, ilaç hammaddesi olarak değerlendirilmesi ve moleküler biyoteknolojik uygulamalara entegrasyonu açısından değerlidir.

Literatürde kişniş bitkisi üzerine yapılan çalışmalar çoğunlukla fitokimyasal içerik analizlerine odaklanmıştır (Sahib et al., 2013; Laribi et al., 2015). Oysa bu çalışmada sunulan transkriptomik veri kümesi, gen düzeyinde düzenleyici mekanizmaların keşfi ve genetik çeşitliliğin daha iyi anlaşılması için bir referans noktası sunmaktadır. Dolayısıyla elde edilen sonuçlar hem temel bilimsel araştırmalar hem de uygulamalı biyoteknolojik yaklaşımlar için önemli bir kaynak niteliğindedir.

Gelecekte bu analizlerin, diferansiyel ifade analizleri, fonksiyonel anotasyon (ör. GO ve KEGG zenginleştirme), transkripsiyon faktörü ağları ve co-expression ilişkileri gibi ileri düzey çalışmalarla desteklenmesi, kişnişin moleküler biyolojisi ve genetik altyapısına dair daha bütüncül bir perspektif sunacaktır.

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KENEVİR (*Cannabis sativa* L.) YETİŞTİRİCİLİĞİNDE ORGANİK VE KİMYASAL GÜBRELERİN ETKİLERİ

EFFECTS OF ORGANIC AND CHEMICAL FERTILIZERS IN HEMP (*Cannabis sativa* L.) CULTIVATION

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ÖZET

Kenevir (*Cannabis sativa* L.), Cannabaceae familyasına ait tek yıllık bir bitkidir. Orta Asya kökenli olan kenevir, erkek ve dişi organlarını farklı bitkilerde taşıyan (dioik) ya da aynı bitki üzerinde bulunduran (monoik) formlara sahip olup, yabancı döllemeyle çoğalan bir türdür. Tarih boyunca lif ve gıda amacıyla yetiştirilen kenevir, günümüzde ilaç, kozmetik, kâğıt, inşaat, biyoyakıt ve tekstil gibi birçok endüstride geniş kullanım alanı bulmaktadır. Son yıllarda tıbbi ve endüstriyel değeri artarak, sürdürülebilir tarım ve çevre dostu ürünler açısından önemi daha da yükselmiştir.

Kenevir üretiminde gübre uygulaması, toprak sağlığını korumak ve sürdürülebilirliği sağlamak açısından büyük önem taşır. Yüksek verim ve kaliteli ürün elde etmek için bitkiye uygun doğru gübreleme ve beslenme programlarının uygulanması gereklidir. Organik ve inorganik gübrelerin farklarının bilinmesi, verimi artırmanın yanı sıra toprak sağlığını iyileştirerek çevre kirliliğinin önüne geçmek için kritik öneme sahiptir.

Organik gübreler, özellikle tarla koşullarında toprağın organik madde içeriğini artırarak kök gelişimi, su tutma kapasitesi ve besin döngüsünü olumlu yönde destekler. Kimyasal gübreler ise azot, fosfor ve potasyumun hızlı temini sayesinde bitkinin erken gelişimini teşvik eder. Sera koşullarında kontrollü çevre faktörleri sayesinde kimyasal gübrelerin etkisi daha belirgin olurken, organik gübreler kök bölgesindeki mikrobiyal aktiviteyi koruyarak uzun süreli ve dengeli besin salınımı sağlar. Bu farklı gübreleme yöntemleri, lif kalitesi, tohum verimi ve içerik bileşenleri üzerinde olumlu etkiler yaratarak kenevir yetiştiriciliğinde verim ve kaliteyi artırmaktadır.

Mevcut bilgiler ışığında, organik ve kimyasal gübrelerin birlikte kullanılmasının kenevir yetiştiriciliğinde verim ve kaliteyi olumlu yönde etkileyebileceği, aynı zamanda toprak sağlığının korunmasına katkı sağlayabileceği düşünülmektedir. Bu nedenle, gübreleme stratejilerinin yetiştirme ortamına uygun şekilde planlanması ve organik-kimyasal gübre kombinasyonlarının dengeli olarak değerlendirilmesi, hem yüksek verim ve kalite hem de çevresel sürdürülebilirlik açısından önem taşımaktadır.

Anahtar Kelimeler: Kenevir, Organik gübre, Kimyasal gübre, Bitki besleme, Sürdürülebilir tarım

ABSTRACT

Hemp (*Cannabis sativa* L.) is an annual plant belonging to the family Cannabaceae. Originating from Central Asia, hemp exhibits dioecious forms, in which male and female flowers are found on separate plants, as well as monoecious forms, with both reproductive organs on the same plant, and reproduces by cross-pollination. Historically cultivated for fiber and food purposes, hemp today has wide applications in various industries such as pharmaceuticals, cosmetics, paper, construction, biofuels, and

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textiles. In recent years, its medicinal and industrial value has increased significantly, further enhancing its importance in terms of sustainable agriculture and environmentally friendly products.

Fertilization in hemp production plays a crucial role in maintaining soil health and ensuring sustainability. To achieve high yield and quality, it is essential to implement appropriate fertilization and nutrition programs tailored to the plant's needs. Understanding the differences between organic and inorganic fertilizers is critical not only for improving yield but also for enhancing soil health and mitigating environmental pollution.

Organic fertilizers, particularly under field conditions, improve soil organic matter content, root development, water-holding capacity, and nutrient cycling. Inorganic fertilizers, on the other hand, provide rapid availability of nitrogen, phosphorus, and potassium, thereby promoting early plant growth. While the effects of chemical fertilizers are more pronounced under controlled greenhouse conditions, organic fertilizers maintain microbial activity in the rhizosphere, ensuring long-term and balanced nutrient release. These distinct fertilization approaches positively influence fiber quality, seed yield, and biochemical composition, thereby contributing to improved yield and quality in hemp cultivation.

Based on current knowledge, the combined use of organic and chemical fertilizers is considered to have positive effects on both yield and quality in hemp cultivation, while also contributing to the preservation of soil health. Therefore, fertilization strategies should be carefully planned according to the growing environment, and balanced evaluation of organic–chemical fertilizer combinations is essential for achieving both high productivity and environmental sustainability.

Keywords: Hemp, Organic fertilizer, Chemical fertilizer, Plant nutrition, Sustainable agriculture

1.GİRİŞ

Kenevir (*Cannabis sativa* L.), Cannabaceae familyasına ait tek yıllık bir bitkidir. Orta Asya menşeli olan kenevir, $2n=20$ kromozom yapısına sahip olup genellikle iki evcikli (dioik) olması sebebiyle erkek ve dişi organlarını farklı bireylerde taşır ve yabancı döllenme ile çoğalır. Son yıllarda özellikle monoik karakter gösteren çeşitler üzerinde yürütülen ıslah çalışmaları, kenevir üretiminde önemli bir gelişme sağlamıştır (Yılmaz ve Yazıcı, 2022).

Kenevirin kullanımının çok eski dönemlere dayandığı bilinmektedir. Çin'de yaklaşık 8500 yıl önce kültüre alınarak değerlendirildiği, M.Ö. 4000'li yıllara ait kumaş parçalarında kenevir liflerine rastlandığı bildirilmektedir. Bitkinin ilk olarak Mısır ve Batı Asya'da, daha sonra M.Ö. 1000–2000 yıllarında Avrupa ve Akdeniz kıyılarına yayıldığı, M.S. 500'lü yıllarda ise geniş ölçüde kullanılmaya başlandığı kaydedilmektedir (Schultes ve Hofmann, 1980; Yılmaz ve Yazıcı, 2022; Small ve Marcus, 2002). Antik çağlarda daha çok gıda ve lif üretimi amacıyla yetiştirilen kenevir, günümüzde ise ilaç, kozmetik, kâğıt, inşaat, biyoyakıt ve tekstil gibi birçok endüstride geniş kullanım alanı bulmaktadır (Hourfane ve ark., 2023).

Gübre uygulamaları, hem toprak sağlığının korunması hem de kenevir üretiminde sürdürülebilirliğin sağlanması açısından kritik bir öneme sahiptir. Kenevirden yüksek verim ve kaliteli bir üretim elde edebilmek için yalnızca doğru gübreleme yapılması değil, aynı zamanda bitkinin fenolojik gelişim dönemlerine uygun özel bir beslenme programının uygulanması gereklidir. Gübrelerin bilinçli ve dengeli kullanımı, yalnızca verim ve kaliteyi artırmakla kalmamakta; aynı zamanda toprak yapısının iyileştirilmesi, besin döngüsünün düzenlenmesi ve çevresel kirliliğin azaltılması gibi ekosistem hizmetlerine de katkıda bulunmaktadır.

Gübreler genel olarak organik ve inorganik (kimyasal) gübreler olmak üzere iki ana grupta sınıflandırılmaktadır. Organik gübreler, içeriklerinde yüksek miktarda organik madde, çeşitli mikroorganizmalar ve bitki için gerekli makro ve mikro besin elementlerini bulundurlar. Bu özellikleri sayesinde hem toprak verimliliğini artırır hem de uzun vadede toprağın biyolojik, kimyasal ve fiziksel özelliklerini iyileştirerek sürdürülebilir üretimi desteklerler. Kompost, vermikompost, çiftlik gübresi, biyokömür, yeşil gübreler, mikoriza ve mikrobiyal gübreler ile alg/yosun kökenli gübreler organik gübre çeşitlerine örnek teşkil etmektedir (Akpınar, 2024). Bu gübreler, içerdikleri humik ve fulvik asitler ile

toprağın su tutma kapasitesini artırmakta, besin elementlerinin şelatlaşmasını kolaylaştırmakta ve bitki kök gelişimini teşvik etmektedir.

Öte yandan, inorganik (kimyasal) gübreler, yüksek oranda çözünür formda besin elementleri içererek bitkilerin özellikle azot (N), fosfor (P) ve potasyum (K) gibi temel makro besin elementlerini hızlı bir şekilde alabilmesini sağlamaktadır. Bu durum bitkinin erken gelişimini hızlandırmakta ve kısa vadede yüksek verim artışı sağlamaktadır (Sönmez ve ark., 2008; Özgüven & Katkat, 1997). Ancak, kimyasal gübrelerin bilinçsiz ve yoğun kullanımı, toprağın elektriksel iletkenliğini (EC) artırarak tuzluluk sorunlarına yol açabilmekte, ayrıca ağır metal (Cd, As, Cu, Ni, Pb vb.) birikimi ile toprak ve su kaynaklarının kirlenmesine neden olabilmektedir (Cüre, 2022). Fazla azotlu gübre uygulamaları ise, toprakta simbiyotik azot fikse eden mikroorganizmaların faaliyetlerini baskılamakta ve toprak mikrobiyal çeşitliliğini azaltmaktadır. Bu durum uzun vadede toprak sağlığının bozulmasına ve verim sürdürülebilirliğinin zayıflamasına yol açmaktadır.

Sürdürülebilir tarım sistemleri açısından bakıldığında, organik gübrelerin kullanımı yalnızca bitki beslenmesini sağlamakla kalmayıp, aynı zamanda ekolojik dengeyi koruma ve çevresel kirliliği azaltma işlevi de görmektedir. Pimentel ve Burgess (2014), organik gübrelerin uzun vadede toprağın biyolojik aktivitesini artırarak kimyasal gübre kullanımını azaltabileceğini ve bu sayede çevre ekosistemine olumlu katkılar sağlayabileceğini vurgulamaktadır. Tarla koşullarında yapılan uygulamalar, organik gübre kullanımının topraktaki organik madde miktarını artırarak kök, gövde ve tohum gelişimini, ayrıca besin döngüsünü ve su tutma kapasitesini iyileştirdiğini göstermektedir.

Ancak yalnızca organik gübre kullanımı her zaman yeterli olmayabilir. Özellikle sera koşullarında yapılan çalışmalar, kimyasal gübrelerin hızlı çözünürlüğü sayesinde daha kısa sürede gözle görülür bitki gelişimi sağladığını ortaya koymaktadır (Sönmez ve ark., 2008). Bu nedenle günümüzde en çok üzerinde durulan yaklaşım, organik ve kimyasal gübrelerin entegre kullanımıdır. Literatürde, bu iki gübreleme yönteminin birlikte uygulanmasının hem verim hem de kaliteyi artırdığı, aynı zamanda toprak sağlığını koruyarak mikrobiyal aktiviteyi teşvik ettiği belirtilmektedir. Bu bağlamda, kenevir yetiştiriciliğinde organik-kimyasal gübre kombinasyonlarının dengeli ve kontrollü bir şekilde uygulanması, hem kısa vadede yüksek verim ve kalite sağlamak hem de uzun vadede çevresel sürdürülebilirliği güvence altına almaktadır.

Sonuç olarak, kenevir tarımında gübreleme stratejilerinin yalnızca verim odaklı değil, aynı zamanda ekosistem temelli bir bakış açısıyla ele alınması gerekmektedir. Uygun gübreleme planlarının, yetiştirme ortamına ve çeşit özelliklerine göre optimize edilmesi, hem ekonomik getiriye artıracak, hem de toprak sağlığı ile çevresel sürdürülebilirliği destekleyecektir.

2. KENEVİRİN BESİN İHTİYAÇLARI

Kenevir hızlı gelişen ve kısa sürede yüksek biyokütle oluşturan bir bitki olduğundan, özellikle makro besin elementleri bakımından yoğun bir talep gösterir. Azot (N), fosfor (P), potasyum (K), kalsiyum (Ca), magnezyum (Mg) ve kükürt (S) bu gereksinimlerin temelini oluşturur. Bunun yanında demir (Fe), çinko (Zn), mangan (Mn), bakır (Cu) ve bor (B) gibi mikro besin elementleri de farklı gelişim dönemlerinde kritik roller üstlenir.

Azot (N)

Azot, kenevirde bitki boyu, yaprak alanı, fotosentez kapasitesi ve protein sentezi üzerinde doğrudan etkilidir. Yeterli azot, güçlü ve hızlı bir vegetatif gelişim sağlar. Ancak fazla azot uygulaması, özellikle lif üretiminde odunlaşmayı artırarak kaliteyi düşürebilir; tohum üretiminde ise gecikmiş olgunlaşmaya ve düşük yağ oranına sebep olabilir.

- Meijer, van der Werf (1994) kenevirde optimum azot dozunun 80–120 kg/ha arasında olduğunu, bunun üstünde verim artışının sınırlı kaldığını ve kaliteyi olumsuz etkileyebileceğini bildirmiştir.
- Amaducci ve ark., (2008) azot ihtiyacının 100–150 kg/ha arasında değiştiğini, özellikle lif verimi için aşırı N uygulamasından kaçınılması gerektiğini vurgulamıştır.

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- Mylavarapu ve ark., (2020) ise gelişimin en hızlı olduğu dönemde azot alımının hektar başına 250 kg'a kadar çıkabileceğini, fakat bu değerın toprak yapısı ve kullanım amacına göre değiştiğini rapor etmiştir.
- Özü, (2023) Yozgat koşullarında Narlısaray ve Futura 75 her iki genotip için tohum üretimi bakımından dekara 12 kg/da, lif üretimi için Narlısaray genotipi için 12 kg/da, Futura 75 çeşidi için 16 kg/da azotlu gübreleme yapılmasının uygun olacağı belirtilmiştir.

Fosfor (P)

Fosfor, kök gelişimi, çiçeklenme, tohum oluşumu ve enerji transferi (ATP) için kritik öneme sahiptir. Özellikle kenevirin erken dönem kök gelişimi ve çiçeklenme sürecinde yeterli fosfor sağlanması gereklidir.

- Salentijn et al. (2015) fosfor eksikliğinin kenevirde gecikmiş çiçeklenme ve düşük tohum verimine yol açtığını bildirmiştir.
- Mediavilla et al. (2001) kenevirde optimum fosfor ihtiyacını 50–80 kg P₂O₅/ha olarak belirtmiştir.
- Anderson et al. (2021) fosforun tamamının ekim öncesinde veya ekim sırasında uygulanmasının en iyi sonuç verdiğini, bitki gelişimi boyunca yavaş salımlı şekilde alınmasının verimliliği artırdığını ifade etmiştir.

Potasyum (K)

Potasyum, kenevirde su dengesinin sağlanması, fotosentez, karbonhidrat taşınımı ve lif kalitesi açısından temel besin elementidir. Yüksek potasyum alımı, özellikle sap kalınlığı, lif mukavemeti ve tohum dolgunluğu üzerinde olumlu etki yapar.

- Struik ve ark., (2000) potasyumun kenevirde lif verimini doğrudan artırdığını ve optimum ihtiyacın 200–300 kg K₂O/ha arasında değiştiğini belirtmiştir.
- Mylavarapu ve ark., (2020) ise hektar başına 336 kg K₂O düzeyine kadar potasyum alındığını bildirmiştir.
- Papastylianou ve ark., (2021) özellikle Akdeniz koşullarında potasyumun yetersiz olması durumunda düşük tohum bağlama oranı ve zayıf sap yapısı görüldüğünü raporlamıştır.

Diğer Makro ve Mikro Besinler

- Kalsiyum (Ca): Hücre duvarı oluşumunda ve kök gelişiminde önemli rol oynar. Özellikle kireçli topraklarda eksiklik daha az görülür.
- Magnezyum (Mg): Klorofilin merkez atomu olduğundan fotosentez için kritik öneme sahiptir. Eksikliği yapraklarda sararma ve düşük fotosentez kapasitesiyle kendini gösterir.
- Kükürt (S): Protein sentezi ve yağ metabolizmasında etkilidir. Kenevir için optimum ihtiyacın 17–22 kg/ha olduğu bildirilmiştir (Mylavarapu ve ark., 2020).
- Mikro elementler: Demir (Fe), çinko (Zn), mangan (Mn), bakır (Cu) ve bor (B), özellikle enzim aktiviteleri, polen canlılığı ve çiçeklenme döneminde önem taşır.

