INTERNATIONAL ACADEMIC STUDIES IN ENGINEERING

June 2024

EDITORS

PROF. DR. COŞKUN ÖZALP

PROF. DR. SELAHATTIN BARDAK

SERÜVEN YAYINEVİ

Genel Yayın Yönetmeni / Editor in Chief • C. Cansın Selin Temana

Kapak & İç Tasarım / Cover & Interior Design • Serüven Yayınevi

Birinci Basım / First Edition • © Haziran 2024

ISBN • 978-625-6319-52-3

Serüven Yayınevi / Serüven Publishing
Türkiye Adres / Turkey Address: Kızılay Mah. Fevzi Çakmak 1. Sokak
Ümit Apt No: 22/A Çankaya/ANKARA
Telefon / Phone: 05437675765
web: www.seruvenyayinevi.com
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Baskı & Cilt / Printing & Volume
Sertifika / Certificate No: 47083

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Chapter 1

PETROGRAPHIC CHARACTERISTICS OF ÇALTEPE FORMATION CARBONATES AROUND CANKURTARAN (AKŞEHIR, KONYA, TÜRKIYE)

Ali Müjdat ÖZKAN[1]

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1. Introduction

Çaltepe Formation limestones (Lower-Middle Cambrian) hold an important place in the geological development of Turkey. The study area is located around Cankurtaran (Akşehir, Konya) Village, in the southeast of the Sultandağları Massif, located within the Taurids Main Tectonic Unit (Figure 1). A measured stratigraphic section was taken from the Çaltepe Formation and 35 limestone (one sample is dolomitic limestone) samples were collected (Figures 2-4). Thin sections were made from these limestone samples collected from the study area, their textural properties were examined under a polarizing microscope, and the rock was named according to Dunham's (1962) classification. In thin-section studies, alizarin red-s staining test was applied to distinguish between calcite and dolomite minerals in the limestones. According to this staining test, it was determined that all of the Çaltepe Formation samples were limestone and did not include dolostone.

Figure 1. Location map of the study field (Google Maps).

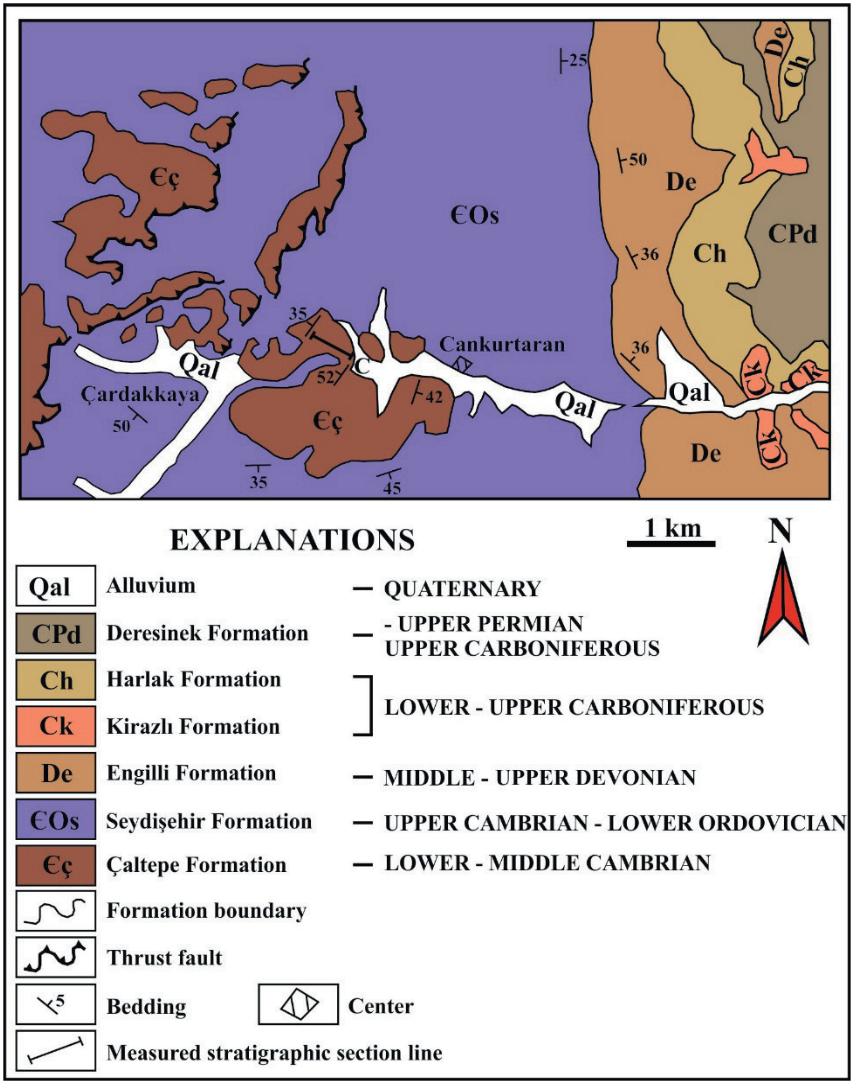


Figure 2. Geological map of the study field (modified from Özkan and Küpeli, 2017).