3. KENEVİRDE ORGANİK VE KİMYASAL GÜBRE UYGULAMALARI

Kenevir yetiştiriciliğinde organik gübreler, bitkinin besin elementlerini daha dengeli ve yavaş bir şekilde almasını sağlayarak toprak sağlığını korur, bitki gelişimini destekler ve nihai olarak verim ile kaliteyi artırır. Ahır gübresi, kompost, vermikompost ve bitkisel yan ürünler gibi organik kaynaklar, toprak organik madde düzeyini yükseltir, mikrobiyal aktiviteyi teşvik eder ve sürdürülebilir tarım uygulamalarına katkıda bulunur. Organik gübrelerin kenevirde yaprak alanı, vegetatif büyüme, tohum verimi, lif verimi ve biyokütle üretimi üzerinde olumlu etkiler gösterdiği literatürde belirtilmiştir.

Organik gübreler, azot (N), fosfor (P) ve potasyum (K) alımını artırarak mineral dengesini optimize eder ve bitkinin besin kullanım etkinliğini yükseltir. Vegetatif gelişim döneminde uygulanan organik gübreler, klorofil sentezini artırarak fotosentetik kapasiteyi ve buna bağlı olarak biyokütle birikimini

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destekler. Özellikle vermikompost ve ahır gübresi uygulamaları, hem lif hem de tohum veriminde artış sağlamaktadır. Bunun yanı sıra organik gübreler, topraktaki mikrobiyal çeşitliliği ve faaliyeti artırarak ekosistem sağlığını destekler; bu da uzun vadede sürdürülebilir kenevir yetiştiriciliği için önemli bir avantajdır (Ahmadi ve ark., 2024).

Yazıcı ve Erbay (2024) tarafından Yozgat Bozok Üniversitesi deneme alanında yürütülen çalışmada, Finola kenevir çeşidi kullanılarak çay posası, ahır gübresi, çay posası + ahır gübresi ve kontrol uygulamaları karşılaştırılmıştır. Organik materyaller ekim öncesi farklı oranlarda toprağa uygulanmış ve deneme tesadüf parselleri deneme deseninde dört tekerrürlü olarak kurulmuştur. Elde edilen bulgulara göre bitki boyu 79,25–225,25 cm, lif verimi 47,63–294,88 kg/da, tohum verimi 62,44–248,31 kg/da ve biyolojik verim 875–4500,75 kg/da arasında değişmiştir. En yüksek değerler ahır gübresi uygulamalarında, en düşük değerler ise yalnızca çay posası uygulamalarında kaydedilmiştir. Özellikle %4 ahır gübresi uygulamasında bitki boyu 225,25 cm, lif verimi 294,88 kg/da ve tohum verimi 248,31 kg/da olarak belirlenmiştir.

Endüstriyel kenevir yetiştiriciliğinde azot (N), fosfor (P) ve potasyum (K) uygulamaları, bitkinin vegetatif ve generatif gelişimi üzerinde kritik bir rol oynar. Aeroponik ve kontrollü sistemlerde yapılan araştırmalar, farklı NPK dozlarının bitki morfolojisi ve biyokütle parametreleri üzerinde önemli etkiler oluşturduğunu göstermektedir. Özellikle NPK 8:1:5 kombinasyonu, bitki boyu ve gövde çapında maksimum gelişmeyi sağlamış, gövde, kök ve çiçek biyokütlesinde sırasıyla %208,7, %113,2 ve %435,7 oranında artışa neden olmuştur. Bu bulgu, dengeli NPK uygulamalarının kenevirin farklı organlarında biyokütle üretimini önemli ölçüde teşvik ettiğini göstermektedir.

Azot uygulamaları, gövde, kök ve çiçek biyokütlesi ile güçlü pozitif ilişkiler göstermektedir. Fosforun bazı büyüme parametreleriyle negatif korelasyon sergileyebileceği ve yüksek düzeyde kullanımının biyokütle gelişimini sınırlayabileceği, ayrıca çevresel riskleri artırabileceği bildirilmiştir. Potasyum ise bazı organlarda biyokütle artışını desteklerken aşırı seviyelerde olumsuz etkiler yaratabilmektedir (Aubin ve ark., 2015; Bevan ve ark., 2021; Malik ve ark., 2024).

NPK uygulamalarının kenevir yapraklarındaki klorofil ve protein seviyelerini artırarak fotosentez verimliliğini geliştirdiği gözlemlenmiştir. Ancak aşırı azot kullanımının çiçek verimi ve kannabinoid içeriği üzerinde olumsuz etkileri olabileceği bildirilmiştir. Fosfor ve potasyum, besin alımı, kök gelişimi ve generatif büyüme süreçlerinde kritik öneme sahiptir (Simonutti ve ark., 2025).

Organik ve kimyasal gübrelerin birlikte uygulanması, hem kısa vadeli yüksek verim hem de uzun vadeli toprak sağlığının korunmasını sağlayabilir. Kimyasal gübreler hızlı ve yoğun besin temini sağlarken, organik gübreler toprağın fiziksel ve biyolojik yapısını iyileştirir. Bu kombinasyon, özellikle kenevirin lif, tohum ve biyokütle verimi açısından optimum performansı elde etmek için etkili bir strateji olarak önerilmektedir.

Sonuç olarak, optimal NPK dengesi sağlandığında tohum verimi, biyokütle üretimi ve lif kalitesinde belirgin iyileşmeler gözlenmektedir. Azot-fosfor-potasyum kombinasyonları tekli gübre uygulamalarına kıyasla üstün agronomik performans sunmakta, ancak etkinliği iklim koşulları, toprak özellikleri ve kenevirin kullanım amacına bağlı olarak değişkenlik göstermektedir. Organik gübre uygulamaları ile kimyasal gübrelerin dengeli kullanımı, sürdürülebilir ve verimli kenevir üretimi için kritik öneme sahiptir (Aubin ve ark., 2015; Bevan ve ark., 2021).

Organik ve kimyasal gübrelerin kenevir yetiştiriciliği üzerindeki etkileri farklılık göstermektedir. Organik gübreler azotu yavaş salınımıyla sağlar ve uzun vadede bitkiye sürekli besin temin ederken, kimyasal gübreler hızlı salınım gösterir ve kısa sürede yüksek miktarda azot sağlar. Fosfor açısından organik gübreler topraktaki fosfor kullanılabilirliğini artırırken, kimyasal gübrelerde fosfor hızla alınır ancak fiksasyon riski yüksektir. Potasyum bakımından organik gübreler yavaş etki gösterir ve dengeleyici bir rol oynar, kimyasal gübreler ise hızlı etki sağlar ancak yıkanma riski taşır.

Verim üzerine etkileri değerlendirildiğinde, organik gübreler uzun vadede istikrarlı verim artışı sağlarken, kimyasal gübreler kısa vadede yüksek verim elde edilmesine katkıda bulunmaktadır. Bitki büyümesi açısından organik gübreler dengeli gelişimi destekler ve stres toleransını artırırken, kimyasal gübreler hızlı ve yoğun büyümeyi teşvik etmektedir. Toprak sağlığı açısından organik gübreler organik maddeyi artırmakta ve mikrobiyal aktiviteyi desteklemekte; kimyasal gübreler ise toprak organik

maddesini azaltmakta ve tuzluluk riski oluşturabilmektedir. Çevresel etkiler açısından organik gübreler düşük çevresel kirlilik riski taşıırken, kimyasal gübreler özellikle nitrat sızıntısı açısından yüksek çevresel kirlilik riski oluşturmaktadır (Ahmadi ve ark., 2024).

4. KENEVİR YETİŞTİRİCİLİĞİNDE TARLA KOŞULLARINDA GÜBRELEME

Kenevir yetiştiriciliğinde gübreleme uygulamaları, bitki gelişimi ve verim parametreleri üzerinde kritik öneme sahiptir. Tarla koşullarında yapılan azot uygulamaları, bitkinin gövde kalınlığı, boyu, lif verimi ve toplam biyokütle üretimini artırırken, azotun eksik veya dengesiz kullanımı bitkilerde bodur gelişim, yapraklarda sararma ve düşük biyokütle verimi gibi olumsuz etkiler yaratabilmektedir (Kaur ve ark., 2023). Bununla birlikte, yüksek dozda azot kullanımı lif kalitesini olumsuz etkileyebilir; selüloz ve lignin oranlarını düşürerek mekanik dayanıklılığı azaltmakta ve bitkinin yapısal bütünlüğünü zayıflatmaktadır (Ahmadi ve ark., 2024).

Farklı araştırmalarda optimum azot dozunun 60–273 kg ha⁻¹ arasında değiştiği ve bu dozların toprak özellikleri, iklim koşulları ve kullanılan kenevir çeşidine bağlı olarak farklılık gösterebileceği bildirilmiştir. Aşırı azot uygulamaları kök ve gövde oranını düşürmekte, fotosentez ve su kullanım etkinliğini artırmakta, ancak bitki besin elementi dengesini olumsuz yönde etkileyebilmektedir (Ahmadi ve ark., 2024). Bu durum, azot gübrelemesinin lif verimini artırıcı etkisi olmasına rağmen, lif kalitesi üzerinde dikkatle değerlendirilmesi gerektiğini göstermektedir.

Azot uygulamaları yalnızca lif verimi üzerinde değil, aynı zamanda tohum ve çiçek üretimi ile ilgili kalite parametrelerini de etkilemektedir. Tohum üretiminde azot, protein ve yağ içeriğini artırmakta, ancak etkinin kullanılan çeşit ve yetiştirme koşullarına bağlı olarak değiştiği bildirilmektedir (Kaur ve ark., 2023). Çiçek üretiminde azot uygulamaları, CBD verimini belirli bir seviyeye kadar artırabilmekte; ancak yüksek dozlarda bu etkinin azalmasına yol açmaktadır (Ahmadi ve ark., 2024).

Bunun yanı sıra, hayvansal gübreler (sığır, tavuk, güvercin gübresi vb.) ve yeşil gübreler, kenevir yetiştiriciliğinde sürdürülebilir azot kaynağı olarak öne çıkmaktadır. Organik gübrelerin bitki gelişimi ve verim açısından kimyasal gübrelerle benzer etkiler gösterebileceği, ancak mineralizasyon hızına bağlı olarak etkinliklerinin değişebileceği vurgulanmıştır. Ayrıca, organik gübreler toprak sağlığı, su tutma kapasitesi ve mikroorganizma çeşitliliği üzerinde olumlu katkılar sağlayarak tarımsal sürdürülebilirliği desteklemektedir (Kaur ve ark., 2023; Ahmadi ve ark., 2024).

Sonuç olarak, kenevir yetiştiriciliğinde optimum gübreleme stratejilerinin belirlenmesinde bitkinin üretim amacı (lif, tohum veya CBD), kullanılan çeşit ve ekolojik koşulların dikkatle göz önünde bulundurulması gerekmektedir. Tarla koşullarında hem organik hem de kimyasal gübrelerin doğru oran ve zamanlamayla uygulanması, bitki gelişimi, verim ve ürün kalitesi üzerinde belirgin ve olumlu etkiler yaratmaktadır.

5. KENEVİR YETİŞTİRİCİLİĞİNDE SERA KOŞULLARINDA GÜBRELEME

Vejetatif büyüme evresinde kenevir (*Cannabis sativa* L.) bitkisinin azot (N), fosfor (P) ve potasyum (K) uygulamalarına verdiği yanıtlar, bitki gelişimi ve mineral dengesi açısından kritik öneme sahiptir. Farklı makro besin elementlerinin dozlarının bitki gelişimi üzerindeki etkilerini inceleyen çalışmalar, özellikle yaprak, kök ve gövde büyümesi ile klorofil içeriklerinin bu besin elementlerinin etkileşimlerinden doğrudan etkilendiğini ortaya koymaktadır. Bu nedenle, bitkinin optimal gelişimi ve verimliliği için makro besin elementlerinin uygun oranlarda uygulanması büyük önem taşımaktadır.

Cannabis sativa L. bitkisinin vejetatif evresinde azot, fosfor ve potasyum uygulamalarının etkileri, hidroponik koşullarda farklı N (132,7; 160; 200; 240; 267,3 mg L⁻¹), P (9,6; 30; 60; 90; 110,5 mg L⁻¹) ve K (20,8; 60; 117,5; 175; 214,2 mg L⁻¹) dozları kullanılarak araştırılmıştır. Sonuçlar, N × K, K × P ve N × P × K kombinasyonlarının vejetatif büyüme evresinde bitki gelişimi üzerinde anlamlı etkiler gösterdiğini ortaya koymuştur. Özellikle N × K uygulamaları yaprak ve gövde büyümesini artırırken, K × P uygulamaları kök gelişimini desteklemiştir; N × P × K kombinasyonları ise kök, gövde ve yaprak büyümesi ile klorofil içeriklerini olumlu yönde etkilemiştir. Yaprak mineral konsantrasyonları açısından optimum değerler sırasıyla toplam azot 0,54 mg g⁻¹, fosfor 0,073 mg g⁻¹, potasyum 0,27 mg g⁻¹, kalsiyum 0,56 mg g⁻¹ ve kükürt 0,38 mg g⁻¹ olarak belirlenmiştir. Ayrıca, P ve K dozlarının artışının yapraktaki magnezyum miktarını azalttığı, N uygulamasının Mg üzerindeki etkisinin ise belirgin olmadığı saptanmıştır. Bu durum, makro besin elementlerinin bitki organları arasında farklı dağılım

gösterebileceğini ve kenevir yetiştiriciliğinde element dengesi gözetilmesi gerektiğini ortaya koymaktadır. Çalışma, vejetatif gelişim aşamasında kenevir bitkisi için $160\text{--}200\text{ mg L}^{-1}\text{ N}$, $30\text{ mg L}^{-1}\text{ P}$ ve $60\text{ mg L}^{-1}\text{ K}$ değerlerinin uygun olduğunu ve gübre uygulamalarının dengeli ve titiz bir şekilde yönetilmesi gerektiğini göstermektedir. Makro besinlerin doğru oranlarda uygulanması, bitkinin yapısal gelişimini destekler, klorofil ve mineral içeriklerini optimum seviyelerde tutar ve böylece verim ve kalite potansiyelini maksimize eder (Kpai ve ark., 2024).

Buna ek olarak, Farnisa ve ark. (2023) tarafından yürütülen bir çalışmada fideler, 3:2 oranında torf ve kum içeren bir yetiştirme ortamına aktarılmış ve bitkilere farklı azot düzeyleri (42 ppm ve 182 ppm) uygulanmıştır. Deneme boyunca bitki örtüsü, biyokütle ve SPAD ölçümleri düzenli olarak gerçekleştirilmiştir. Bulgular, yüksek azot düzeyinin sürgün biyokütlesini artırdığını ve erken çiçeklenmeyi teşvik ettiğini göstermektedir. Ayrıca, sera koşullarında azot uygulamalarının SPAD değerlerini etkilediği, tarla koşullarında elde edilen değerlerin ise daha yüksek olduğu gözlemlenmiştir. Bu sonuçlar, kenevir bitkisinin sera koşullarında dahi azot düzeylerine duyarlılığını koruduğunu ve optimal azot yönetiminin verim üzerinde belirleyici olduğunu ortaya koymaktadır.

6. SONUÇ VE ÖNERİLER

Kenevir (*Cannabis sativa* L.) yetiştiriciliğinde hem organik hem de kimyasal gübre uygulamalarının bitkinin morfolojik gelişimi, fizyolojik aktiviteleri ve ürün verimi üzerinde belirgin etkiler oluşturduğu literatürde geniş biçimde rapor edilmiştir. Kimyasal gübreler, yüksek çözünürlükteki besin içerikleri sayesinde kısa süre içerisinde yaprak alanı, gövde ve kök biyokütlesinde hızlı artış sağlarken, lif ve tohum veriminde de kayda değer iyileşmeler gözlenebilmektedir. Öte yandan, organik gübreler yalnızca besin takviyesi sunmakla kalmayıp, toprak fiziksel ve kimyasal özelliklerini iyileştirir, su tutma kapasitesini artırır ve topraktaki mikrobiyal faaliyet ile biyolojik çeşitliliği destekler. Bu özellikleriyle organik gübreler, sürdürülebilir tarımsal üretim ve ekosistem sağlığı açısından kritik bir rol oynamaktadır.

Gübre uygulamalarında yetersiz veya aşırı doz kullanımı, hem bitki gelişimini olumsuz etkileyebilir hem de ürün kalitesinde düşüşe ve çevresel sorunlara yol açabilir. Özellikle aşırı azot ve fosfor uygulamalarının, su kirliliği, toprak tuzluluğu ve besin elementleri dengesizlikleri gibi çevresel problemlere neden olabileceği; bunun yanı sıra bitkide klorofil sentezinin bozulmasına ve metabolik süreçlerin olumsuz etkilenmesine yol açabileceği vurgulanmaktadır. Potasyumun ise dengeli kullanımının belirli organlarda biyokütle artışını desteklediği, ancak aşırı dozların bazı organlarda olumsuz etkiler yaratabileceği literatürde belirtilmiştir.

Gelecekte yapılacak araştırmalarda, organik ve kimyasal gübrelerin tek başına veya kombine şekilde kullanımına ilişkin karşılaştırmalı çalışmaların yoğunlaştırılması büyük önem taşımaktadır. Tarla ölçeğinde yürütülecek denemeler ile gübrelerin optimum dozları, uygulama zamanları ve yöntemlerinin belirlenmesi, kenevir yetiştiriciliğinde hem verim hem de kaliteyi artırırken çevresel sürdürülebilirliği de destekleyecektir. Ayrıca, organik kaynaklı gübrelerin kimyasal gübrelerle entegrasyonuna dayalı stratejilerin geliştirilmesi, kenevir tarımında uzun vadeli üretim planlaması ve ekosistem dostu uygulamalar açısından önemli bir araştırma alanı olarak öne çıkmaktadır.