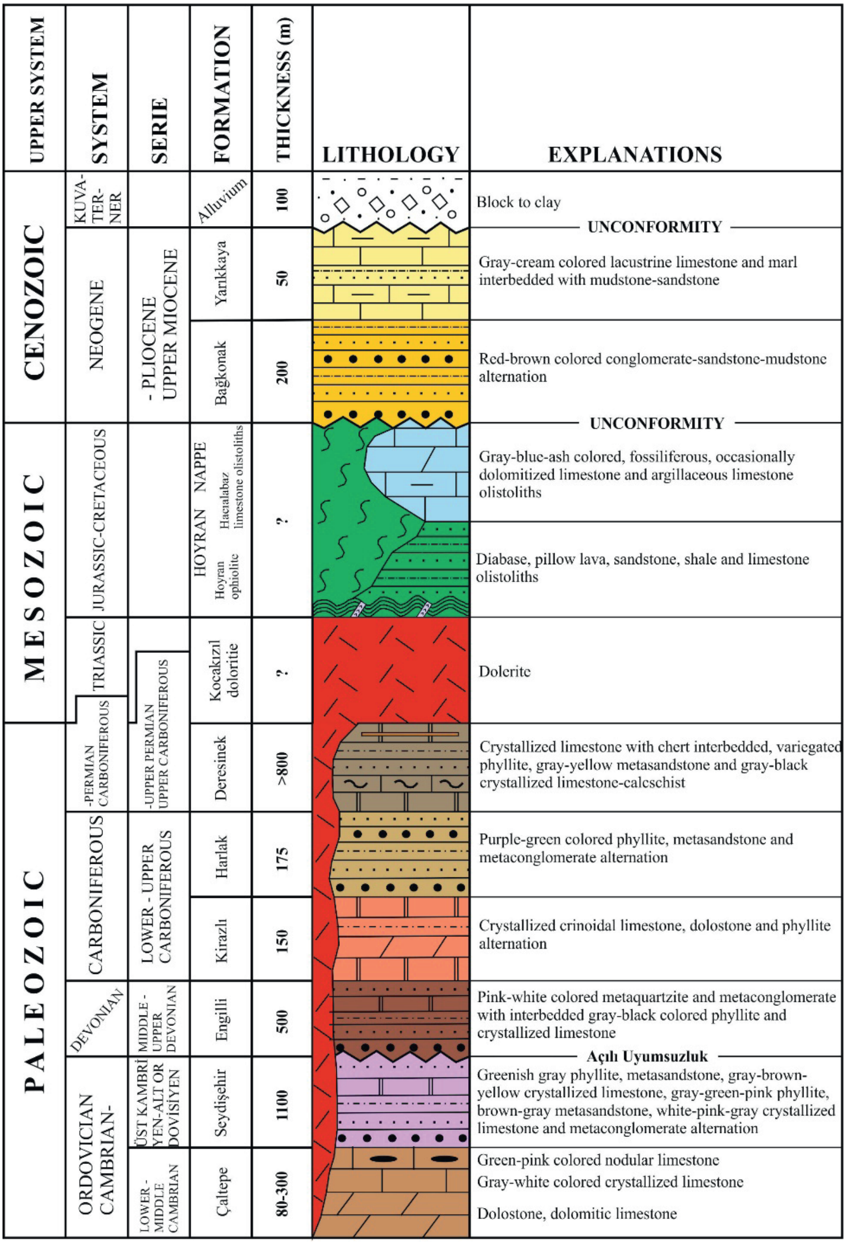


Figure 3. Stratigraphic colon section of the study field (modified from Özkan and Küpeli, 2017).

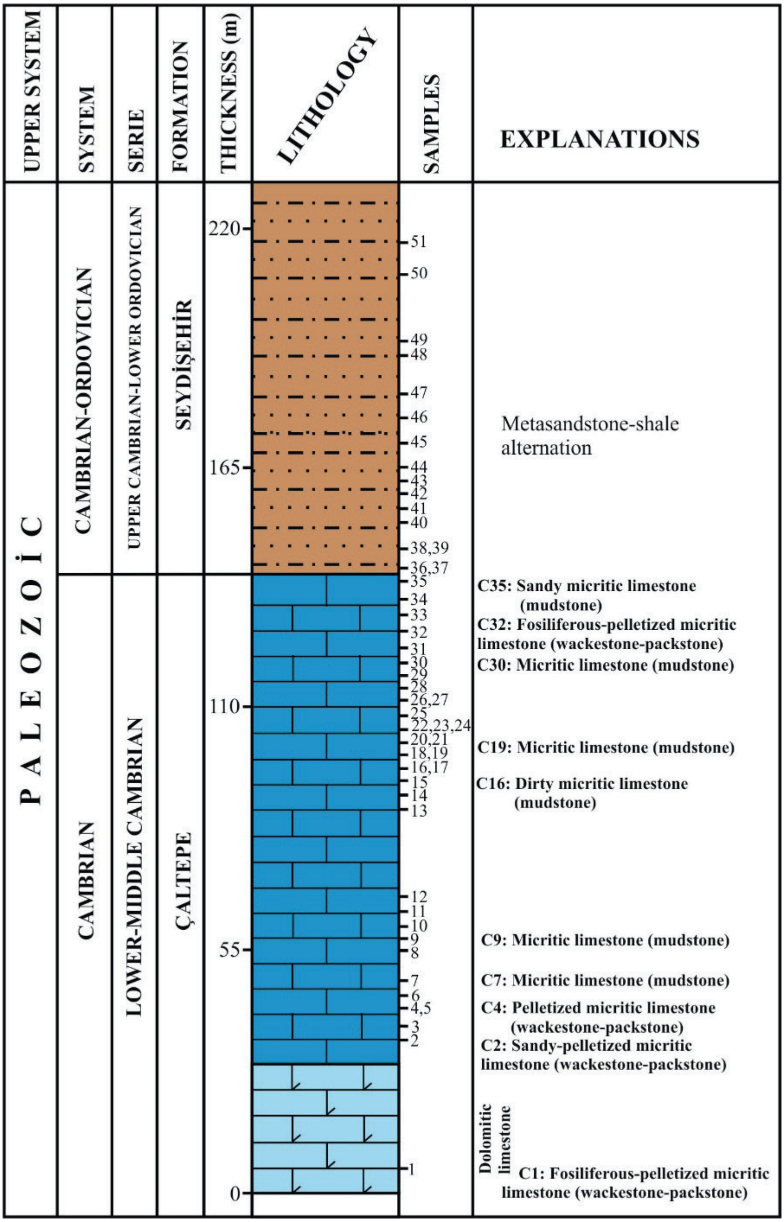


Figure 4. Measured stratigraphic section of the Çaltepe Formation (modified from Özkan and Küpeli, 2017).

Özgül (1997), in his study outside the study area, stated that the Çaltepe Formation consists of dolostone, dolomitic limestone, and neritic limestone at the base, and that it consists of variegated colored nodular limestones with thin shale intercalations at the upper levels. In our study area, the Çaltepe Formation does not include dolostone and features dolomitic limestone, limestone, and nodular limestone (Figure 5-9).

Figure 5. Dolomitic limestone of the Çaltepe Formation (west of Cankurtaran Village).

Figure 6. Laminated of the Çaltepe Formation (west of Cankurtaran Village).

Figure 7. Thin-thick layered limestone belonging to the Çaltepe Formation (west of Cankurtaran Village, looking N).

Figure 8. Thin-medium layered shale belonging to the Çaltepe Formation (west of Cankurtaran Village).

Figure 9. Nodular limestone belonging to the Çaltepe Formation (west of Cankurtaran Village).

The formation begins with beige-gray colored, thick-layered, hard, partially dolomitic limestone at the bottom around Cankurtaran Village (Figures 4, 5). It passes into cream-coloured, medium-thick-bedded, laminated limestone towards the top (Figures 4, 6). While the formation passes into light gray, thin-thick layered limestone towards the upper level (Figures 4, 7), it passes into intermediate levels limestone with yellowish green shale (Figures 4, 8) at the higher level. At the highest level, the formation passes into purplish-pink-colored nodular limestone (Figures 4, 9).

Since the Çaltepe Formation represents the oldest unit in the study area, it has not been determined which unit it overlaps and in what way. However, outside the study area, Özgül (1997) stated in his study that the Çaltepe Formation overlies the Hamzalar Formation with a conformable contact.