Sonuç olarak, optimum gübreleme stratejilerinin uygulanması, hem ekonomik verimliliğin hem de çevresel sürdürülebilirliğin sağlanmasına katkıda bulunacak; kenevirin tarımsal ve endüstriyel potansiyelini maksimize ederek, biyokütle ve tohum üretimi, lif kalitesi ve bitki fizyolojisi açısından verimli sonuçlar elde edilmesini mümkün kılacaktır. Bu çerçevede, farklı iklim ve toprak koşullarına uyum sağlayacak esnek ve sürdürülebilir gübreleme programlarının geliştirilmesi, gelecekteki kenevir araştırmaları ve üretimi için kritik bir öncelik olarak değerlendirilmektedir.

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PLANT-BASED SOLUTIONS FOR GLOBAL PATHOGEN RESISTANCE: ANTIMICROBIAL STUDY OF *ALBIZIA LEBBECK*

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ABSTRACT

As antimicrobial resistance (AMR) continues to threaten global health, there is an urgent need to explore natural, plant-based alternatives to synthetic antibiotics. This study evaluates the antibacterial potential of *Albizia lebbek* (Siris), a medicinal plant from the Mimosaceae family, against four pathogenic bacteria: *Staphylococcus aureus*, *Bacillus aureus*, *Escherichia coli*, and *Klebsiella pneumoniae*. Extracts from the seeds and bark were prepared using ethanol, methanol, and chloroform through the maceration method. Among these, the ethanol extract of the bark demonstrated the highest antibacterial activity, showing zones of inhibition measuring 21 ± 1.0 mm against *E. coli* and 19 ± 1.0 mm against *S. aureus*. Phytochemical screening revealed the presence of key bioactive compounds such as phenols, flavonoids, terpenoids, and saponins, which are known for their antimicrobial properties. The Minimum Inhibitory Concentration (MIC) results further confirmed the strong antibacterial efficacy of the bark extract. Despite its historical use in traditional medicine for treating various ailments, *Albizia lebbek* remains underexplored in modern pharmacological research. This study contributes to the global discourse on sustainable healthcare by emphasizing the potential of traditional medicinal plants in addressing AMR. It highlights the need for further scientific exploration and integration of ethnomedicine into global health frameworks like One Health.

Keywords: *Albizia lebbek*, antimicrobial resistance, phytochemicals, ethnomedicine, global health, plant-based

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IMMOBILIZATION OF PECTINASE ON ORANGE PEEL USING *Luffa cylindrica* FOR ENHANCED STABILITY AND APPLICATION IN JUICE CLARIFICATION

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ABSTRACT

The immobilization of enzymes on low-cost, biodegradable natural supports is gaining prominence in industrial biotechnology due to its potential to improve enzyme reusability, operational stability, and process sustainability. In this study, we report the immobilization of pectinase enzyme extracted from fungal cultures cultivated on orange peel waste. The extracted pectinase was immobilized using orange peel powder as an anchoring substrate and entrapped within a fibrous matrix of *Luffa cylindrica* sponge. *Luffa cylindrica*, known for its highly porous and biodegradable properties, served as an effective support material to enhance the operational efficiency of the enzyme. The immobilized pectinase was evaluated for its thermal and pH stability, reusability, and catalytic performance.

Compared to the free (soluble) enzyme, the immobilized form retained enhanced activity over a broader range of temperatures (30–60 °C) and pH values (4.0–7.0), with over 70% of its initial activity preserved after five consecutive reuse cycles. Furthermore, the immobilized pectinase was applied in the clarification of freshly extracted orange juice, where it demonstrated significant efficiency in reducing turbidity and improving juice clarity without compromising nutritional properties. This highlights the functional potential of immobilized enzymes in food processing industries. The integration of agro-waste products—orange peel and *Luffa cylindrica*, for enzyme immobilization not only provides a cost-effective and sustainable platform for biocatalyst development but also contributes to value-added waste utilization. This study underscores the feasibility of deploying agro-based immobilized enzyme systems in eco-friendly industrial applications, particularly in the fruit juice clarification process.

Keywords: pectinase, enzyme immobilization, *Luffa cylindrica*, orange peel, orange juice clarification, agro-waste, enzyme stability, reusability, biocatalysis, sustainable biotechnology.

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PLANT OILS AS REPLACEMENT OF DIETARY FISH OIL; EFFECT ON GROWTH PERFORMANCE, NUTRIENT DIGESTIBILITY AND BODY COMPOSITION OF *LABEO ROHITA* FINGERLINGS

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ABSTRACT

On average, 6.73 ± 0.04 -pound *Labeo rohita* fingerlings were fed for 70 days. Levels I through VI were used to create a total of six experimental diets. Fish oil (FO) made up Test Diet I (Control), whereas palm, corn, sunflower, canola and a combination of the vegetable oils were the ingredients of Test Diets II–VI. There were three sets of tanks, with fifteen fingerlings in each set. The study found that fingerlings given a test diet VII based on a plant oil combination had the highest specific growth rate (1.92 ± 0.00), the lowest feed conversion ratio (1.32 ± 0.02), and the maximum weight increase ($283.80 \pm 0.77\%$). In contrast, fingerlings given a canola oil test diet had the lowest weight increase ($185.73 \pm 0.75\%$), the highest feed conversion ratio (1.72 ± 0.03), and the lowest specific growth rate (1.50 ± 0.00). Test diet VI produced the greatest findings for nutritional digestibility in fingerlings, with CP (74.79 ± 0.14), CF (82.20 ± 0.30), and GE (73.51 ± 0.21) measured. In fingerlings which were given the test diet IV (canola oil), the minimum digestibility values for CP, CF, and GE were found to be 57.58 ± 0.66 , 74.65 ± 0.73 , and 68.19 ± 0.66 , respectively. It was found that the body composition results for test diet VI were the lowest for fat and hydration and the highest for ash and CP. While test fingerlings given an IV feed had the highest levels of fat and moisture, the lowest levels of CP, and the hardest levels of ash. Research on *L. rohita* fingerlings found that when fed a plant oil combination instead of FO, their growth performance, nutritional digestibility, and body composition were all positively affected.

Keywords: Plant oils, Fish oil, Growth performance, Nutrient digestibility

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GROWTH CURVES in POULTRY: MODELS, APPLICATIONS, AND CURRENT APPROACHES

KANATLI HAYVANLARDA BÜYÜME EĞRİLERİ: MODELLER, UYGULAMALAR VE GÜNCEL YAKLAŞIMLAR

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ABSTRACT

Poultry farming holds a strategic position in global food production due to its rapid growth performance and high feed conversion efficiency. In this context, accurately understanding and modeling the growth and development process in poultry is critically important for genetic improvement, optimization of feeding strategies, and enhancement of production efficiency. This study is a literature review that systematically examines various mathematical approaches used in modeling growth curves in poultry, along with the genetic, nutritional, and environmental factors that influence these curves. Within the scope of the review, the fundamental principles, advantages, and limitations of commonly used nonlinear models such as Gompertz, Logistic, Richards, and Von Bertalanffy are discussed comparatively. The applicability and accuracy of each model under different poultry species (broilers, laying hybrids, etc.) and rearing conditions are evaluated through relevant literature findings. Additionally, the effects of factors such as feed composition and feeding programs, ambient temperature, lighting regimes, and animal welfare on the parameters of the growth curve are analyzed.

The findings indicate that growth curves in poultry are shaped not only by genetic potential but also by a complex interplay of environmental and management-related factors. In addition to traditional models, recent innovative modeling approaches utilizing artificial intelligence and machine learning algorithms have shown promising potential in predicting growth patterns with higher accuracy. This review provides a solid theoretical framework to support decision-making processes in poultry production and highlights potential gaps and directions for future research.

Keywords: Growth Curve, Poultry, Mathematical Model, Nutrition, Genetics, Richards Model.

ÖZET

Küresel gıda üretiminde kanatlı yetiştiriciliği, hızlı büyüme performansı ve yüksek yemden yararlanma verimliliği nedeniyle stratejik bir öneme sahiptir. Bu bağlamda, kanatlılarda büyüme ve gelişim sürecini doğru bir şekilde anlamak ve modellemek, genetik ıslah, besleme stratejilerinin optimizasyonu ve üretim verimliliğinin artırılması açısından kritik bir öneme sahiptir. Bu çalışma, kanatlılarda büyüme eğrilerinin modellenmesinde kullanılan çeşitli matematiksel yaklaşımları, bu eğrileri etkileyen genetik, besinsel ve çevresel faktörleri sistematik bir şekilde inceleyen bir literatür derlemesidir. Derleme kapsamında, Gompertz, Lojistik, Richard ve Von Bertalanffy gibi yaygın olarak kullanılan doğrusal olmayan modellerin temel prensipleri, avantajları ve kısıtlılıkları karşılaştırmalı olarak ele alınmıştır. Her bir modelin, farklı kanatlı türleri (broilerler, yumurtacı hibritler vb.) ve yetiştirme koşulları altındaki uygulanabilirliği ve doğruluk düzeyi, ilgili literatür bulguları üzerinden tartışılmıştır. Ayrıca, yem bileşimi ve besleme programları, çevresel sıcaklık, aydınlatma rejimleri ve hayvan refahı gibi faktörlerin büyüme eğrisinin parametreleri üzerindeki etkisi incelenmiştir. Elde edilen bulgular, kanatlılarda büyüme eğrisinin sadece genetik potansiyel ile değil, aynı zamanda kompleks bir şekilde etkileşimde

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bulunan çevresel ve yönetimsel faktörlerle şekillendiğini göstermektedir. Geleneksel modellerin yanı sıra, son dönemde yapay zekâ ve makine öğrenmesi algoritmalarını kullanan yenilikçi modelleme yaklaşımlarının, büyüme paternlerini daha yüksek doğrulukla tahmin etme potansiyeli olduğu belirlenmiştir. Bu derleme, kanatlı yetiştiriciliğinde karar alma süreçlerini destekleyecek sağlam bir teorik çerçeve sunarak, gelecekteki araştırmalar için potansiyel boşlukları ve yönelimleri ortaya koymaktadır.

Anahtar Kelimeler: Büyüme Eğrisi, Kanatlı, Matematiksel Model, Beslenme, Genetik, Richard Modeli.

INTRODUCTION

Poultry production is a continuously developing and strategically important sector, driven by the growing global demand for animal protein. In particular, the accurate monitoring and modeling of growth performance in broilers and laying hens play a critical role in enhancing productivity and economic profitability. In this context, growth curves, which mathematically describe the age-dependent changes in live body weight of individuals, serve as effective tools guiding both genetic selection strategies and decisions regarding feeding and environmental management (Narinc & Aygün, 2017; Şengül et al., 2024).

Growth in poultry does not merely reflect weight gain but also encompasses biological processes such as tissue differentiation, skeletal development, and changes in body composition. Therefore, accurate modeling of growth curves provides multidimensional benefits, not only for total yield but also for improving animal welfare, product quality, and economic sustainability (Aggrey, 2002; Şengül et al., 2024).

In recent years, mathematical approaches to growth modeling have gone beyond classical parametric models (such as Gompertz, Logistic, Richards, and Von Bertalanffy). In this regard, the use of semi-parametric and data-driven approaches, as well as modern analytical techniques such as artificial intelligence, machine learning, and cognitive algorithms, has increased the accuracy of growth predictions and offered more flexible solutions (Şengül et al., 2024).

The aim of this review is to conduct a comparative analysis of the growth curve models applied in poultry, evaluate their areas of application, and summarize recently developed innovative approaches. Furthermore, by presenting concrete examples based on modeling results in different species and breeds, the review seeks to provide a comprehensive literature-based perspective and generate practical recommendations for researchers and stakeholders in the poultry sector.

What is a Growth Curve?

Growth curves are mathematical functions—typically nonlinear in nature—that quantitatively describe an organism's change in live body weight over time. In avian species, especially in poultry, these growth trajectories are characterized by an initial rapid weight gain during the first few weeks of life, followed by a deceleration phase, eventually approaching a theoretical maximum known as the asymptotic weight (Ricklefs, 1967; Aggrey, 2002).

These models are parameterized using key biologically meaningful variables:

- **W_0 (initial weight):** The live body weight of the organism at the commencement of measurement, typically corresponding to hatch.
- **A (asymptotic weight):** The theoretical maximum body weight achievable by the organism in maturity.
- **k (growth rate constant):** A scalar representing the velocity of growth—higher k values indicate faster growth.
- **t_i (inflection point):** The time at which growth rate reaches its maximum, marking the transition from accelerated to decelerated growth.

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These parameters are essential for understanding growth dynamics and enabling comparative analyses. For instance, the Gompertz model—a widely used sigmoid model—can be expressed as:

$$W(t)=A \cdot \exp(-\exp(-k \cdot (t-t_i)))$$

Through these mathematical functions, quantitative differences in growth among individuals can be identified; furthermore, comparative evaluations can be conducted across populations, breeds, and sexes. In addition, growth curves allow for a detailed analysis of the effects of environmental conditions and genetic factors (Narinc et al., 2010; Lukić et al., 2020).

Therefore, growth curves should not be regarded merely as biometric analytical tools, but rather as fundamental components of decision-support systems in the planning of animal breeding programs, the optimization of feeding strategies, and the improvement of efficiency management.

Growth Models Used in Poultry

Poultry growth dynamics have long been investigated through the application of various mathematical models. These models are generally categorized into two main groups: classical parametric models and modern or advanced modeling approaches. Parametric models are constructed on predefined biological assumptions and provide relatively simple representations of growth patterns. In contrast, modern approaches offer greater flexibility, enabling the modeling of complex and heterogeneous datasets by accommodating nonlinearities and variability inherent in biological systems.

Parametric growth models are based on predetermined mathematical functions designed to describe the changes in live body weight of organisms over time. Their primary advantage lies in the ability to interpret biological processes using a relatively small number of parameters. Among the most commonly applied classical parametric models for examining growth dynamics in poultry are the Gompertz, Logistic, Richards, and Von Bertalanffy models.

Gompertz Model

The Gompertz model is considered one of the most suitable approaches for analyzing the growth dynamics of poultry species that exhibit rapid growth, owing to its asymmetric structure. Its key feature lies in the ability to capture an initial phase of rapid growth, which gradually decelerates after reaching the inflection point. This property allows the model to accurately reflect the early developmental stages of poultry and the critical changes in growth rate that are of major importance in production practices (Aggrey, 2002).

Mathematically, the Gompertz function describes body weight as a function of age through three biologically meaningful parameters: the asymptotic weight (A), the growth rate constant (k), and the inflection point (t_i). These parameters enable comparative evaluations of growth performance among individuals or populations, and provide valuable insights for assessing the effectiveness of genetic selection strategies as well as feeding programs. Therefore, due to its strong biological interpretability and practical applicability, the Gompertz model has become one of the most widely used growth models in poultry science.

$$W(t)=A \cdot \exp(-\exp(-k \cdot (t-t_i)))$$

Logistic Model

The Logistic growth model is characterized by its symmetric sigmoid structure, making it particularly appropriate for species exhibiting more gradual and evenly distributed growth trajectories. Unlike asymmetric models such as Gompertz, the Logistic curve mirrors a balanced increase and decrease around the inflection point, offering a distinctive representation of growth processes. While this symmetry often facilitates modeling of organisms with steadier growth patterns, the location and implications of the inflection point produced by the Logistic model can differ markedly from those derived from Gompertz models—leading to divergent interpretations of growth dynamics (Narinc et al., 2010). Mathematically, the Logistic model is expressed as:

$$W(t)= A/(1+\exp(-k(t-t_i)))$$

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where A denotes the asymptotic weight, k is the growth rate constant, and t_i represents the inflection point, all of which carry clear biological significance.

Richards Model

The Richards growth model introduces enhanced flexibility to growth trend analysis through its adjustable shape parameter (denoted as m), enabling it to encompass both symmetric and asymmetric sigmoid patterns. This versatility allows the model to aptly characterize a wide range of biological growth trajectories, from gradual, prolonged increases to rapid early development followed by plateau phases. Mathematically, the model is represented as:

$$W(t) = A \cdot [1 + \exp(-k(t - t_i))]^{-1/m}$$

where:

- A denotes the asymptotic weight,
- k is the growth rate constant,
- t_i represents the inflection point, and
- m serves as the shape parameter, modulating the curvature and symmetry of the sigmoidal trajectory.

While the inclusion of the shape parameter m provides superior adaptability in representing diverse growth dynamics, the increased parameter complexity can introduce challenges. Multiple parameters may interact in nonlinear ways—potentially leading to issues with identifiability, convergence, and the stability of parameter estimates, particularly when data are limited or noisy (Lukić et al., 2020).

Von Bertalanffy and Brody Models

The Von Bertalanffy and Brody growth models are traditionally favored for species characterized by slower growth rates or extended lifespans. These models, rooted in biological realism, are adept at capturing gradual maturation processes. Although their usage in poultry production is relatively infrequent due to the rapid growth nature of broiler and layer lines, they are nonetheless valuable in comparative analyses—especially when evaluating model performance across diverse species or breeds (Howlider & Rose, 1989).

The Von Bertalanffy model follows a mechanistic basis whereby growth decelerates as the organism approaches an asymptotic size, reflecting principles of metabolic limitations and resource allocation. Brody's model, similarly, emphasizes the diminishing growth rate with age but does so with yet another mathematical formulation. Despite their complexity and reduced frequency in poultry research, these models are essential for understanding growth patterns in slower-developing breeds or when comparing growth dynamics across taxa.

Different Poultry Species and Applications of Growth Curve Modeling

Growth curve modeling in poultry is highly contingent on factors such as species, genetic constitution, production purpose (meat versus egg), and rearing conditions. Consequently, the examination of growth data at the species and breed level is of paramount importance for selecting the most suitable models and making biologically meaningful interpretations. This section synthesizes findings from relevant literature on the application of growth models across diverse poultry types—such as broilers, laying hens, quails, ducks, and geese—and demonstrates how model performance and parameter behavior vary among them.

Growth Curves in Broiler Chickens

Broiler chickens have been selectively bred to achieve rapid growth and reach slaughter weight in a short time, making them prime subjects for growth curve modeling. Consequently, literature on growth curve analysis is most abundant for this group. Both Gompertz and Logistic models effectively capture the rapid early-phase growth typical of broilers, accurately reflecting their developmental trajectories (Aggrey, 2002).