In the study area, the Çaltepe Formation tectonically thrusts itself onto the Seydişehir Formation and is covered by the Seydişehir Formation with a conformable contact from above (Figure 2-4). The thickness of the Çaltepe Formation was measured as 137 meters in the measured stratigraphic section (Figure 4).

In this study, no fossils that could give an age were found from the limestones of the Çaltepe Formation. Dean and Monod (1970) found trilobite fossils indicating Early Cambrian in the lower levels and Middle Cambrian in the upper levels of the upper part of the dolomitic limestone member of the Çaltepe Formation, where they worked around Seydişehir, and gave the unit a Lower-Middle Cambrian age. In this study, the unit was given a Lower-Middle Cambrian age.

Çaltepe Formation limestones were deposited in a shallow-deep shelf environment dominated by carbonate development, according to their paleontological and microfacies characteristics.

2. Petrographic Characteristics of the Çaltepe Formation Limestones

According to the measured stratigraphic section, Çaltepe limestones begin with gray-coloured, thick-layered dolomitic limestones (wackestone-packstone) at the base and end with sandy micritic limestone (mudstone) at the ceiling (Figure 4).

Beige-gray colored, dolomitic limestones (in the C1 sample) are medium-thickly bedded, microsparitic in nature, and contain small-grained, subhedral quartz crystals (Figure 10A). In addition to microsparitic cement, micritic matrix (Figure 10B) is also commonly found. Dissolution cavities with a diameter of 0.16 to 3.5 mm are observed (Figure 10A-C). In addition, small amounts of small grained (silt sized) iron oxide components (Figure 10A) and iron oxide cement (Figure 10B) are also observed in the sample. These dolomitic limestones contain allochems in the form of fossils (10-12%) and pellets (22-26%). Dolomite crystals are euhedral and subhedral. Microsparicalcite cement and micritic matrix were observed as binders in these dolomitic limestones. Considering the microscopic features of this sample, it was observed that they were wackestone-packstone according to Dunham's (1962) classification.

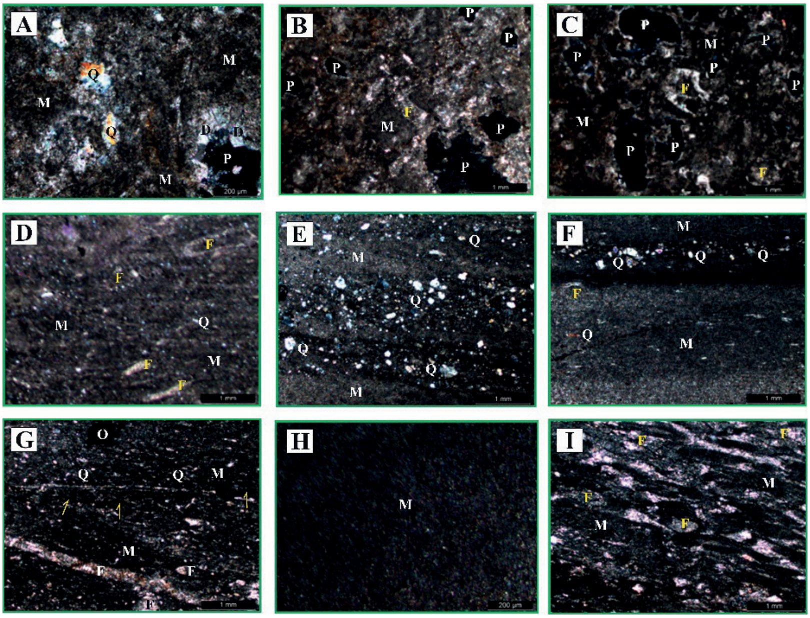


Figure 10. A) Subhedral quartz crystals, fossil fragment preserved as ghost, and porosity in fossiliferous-pelletized limestone (Sample: C1; XPL), B) Fossil, iron oxide cement, opaque mineral, micritic matrix and microsparitic cement in fossil-pelleted limestone (Sample: C1; XPL), C) Fossil, iron oxide cement, opaque mineral, micritic matrix and microsparitic cement in fossil-pelleted limestone (Sample: C1; XPL), D) Fossil, pellet, quartz, opaque mineral, micritic matrix (Sample: C2; XPL), E) Quartz minerals, opaque minerals and lamination observed occasionally in sandy-pelleted limestones (Sample: C2; XPL), F) Quartz minerals, opaque minerals and lamination observed occasionally in sandy-pelleted limestones (Sample: C2; XPL), G) Stylolite and calcitic vein in pelletized-micritic limestones (Sample: C4; XPL), H) Micritic limestone and occasionally opaque minerals (Sample: C19; XPL), I) Fosil, pellet, mikritik matriks, elongation and orientation developed in quartz and calcite crystals as a result of low-grade metamorphism in dirty limestone (Sample: C32; XPL).

Çaltepe Formation, which develops entirely as limestone (in the C2 sample) towards the top, is gray in color, medium-thickly layered, and laminated (Figure 4, 10D-F). It contains abundant silt-sized quartz minerals at some levels (Figure 10E, F). A small amount of fossils (2-6%; mostly bioclasts; Figure 10D) and abundant pellets (15-30%; Figure 10D-F) were observed in the limestones at this level. It contains microsparicalcite cement and micritic matrix as binders. Considering the microscopic features of this sample, it was observed that they were wackestone-packstone (dirty/sandy) according to Dunham's (1962) classification.

In some levels of Çaltepe limestone (C4 sample), fossils (8-15%), pellets (15-25%), trace amounts of apatite minerals, micritic matrix, and microsparicalcitic cement (Figure 10G) were observed. Additionally, opaque mineral-filled stylolite development and sparicalcitic veins were also observed in this sample (Figure 10G). Considering the microscopic features of this sample, it was determined that they were wackestone-packstone according to Dunham's (1962) classification.

Trace amounts of opaque minerals and micritic matrix were observed in some levels of the Çaltepe limestone (C19 sample) (Figure 10H) and it was called mudstone according to the classification of Dunham (1962).

In the microscopic examination of the nodular limestone sample (C-32) taken from the upper level of Çaltepe limestone, fossils (10-17%), pellets (13-20%), quartz (5-10%), and micritic matrix and microsparicalcitic cement were observed (Figure 11I). As a result of microscopic examination, this sample was named wackestone-packstone according to Dunham's (1962) classification.

3. Discussion

Çaltepe Formation limestones represent the development in limited circulation shelf (facies zone 8) and open circulation shelf lagoon (facies zone 7) depositional environments, according to their paleontological and sedimentological characteristics.

The main diagenetic processes affecting carbonate sediments and rocks are; micritization, dissolution and cementation, compaction, neomorphism, dolomitization, and the transformation of carbonate grains and matrix into non-carbonate minerals (Flügel, 2010). The components that make up carbonates are: fossils (whole and/or bioclasts), ooids, pellets, and intraclasts, and their binders are micritic matrix and/or sparicalcitic cement (Flügel, 1982; Flügel, 2010).