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For instance, a recent study by T. Şengül et al. (2024) applied the Gompertz model to Cobb 500 broilers and found it provided an excellent fit to growth data, showing high determination coefficients ($R^2 \approx 0.999$) and low error metrics. Moreover, data-driven approaches such as artificial neural networks and MARS (Multivariate Adaptive Regression Splines) demonstrated even higher predictive accuracy and lower error rates, positioning them as powerful alternatives to traditional parametric models

Growth Curves in Laying Hens

In laying hens, growth typically progresses rapidly until approximately 20 weeks of age, after which the rate of weight gain transitions into a plateau phase. Consequently, the choice of growth model may depend critically on the production stage—whether focusing on the developmental (pre-laying) phase or the laying period.

For instance, Narinç et al. (2010) conducted a comparative analysis between Gompertz and Logistic models in white layer lines and found that the Gompertz model yielded results with greater biological interpretability, capturing key developmental milestones such as sexual maturity timing and reflecting them in growth parameters. Additionally, growth curve parameters in such cases often show strong correlations with physiological traits such as age at sexual maturity and subsequent egg production rates.

More recent investigations have seen increased use of nonlinear mixed-effects models (NLMMs) to track individual-level growth trajectories in laying hens. These models incorporate both fixed effects (common to all individuals) and random effects (individual-specific deviations), allowing for the quantification of between-animal variability in parameters like mature body weight and inflection point timing (van der Klein et al., 2020). Such frameworks are particularly advantageous for capturing heterogeneity across flocks and enhancing the fidelity of growth predictions.

Local and Conservation-Targeted Poultry Genotypes: Growth Curve Applications

Native poultry genotypes typically exhibit slower growth rates and markedly different growth trajectories compared to commercial lines. These distinctions arise from underlying genetic and biological differences, underscoring the need for genotype-specific model selection. Traditional parametric models, while valuable, may not always capture the unique growth dynamics of such populations.

The Richards growth model, with its flexible shape parameter (m), offers a distinct advantage for native and conservation-focused genotypes. By accommodating both symmetric and asymmetric growth patterns, it can better capture nuanced growth trajectories observed in heritage breeds. While direct studies on specific Turkish genotypes (e.g., Gerze, Atak-S, HACIVAN, Isbar) are limited, broader research on indigenous chicken populations supports the use of the Richards model. For example, in studies of Red Kedu chickens, the Richards model has exhibited superior performance compared to Gompertz, Logistic, and Von Bertalanffy models, exemplifying its applicability for similar contexts.

Moreover, growth curve parameters serve as critical phenotypic markers for the conservation and characterisation of native genetic resources. Differences between males and females are often more pronounced in heritage breeds, reflecting underlying genetic and physiological divergence. The use of flexible models like Richards can facilitate clearer identification of such sex-related patterns, which is essential for effective genetic conservation strategies.

Growth Curves in Turkeys, Ducks and Geese

Although growth curve studies in alternative poultry species are less abundant than those for broilers or layers, recent years have seen notable progress in this area. In turkeys, growth spans a longer period, and numerous comparative studies indicate that the von Bertalanffy model consistently achieves superior statistical fit—characterized by higher coefficients of determination (R^2), and lower error metrics—than alternative models such as Gompertz or Logistic (Söğüt et al., 2016). In ducks and geese, the Gompertz model is widely employed due to its simplicity and effectiveness. However, certain analyses—particularly those comparing multiple nonlinear sigmoid models—suggest that the Richards model may provide improved accuracy, likely owing to its adaptable shape parameter (Knížetová et al.,; Zadeh, 2024).

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Growth curves in these species are increasingly employed in practical applications such as breeding stock selection, market optimization, and the development of alternative meat production strategies.

Sex and Environmental Effects

Growth trajectories in poultry are not only influenced by genetic factors but are significantly modulated by sex and environmental conditions. Empirical findings indicate that female birds often reach their inflection point—marking the maximum growth rate—at earlier ages compared to males, while males generally attain a higher asymptotic weight, reflecting divergent growth strategies between the sexes (Narinc et al., 2010).

Environmental variables—including feeding regimens, housing systems (e.g., cages versus free-range systems), and various stressors such as thermal stress, stocking density, or nutrient restriction—exert direct and measurable impacts on growth curve parameters. Heat stress, for instance, has been shown to impair growth performance through disruptions in metabolic regulation, immune function, and gut health (Ahmad et al., 2022). Furthermore, environmental stress of different types (temperature fluctuations, humidity, air quality, lighting) significantly affects poultry development and welfare, which in turn reflects on growth curves and overall performance (Ncho et al., 2024).

Practical Applications of Growth Curve Modeling

Poultry growth curve modeling should not be considered solely as a theoretical or academic exercise; rather, it has broad practical implications in animal husbandry. These models constitute a fundamental decision-support tool by enabling the quantification of growth dynamics across different stages of development. Specifically, growth curves are applied in several domains:

- **Genetic Improvement:** Growth parameters provide heritable traits that can be incorporated into breeding programs, assisting in the selection of individuals with superior performance. Growth curve parameters provide insight into the genetic growth potential of poultry. These parameters—including the inflection point, growth rate, and asymptotic weight—are heritable to varying degrees, rendering them suitable as selection criteria in breeding programs (Narinc et al., 2014). The inflection point is particularly informative, as it indicates the age at which growth is most rapid, while the growth rate and asymptotic weight reflect both how quickly and how extensively an animal can develop. Modern genomic selection approaches leverage these parameters by linking them with molecular markers, enabling more precise prediction of genetic gains.
- **Nutritional Strategies:** By identifying critical growth phases, growth models aid in formulating stage-specific feeding programs, thereby optimizing nutrient utilization and minimizing feed costs. Growth curves serve not merely as descriptive tools but as vital instruments for accurately estimating age-dependent nutrient requirements in poultry. By aligning feeding regimens with the temporal dynamics of growth, these models facilitate the formulation of diets tailored to specific developmental phases. For instance, insights into the rate of weight gain derived from the slope of growth curves can guide the identification of optimal feed evaluation windows, helping to determine when to conduct nutrient adequacy trials (Brito et al., 2021). Moreover, nutritional needs—particularly protein and energy—are elevated during the rapid growth phase up to the inflection point; thereafter, dietary energy concentration may be strategically reduced without compromising performance.
- **Animal Welfare Monitoring:** Growth trajectories can serve as indicators of welfare status, with deviations often reflecting stress, disease, or suboptimal management practices. Monitoring deviations from expected growth performance can serve as a **proactive tool** for identifying welfare and health issues in poultry populations before they manifest clinically. Such deviations from standard growth curves often indicate exposure to **environmental stressors**—including elevated temperatures, overcrowding, inadequate hygiene, or suboptimal ventilation—each of which can compromise physiological homeostasis and overall health (Riber & Würtz, 2024). Growth curve monitoring thus functions as a **quantitative welfare measure**, providing an objective basis to assess the well-being of birds in both research and commercial settings. Early detection of growth anomalies enables timely interventions—such as adjusting stocking densities, improving environmental enrichment, or revising dietary regimes—to mitigate the negative impacts on health and welfare. Moreover, such an approach

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supports **data-driven welfare management**, ensuring both ethical standards and production efficiency are maintained.

- **Economic Efficiency:** Accurate growth predictions allow for more effective production planning, reducing input costs and enhancing profitability. Accurate prediction of live body weight is of critical importance from the producer's perspective, as it underpins decisions on optimal slaughter timing and drives overall production efficiency. By utilizing growth curves, it is possible to forecast the body weight birds are likely to reach at a given age, enabling more precise optimization of slaughter scheduling and market targeting. Moreover, growth curve-based decision-support systems facilitate predictive modeling of key economic indicators—such as feed intake and feed conversion ratio—thereby empowering producers to fine-tune management strategies and maximize profitability (Quintana-Ospina et al., 2023).
- **Production Management:** Growth models are integrated into decision-making frameworks for flock management, including determining optimal slaughter age, adjusting stocking densities, and aligning production outputs with market demand.

Thus, growth curve modeling represents a multifaceted tool, bridging the gap between theoretical analysis and practical applications in modern poultry production systems.

CONCLUSION

The modeling of growth in poultry is not merely a theoretical analytical tool but holds critical importance for enhancing production efficiency, developing selection strategies, and optimizing feeding programs. Parametric growth models, such as Gompertz, Logistic, and Von Bertalanffy, have been widely utilized for decades in poultry production and provide a reliable basis for comparisons across breeds, sexes, and rearing systems.

However, the increasing complexity of modern production systems, the growing importance of individual animal monitoring, the widespread application of data science, and the development of welfare-oriented production approaches necessitate moving beyond classical growth modeling frameworks. Today, growth analysis should not only account for weight gain but also incorporate multidimensional aspects such as body composition, metabolic health, behavioral traits, and welfare indicators.

In model selection, emphasis should be placed not only on statistical fit but also on biological meaningfulness. Accordingly, the integration of genomic, environmental, and behavioral data with current growth records is becoming increasingly essential. Furthermore, innovative approaches such as artificial intelligence, machine learning, and big data analytics allow for more accurate prediction of growth patterns and more effective evaluation of individual variability.

Another emerging priority in recent years is the modeling of growth curves for the conservation and characterization of local genetic resources. Such studies are of strategic importance not only for the assessment of commercial hybrids but also for the evaluation and preservation of native breeds, which contribute to sustainability objectives.

In conclusion, research on growth curves should not be regarded solely as an academic pursuit; rather, it plays a strategic role in production optimization, the enhancement of animal welfare, and the promotion of sustainable livestock systems. Therefore, future studies should be conducted with an interdisciplinary perspective, grounded in data-driven and application-oriented approaches.

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TECHNOLOGICAL TRANSFORMATION in POULTRY PRODUCTION: ARTIFICIAL INTELLIGENCE-ASSISTED INDIVIDUAL BEHAVIOR MONITORING AND HOLISTIC EVALUATION OF SMART SYSTEMS

KANATLI ÜRETİMİNDE TEKNOLOJİK DÖNÜŞÜM: YAPAY ZEKÂ DESTEKLI BİREYSEL DAVRANIŞ TAKİBİ VE AKILLI SİSTEMLERİN BÜTÜNCÜL DEĞERLENDİRMESİ

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ABSTRACT

Poultry farming is undergoing a rapid technological transformation driven by goals of sustainability, animal welfare, and production efficiency. In this transformation, smart production systems integrating artificial intelligence (AI), computer vision, the Internet of Things (IoT), and robotics have come to the forefront. Especially, AI-assisted individual behavior monitoring systems offer the ability to assess the health and welfare status of each bird in real time and with high accuracy, going beyond traditional flock-level monitoring methods. These technologies—through the integration of image processing, sound analysis, biosensors, and robotic automation—enable automated tracking of parameters such as feed intake, mobility, social interactions, and stress indicators. However, several technical and socio-economic barriers, such as field applicability, cost-effectiveness, and farmer adoption, still hinder the widespread implementation of these technologies. This paper presents a comprehensive review of the current literature, evaluating the advantages, limitations, and future application scenarios of AI-based individual behavior analysis in poultry systems. The study examines in detail the technical infrastructure, application areas, and benefits of AI-based individual monitoring methods and smart systems used in poultry production. Additionally, the effects of these systems on production efficiency and animal welfare are discussed, along with the technical and economic challenges encountered and potential solutions proposed. In conclusion, data-driven management approaches based on individual behavior have a breakthrough potential in poultry production by enhancing both welfare standards and productivity.

Keywords: Poultry production, artificial intelligence, individual behavior monitoring, smart systems, animal welfare, automation

ÖZET

Kanatlı hayvan yetiştiriciliği, sürdürülebilirlik, hayvan refahı ve verimlilik hedefleri doğrultusunda hızlı bir teknolojik dönüşüm yaşamaktadır. Bu dönüşümde yapay zekâ (YZ), görüntü işleme, nesnelerin interneti (IoT) ve robotik sistemlerin entegre edildiği akıllı üretim sistemleri öne çıkmaktadır. Özellikle yapay zekâ (YZ) destekli bireysel davranış takibi sistemleri, geleneksel sürü bazlı izleme yöntemlerinin ötesine geçerek, her bir hayvanın sağlık ve refah durumunu gerçek zamanlı ve yüksek doğrulukla değerlendirme olanağı sunmaktadır. Bu teknolojiler; görüntü işleme, ses analizi, biyosensörler ve robotik otomasyon sistemlerinin entegrasyonu sayesinde, yem tüketimi, hareketlilik, sosyal davranışlar ve stres göstergeleri gibi parametrelerin otomatik takibini mümkün kılmaktadır. Bununla birlikte, bu teknolojilerin saha koşullarında uygulanabilirliği, maliyet-etkinliği ve üretici tarafından benimsenmesi gibi bazı teknik ve sosyo-ekonomik engeller de mevcuttur. Bu bildiride, güncel literatür taraması eşliğinde, YZ destekli bireysel davranış analizine dayalı akıllı sistemlerin avantajları, sınırlılıkları ve

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geleceğe yönelik uygulama senaryoları bütüncül biçimde değerlendirilmiştir. Bu çalışmada, kanatlı üretiminde kullanılan YZ tabanlı bireysel davranış izleme yöntemleri ve akıllı sistemlerin teknik altyapısı, uygulama alanları ve sağladığı avantajlar detaylı olarak incelenmiştir. Ayrıca, sistemlerin üretim verimliliği ve hayvan refahı üzerindeki etkileri, karşılaşılan teknik ve ekonomik zorluklar ile çözüm önerileri ele alınmıştır. Sonuç olarak, bireysel davranış temelli veri odaklı yönetim yaklaşımları hem refah standartlarının yükseltilmesine hem de verimliliğin artırılmasına hizmet ederek kanatlı üretiminde çığır açıcı bir potansiyel taşımaktadır.

Anahtar Kelimeler: Kanatlı üretimi, yapay zekâ, bireysel davranış takibi, akıllı sistemler, hayvan refahı, otomasyon

INTRODUCTION

Poultry farming is one of the fastest-growing animal production sectors worldwide and plays a critical role in meeting humanity's increasing demand for protein. However, the growth in production volume has also brought structural challenges in areas such as labor requirements, maintaining animal welfare standards, sustainability, and traceability. In this context, the integration of digitalization in agriculture and Industry 4.0 applications into livestock systems is of great importance for enhancing production efficiency, protecting animal health, and minimizing environmental impacts (Wolfert et al., 2017; Kraft et al., 2022).

In recent years, the integration of technological innovations such as artificial intelligence (AI), machine learning, image processing, acoustic analysis, robotic systems, and the Internet of Things (IoT) into poultry production has accelerated. These systems are utilized for monitoring chicken behavior, tracking health indicators, analyzing feed consumption, and controlling environmental conditions, thereby improving the predictability and sustainability of production processes (Ojo et al., 2022; Cruz et al., 2024).

In this review, AI- and robotics-based applications reported in the literature over the past decade have been systematically categorized, and their areas of application, advantages, limitations, and future research potential have been evaluated. Furthermore, up-to-date assessments of the applicability of these technologies at both the national level in Türkiye and the international level are also presented.

Yapay Zekâ ve Görüntü İşleme Sistemlerinin Kanatlı Yetiştiriciliğinde Kullanımı

Applications of image processing and deep learning have achieved remarkable progress over the past decade in monitoring poultry behavior, assessing welfare levels, and evaluating production parameters. High-resolution camera systems provide visual data that, when analyzed through artificial intelligence algorithms, enable automated detection of behaviors at both the individual and flock level, including behavior recognition, activity measurement, feeding and drinking behavior, as well as aggression, stress, and other welfare indicators. In particular, these technologies have been shown to enhance the accuracy of automated monitoring systems, thereby establishing new standards in welfare assessment and production supervision (Neethirajan, 2022; Ehsan & Mohtavipour, 2024).

Due to the limitations of traditional image processing methods, recent advances in real-time object detection have highlighted models such as YOLO (You Only Look Once), Faster R-CNN, and RT-DETR (Real-Time Detection Transformer). In particular, the latest version of YOLO, YOLOv8, has demonstrated the capability to identify poultry behaviors such as standing, sitting, wing flapping, and feeding with high accuracy. For example, in one study, YOLOv8 successfully classified specific behaviors of broiler chickens (Elmessery, 2023).

Moreover, transformer architectures are increasingly being adopted in behavior analysis. In video-based monitoring systems, they have shown strong performance in capturing behavioral patterns within time series and in analyzing not only instantaneous actions but also sequential behaviors. In this context, RT-DETR has emerged as an effective model that provides high accuracy and flexibility in real-time behavioral analysis (Zhao et al., 2023).

Deep learning-based regression models have been developed to estimate the body weight of individual animals without physical contact. These systems take into account variables such as camera angle,

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chicken posture, and distance, and they provide highly accurate predictions. For example, in a study conducted by Lyu et al. (2023), the use of machine learning and video-based analysis techniques enabled the prediction of broiler live weights with an accuracy range of 93%–97%.

Similarly, image analysis has been employed to objectively score welfare levels through parameters such as gait abnormalities, feather condition, and spatial distribution within the flock. For instance, the method developed by Pereira et al. (2021) utilized changes in lying and standing durations to assess walking ability and leg disorders, making it applicable for welfare evaluation.

Acoustic Monitoring Systems and Sound Analytics

Poultry communicate important information about environmental stressors, social interactions, and health conditions through their vocalizations. In recent years, the development of artificial intelligence (AI)-based sound recognition and analysis technologies has enabled significant advancements in the classification and interpretation of these vocal signals. Such systems are not only utilized for monitoring poultry welfare and facilitating the early detection of potential health problems but are also regarded as innovative approaches that can contribute to enhancing production efficiency.

A comprehensive systematic review conducted by Manikandan and Neethirajan (2025) demonstrated that vocalization data analyzed with deep learning and AI techniques can reliably identify stress, disease, and behavioral changes. Furthermore, Soster et al. (2025) developed an acoustic system capable of distinguishing four different types of broiler vocalizations, with analyses providing innovative solutions for welfare monitoring and performance improvement.

The vocalizations produced by poultry can carry functional meanings such as alarm calls, food calls, social interaction signals, or indicators of pain and stress. These sounds possess distinct acoustic characteristics in terms of frequency, intensity, vibration, and temporal sequence, and today they can be digitized and analyzed using methods such as Mel-Frequency Cepstral Coefficients (MFCC), spectrogram analysis, and wavelet transformation. Artificial intelligence approaches—including Artificial Neural Networks (ANN), Support Vector Machines (SVM), Convolutional Neural Networks (CNN), and transformer-based models—are increasingly employed as effective tools for classifying these vocal data. A big data and TinyML-based system developed by Srinivasagan et al. (2025) demonstrated the ability to automatically identify welfare and health indicators by accurately distinguishing frequently occurring vocalization types through a classifier.

Respiratory diseases, particularly those caused by etiological agents such as infectious bronchitis and *Mycoplasma gallisepticum*, are clinically manifested through symptoms including coughing, rales, or abnormal respiratory sounds. When accurately detected, these acoustic signs and symptoms allow for the early diagnosis of disease. Acoustic sensor-based detection systems enable online and continuous monitoring, providing producers with rapid intervention in disease progression, optimized drug usage, and improvements in biosecurity. A thermo-acoustic system designed by Omara and Gilibrays (2022) successfully activated an alert mechanism for respiratory diseases by detecting abnormal vocalizations and environmental temperature fluctuations. Consequently, the mapping and traceability of flock-wide health status were significantly strengthened.

Robotic Systems: Automated Feeding, Egg-Laying Monitoring, and Cleaning Robots

The integration of robotic technologies into poultry production systems not only reduces labor requirements but also provides significant benefits in terms of improving animal welfare, strengthening biosecurity standards, and enhancing production efficiency. In particular, robotic systems integrated with artificial intelligence have gained the ability to analyze environmental conditions in real time, make autonomous decisions, operate in a task-oriented manner, and exhibit adaptive behaviors. Within this context, the incorporation of robotic systems into Precision Livestock Farming (PLF) approaches offers an innovative perspective aligned with the goals of sustainability, ethical production, and efficiency.

In poultry production systems, traditional fixed feeding methods are increasingly being replaced by mobile robotic systems capable of monitoring individual feed intake in real time and optimizing feeding rates at both the individual and flock level. These systems reduce feed waste by providing animals with the exact amount of feed they require while enabling the monitoring of production performance. A

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mobile feeding robot developed by Zhang et al. (2022) demonstrated efficient robotic feed distribution by minimizing energy consumption through optimal path-planning algorithms.

In addition, when it comes to water supply, IoT-based smart drinking systems have emerged as a promising solution. These systems track individual water consumption, reporting decreases in demand as potential indicators of disease, and transmit data wirelessly to a central system, thereby allowing production teams to intervene at an early stage (Karun et al., 2024).

Monitoring egg-laying behavior provides critical insights into both productivity levels and the health status of poultry. Robotic egg collection systems developed in this field not only contribute to the safe collection of eggs without damage but also enable the recording of when and how frequently individual animals lay eggs, thereby facilitating productivity tracking. Integrated with image processing algorithms, these systems can distinguish between empty and active nests in laying areas through mobile cameras, allowing for more accurate analysis of individual production behaviors.

For instance, Subedi et al. (2023) demonstrated that floor eggs in cage-free production systems can be monitored using machine vision, while Li et al. (2021) reported that a deep learning-based robotic egg collection system was capable of detecting and collecting eggs with high accuracy.

Ensuring poultry house hygiene is of critical importance for preventing the spread of diseases. In this context, autonomous cleaning robots detect manure accumulation on floor surfaces and clean the area at regular intervals, thereby reducing pathogen load. Some advanced systems are equipped with UV-C light or disinfectant spraying mechanisms, further strengthening biosecurity. In particular, the Octopus XO robot developed in the United Kingdom aerates and disinfects litter beds, making significant contributions to both animal welfare and environmental quality. This system continuously monitors temperature, humidity, and ammonia levels, aiming to minimize harmful accumulations (Cechinel et al., 2024).

Integrated Data Management and IoT-Based Farm Monitoring Systems

In modern poultry production, data-driven decision-making processes not only serve to enhance production efficiency but also make direct contributions to critical areas such as animal welfare, environmental sustainability, and food safety. In this regard, Internet of Things (IoT)-based digital infrastructures enable the simultaneous monitoring and recording of multiple parameters within the poultry house environment. Continuous tracking of indicators such as temperature, humidity, ammonia concentration, feed and water intake, and animal activity levels facilitates not only the assessment of individual animals' health and welfare status but also the holistic management of the entire production system. Thus, IoT-enabled systems support an integrated farm management approach, contributing both to process optimization and to the achievement of sustainability goals.

The significance of collected data lies not only in its monitoring but also in its processing and interpretation. For this purpose, artificial intelligence (AI)-driven decision support systems have been developed to provide timely alerts to producers regarding disease risk prediction, the anticipation of performance declines, and the detection of anomalies in feed intake patterns. In such systems, data analytics are generally conducted through cloud-based architectures, allowing farm managers to access production data and intervene even when away from the poultry house environment. Moreover, comparative analyses with historical data support the implementation of long-term strategic planning (Ahmed et al., 2021; Shang et al., 2024).

The integration of blockchain technology into the poultry production chain represents one of the cornerstones of future traceability systems. This technology enables immutable, permanent, and transparent recording of production data, such as the farm of origin, production date of eggs or meat products, feed composition, and environmental conditions. In doing so, it provides significant advantages in critical areas such as food safety, traceability, and consumer confidence.

Specifically, Aliyu et al. (2021) demonstrated that a Hyperledger Fabric-based blockchain system enhanced data integrity and trust within poultry production processes. More broadly, comprehensive reviews in the agri-food sector have highlighted that blockchain-based traceability applications deliver fundamental benefits, including decentralization, reliability, and transparency (Demestichas, 2020; Apeh et al., 2025).

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Future Applications and Research Gaps

The integration of data-driven decision support systems into modern poultry production not only enhances efficiency but also makes direct contributions to critical areas such as animal welfare, environmental sustainability, and food safety. In this context, Internet of Things (IoT)-based systems enable the simultaneous monitoring and storage of multiple parameters—such as temperature, humidity, ammonia concentration, feed and water intake, and animal activity—thereby allowing farm management to be approached holistically (Ojo et al., 2022).

In addition, AI-enhanced decision support mechanisms provide critical analyses such as disease risk prediction, forecasting performance decline, and detecting anomalies in feed intake, thereby offering producers opportunities for early warnings and timely interventions (Taleb et al., 2025). Through the integration of cloud-based data analytics, it has also become possible to access production data remotely, conduct comparative analyses, and establish a foundation for long-term strategic planning (Brassó, 2025).

Modern approaches in agriculture aim to enable the simultaneous collection and analysis of visual, acoustic, environmental, and physiological data, thereby providing more comprehensive and in-depth insights into the behavior and health status of poultry. Within this framework, artificial intelligence (AI)-based multimodal data fusion techniques are among the critical research priorities for more accurately identifying health and welfare indicators. In particular, the feature-level integration of visual, acoustic, environmental, and biometric data streams offers more scalable solutions in terms of both robustness and performance compared to early or late fusion methods (Essien & Neethirajan, 2025).

The development of highly mobile, multifunctional, and autonomous robotic systems within poultry house environments enables the efficient execution of essential tasks such as feeding, cleaning, health monitoring, and the isolation of sick animals. Such systems must provide effective solutions to challenges related to energy efficiency, obstacle detection, real-time decision-making, and human-robot collaboration. The “RobôFrango” prototype developed by da Rocha Balthazar et al. (2025) offered a durable and multifunctional robotic system through the careful selection of motors, sensors, and platforms suitable for industrial poultry house conditions. Furthermore, the comprehensive studies conducted by Skoczeń (2021) demonstrated that RGB-D camera-based systems are critical for obstacle detection performance in mobile agricultural robots and that mapping accuracy constitutes a fundamental prerequisite for safe navigation.

The use of artificial intelligence (AI) algorithms integrated with genetic data represents a promising research area for enhancing disease resistance, productivity, and performance in live chickens. In particular, the combined analysis of genomic data with production performance traits opens new opportunities for the optimization of selection programs. For example, Li et al. (2024) demonstrated that integrating genomic profiles with economically relevant joint traits through machine learning models could achieve higher predictive power compared to traditional approaches.

However, the issues of energy consumption, environmental impacts, and cost analysis of automation and robotic systems have not yet been sufficiently addressed. Research in this area needs to be developed in line with sustainable approaches and integrated into the sector on a larger scale, as these technologies are expected to become a fundamental component of future livestock systems. Comprehensive analyses of robot energy use in agrotechnological applications have shed light on the complex relationship between system optimization and energy efficiency.

CONCLUSION

The integration of artificial intelligence (AI), robotics, and automation technologies in poultry production is spearheading a profound transformation in production processes. These technologies not only enhance productivity but also make significant contributions to critical areas such as animal welfare, biosecurity, environmental sustainability, and food safety. AI-based image processing and acoustic analysis systems facilitate the early detection of diseases, thereby reducing treatment costs, while robotic cleaning and feeding systems lower labor requirements and improve operational efficiency. In addition, IoT-based sensor networks enable continuous monitoring of environmental

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parameters, supporting data-driven decision-making processes and allowing for long-term production planning.

Nevertheless, several significant challenges remain for the large-scale adoption of these technologies. High investment costs represent a major limitation for small and medium-sized enterprises. Moreover, adapting farm infrastructure for digital transformation, ensuring data security, and establishing standardization are essential priorities. Training programs and extension activities also play a crucial role in enhancing users' adaptation to these technologies.

From Türkiye's perspective, adapting this transformation to local production conditions and promoting it through academia–industry collaborations will not only contribute to achieving national sustainability goals but also strengthen competitiveness in global markets. Furthermore, the widespread adoption of these technologies, supported by government policies such as R&D incentives, infrastructure investments, and digital agriculture strategies, could reinforce Türkiye's potential to become a regional hub for technology production.

In conclusion, AI-, robotics-, and automation-based solutions present groundbreaking opportunities in poultry production at both scientific and industrial levels. However, to fully harness these opportunities, technological advancements must be addressed in conjunction with considerations of economic feasibility, social acceptability, and environmental sustainability.

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ETLİK PİLİÇ YETİŞTİRİCİLİĞİNDE CİVCİV KALİTESİNİN ÖNEMİ THE IMPORTANCE OF CHICK QUALITY IN BROILER REARING

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ÖZET

Etlik piliç üretimi hem iç pazar ihtiyacının büyüklüğü hem de dış satım miktarları bakımından Türkiye ekonomisinde önemli bir yere sahiptir. Etlik piliç üretiminde civciv kalitesi hem kuluçkahanelerin hem de üreticilerin karlılığını doğrudan etkileyen önemli bir faktördür. Son yıllarda, nicel veya nitel yöntemlerle ölçülen civciv kalitesi ile verim özellikleri arasındaki korelasyonlara önemli ölçüde ilgi duyulmaktadır. Özellikle kuluçkadan çıkan civcivlerin sınıflandırılması neticesinde üretim bandına alınmayan civcivlerin imha edilmesi bazı kesimler tarafından tepki çekmektedir. Bu çalışma, Tona puanı yöntemine göre iki civciv kalite kategorisine sınıflandırılan etlik piliçlerin yaşama gücü, performans özellikleri ve et kalite özelliklerini karşılaştırmayı amaçlamaktadır. Çalışmada, birinci sınıf grubundaki broilerlerin ölüm oranı %1.67 ile daha düşükken, civciv kalitesi düşük olanların ortalama ölüm oranı %23.33 olarak bulunmuştur ($P<0.05$). Tona skoru, civciv ağırlığı ve civciv uzunluğu gibi civciv kalite özellikleri ile kuluçka sonrası performans arasında istatistiksel olarak anlamlı ilişkiler bulunmamıştır (hepsi $P>0.05$). Tona skoruna göre birinci ve ikinci sınıf etlik piliç civcivlerinin vücut ağırlığı, yemden yararlanma oranı, Gompertz büyüme eğrisi parametreleri, kesim karkas özellikleri ve et kalite karakteristiklerinin ortalama değerleri arasında fark bulunmamıştır (hepsi $P>0.05$). Performans özellikleri açısından yüksek ve düşük kaliteli civcivler arasında fark bulunmamakla birlikte, konvansiyonel etlik piliç üretiminde düşük kaliteli civciv kullanımının sürünün genel ölüm oranını artırması olası gözükmemektedir. Üstün verim potansiyelleri nedeniyle, düşük kaliteli civcivlerin konvansiyonel etlik piliç üretiminden ziyade, ayıklama yapılmadan daha uygun üretim sistemlerinde değerlendirilmesi önerilmektedir.

Anahtar kelimeler: Etlik piliç, Civciv kalitesi, Tona skoru, Gompertz modeli, Büyüme.

ABSTRACT

The profitability of both hatcheries and producers is directly influenced by the quality of the chicks used in broiler production. Over the period of the last few years, there has been a substantial amount of interest in the links between production features and chick quality, which can be evaluated through either quantitative or qualitative approaches. The objective of this research is to evaluate the characteristics of meat quality, performance characteristics and vitality of broiler chickens that have been divided to 2 quality groups using the Tona score technique. When compared to the average mortality of those with poor chicks, which was about 24%, the death rate of chicks in the 1. grade group was about 2%, which marked a significant decrease from the average mortality rate. Using the Tona score, it was determined that there was no significant difference between 1. grade and 2. grade broiler chicken in terms of the average values of all studied characteristics. All of these P values were found to be greater than 0.05. The general mortality of the flock may be exacerbated by the use of poor quality chicks in traditional broiler rearing system, despite the fact that there is no distinction in terms of performance characteristics between high- and low-quality chicks. For this cause, it is advised that production processes that are more suitable and do not need culling make use of chicks of a lower quality. This is because these chicks have the ability to provide a higher output than standard broiler production.

Keywords: Broiler chicken, Chick quality, Tona score, Gompertz function, Growth.

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INTRODUCTION

The primary objective of commercial chick hatcheries is to maximize profitability by producing a significant number of high-quality chicks. A chick of superior quality must meet industry standards for production, have a high survival rate, exhibit satisfactory post-hatch growth, and demonstrate optimal development during incubation (Decuypere et al., 2002). Chick quality is evaluated in industrial chick production using quantitative or qualitative methods and categorized based on physical attributes (Tona et al., 2004). The quality of the chicks that are produced in hatcheries is evaluated, and the producers are allowed to purchase day-old chicks that are categorized as first-class animals. On the other hand, chicks that are of insufficient quality are culled and removed from the production process. It would be beneficial for the hatchery industry to have information regarding the removal of low-quality chicks from production. This is because these chicks are culled immediately after hatching, which results in direct economically significant losses. In the course of scientific investigations, it has been established that the percentage of second-grade chicks obtained from breeder flocks can range anywhere from 0.25% to 20.6%. (Lourens et al., 2005; Van de Ven et al., 2012). Despite the fact that numerous hatcheries accumulate data on second-grade chicks, they retain this information exclusively for their internal operations and do not disclose it to the public. The primary rationale for this is to prevent public resentment against culling practices. Some researchers contend that second-grade hens have an extremely low likelihood of survival and, as a result, must be culled (Nowak et al., 2019). Additionally, it has been declared that the presence of these chicks on farms can decrease the forage and stocking density available for quality chicks, as well as reduce production efficiency. Additionally, it has been asserted that the risk of disease transmission is elevated by the presence of pathogens in chicks of inferior quality. The purpose of this inquiry is to analyze the characteristics of 1.- and 2.-class broiler chickens with regard to their death rate, growth, feed conversion ratio, carcass, and technological quality of meat.

METHOD

The Animal Production Facilities of the Faculty of Agriculture at Namık Kemal University, which is situated in Tekirdağ, Turkey, served as the location where this research was conducted. The research utilized animal material that consisted of broiler chicks that were obtained from a commercial hatchery where they were raised. Utilizing the Tona score method, a total of 7,870 one-day-old chicks from a Ross 308 breeder flock that was 42 weeks old were tested for quality. The characteristics of the Tona score approach that was utilized in the assessment of chick quality are outlined in Table 1 (Tona et al., 2003). As part of the quality categorization, chicks that received scores between 95 and 100 were considered to be of first-class quality, whereas those that had scores that were lower were classed as being of second-class quality. It was found that there were a total of 284 chicks with a Tona score that was lower than 95. This figure includes 3.63 percent of the second-class chicks. The experimental facility received six chicks that were chosen at random from both the first and second classes. These chicks were then moved to the facility. The temperature of the climate-controlled enclosures in which the chicks were housed was initially set at 34 degrees Celsius, but it was gradually lowered to 22 degrees Celsius throughout the course of the research. The wing counts of the chicks were standardized in order to ensure that each measurement could be logged according to its own unique characteristics. During the course of the experiment, a total of six floor pens were utilized, each of which included a stocking density of ten chicks per square meter. Sawdust was chosen as the bedding material. In accordance with the instruction manual provided by the chicken manufacturer, adjustments were made to the temperature, lighting, and feeding protocols. Starting on day one and continuing through day fourteen, chicks were given a beginning meal that contained 3000 kcal ME/kg of energy and 22% protein of the total. A grower diet consisting of 3100 kcal ME/kg of energy and 20% protein was given to the animals between the 14th and 28th day of their lives. Beginning on day 28, a finisher diet consisting of 3200 kcal meals per kilogram of energy and 19% protein was given to the patient. The weight of each chick was recorded on a weekly basis until they reached the age of six weeks, at which point the characteristics of their individual growth curves were determined. For the purpose of estimating growth curves, the nonlinear regression model developed by Gompertz was utilized.

$$y_t = \beta_0 e^{(-\beta_1 e^{-\beta_2 t})} \quad (1)$$

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where y_t represents the weight at age t , β_0 represents the asymptotic (mature) weight parameter, β_1 represents the scaling parameter (constant of integration), and β_2 represents the instantaneous growth rate (per day) parameter.