Micritization processes are controlled by biological and chemical factors and can occur in shallow and deep marine environments as well as in terrestrial and lacustrine environments (Flügel, 2010). Permanent micritization results in the formation of carbonate muds (Flügel, 2010). The micritization (mudstone/micritic matrix development) observed in Çaltepe limestones was also caused by biological and chemical factors.

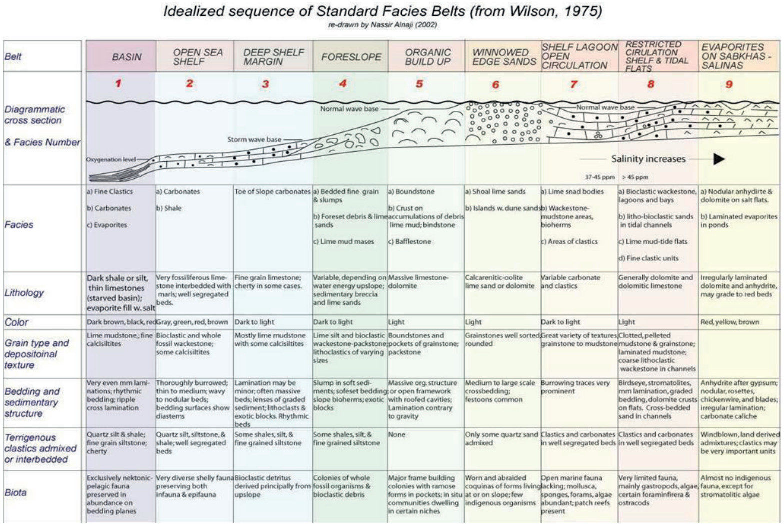
Insufficient saturation of pore fluids compared to carbonate causes the unstable carbonate grains and cement to dissolve (Flügel, 2010). Dissolution is especially effective in shallow meteoric environments near the surface, deep burial environments (Steinsund and Hald, 1994; Flügel, 2010), and deep marine environments (Berelson et al., 1994; Flügel, 2010), seawater is less saturated than aragonite and Mg-calcite (Morse and Rolf, 2002; Flügel, 2010). The dissolutions observed in Çaltepe limestones must have developed as the dissolution of unstable minerals under the influence of pore fluids in shallow, near-surface meteoric environments and shallow-medium-deep environments.

Following mechanical compaction, many sediments undergo chemical compaction, expressed by pressure dissolution and the formation of stylolites and dissolution wrinkles, often associated with fracture structures (Flügel, 2010). It is caused by pressure dissolution, loading, and/or tectonic stress. In stronger cemented rocks, dissolution forms over large surfaces, forming stylolites (Flügel, 2010). Concentrations of insoluble residues along stylolite surfaces are commonly observed. Dissolution wrinkles have isolated or stack-like lines characterized by fine wrinkles, where mostly insoluble residues accumulate (Flügel, 2010). Stylolitization replaces original depositional textures and produces new diagenetic textures (Flügel, 2010). Compaction and pressure dissolution (stylolitization) explain the mechanical and chemical processes triggered by increased overload, increased temperature, and pressure conditions of sediments during the burial process (Flügel, 2010). The stylolites observed in the Çaltepe limestones were interpreted as being developed by both mechanical and chemical compression and tectonic effects.

Cementation involves processes that lead to the precipitation of minerals in primary or secondary pores and requires supersaturation of pore fluids with respect to the mineral (Flügel, 2010). The calcite cement observed in Çaltepe limestones developed as a result of the pore fluids reaching supersaturation in terms of $CaCO_3$.

Neomorphism (Folk, 1965) is a term that summarizes all the transformations that occur between a mineral and itself or a polymorph in the presence of water through dissolution-reprecipitation processes (Flügel, 2010). Recrystallization refers to changes in crystal size, crystal shape, and crystal lattice orientation without changes in mineralogy (Flügel, 2010). Recrystallized limestones are predominantly characterized by changes in the size, shape, and arrangement of crystals and destruction of the original depositional textures and components. Recrystallization of micritic limestones can be controlled by the clay content of the limestones, and it is suggested that a clay content of >2% restricts or prevents crystal coarsening (Bausch, 1968; Flügel, 2010). We can state that the recrystallization observed in the limestones of the Çaltepe Formation also developed due to neomorphism processes.

As a result, the depositional environment of Çaltepe Formation limestones is a carbonate-dominated shelf environment. We can state that it developed as mudstone, wackestone and packstone microfacies in the carbonate belt environments expressed by Wilson's (1975) numbers 7 (shelf lagoon; open circulation) and 8 (shelf and tidal flats; limited circulation) (Figure 19).



Belt	BASIN	OPEN SEA SHELF	DEEP SHELF MARGIN	FORESLOPE	ORGANIC BUILD UP	WINNOWED EDGE SANDS	SHELF LAGOON OPEN CIRCULATION	RESTRICTED CIRULATION SHELF & TIDAL FLATS	EVAPORITES ON SABKHAS - SALINAS
Diagrammatic cross section & Facies Number	1	2	3	4	5	6	7	8	9
Facies	a) Fine Clastics b) Carbonates c) Evaporites	a) Carbonates b) Shale	Toe of Slope carbonates	a) Bedded fine grain & slumps b) Foreset debris & lime sands c) Lime mud mases	a) Boundstone b) Crust on accumulations of debris lime mud; bindstone c) Bafflestone	a) Shoal lime sands b) Islands w. dune sands	a) Lime snad bodies b) Wackestone-mudstone areas, bioherms c) Areas of clastics	a) Bioclastic wackestone, lagoons and bays b) litho-bioclastic sands in tidal channels c) Lime mud-tide flats d) Fine clastic units	a) Nodular anhydirte & dolomite on salt flats. b) Laminated evaporites in ponds
Lithology	Dark shale or silt, thin limestones (starved basin); evaporite fill w. salt	Very fossiliferous limestone interbedded with marls; well segregated beds.	Fine grain limestone; cherty in some cases.	Variable, depending on water energy upslope; sedimentary breccia and lime sands	Massive limestone-dolomite	Calcarenitic-oolite lime sand or dolomite	Variable carbonate and clastics	Generally dolomite and dolomitic limestone	Irregularly laminated dolomite and anhydrite, may grade to red beds
Color	Dark brown, black, red	Gray, green, red, brown	Dark to light	Dark to light	Light	Light	Dark to light	Light	Red, yellow, brown
Grain type and depositoinal texture	Lime mudstone,; fine calcisiltites	Bioclastic and whole fossil wackestone; some calcisiltites	Mostly lime mudstone with some calcisiltites	Lime silt and bioclastic wackestone-packstone; lithoclastics of varying sizes	Boundstones and pockets of grainstone; packstone	Grainstones well sorted; rounded	Great variety of textures; grainstone to mudstone	Clotted, pelleted mudstone & grainstone; laminated mudstone; coarse lithoclastic wackestone in channels	
Bedding and sedimentary structure	Very even mm laminations; rhythmic bedding; ripple cross lamination	Thoroughly burrowed; thin to medium; wavy to nodular beds; bedding surfaces show diastems	Lamination may be minor; often massive beds; lenses of graded sediment; lithoclasts & exotic blocks. Rhythmic beds	Slump in soft sediments; sofeset bedding; slope bioherms; exotic blocks	Massive org. structure or open framework with roofed cavities; Lamination contrary to gravity	Medium to large scale crossbedding; festoons common	Burrowing traces very prominent	Birdseye, stromatolites, mm lamination, graded bedding, dolomite crusts on flats. Cross-bedded sand in channels	Anhydrite after gypsum; nodular, rosettes, chickenwire, and blades; irregular lamination; carbonate caliche
Terrigenous clastics admixed or interbedded	Quartz silt & shale; fine grain siltstone; cherty	Quartz silt, siltstone, & shale; well segregated beds	Some shales, silt, & fine grained siltstone	Some shales, silt, & fine grained siltstone	None	Only some quartz sand admixed	Clastics and carbonates in well segregated beds	Clastics and carbonates in well segregated beds	Windblown, land derived admixtures; clastics may be very important units
Biota	Exclusively nektonic-pelagic fauna preserved in abundance on bedding planes	Very diverse shelly fauna preserving both infauna & epifauna	Bioclastic detritus derived principally from upslope	Colonies of whole fossil organisms & bioclastic debris	Major frame building colonies with ramose forms in pockets; in situ communities dwelling in certain niches	Worn and abraided coquinas of forms living at or on slope; few indigenous organisms	Open marine fauna lacking; mollusca, sponges, forams, algae abundant; patch reefs present	Very limited fauna, mainly gastropods, algae, certain foraminfirera & ostracods	Almost no indigenous fauna, except for stromatolitic algae

Figure 19. Wilson's standard microfacies belt (Wilson, 1975; reproduced by Alnaji, 2002).

4. Conclusions

Çaltepe Formation limestones were formed as mudstone, wackestone, and packstone microfacies in the open circulation shelf lagoon and limited circulation shelf and tidal flat carbonate belt environments.

The abundance of fossils in the Çaltepe limestones emphasizes the development of environmental conditions in which these limestones were deposited in a warm climate that was conducive to organism life.

While the presence of abundant micritic matrix in Çaltepe limestones indicates precipitation under low energy conditions, the observation of bioclasts indicates relatively high energy conditions.

While the pellets found in Çaltepe limestones indicate the formation of invertebrate organism excretions as fecal pellets, bioclasts indicate the formation of the shells of organisms on the ground by seawater waves and currents during stormy phases.

The observation of microsparites together with the micritic matrix shows the effect of neomorphism in the diagenetic process.

Stylolites observed in Çaltepe limestones indicate pressure dissolutions in the diagenetic process that developed under the influence of loading and/or tectonic stresses.

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Chapter 2

FRAUD PREVENTION AND DETECTION SYSTEMS RUNNING WITH DIGITAL ONBOARDING

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1. INTRODUCTION

In recent years, advancements in technology within the banking system, coupled with an increasing interest in technology, have led to a proliferation of usage and diversity in the financial sector, making banking fraud a problem with widespread ramifications. The growing dependence on new technologies such as cloud computing and mobile computing further exacerbates the issue. Traditional methods involving manual detection are not only time-consuming, expensive, and prone to errors, but also impractical in the era of big data. It is inevitable for financial institutions to transition towards automated and more efficient processes using statistical, computational methods, machine learning, and artificial intelligence.

It is not surprising that numerous organizations are investing significant resources in safeguarding their networks and data from both internal and external threats, leveraging a combination of technologies and advanced mechanisms (Eberle & Holder, 2009). Specifically, the focus is on examining the interactions and behaviors of commercial customers or users within a network. Interactions, depicted as intermediate connections and relationships among data objects, are scrutinized using data mining and machine learning techniques to identify potential anomalies indicative of fraud (Leman Akoglu, 2014).

The rapid and almost simultaneous emergence of technologies such as smartphones, mobile payments, cloud computing, contactless payments, and online shopping, among others, has facilitated the occurrence of large scale data breaches (Ferreira, 2020)

However, innovative and sophisticated techniques related to fraud consistently emerge, hence the urgent necessity for the development of advanced and dynamic techniques capable of adapting to rapidly evolving fraud patterns (Ferreira, 2020).

This article examines the implementation of an integrated fraud detection and prevention system in a banking environment, focusing on emerging next-generation rule-based techniques and incorporating trend technologies such as Artificial Intelligence-supported systems, Voice Biometrics, and Digital Onboarding systems. With the increasing use of channels in the financial sector (Digital Banking, Mobile Banking, ATMs, Internet banking, etc.), bank customers are exposed to greater threats and fraud. Consequently, there is a growing need for smarter, advanced, and autonomous fraud systems driven by evolving technology. Particularly, the banking sector's customers face greater challenges and various threats. The Turkish banking sector, aiming to detect and prevent potential threats to its customers, is increasingly leveraging evolving technologies to maximize customer protection. The implementation of a fraud detection system in the banking sector is of vital importance for preemptively identifying and mitigating financial losses, thereby safeguarding customers. Banks are obligated to fulfill their responsibility of customer protection using the most advanced technologies available.

1.1 Definition and Purpose:

Fraud detection entails identifying and preventing fraudulent activities occurring within applications, APIs, systems, transactions, and datasets. By leveraging a variety of methods and technologies to monitor transactions and customer behaviors, it aims to detect patterns, anomalies, or suspicious behaviors that may signify fraudulent actions or transactions. The primary objective of fraud detection is to preemptively identify and counteract fraudulent activities, thereby reducing financial losses, safeguarding assets, maintaining operational integrity, ensuring regulatory compliance, and preserving customer trust and loyalty (F5.com, 2024).

Fraud prevention and detection systems hold significant importance for various reasons. Fraudulent activities can lead to substantial financial losses and disrupt regular business operations, causing delays and damaging reputations for both individuals and organizations. Many sectors are subject to regulatory obligations concerning fraud prevention, and failure to detect and report fraud can result in legal repercussions and monetary penalties. Additionally, fraud detection is closely linked to data security; safeguarding sensitive information against fraudulent access or theft constitutes a crucial aspect of overall cybersecurity efforts (F5.com, 2024).