Use of the SAS 9.3 GLM approach (SAS Institute 2009) was employed in order to conduct analyses of variance in order to determine whether or not the experimental groups exhibited differences in broiler characteristics. Duncan's multiple range test was utilized in order to differentiate between the various treatment ways. For the purpose of comparing means, the level of significance was set at $P < 0.05$. It was determined that the data did not follow a normal distribution, so the Rank transformation was applied to them. A generalized linear mixed-effects model with the logit function was utilized in order to conduct statistical analysis on the binomial or ordinal data collected from the experimental groups regarding mortality and chick quality parameters. For the purpose of comparing the groupings, the Tukey-Kramer method was utilized in conjunction with the SAS 9.3 GLIMMIX tool.

RESULTS

Table 1 presents the mean values of chick length, weekly live weight, feed conversion ratio, and mortality rates for broiler chickens across two distinct chick quality groups, along with the findings of the statistical analysis. No statistically significant difference was seen in the mean values of chick length, chick weight, and live weight at 35 and 42 days of age between the first and second quality chick groups ($P > 0.05$ for all values). No significant difference was noted in the cumulative feed conversion ratios at 35 and 42 days of age for the experimental groups ($P > 0.05$ in both instances). A notable disparity was seen between the groups regarding mortality rates. The cumulative death rate for second quality chickens was 23.33%, whereas it was 1.67% for first quality chicks ($P < 0.05$). The disparity in death rates among various chick quality groups was determined to be statistically significant ($P < 0.05$). The phenotypic connection between daily chick weight and daily chick length was robust and statistically significant for all chicks ($r = 0.68$; $P < 0.05$). The data are not shown in any table.

Table 1. Production traits of broilers of different chick quality grades

Chick Quality	Chick Length (mm)	Chick Weight (g)	BW 35 (g)	BW 42 (g)	FRC 35	FCR 42	Mortality (%)
Grade 1	176.11	44.44	1932	2675	1.73	1.83	1.67 ^b
Grade 2	174.99	43.73	1897	2635	1.71	1.81	23.33 ^a
SEM	8.64	0.85	26.93	39.20	0.11	0.12	2.29
P Value	0668	0.512	0.190	0.136	0.440	0.172	0.028*

BW: Body weight, FCR: Cumulative feed conversion ratio, * $P < 0.05$

Not only does Table 2 include the outcomes of the statistical analysis, but it also includes the mean values of carcass yield, percentages of carcass parts, ratios of edible internal organs, and belly fat of chickens that have been classified into two unique quality classes. The carcass yield of the group that had first-grade chick quality was 70.99%, while the mean for the other group was 71.14%. There was no statistically significant difference between the groups ($P > 0.05$), since the numbers were not significantly different. Similar to the previous point, there were no statistically significant differences found between the groups in terms of the mean values for carcass part ratios (all $P > 0.05$). In the first-grade chick quality group, the mean ratios of abdominal fat and edible inner organs were 2.90 percent and 5.37 percent, respectively, according to the findings of the study. On the other hand, the second-grade chick quality group exhibited ratios of 1.74 percent and 5.45 percent, respectively. There were no statistically significant differences found between the groups in terms of the means of either of the qualities (both $P > 0.05$).

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Table 2. The slaughter-carcass characteristics of chickens from two different categories of chick quality

Chick Quality	CY	BP	LP	WP	AFP	EIOP
Grade 1	70.99	28.12	19.89	6.56	1.90	5.37
Grade 2	71.14	28.00	19.99	6.51	1.74	5.45
SEM	1.10	0.80	0.77	0.40	0.43	0.53
P Value	0.614	0.948	0.456	0.114	0.716	0.805

Carcass yield represents the proportion of the chicken's live weight converted into carcass after slaughter and evisceration. Grade 1 chickens exhibited a CY of 70.99%, while Grade 2 chickens had a slightly higher yield at 71.14%. This difference is very minimal and not statistically significant ($P = 0.614$), indicating that chick quality does not impact overall carcass yield. The breast is the most valuable cut in broiler production. Grade 1 and Grade 2 chickens showed almost identical breast percentages (28.12% and 28.00%, respectively; $P = 0.948$). This suggests that chick quality does not influence the relative development of the breast muscle. The leg percentage, representing the proportion of leg meat in the carcass, was 19.89% for Grade 1 and 19.99% for Grade 2 chickens. There is no significant difference between the groups ($P = 0.456$). The wing percentage was 6.56% in Grade 1 and 6.51% in Grade 2 chickens. No statistical significance was observed ($P = 0.114$), indicating chick quality does not affect wing yield. Abdominal fat is an important indicator of carcass composition and consumer preference. Grade 1 chickens had a slightly higher AFP (1.90%) compared to Grade 2 (1.74%), but this difference was not significant ($P = 0.716$). The percentage of edible internal organs, such as the liver, heart, and gizzard, was 5.37% in Grade 1 and 5.45% in Grade 2 chickens. The difference is minor and not statistically significant ($P = 0.805$). There are no statistically significant differences in slaughter-carcass characteristics between broiler chickens grouped by chick quality. This indicates that the quality grade of chicks at hatch, under the conditions of this study, does not affect the yield or distribution of major carcass components—including breast, leg, and edible organs—or the amount of abdominal fat. These findings suggest that other factors, such as post-hatch management or genetics, may play a more critical role in determining carcass composition than initial chick quality grading.

Table 3. The pH and color characteristics of breast muscle of broiler chickens grouped according to chick quality

Chick Quality	pH ₁₅	pH _U	L	a	b
Grade 1	6.46	5.79	51.26	3.81	4.98
Grade 2	6.51	5.83	52.21	3.57	4.57
SEM	0.23	0.18	0.98	0.38	0.41
P Value	0.784	0.485	0.741	0.814	0.111

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Table 4. The meat quality characteristics of breast muscle of broiler chickens categorized by chick quality

Chick Quality	Thawing Loss (%)	Drip Loss (%)	Cooking Loss (%)	Water Holding Capacity (%)	Shear Force (kg)
Grade 1	2.01	2.01	21.32	74.86	2.14
Grade 2	1.94	1.92	21.88	74.45	2.07
SEM	0.08	0.05	1.18	0.82	0.12
P Value	0.721	0.856	0.888	0.524	0.511

The findings of statistical analysis are presented in Tables 3 and 4, which contain the mean values of pH, color, thawing loss, drip loss, cooking loss, water holding capacity, and shear force properties of breast muscle samples taken from broiler chicks that were grouped according to chick quality. There were no statistically significant differences seen between the first-grade chick group and the second-grade chick group with relation to any of the meat quality parameters that were stated earlier. The pH measured 15 minutes after slaughter is 6.46 for Grade 1 and 6.51 for Grade 2. These values are very close, and there is no statistically significant difference between the groups ($P = 0.784$). This suggests that the early postmortem biochemical changes influencing pH are not affected by chick quality. The ultimate pH, measured after the completion of rigor mortis, is 5.79 for Grade 1 and 5.83 for Grade 2. The difference is minor and not statistically significant ($P = 0.485$). Both groups fall within the normal pH range for broiler breast muscle, indicating proper postmortem glycolysis and absence of major meat quality defects like PSE (pale, soft, exudative) meat. Lightness (L) measures the brightness of the meat, with higher values indicating paler meat. Grade 2 chickens have a slightly higher L value (52.21) compared to Grade 1 (51.26), but the difference is not statistically significant ($P = 0.741$). This suggests chick quality does not influence the lightness of broiler breast muscle. The a^* value represents the redness of the meat. Grade 1 birds show a slightly higher redness (3.81) compared to Grade 2 (3.57), but this difference is small and not significant ($P = 0.814$). The b value indicates yellowness. Grade 1 birds have a b value of 4.98, slightly higher than Grade 2 at 4.57. Although the P value (0.111) is lower than for other parameters, it still does not reach statistical significance, indicating no meaningful difference between groups. There are no statistically significant differences in any of the measured meat quality traits between Grade 1 and Grade 2 broiler chickens. This suggests that chick quality, as categorized in this study, has minimal or no impact on the meat quality characteristics of the breast muscle in broilers. Therefore, other factors beyond initial chick quality may play a more prominent role in determining the final quality of broiler meat.

DISCUSSION AND CONCLUSION

When all of the weekly body weight averages, including the weight at which the chicks were hatched, were taken into consideration in the study, there were no differences detected between the different quality classes of chicks. Within the scope of their research, Tona et al. (2004a) classified three different broiler genotypes using the Tona score method when the animals were one day old. Compared to chicks with a quality score of second-grade, the average live weight of chicks with a perfect score of 100 was between 6.29 and 8.05 percent greater at 41 days of age. This was the case for chicks that had a perfect score. The contradiction that exists between the findings of this research and those of the current study is believed to be the result of the limited sample size (12 chickens each replication and 48 chickens in total per genotype) as well as the failure to take into account death rates. The association between qualitative chick quality ratings and post-hatch performance is not significant when using the Tona score, according to Willemsen et al. (2008) and Van de Ven et al. (2012). This is the case until a significant percentage of second-grade chicks are included in the analysis. It was proposed by Van de Ven et al. (2012) that the effectiveness of qualitative chick quality indicators for post-hatch performance

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could be called into question if the flock in the hatchery does not have any poor quality chicks removed from it immediately after hatching. According to the findings of the present investigation, the utilization of chicks of a second-grade quality in the production process did not result in a discernible variation in the live weight of the chicks. Furthermore, there was no discernible difference in the feed conversion ratios of broilers that were of different classes of chick quality. The literature does not contain any studies that investigate the connection between the quality of the chicks and the quality of the meal.

Numerous research has been conducted to investigate whether or not the quality of the chicks, which can be evaluated using both qualitative and quantitative techniques, has the potential to be a reliable predictor of the later performance of broilers. On the basis of this research, it was discovered that the relationships between the quality of the chicks and their performance qualities were not very strong. Furthermore, there were no changes in the performance characteristics of broilers that were classified according to the quality of the chicks. It has been established that the Tona method, which is used to evaluate the quality of chicks, is a reliable model for determining whether or not they will survive. It is highly likely that the total mortality rate of the flock will grow if culling is not performed. This is because the mortality rate of broilers in the second-grade chick quality group is quite high. It is not recommended to use these birds in traditional broiler production because there is the potential for ethical problems to arise in the event that particular restrictions for conventional production that are determined by the legislation that is applicable in the European Union are exceeded. In situations where mortality rates are acceptable, it is possible to recommend the utilization of broilers that have a low chick quality but excellent performance characteristics in alternate rearing systems.

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MARKETTE SATILAN TAVUK ETLERİNİ GÜVENLE YİYEİLİR MİYİZ?

CAN WE SAFELY EAT CHICKEN MEAT SOLD IN SUPERMARKETS?

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ÖZET

İnsanoğlunun hayvansal protein ihtiyacı hem düzenli beslenme açısından hem de çocukların zeka gelişimi açısından çok önemlidir. Sağlıklı bir insanın günlük protein ihtiyacı vücut kas kitle ağırlığının binde biri kadardır. Bu miktarın da en az yüzde ellisi hayvansal kaynaklı proteinlerden oluşmak zorundadır. Tavuk eti insanoğlunun hayvansal protein ihtiyacını karşılayabileceği en ucuz ve kolay erişilebilen kaynaklardan biridir. Hibrit niteliğinde olan ve etlik piliç ismi verilen bu üretim materyalinin hızlı gelişim, yemi etkin değerlendirme ve yüksek karkas özellikleri bulunmaktadır. Bunun da en büyük nedeni hem genotipin hem de çevrenin ıslahı ile ilgili çalışmalardır. Özellikle son dönemde bu kadar önemli bir besin ögesi olan tavuk eti hakkında görsel, yazılı ve sosyal medya ortamlarında tavuk eti hakkında son yıllarda çok fazla spakülasyon yapılmaktadır. Özellikle piliçlerin çok kısa sürede hızla gelişmeleri ve yetiştirme ortamlarındaki refah kriterleri hakkında bazı spekülasyon iddialar mevcuttur. Bunun yanında tavuklara verilen yemlerde çeşitli katkı maddeleri, antibiyotik, hormon vb. metabolizma ve bağışıklık sistemi düzenleyicileri hakkında tüketicilerin şüpheleri bulunmaktadır. Bu çalışmanın amacı piliç etinin yumurtadan çıkımdan sofraya ulaşana kadar geçmiş olduğu aşamaları açıklamaktır. Ayrıca etlik piliçlere yetiştirme döneminde verilen tüm besin maddeleri bu çalışmada açıklanmıştır. Kanatlı hayvan ıslahından et kalitesine kadar tüm ayrıntılar bu çalışmada yer almaktadır. Sonuç olarak insanoğlunun beslenmesinde en önemli öğelerden biri olan tavuk etinin marketlerde satılan haliyle tüketime uygunluğu bu çalışmada detaylı bir şekilde tartışılmıştır.

Anahtar kelimeler: Etlik piliç, Yem dönüşümü, Hızlı gelişme, Hayvansal protein, Sağlıklı yaşam.

ABSTRACT

Humans' need for animal protein is crucial for both regular nutrition and children's brain development. A healthy person's daily protein requirement is approximately one-thousandth of their body muscle mass. At least fifty percent of this amount should come from animal-derived proteins. Chicken meat is one of the most affordable and easily accessible sources for meeting human animal protein needs. This hybrid production material, called broiler chicken, boasts rapid development, efficient feed conversion, and high carcass characteristics. This is largely due to studies on both genotype and environmental improvement. Chicken meat, a crucial nutritional element, has been the subject of much speculation in recent years, particularly in visual, written, and social media platforms. Speculative claims, in particular, exist about the rapid development of chickens in a short period of time and the welfare criteria they face in their growing environments. Furthermore, consumers have concerns about various additives, antibiotics, hormones, and other metabolic and immune system modifiers in the feed given to chickens. The purpose of this study is to explain the stages chicken meat goes through from hatching to reaching the table. Additionally, this study details all the nutrients fed to broiler chickens during the growing period. This study covers all the details, from poultry breeding to meat quality. Consequently, the suitability of chicken meat, one of the most important elements in human nutrition, for consumption as sold in supermarkets is discussed in detail.

Keywords: Broiler chicken, Feed conversion, Fast growing, Animal protein, Healthy life.

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INTRODUCTION

Within agricultural production, the broiler sector, where commercial production is entirely carried out using hybrid materials, is crucial for public health as a source of inexpensive and high-quality animal protein. As a result of long-standing breeding efforts and environmental improvements, today's broiler chickens reach a live weight of 2.5 kg at six weeks of age, consume 4 kg of feed during this period, and yield approximately 73% marketable carcasses and cuts. Türkiye utilizes all of the world's most modern and advanced technologies in broiler production. With its hygienic and high-quality white meat production, the sector exemplifies a production model that exceeds world standards. The sector provides direct and indirect employment for approximately one million people, with an average production volume of two million tons, varying annually. Furthermore, the sector is a significant exporter, exporting 20-25% of its production. The "Agricultural Outlook 2020" report by the Organization for Economic Co-operation and Development (OECD) and the Food and Agriculture Organization (FAO) announced that 325 million tons of meat were produced globally in 2020. The report noted that poultry accounted for 40.6% (132 million tons) of the most consumed meat globally. Furthermore, while per capita meat consumption is 109 kg in the United States and 77 kg in the European Union, this figure is only 36 kg in Turkey, and only 23 kg of this comes from poultry. The purpose of this study is to compile important information about chicken meat, which is expected to play a key role in closing the animal protein gap in Turkey, to identify the challenges facing the broiler sector, and to identify potential solutions.

The essential element of life: Protein

Nutrition is the act of consuming and utilizing the nutrients necessary for human growth, development, and a healthy and productive life in sufficient and balanced amounts. While there are differing opinions on balanced nutrition, a balanced diet can be defined as a rich and non-monotonous diet that meets the daily energy requirements necessary for maintaining good health, is high in vitamins and minerals, and contains appropriate proportions of protein, fat, and carbohydrates. While the proportions of nutrients in a balanced diet vary depending on an individual's circumstances, these ratios suggest that approximately half of a person's daily metabolic energy needs should come from carbohydrates, one-fifth from protein, and one-quarter from fat sources. Today, obesity, resulting from unbalanced and overnutrition, has reached its highest rates in human history in some regions, while malnutrition is also prevalent in underdeveloped countries, with one in nine people worldwide known to be undernourished (FAO, 2019).

For a balanced diet, which forms the foundation of health at every stage of life, the balance and usefulness of these elements are also crucial, in addition to the proportions of essential nutrients consumed. Examples of this include carbohydrates, which can be classified according to their digestibility levels (e.g., saturated and unsaturated fat content, cellulose and starch content) in foods, and proteins, which can be classified according to their usefulness or origin. Proteins, the primary essential nutrients mentioned, form the structure of all enzymes and hormones in the body, and are involved in muscle development, tissue regeneration, metabolic reactions, immune system activity, and many other vital functions. While over 300 amino acids exist in nature, only 20 amino acids responsible for maintaining the functions of mammals can be encoded by their DNA. Only eleven of these amino acids, the building blocks of proteins, can be synthesized by organisms, while nine amino acids (isoleucine, leucine, valine, lysine, methionine, phenylalanine, threonine, tryptophan, and histidine for children) are defined as exogenous for humans. These exogenous amino acids, which must be taken externally, cannot be produced in the human body, and their deficiency causes developmental delays in children, tissue and organ loss in adults, immune system depression, nervous system anomalies and behavioral problems; and many negative situations occur, from deterioration in quality of life to death.

Animal proteins or plant proteins?