1.2 Types of Fraud in Banking

The banking sector faces significant challenges in detecting and preventing fraud due to the diverse nature of potential criminal activities. Fraud manifests itself in various forms:

• Account hijacking deception • Corporate electronic correspondence exploitation • Affiliation deception • Romantic deception schemes • Senior citizen deception • Deception schemes regarding remote employment opportunities • Triangulation deception • Personnel deception (internal deception) • Deception regarding goods and services • Impersonation schemes resembling the IRS • Impersonation schemes mimicking social security administration • Deception schemes related to travel • Fabricated item schemes • Fraudulent billing deception • Deception involving authorized fund transfers • Fabricated assertion • Artificial identity deception • Deception regarding credit cards • In-person credit card deception • Remote credit card deception • Pushing credit limits deceitfully • Deceptive trial usage of cards	• Wire transfer deception • Incoming wire scam • FedNow payment manipulation • Real-time payment deception • ATM deposit manipulation • ATM withdrawal manipulation • Cheque deception • Title manipulation • Deception regarding mortgages • Mobile cheque deposit scam • Duplicate cheque identifier • Cheque identifier alteration • Fraudulent return transactions • Stolen or duplicated cheques • Advanced payment fraud • Deception involving chargebacks • Scams in the medical sector • Fraudulent merchant acquirer activities • Fraudulent front-facing businesses • Deception in payroll or disbursements • Deception involving loans • Deception perpetrated by the first party • Abnormal loan defaults • Abnormal loan activity • Fraud involving inactive accounts • Identity deception • Manipulative card resale • Shared fraudulent purchase origin • Seized employee payroll

Beyond these well-known methods of fraud, the inevitable reality in the modern financial system is the continual emergence of new forms of fraud and innovative criminal activities (Advantage, 2024).

1.3 Fraud Types

It poses a significant threat to businesses across all sectors and necessitates the implementation of robust fraud detection processes to mitigate its adverse impacts. Fraud detection encompasses a systematic approach to identifying, monitoring, and preventing fraud, which can be executed manually or through automation.

To mitigate risks, businesses can adopt various risk management strategies, including the use of fraud detection software, the establishment of company policies, and the assignment of personnel such as risk managers, security officers, and fraud analysts.

Fraud can manifest in various forms. Here are some of the most common ones:

- Credit Card Information Theft: This occurs when someone steals credit card information and makes unauthorized purchases from the original cardholder.

- Account Takeover: This involves stealing identity information used to steal money or sensitive data ranging from identification documents to financial information.

- Creation of Fake Accounts: Fraudsters create fictitious accounts for financial or personal identification purposes for their own gain.

- Misuse of Rewards/Loyalty: This fraud includes the misuse of accounts offering rewards or loyalty points, including registration bonuses, purchase points, and other related rewards.

- Friendly Fraud: Friendly fraud occurs when the real credit card holder, typically forgets or encounters unexpected issues and disputes a payment.

- Affiliate Fraud: Affiliates in marketing arrangements intentionally direct low-quality traffic to the target site, known as affiliate or traffic fraud, especially affecting sectors like online gambling where aggressors exploit the PPC (pay-per-click) model for profit from artificial traffic.

Return Fraud: Also known as online purchase return fraud, it involves fraudulent individuals exploiting e-commerce store return policies by purchasing products with the intention of obtaining free goods or services through returns with minimal or no cost (cybeready.com, 2024).

1.4 Benefits of Fraud Management Tools:

Using appropriate fraud management tools provides numerous benefits to your organization, including:

Enhanced Security: Fraud management tools allow organizations to detect and prevent fraud in real-time by adding an extra layer of security.

Cost Reduction: Fraud can lead to significant financial losses and damage to reputation. Fraud management tools help reduce these losses and associated expenses.

Regulatory Compliance: These tools assist organizations in complying with legal requirements for fraud prevention and avoiding penalties associated with non-compliance.

Improved Customer Experience: Implementing fraud management tools protects customers from fraud, enhances trust in the organization, thus increasing satisfaction and loyalty.

Time Efficiency: Automation of processes such as fraud detection and investigation with fraud detection and management tools saves organizations time and resources.

Data-Driven Decision Making: Fraud management tools provide real-time data and analytics to facilitate informed decisions regarding fraud prevention and detection.

Cultivation of Fraud Prevention Culture: Implementing fraud management tools encourages a culture within the organization where all employees are vigilant about fraud risks and take proactive measures to combat them.

Integration with Other Systems: Fraud management tools can seamlessly integrate with various systems such as payment processing and customer management, providing a holistic approach to fraud prevention (cybeready.com, 2024).

1.5 Purpose

In the past decade, technology has made significant advancements, making life easier for humans but also bringing various challenges. With the proliferation of technology, banking transactions conducted through the internet and mobile devices have rapidly increased.

As a natural consequence of the widespread use of mobile devices and internet banking, fraudulent activities have also surged. The aim of the project is to detect fraudulent transactions in real-time during financial transactions, thereby reducing the financial and reputational losses incurred by banks by analyzing past cases of fraud and proactively identifying misuse with the latest technologies in a dynamic manner. The banking system continuously strives to combat increasing fraudulent activities by leveraging new technologies. Our article focuses on the development and implementation of a new fraud system based on rule-based and AI-compatible methods in the banking sector. We examine the project with real-life examples, discussing designs, analysis of the methods used, and software infrastructures.

Fighting fraud in the financial sector is a dynamic process that requires constant updates and adaptation to new threats. Therefore, it is essential to design a flexible structure that can easily adapt to innovations and changes. The newly developed fraud system for the banking sector prioritizes clear performance criteria, with various open-source systems included in the architecture to enhance speed

2. LITERATURE REVIEW

Fraud, characterized by deliberate deception or the utilization of unfair tactics, seeks to unlawfully deprive individuals or organizations of property or funds. It represents a pervasive global challenge, affecting organizations across diverse regions and industries worldwide. Evaluating the precise extent of the harm inflicted by occupational fraud can prove challenging due to the intrinsic concealment and deceit inherent in most schemes. Nevertheless, our study provides valuable insights into the magnitude of this issue and its far-reaching repercussions on organizations globally (Warren, 2024).

According to Cressey (1973) fraud can be depicted as a triad structure comprising motive, rationalization, and opportunity. Motive typically arises from acute financial needs, and individuals justify their fraudulent behavior through rationalization, which involves legitimizing such actions through mental states. This behavior is often facilitated by the opportunity to commit fraud due to inadequate internal controls in both private and public institutions (Alfordy, 2022).

In the literature, there exists a concept known as the "fraud triangle," which stems from Donald Cressey's hypothesis (Cress, 1973). The fraud triangle consists of three components: pressure, opportunity, and rationalization. For an individual to commit fraud, all three factors must be present simultaneously.

Pressure is the primary driving force behind the crime. The perpetrator may face financial difficulties that cannot be resolved through legitimate means. For example, they may have a serious illness requiring expensive treatment, unpaid bills, or a desire to earn income to gain the trust of an investor. These circumstances create pressure, leading the individual to engage in fraudulent activities such as embezzlement or falsifying financial records.