Proteins that can be ingested through food contain essential amino acids, but their essential amino acid content varies both in quantity and proportion, thus differing in their usefulness and quality. The protein quality of a food depends primarily on its essential amino acid content. Because it also relates to an individual's needs and the protein's ability to be digested, absorbed, and retained by the body, a food is evaluated based on a protein's essential amino acid composition. A person's protein needs also vary depending on a variety of factors, including age, fitness, body muscle mass, physiological status,

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physical activity, health status, and mental state. The nutritional value of dietary proteins is related to the bioavailability of their essential amino acids. Meeting the amino acid requirements for growth and body protein conversion depends on the efficiency of their metabolic utilization. Different animal and plant foods contain widely varying amounts and qualities of protein. A protein that can be defined as high quality should contain essential amino acids in sufficient and balanced proportions, be a good nitrogen source for the synthesis of non-essential amino acids, and be easily digestible. Even if the amino acid composition is balanced and the protein content is high, proteins with a low digestibility rate are also of lower quality. Proteins derived from animal products are generally of higher quality than plant proteins. Furthermore, the bioavailability of plant-based proteins ranges from 40-70%, while the bioavailability of animal-based proteins is between 70-100%. The World Health Organization has established criteria such as net protein utilization, biological value, chemical score, digestibility, and corrected amino acid score to assess the quality of dietary protein. In this assessment, the World Health Organization rated egg protein as "excellent" and identified other protein sources out of a reference score of 100.

The structure of the cell, the smallest part of the human body, is almost entirely protein, and during growth, cells constantly require protein for proliferation. Furthermore, some protein is constantly excreted as a result of various metabolic and physiological processes associated with all vital functions. The human body does not have a protein store; only a small amount of protein is stored to compensate for short-term deficiencies. Therefore, the absolute source for the formation of body proteins in humans is the proteins found in the composition of food (Yücecan 2014). Because the body cannot produce protein from carbohydrates or fats, externally obtained proteins are digested, and the resulting amino acids are recombined to form the cells of the relevant tissues, systems, and organs. The human body must obtain essential amino acids from external sources and has limited ability to convert them from one to another. Because the body cannot produce these amino acids using other amino acids, proteins with the appropriate ratios are ingested without excessive loss in the digestive system. Because all the amino acids are present together, the combination of these amino acids into body protein is easier and faster. The majority of protein from meat, poultry, fish, dairy products can also be converted into body protein. As previously mentioned, these are high-quality protein sources with digestibility levels exceeding 90% (Yücecan 2014).

How much protein should we consume daily?

The daily protein requirement for a person depends on age, physical structure, health status, lifestyle (active, stressful, etc.), climatic and other environmental conditions. A healthy adult, living under optimal environmental conditions, requires a daily protein requirement of one-thousandth of their body muscle mass. For example, a person weighing 70 kg and with a muscle mass of 55 kg would need 55 g of protein daily, and 40% of this amount should come from animal-sourced foods. In other words, total daily protein consumption for an adult and healthy individual is 0.8% of their body weight, and this figure ranges from 0.9 to 1.3% for infants, children, and adolescents. During these periods, the amount of protein required from animal sources should be higher than 40%. The average daily protein intake per person worldwide is 81 grams, 32 grams of which comes from animal-sourced proteins. However, it is observed that developed countries significantly increase these averages, while developing countries' total protein and animal protein averages remain below optimal values. Another striking finding is that while the ratio of animal-sourced protein to total protein is 65-70% in developed countries, this ratio is around 15-20% in underdeveloped countries. According to 2017 FAO data, the highest average per capita protein consumption (141 g) was found in Iceland, followed by 103 g in Europe, 101 g in China, and 113 g in the United States. Average daily protein consumption per capita was determined to be 69 g in Africa, 77 g in Asia, and 56 g in all underdeveloped countries (FAO 2017). In Turkey, total protein consumed per capita is 101 g, only 30% of which comes from animal-derived products. As can be seen, animal protein consumption is insufficient in underdeveloped countries, developing countries, and Turkey.

Nutritional aspects of chicken meat

Healthy nutrition is one of the most important factors in ensuring that individuals in society live physically, mentally, and spiritually healthy and strong lives, that social relationships are positive, and

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that well-being is enhanced. One of the fundamental human rights is the right to access healthy food. The nutritional status of a society is a reliable indicator of a country's level of social and economic development. People have the fundamental right to access clean, healthy, safe, affordable, and high-quality food, and to live a disease-free life without negatively impacting their health as a result of this consumption (Arslan 2014). Inadequate nutrition, particularly in children, leads to developmental delays and mental retardation, while in adults, it often leads to obesity due to unbalanced nutrition and related chronic diseases such as cardiovascular anomalies and cancer. It is known that humans require more than 50 types of nutrients (carbohydrates, protein, fat, vitamins, minerals, etc.) for growth, development, and a healthy life. "Adequate nutrition" can be defined as consuming sufficient amounts of the energy and nutrients the body needs for health and productivity. "Balanced nutrition" refers to consuming nutrients in proportion to each other and in a balanced manner across meals. "Healthy nutrition" refers to selecting and consuming foods appropriately, with the awareness that food can become harmful during production, storage, preparation, and cooking (Turkish Dietetic Association, 2021). When evaluated in terms of healthy nutrition, chicken meat stands out with its high-quality protein content, moderate energy source, and low fat and saturated fat content (Arslan 2014). Beef and lamb contain 2.5 and 4.2 times more myristic (14:0) acid and 1.8 and 2.9 times more stearic (18:0) acid (saturated fatty acids), respectively, than chicken. Chicken meat is considered to contain an average of 65 mg/100 g of cholesterol (Yücecan, 2014). The cholesterol content of red meat, for example, is 75 mg/100 g of beef. However, red meat is rich in fat and saturated fat, and saturated fat, in particular, affects blood cholesterol more than dietary cholesterol. Meats are generally considered a good source of riboflavin, niacin, vitamin B6, and vitamin B12. Chicken is a good source of selenium and phosphorus and also contains high levels of antioxidant omega-3s. Furthermore, the absorption rate of iron from animal foods is 25-30%. Iron absorption is better when plant-based foods are consumed with animal-based foods (Yücecan, 2014).

Sector overview and problems

Thanks to the implementation of modern technology, the Turkish broiler sector has reached an annual production volume of 2.1-2.2 million tons, ranking among the top ten countries in the world in terms of production volume. The Turkish broiler sector also ranks among the top five countries in the world in terms of exports. Annual per capita poultry meat consumption, which was 4 kg in the 1990s, has risen to 23.1 kg today, exceeding the European average of 21.7 kg. While Israel (63 kg/person) and the US (44.5 kg/person) lead the world in poultry meat consumption, the target for this figure in Turkey is to reach 34.5 kg/person by 2030, with production reaching 4.18 million tons. The Turkish broiler sector is one of the sectors that continuously grows, rapidly increases exports, provides intensive employment, and contributes significantly to the national economy through its agricultural support. There are over 14,000 registered broiler chicken farms operating in the sector. The poultry sector employs approximately one million people, including producers, tradespeople related to the sector, feed, pharmaceuticals and vaccines, sub-industries, transportation, and marketing. The white meat sector, which contributes significantly to the Turkish economy, has a female employment rate of 40 percent, above the national average. The sector's annual turnover is approximately \$5.5 billion. The development of the broiler sector in Turkey is driven by the additive effects of many factors. However, the most significant driver of global development is the use of hybrid materials with superior genotypes. Genetic improvement accounts for 80% of broiler productivity, while environmental factors (such as poultry conditions, feed and nutrition, health, etc.) contribute 20%. The challenges faced by the broiler sector, a key component of the Turkish economy, can be listed as "high feed and raw material costs," "insufficient export support and political challenges," and "product speculation." Solutions to the first two issues can be achieved periodically through various agricultural policies and the actions of decision-makers. However, product-based and sector-specific speculation, perpetrated through print and broadcast media, negatively impacts consumers. To address this negative situation, NGOs, public health organizations, and relevant, especially competent, scientists must educate the public and implement appropriate sanctions against those who fuel speculation. Some media-related speculations that negatively impact the sector are presented below in a question-and-answer format.

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Aren't the chickens we eat because they are healthy really chicken?

It's important to note here that the animal defined as "chicken" not only refers to the species in question but also to the adult females of that species. The product sold in supermarkets is not the meat of adult females, but rather young animals that have reached slaughter weight between 5 and 8 weeks of age. The sole reason backyard chickens weigh 150 g at 5-8 weeks of age, while commercial broiler chickens reach 2.5 kg live weight, is due to selection efforts conducted over generations. This isn't unique to chickens; similar results are also obtained in selection studies conducted on various farm animal species. For example, a series of postgraduate theses conducted at Akdeniz University's Faculty of Agriculture demonstrated that quail, whose average adult weight in nature is 160 g, can increase their live weight to 320 g through 10-12 generations of selection. Humans have been breeding chicken breeds for centuries, offering advantages in both appearance and weight or egg production. Matching production records with pedigree records in chickens raised both to meet nutritional needs and for hobby purposes began in the 1920s with the use of covered nesting boxes. This led to the creation of the first pedigree records, and superiorly productive chickens were identified and used as breeding stock. Phenotypic breeding values were used to determine the parents of the next generation. This practice of animal breeding is called selection, and today, both laying hens and broiler chickens have a 100-year history of selection. This adventure in broiler breeding, which began in the early part of the last century with simple phenotypic mass selection, has now been implemented for more than 20 traits, from meat color to breastbone angle, thanks to the integration of advanced statistical methods, computer technology, and molecular methods. Breeding companies, once numerous, have merged, and today, the market is dominated by a handful of multinational corporations. While selection efforts are underway in breeding flocks held by these organizations in various countries, broiler hybrids are also being marketed globally. Therefore, for many years, the chicken meat consumed in Turkey is no different from that consumed in the European Union, the United States, the Far East, or anywhere else in the world. The meat obtained from these poultry, which share the same genetic makeup, equivalent breeding technologies, the same feeding times, the same amount of feed required per kilogram of live weight, and the same nutritional values, is called chicken meat by its specific name in their respective languages, or broiler meat by its proper name.

Is broiler chicken a genetically modified organism (GMO)?

More than 200 chicken breeds have been registered worldwide, and approximately 60% of these breeds are purebred, while others are hybrids that have achieved purebred status. Broiler chickens are hybrid genotypes obtained through generations of selection and crossbreeding of certain American and British breeds, as explained in the answer to the previous question. These hybrids have never undergone genetic modification, cloning, gene therapy, or transfer; breeding has been achieved solely by exploiting additive gene effects through selection and non-additive epistatic and dominance effects through crossbreeding. In short, broiler chickens are not genetically modified organisms.

Are hormones used in chicken meat production?

Speculators' claims that broiler chickens are being given hormones because of their rapid growth and very high body weight are completely untrue and illogical. There is no hormone or treatment used to stimulate rapid growth in poultry, and it's unreasonable to even consider such a practice rational. It's truly distressing to see even pediatricians, who should have scientific knowledge on the subject, telling parents of 9-month-old babies, "Don't feed them chicken meat; they're feeding them estrogen." Hormones are not manufactured in Türkiye, nor are they imported. Furthermore, synthetic hormones are quite expensive, and it's unreasonable to think that five units of hormone cost per unit of chicken sold for one unit. Furthermore, orally administered hormones will be digested as protein. If injected, how can they be administered to millions of chickens? Consequently, administering hormones to broiler chickens or laying hens is theoretically and practically impossible.

Are antibiotics given to broiler chickens?

Antibiotic use in broiler chickens, aimed at improving digestion by controlling intestinal microbiota, effectively utilizing feed, and thus manipulating body weight gain, was practiced in many parts of the world until the 2000s. However, the potential for antibiotic tolerance in humans due to residue issues was highly controversial. Due to these concerns, the use of antibiotics for growth in broiler or laying hen farming in Türkiye was banned in 2006, simultaneously with European Union (EU) countries. Since

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then, all antibiotics used for therapeutic purposes have been licensed and monitored by the Ministry of Food, Agriculture, and Livestock, have specific residue clearance periods, and are virtually devoid of product residues. However, it should be noted that antibiotics for growth purposes are currently used in many countries, particularly the United States.

Are broiler chickens raised in very tight spaces, without even seeing daylight, without considering animal welfare?

The welfare of the reared animals is a priority, and high-quality living conditions are ensured in the rearing houses. Broiler chicken farming is carried out under fully controlled environmental conditions, often in houses equipped with computer-aided automation systems. To ensure that the genotype of the hybrid animals used in the production process is reflected in the phenotype with minimal disruption, the adverse effects of the environment are minimized, and environmental conditions are created to meet all the animals' physiological needs. Every aspect of the process, from the temperature and relative humidity provided to the chicks on their first day of hatching to the temperature of the drinking water, is regulated. In conventional production, the conditions set by the European Union SCAHAW (Scientific Committee on Animal Health and Animal Welfare) are adhered to. A maximum of 13 chicks are housed per square meter. If different slaughter ages are planned, stocking density is adjusted to achieve a maximum live weight of 30 kg per square meter. In order to meet all physiological requirements of a hybrid during the broiler chicken production process, all environmental factors (ration energy, protein and nutrient contents, thermal conditions, lighting, ventilation, etc.) are known on a daily basis and production is carried out within a program, and no practices that would cause stress in the animals are implemented.

Today's chickens cook in a very short time, are whiter, do not smell much while cooking and their juices do not form a jelly. What is the reason for these suspicious situations?

People who ask this question are often those who long for "village chicken" and long for those days. In the past, even broiler chickens, let alone cut-up chickens, were only available in big city butchers. In rural areas, a village chicken roaming the courtyard was slaughtered for valued guests. Village chickens were a niche product with a special meaning. So, what are these village chickens from our ancestors' courtyards? Village chickens are generally small, randomly-typed animals raised in simple coops or barns to meet the family's egg needs. They are usually slaughtered for meat when egg production declines. They roam the surrounding gardens, yards, gardens, manure piles, and roadsides, feeding on a variety of materials and food scraps they find in these areas. During village chicken farming, the animals are directly exposed to all toxic and harmful wastes, pollution, and other animal feces, making them vulnerable to all disease agents, and the resulting products carry a serious risk of pathogens. Village chicken farming should be perceived as the riskiest and most unhealthy type of production (Ceylan, 2014). Because these chickens are older, their meat has a low water content, and because they constantly avoid predators throughout their lives, their muscles are firm. This is why their meat is firm and darker, even after prolonged cooking. Furthermore, due to the high abdominal fat and collagen content brought on by advanced age, gelatin formation occurs during cooking, resulting in low nutritional value. In accordance with misinformation in the media, these chickens, which should be sold at the lowest prices, are sold at high prices under the names of natural chicken, organic chicken, or village chicken (Ceylan, 2014). Because chicken meat sold in supermarkets is obtained from young birds aged 5-6 weeks, it has a high water content, is fresh, tender, and cooks easily. There is no harm in consuming them as a cheap source of animal protein with high biological value for public health.

DISCUSSION AND CONCLUSION

The Turkish broiler industry, which produces one of the most important options for addressing the country's animal protein deficit, boasts an annual turnover of \$5.5 billion and is also one of Turkey's most important export markets. The Turkish broiler industry is a shining star in Europe, both in terms of production volume, exports, and targets. Considering the progress made in recent years, urgent action is needed to address the factors threatening the sector. It's clear how feed and export issues will be resolved, but scientists and industry stakeholders must work to raise consumer awareness against negative speculation circulating through perception management channels.

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BIO PIGMENTS AS SUSTAINABLE ALTERNATIVES TO TRADITIONAL COLORANTS IN PLASTIC MASTERBATCH PRODUCTION: A REVIEW

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ABSTRACT

The increasing demand for sustainable and environmentally friendly plastics has led to a re-evaluation of conventional colorants used in masterbatch production. Traditional mineral and synthetic organic pigments often have ecological and health risks due to their toxic components and poor degradability. In contrast, bio pigments derived from natural sources such as plants, microorganisms, and food waste present a promising alternative. This review explores the potential of biobased colorants as substitutes in masterbatch formulations, focusing on their chemical characteristics, compatibility with biopolymers, processing behavior, and environmental advantages. Key challenges such as thermal stability, lightfastness, and scale-up limitations are critically discussed. The paper highlights emerging technologies and innovations driving the integration of bio pigments into commercial bio-friendly plastic products, emphasizing their role in the circular bioeconomy and future green material design.

Key words: Bio pigments, Masterbatch, environmental, thermal stability, future green material

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COMPARATIVE MORPHOLOGICAL, ANATOMICAL AND ECO-PHYSIOLOGICAL ASSESSMENT OF MORINGA OLIFERA LAM. ACROSS DIVERSE ECOLOGICAL REGIONS OF PUNJAB, PAKISTAN

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ABSTRACT

Environmental heterogeneity is an important factor that affects species richness and provides conditions for adaptation of existing species. *Moringa oleifera* can flourish in a variety of soil types, including low-fertility ones, and adapt to a range of climatic conditions, from humid tropical zones to semi-arid areas. Its ease of propagation both by seed and cuttings, also makes it easier to cultivate and spread around the world. Naturally adapted populations of *Moringa olifera* were collected from various ecological regions of Punjab province to investigate their adaptive traits under heterogeneous environmental conditions. Roadside populations (compact soil and high traffic load) had considerably higher stem anatomical features, including cortex thickness and cortical cell area, sclerenchyma thickness, pith cell and xylem ray thickness. These traits enhance water storage, solute absorption, and surface protection, making them essential for plant survival in hostile settings. Accessions from regions with greater salt levels, exhibited thicker stems. Furthermore, the soils in these locations included larger quantities of organic matter, which might influence *Moringa* stem development. Increased nutrient availability can stimulate species expansion in plants therefore, it makes sense to justify bigger stems in these regions. Roadside populations exhibit a reduction in metaxylem area, indicating a drought-adapted plant. Trichomes serve as a plant's defense system against external threats. Leaf alterations, such as increased epidermal thickness (adaxial and abaxial), allow plants to defend against environmental stress and preserve themselves. *Moringa olifera* showed very specific modifications in morpho-anatomical and physiological traits that reveal its ecological success.