The second component is opportunity, representing the ability to commit fraud. The offender may exploit the trust built during their time working at the company to conceal the crime. They perceive the risk of detection to be low, which encourages them to engage in fraudulent activities.

During the rationalization stage, the perpetrator attempts to justify their actions. They convince themselves that they are innocent or morally justified in their actions, believing that the circumstances or external factors compelled them to commit the crime. This process of rationalization allows them to reconcile their behavior with their ethical standards, making the fraudulent activity appear acceptable in their minds

Figure1: *Detection Occupational Fraud 2024: A Report to the Nations (Warren, 2024).*

2.1 Fraud Systems Used by Organizations:

Transaction Monitoring: These systems analyze real-time transactions to flag suspicious activities such as unusual purchases or transactions.

Identity Verification: These tools are used to authenticate customers' identities during onboarding or authentication processes, utilizing methods such as biometrics, facial recognition, video calls, liveness analysis, and document verification.

Risk Scoring: These systems assess various factors, including user behavior, transaction history, and device information, to calculate the likelihood of fraud.

Data Analytics: Leveraging advanced analytics, these systems enable organizations to identify patterns and anomalies in large datasets, helping to identify potential fraudsters.

Advanced Behavioral Analysis: Using machine learning algorithms, these systems analyze user behaviors such as mouse movements and typing patterns to identify unusual activities indicative of fraud.

Device Fingerprinting: By analyzing device-specific information like IP address and browser type, these systems create unique "fingerprints" for each device to detect fraudulent activities originating from unfamiliar devices.

Case Management: These tools facilitate fraud investigations by providing a central platform to track and manage cases, collaborate with team members, and generate reports.

AI-Powered Systems: Utilizing artificial intelligence and machine learning algorithms, these systems analyze large volumes of data in real-time to identify patterns and anomalies indicative of fraud.

Threat Intelligence Stream Monitoring: These tools monitor and analyze threat intelligence streams to detect potential fraud and cyber threats before they impact the organization.

Security Awareness Training: This involves educating employees about fraud and cyber threats, teaching them to recognize and report suspicious activities, and reducing the risk of human error or negligence leading to fraudulent activities.

2.2 Indentity Theft Fact and Statistics :

The Federal Trade Commission's Consumer Sentinel Network took in over 5.39 million reports in 2023, of which 48 percent were for fraud and 19 percent for identity theft. Credit card fraud accounted for 40.2 percent of identify thefts, followed by miscellaneous identity theft at 25.1 percent, which includes online shopping and payment account fraud, email and social media fraud, and other identity theft. Georgia, Florida, and Nevada had the most identity theft reports (Comission, 2024).

According to the Insurance Information Institute in 2023, the five most common types of identity theft are shown as depicted in Table-1 (Institue, 2024) . The report examines various types of identity theft, categorized as Various instances of identity theft, including online shopping and payment account fraud, email and social media scams, medical services, insurance and securities account fraud, and other forms of identity theft. Consumers involved in the study reported multiple types of identity theft, with 15% having records of at least two types of identity theft.

Table 1: *Top Five Types of Identity Theft, 2023 (Institue, 2024)*

Theft identity Type	Quantity of occurrences	Top five (%)
Unauthorized credit card applications leading to fraud	381,122	42.00
Various instances of identity theft	279,221	30.7
Unauthorized bank account openings resulting in fraud	84,335	9.3
Application for/receipt of government benefits through fraudulent means	82,419	9.1
Deception involving business or personal loans	81,342	9
Unauthorized credit card applications leading to fraud	**908,439**	**100.00**

Cases of fraud and identity theft have nearly tripled in recent years, and continue to escalate dramatically as depicted in Figure 2 (Comission, 2024). It is expected that the increase will continue to accelerate in the coming years, driven by advancing technology and increasing diversity of usage.

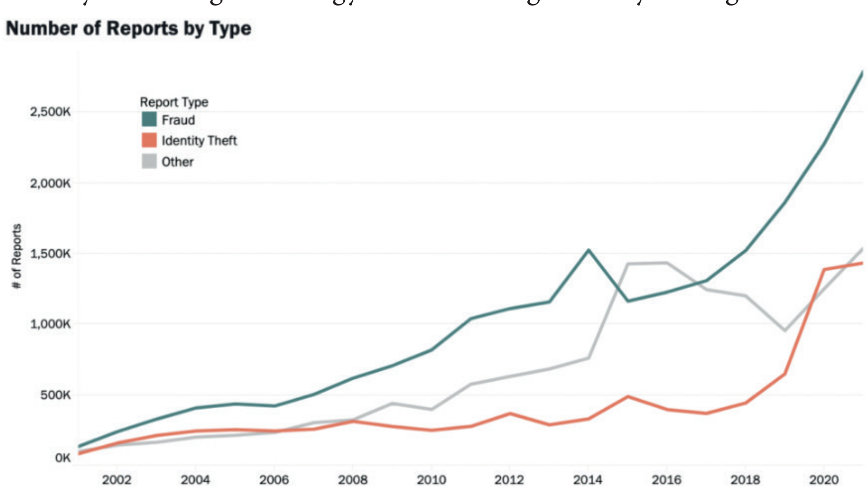

Figure 2: *Number of Reports by type (Comission, 2024).*

Identity theft cases have reached unprecedented levels due to the proliferation of various identity theft methods. From conventional forms of identity theft to more sophisticated ones like synthetic identity theft, the spectrum of techniques employed is widening. Experts suggest that these incidents are occurring with such frequency that a new victim emerges every 22 seconds. Most studies forecast that this rate will further escalate in 2024, exacerbating the issue for Americans (identitytheft.org, 2024 Identity Theft Facts and Statistics, 2024)

3.STATE OF ART

The aim of the project is to detect and prevent any fraudulent activities and scams in the financial domain. The newly developed system can be utilized in preventing fraud within financial sector systems, as well as detecting fraud in the constantly expanding network of electronic commerce, identity theft, and social engineering scams. By implementing the application in institutions, it aims to prevent financial losses for both the institution itself and its clientele. A robust fraud prevention system not only boosts customer trust but also significantly enhances operational efficiency within organizations. Consequently, high performance and speed hold paramount importance in the project. Utilizing next-generation technologies in the development of the fraud system, fraud rules will be written on the rule engine while analyzing historical data to prevent fraudulent transactions. Since most fraudulent activities nowadays occur in digital environments, the banking sector is prioritized as the primary sector for the implementation of the project.

The project is focused on developing solutions for the detection of the following fraudulent cases.