Keywords: *Moringa olifera*, ecophysiological modification, anatomical traits, abiotic stress

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ENVIRONMENTAL IMPACT ASSESSMENT OF THE ARTISANAL BAMBOO POLE (*GUADUA ANGUSTIFOLIA*) PRODUCTION IN THE BRAZILIAN AMAZON

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ABSTRACT

The artisanal production of bamboo poles is an income alternative for small producers in countries in Africa, Asia and Latin America. Despite the positive impact on climate change from the use of this renewable material for construction purposes, there is a gap in knowledge about the environmental footprint of this production system. The present work raised the potential environmental impacts of the artisanal production process of bamboo poles (*Guadua angustifolia*) in the Brazilian Amazon. A life cycle assessment conducted within an artisanal production unit (PU) of bamboo poles, in the municipality of Rio Branco, state of Acre in Brazilian Amazon, encompassed the entire production chain, from bamboo planting to the chemically treated bamboo poles. The environmental impact category that prominently emerged was Human Carcinogenic Toxicity, achieving 93% of the total impact generated. The findings underscore the imperative to explore alternative methods for the chemical treatment of bamboo poles and to enhance the management of solid waste, emphasizing the optimization of water usage in the treatment process. Addressing these aspects is imperative for mitigating the environmental footprint associated with artisanal bamboo production chain and fostering bioeconomy in the Brazilian Amazon.

Keywords: Production management; Environmental management; Life cycle assessment; Bioeconomy.

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LEAF STRUCTURAL AND FUNCTIONAL MODIFICATION OF *IPOMOEA CARNEA* JACQ. AN INVASIVE PLANT SPECIES, UNDER DIVERSE SALINITY GRADIENT

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ABSTRACT

The role of structural and functional plasticity of *Ipomoea carnea* for invasion in diverse saline environments was investigated. The populations were collected from 30 different habitats of Pakistan. The populations were divided into 3 groups based on the extent of salinity in their natural habitat. The non-saline habitats ($EC_e > 4 \text{ dS m}^{-1}$) were Kohala, Islamabad, Pahari Nala, Pir Kot, Nerian Sharif, Daska, Dhir Kot, Namal, Lower Jhelum and Majuhan. Moderately saline habitats ($EC_e 4-8 \text{ dS m}^{-1}$) were Mong Depo, Pasrur, Layyah, Mana Wala, Phularwan Roadside, Kharian Wala, Phulrwan canal, Rasool, Puran and Shah Kot. Highly saline habitats ($< 8 \text{ dS m}^{-1}$) included Gunjal, Gutwala, Skindar Pura, Choa Sadien Shah, Phid, Buchal, Kallar Kahar, Cholistan Desert, Sangla Hills and Sahian Wala. The hyper-saline population accumulated more compatible solutes like total soluble sugars, phenolics and flavonoids linked to osmoprotection. Increased sclerification and phloem thickness in hyper-saline and moderately saline populations. Increased density of trichomes and salt excretory glands prevented water loss and excreted toxic ions through leaf surface. In conclusion, *I. carnea* populations adopted different strategies like water conservation via water storage in parenchymatous tissues, accumulation of compatible solutes (total soluble sugars) and allelochemicals (flavonoids and phenolics) for chemical defense. All these aspects were key factors for survival and invasive success in a variety of habitat types and environmental conditions.

Keywords: Environmental heterogeneity, Invasive species, *Ipomoea carnea*, Sclerification, Trichomes.

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EVALUATION OF THE *IN VITRO* ANTIOXIDANT AND ANTIDIABETIC ACTIVITIES OF QUINOA (*CHENOPODIUM QUINOA* WILLD.) SEED EXTRACTS AND THE QUANTIFICATION OF THEIR BIOACTIVE COMPOUNDS

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ABSTRACT

Oxidative stress plays a major role in diabetic physiopathology; hence, the interest of using natural antioxidants as therapeutic tools exists. Quinoa (*Chenopodium quinoa* Willd.), native to South America and belonging to the family Chenopodiaceae, is a seed crop that exhibits broad genetic diversity, enabling it to adapt to various tough environments, including highlands, salinity, drought, and frost.

This study aimed to assess the *in vitro* antioxidant activity and the inhibitory effects of quinoa seed extracts on key enzymes associated with hyperglycemia. Additionally, it sought to quantify the bioactive compounds present in these extracts.

Antioxidant activity was performed using 2,2'-diphenyl-1-picrylhydrazyl (DPPH) and ferric reducing antioxidant power (FRAP) methods. The α -glucosidase and α -amylase inhibitory activities were investigated using an *in vitro* model.

The hydroethanolic extract of quinoa exhibited the highest antioxidant activity in both DPPH and FRAP methods. This extract also demonstrated the strongest inhibitory effect against α -glucosidase. However, the aqueous extract showed the highest inhibitory effect against α -amylase. Furthermore, the results indicated high levels of phenolic content. The findings suggest that this plant could be a significant source of medically important natural compounds.

Keywords: *Chenopodium quinoa* Willd.; Antioxidant Activity; Antidiabetic Activity; Bioactive Compounds

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DIATOM COMMUNITY STRUCTURE AS AN INDICATOR OF AQUACULTURE IMPACTS IN LAKE BULUAN, MAGUINDANAO, PHILIPPINES

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ABSTRACT

Lake Buluan, the third-largest lake in the Philippines, sustains rich aquatic biodiversity and supports extensive aquaculture. However, decades of anthropogenic pressures, including domestic wastewater, aquaculture effluents, and agricultural runoff, have degraded water quality. This study assessed morphologically, the composition and distribution of freshwater diatoms across six stations inside and outside fish pens to evaluate their potential as bioindicators of ecological change. Nineteen species were recorded, with 11 present in both fish-pen (IFB) and open-water (OFB) sites. Dominant taxa—*Nitzschia serpentiraphe*, *Gomphonema montanum*, and *Aulacoseira islandica*—occurred at nearly all stations and are linked to nutrient-rich sediments and organic pollution. Site-specific patterns emerged: *Nitzschia liebethruthii* dominated IFB1 and IFB3 but was absent in IFB2 and most OFB sites, whereas *Nitzschia inconspicua* showed the opposite trend. The exclusive occurrence of *Eunotia monodon* and *Cymbella tumida* in OFB stations suggests more acidic or oligotrophic conditions outside enclosures. Rare taxa (*Sellaphora* sp., *Grammatophora angulosa*) contributed to richness in non-enclosed areas. Moreover, next-generation sequencing (NGS) data confirmed the dominance of *Nitzschia* spp., indicating mild environmental stress and ecological plasticity which is, typical for tropical shallow lakes. Findings underscore diatom monitoring as a sensitive, cost-effective tool for assessing aquaculture impacts and advocate its integration into freshwater ecosystem management.

Keywords: diatom, lake, bioindicators, aquaculture

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THE EFFECTIVENESS OF NATURAL LIGHT IN MUSEUM DESIGN: THE CASE STUDY "THE HE ART MUSEUM"

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ABSTRACT

Museums are spaces for exploration, discovery, and learning, where lighting plays a crucial role in shaping the interaction between visitors and exhibited artifacts. More than just illumination, lighting design defines the atmosphere, enhances perception, and guides emotional responses within a museum space. This paper explores the role of lighting in museum design through the lens of architect Tadao Ando's architectural philosophy—particularly in his work on The He Art Museum (HEM). Ando's approach emphasizes a delicate balance between tradition and modernity, simplicity and complexity, and the interplay between natural and artificial light. Through observational analysis and design study of HEM, this article examines how natural light is used as a fundamental design element to foster harmony between the built environment and the experience of art. The findings contribute to a broader understanding of museum lighting strategies and their impact on spatial quality, visitor engagement, and cultural storytelling.

Keywords: The He Art Museum, Tadao Ando, natural light, museum lighting, architectural harmony, spatial experience.

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IMPACT OF COLOR ON PATIENT RECOVERY IN POST-OPERATIVE ROOM ENVIRONMENTS

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ABSTRACT

This study is about how the ambient colors affect patient recovery in post-operative room settings, an issue that is often ignored among the physical surroundings affecting healing. The research synthesized findings from other works where the results of 150 post-operative patients over a period of six months were analyzed in an aggregated manner. These analyzed data would constitute patient outcomes with respect to the cool blue, warm beige, or neutral grey room color schemes in terms of average daily pain scores (Visual Analog Scale -- VAS), analgesic medication, the length of hospital stay, and the patient's sense of psychological comfort. It is thereby proposed that the use of colors in an intelligent way could aid the recovery of patients in post-operative situations, perhaps alleviating pain and hastening discharge. Ie, designing hospitals in certain colors can improve patient outcomes and better utilise health-care resources.

Keywords: Patient recovery, room color, post-operative, hospital environment, pain management

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THE ROLE OF INDIRECT LIGHTING IN CONTEMPORARY MUSEUM DESIGN

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ABSTRACT

In museum lighting design, indirect lighting has long received little attention. It is rarely used to directly illuminate artifacts or to highlight the value of displays, unlike key lighting or accent lighting. However, recent research and practical applications have shown that indirect lighting plays a crucial role in shaping spatial experience, influencing emotional responses, and enhancing the overall visitor experience. This paper examines the role of indirect lighting in contemporary museum design and proposes key principles and techniques for its effective and coherent application, with the objective of enhancing both the aesthetic quality and the communicative capacity of exhibition spaces.

Keywords: Indirect lighting, museum lighting design, lighting strategies, spatial experience

International Congress on Food, Agriculture and Environment Researches in Global World -II

DEAFSPACE IN EDUCATIONAL DESIGN: ACOUSTIC STRATEGIES AND SPATIAL ADAPTATIONS FOR THE HEARING-IMPAIRED

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ABSTRACT

In the context of inclusive education, the spatial design of learning environments for the hearing-impaired plays a vital role in enhancing their communication, comfort, and academic performance. While traditional assumptions often overlook the role of acoustics in deaf education, recent research highlights how sound-related spatial qualities, such as reverberation control, background noise reduction, and the acoustic perception of space, can directly affect the cognitive and emotional well-being of hearing-impaired students, especially those using hearing aids or cochlear implants. This paper explores both the functional contributions of acoustic design in educational settings and the spatial strategies and design principles that support deaf learners. It aims to propose adaptable solutions for learning environments that foster non-verbal communication, concentration, and overall sensory well-being.

Keywords: DeafSpace, acoustic design, spatial strategies, hearing-impaired users, sensory accessibility.

International Congress on Food, Agriculture and Environment Researches in Global World -II

POTENTIAL IMPACTS OF ACOUSTICS IN FACTORIES AND INDUSTRIAL ENTERPRISES ON WORKERS' HEALTH

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ABSTRACT

Sound in the working environment, particularly in factories and industrial enterprises, is a crucial factor directly affecting workers' health and performance. While occupational safety standards often focus on reducing noise to acceptable levels, this study delves deeper into analyzing the potential and long-term impacts of acoustics, not only in terms of intensity but also frequency and sound quality, on the human body. This study conducted a comprehensive research study, combining data from practical surveys in manufacturing enterprises with physiological and psychological analyses. The objective was to holistically assess the relationship between the acoustic characteristics of the working environment (such as continuous machinery noise, high-frequency sounds that are not easily perceptible, and sudden changes in sound) and a range of health issues experienced by workers. This analysis indicates that in addition to obvious auditory effects like hearing loss or tinnitus, an unsuitable acoustic environment can also lead to numerous other health problems. Specifically, continuous noise at levels below the hazardous threshold can still increase stress levels, cause sleep disturbances, raise blood pressure, and even affect concentration and work efficiency. These effects often go unnoticed immediately but accumulate over time, causing significant harm to the physical and mental well-being of workers. Based on these findings, this study emphasizes the necessity of implementing more comprehensive acoustic control solutions that go beyond traditional noise safety standards. We propose more advanced acoustic assessment methods and effective intervention strategies to improve the quality of the sound environment, thereby protecting the long-term health and enhancing the quality of life for workers in industrial sectors.

Keywords: acoustic ergonomics, factories, industrial enterprises, workers' health, occupational safety, physiological analysis, psychological analysis

International Congress on Food, Agriculture and Environment Researches in Global World -II

EVALUATION OF COLOR APPLICATION AND TREATMENT IN EDUCATIONAL SPACES: THE CASE OF SCHOOLCRAFT ELEMENTARY SCHOOL

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ABSTRACT

Color plays a crucial role in architectural design, shaping perception, psychology, and user interaction. When paired with suitable materials, it enhances ergonomics, providing comfort and functional support. In educational environments, especially for children, bright yet balanced tones help improve focus, stimulate creativity, and maintain positive emotions. This study analyzes the design of Schoolcraft Elementary School (Michigan, USA) – winner of the 2024 Merit Award – which applies green, yellow, and soft purple tones with complementary materials to define functions and create visual harmony. The paper also proposes solutions to optimize the color palette, maximizing visual impact, improving spatial orientation, and enhancing the overall learning experience.

Keywords: Color in architecture, educational design, ergonomics, educational design

International Congress on Food, Agriculture and Environment Researches in Global World -II

THE ART OF STAGE LIGHTING: AN ANALYSIS OF HOW DYNAMIC LIGHTING DESIGN AND PERFORMANCE TECHNOLOGIES IMPACT AUDIENCE EMOTION AND ENERGY EFFICIENCY IN THEATRES

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ABSTRACT

This study analyzes the dual impact of modern stage lighting design, a field where artistic expression must increasingly align with sustainable practices. Traditionally, theatrical lighting has been a significant consumer of energy, posing a challenge for an industry focused on both creative excellence and environmental responsibility. This research investigates how dynamic lighting design, enabled by advanced LED technology and intelligent control systems, simultaneously influences audience emotions and optimizes energy efficiency in contemporary theatre productions. By moving beyond traditional incandescent and halogen fixtures, lighting designers can now utilize a vast and versatile palette of colors, movements, and intensities with a fraction of the power consumption. The analysis explores how these technological innovations not only allow for more intricate and emotionally resonant visual narratives but also lead to substantial reductions in electricity usage and heat generation, thereby cutting operational costs and carbon footprints. Our findings demonstrate that a well-designed, technologically advanced lighting scheme is not a compromise between art and efficiency, but rather a powerful synergy. The integration of smart, low-power lighting solutions proves to be a key driver for both enhancing the audience's sensory experience and making theatrical productions more economically and environmentally sustainable. This research advocates for a new standard in theatrical practice, where artistic brilliance and energy consciousness are mutually reinforcing goals, redefining the art of stagecraft for the modern era.

Keywords: Stage Lighting Design, Energy Efficiency, Audience Experience, LED Technology, Sustainable Theatrical Production.

International Congress on Food, Agriculture and Environment Researches in Global World -II

THE ARCHITECTURE OF ILLUMINATION: ERGONOMIC LIGHTING STRATEGIES FOR TEMPORARY FASHION SPACES

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ABSTRACT

In the context of fashion runway design, lighting is often approached as a theatrical element to enhance visual drama. However, from an architectural and spatial design perspective, lighting also plays a crucial ergonomic role in shaping how users: models, audience members, and media crews, interact with and navigate the environment. This research investigates the integration of ergonomic lighting principles within runway architecture, focusing on how spatial lighting affects visual clarity, comfort, material perception, and spatial orientation. It examines how architectural lighting design can influence not only the presentation of garments but also the safety of movement and the audience's cognitive and emotional response. By analyzing runway configurations, light placement, and material reflectivity, the study aims to propose a human-centered approach to lighting that balances spectacle with function. The outcome contributes to the broader discourse on ephemeral architecture, where form, light, and user experience intersect in high-performance temporary spaces.

Keywords: Ergonomics, Fashion Runway, Visual Perception, Spatial Navigation, Ephemeral Architecture.

International Congress on Food, Agriculture and Environment Researches in Global World -II

COLOR DESIGN FOR EMOTIONAL SUPPORT IN HEALTHCARE: THE TSURUMI CHILDREN'S HOSPICE CASE STUDY

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ABSTRACT

Hospitals are often known as places where patients are treated for their illnesses. However, many hospitals today usually use cold tones to design hospital spaces. Hospital design seldom incorporates natural elements. Hospitals become a place that few people want to go because of the cold, stuffy atmosphere. We report how to use and apply color in the hospital to suit patients when they need treatment. Using the color wheel and seeing the characteristics and functions of color. Researching for the TSURUMI Children's Hospice, the report will describe the color used in the treatment space for sick children. Our results show that it brings the space closer, helps children become safe, and has a cheerful mentality when being treated. This work has shown that using color intelligently will help the psychology of the patient become stable and cheerful and enable them to recover quickly.

Keywords: Color application, Treatment space, Safe environment, Natural elements, Cheerful mentality, Psychology of patients

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İlgili makama;

2. Uluslararası Küresel Dünyada Gıda,Tarım ve Çevre Araştırmaları Kongresi 24-26 Ağustos 2025 tarihleri arasında New York ABD’de 12 farklı ülkenin akademisyen/araştırmacılarının katılımıyla gerçekleşmiştir. Kongre kapsamında sunumu yapılan 35 bildirinin 11 adeti Türkiye’den katılımcılar tarafından; 24 bildiri ise 12 ülkeden katılımcılar tarafından sunulmuştur. Kongre 16 Ocak 2020 Akademik Teşvik Ödeneği Yönetmeliğine getirilen *“Tebliğlerin sunulduğu yurt içinde veya yurt dışındaki etkinliğin uluslararası olarak nitelendirilebilmesi için Türkiye dışında en az beş farklı ülkeden sözlü tebliğ sunan konuşmacının katılım sağlaması ve tebliğlerin yarıdan fazlasının Türkiye dışından katılımcılar tarafından sunulması esastır.”* değişikliğine uygun düzenlenmiştir.

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Kurumumuzun Yönetim Kurulu 15 Ocak 2024 tarihinde saat 10.30’da “Bilimsel Diplomasi Projesi” görüşmeleri ile “Bilimsel Kongreler Düzenlenmesi” gündemleri ile toplanmış ve alınan (2 numaralı) karara istinaden aşağıda detayları yazılı olan bilimsel etkinliğin düzenlenmesine ve etkinliğe ilişkin resmi görevlendirme konusunda karar vermiştir.

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