3.1 Prevention of Social Engineering Frauds:

Social engineering is the most prevalent form of fraud where financial losses are high. The project aims to prevent potential losses by addressing the likely adverse effects of social engineering cases on the institution, as outlined below:

- Damage to reputation and/or goodwill
- Financial loss
- Irreversible disclosure of information
- Legal issues, penalties
- Regulatory fines related to vulnerabilities in institutions
- Institutional asset loss
- nvestment costs for prevention measures

- Loss of time and workforce
- Loss of trust

3.2 Preventing cybercrime and fraud online:

The newly developed solution aims to prevent any fraudulent activities and scams in the financial domain. By ensuring the proper formulation of fraud rules with the new system, alarms will be generated. Instead of expensive foreign products, affordable domestic solutions will be produced. By utilizing open-source code, license costs will also be reduced. A centralized analysis platform will be developed to manage fraud operations, providing management from a single screen. The product will be easily integrated with the systems of institutions using APIs, and a high-performance design will be developed.

- Financial losses due to malware
- Losses due to SIM card swaps
- Losses via information alteration
- Fraudulent activities targeting international money transfer companies
- SWIFT frauds

According to a report published by the Certified Fraud Examiners Association 5% of corporate income is lost annually due to fraud. This figure is estimated to be $5 trillion worldwide. We anticipate an increase in efforts to overcome malicious software installations and more advanced security measures such as biometric authentication, in addition to two-factor authentication. As mobile banking and payments continue to rise, so will fraud. However, just as criminals use technology to commit fraud, companies are also developing technologies to prevent it. We will see further development of intelligent systems using artificial intelligence and machine learning to detect and stop fraud. Custom-built and adaptive software, capable of learning over time, are proving to be indispensable in the fight against fraud. As the threat continues to grow, there will be an increasing demand for these effective fraud prevention solutions from banks and stakeholders.

Identity fraud: Every day, millions of fake official emails or text messages are sent from banks, companies, and many other sources. These emails contain links that, when clicked by an unsuspecting victim, automatically download and install malicious software on their device to collect the personal information needed to take over the account. A separate study by the National Cyber Security Centre shows that the average loss amount has also increased; from £549 between November 2020 and January 2021 to £775 in the same period a year later.

Social Engineering: Social engineering and simple impersonation techniques over the phone can also be used to trick victims into making payments to accounts controlled by fraudsters. For example, victims may be told that their accounts have been compromised and that they need to transfer their money to a new account to prevent it from being stolen.

Losses are expected to double in the UK, India, and the US over the next four years. This suggests that in the UK alone, it could reach $1.56 billion by 2026. Therefore, although a wide variety of banking frauds are commonly attempted, there is only one reliable way to detect and prevent them: comparing the fraudulent transaction with the historical behavior model associated with the account holder or system user. Focusing on the account holders' normal behavior is critical for detecting and flagging anomalies (Warren, 2024) .

Artificial intelligence-based anti-fraud software monitors all account transactions and evaluates them against the built-in behavioral profile of the account holder or their counterparts. Thus, inconsistent transactions with the user's profile will be detected, preventing fraudulent payment requests and withdrawal transactions.

3.3 The Impact of Video Calls and Livelihood Analysis on Fraudulent Transactions

The technology of video calls has become an integral part of fraud detection and prevention methods in the financial sector. With many advantages such as identity verification, behavioral analysis, dynamic authentication processes, and enhancing customer trust, banks can more effectively detect and prevent fraudulent attempts. This technology, offering real-time detection capabilities, strengthens financial fraud prevention strategies and subsequently enhances customer satisfaction. The importance of video calling in combating fraud underscores the need for financial institutions to adopt and utilize this technology more widely and effectively.

In the process of monitoring fraudulent transactions, the importance of directly communicating with the real customer and confirming transactions when unusual activities are detected is undeniable. When a transaction on an compromised account is confirmed by the fraudster during a call, it can lead to financial loss as well as damage to customer and sector reputation.

Video calling is the most effective way to directly communicate with the customer and verify their identity. It provides a personal and reliable communication channel for the customer, while also allowing the financial institution to evaluate the overall behavior of the person through techniques such as tone of voice, facial expressions, and speech-to-text, thus clarifying suspicious situations.

With advancements in technology and the increase in sample cases, video call data can be quickly analyzed using machine learning and artificial intelligence algorithms to identify transactions with fraudulent characteristics without the need for individual assessment.

3.4 Technology Used in Fraud Detection and Prevention System Project

Net Core: It is used as the programming language for API integrations. Angular: It is the programming language used for developing front-end web screens.

Mongo DB: It serves as an open-source system for performing efficient queries and plays a significant role in minimizing license costs in the project.

Postgre SQL: While used as the database, the application can also work compatibly with different database systems. Open-source Linux-based systems are preferred as the infrastructure for the project, benefiting from advantages such as licensing benefits, continuity, and low resource requirements with high performance.

Rule Manager Engine: Fraud rules are developed on the Rule Engine, and fraudulent transactions are managed with these rules. The Rule Engine mechanism, specially developed for the project, is designed to be compatible with new technologies and capable of rapid adaptation.

Artificial Intelligence: Learning mechanisms are established with AI systems. The fraud prevention system is integrated with the identity verification system to create more intelligent and advanced systems with current technologies. Through integration with the Identity Verification system, fraud prevention systems can more easily identify individuals resorting to banking fraud. With the support of Artificial Intelligence in video conferencing systems, fraud attempts can be detected more easily, quickly, and accurately through live analysis.

4. CONCLUSION

The need for fraud monitoring modules to prevent fraud is an inevitable reality. Systems that monitor transactions in real-time, detect suspicious activities, and intervene analyze large amounts of data to distinguish between normal and abnormal transactions.

With advancing technology, financial transactions have become prevalent in every aspect of our lives and have become easier to use. Smart mobile phone technologies increase the usage frequency and variety of financial transactions, regardless of time and location. With the increasing frequency and variety of usage, fraud detection with traditional methods becomes more challenging, and the adaptation period to new methods may lengthen, resulting in longer response times. Artificial intelligence systems, including live analysis, can facilitate the faster detection of fraudulent activities, along with identity card verification and video conferencing systems.

In the project, new technologies make fraud prevention systems indispensable by eliminating human impact and interpretation through methods. Advanced technologies can control fraud activities with easy integration and usage. New methods, techniques, and integrations will make it easier to prevent both financial and prestige losses in the financial sector. In addition to domestic use, technology capable of meeting the needs of financial institutions in overseas countries through exports is essential.

Performance-focused tool development and usage are crucial aspects of fraud prevention systems. In the conducted R&D activities, performance-focused design has been emphasized, achieving dramatic response times through load tests. Open-source systems have also played a significant role in the architectural design of the project tailored to the bank's specific needs.

Considering that fraud methods will reach different levels and continue to diversify with the increasing prevalence of wearable technologies, it is inevitable to ensure that prevention and detection systems can easily adapt to changes.

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Chapter 3

TURKEY'S PACKAGING PRODUCTION AND PACKAGING WASTE STATISTICS

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Introduction

According to the Ministry of Environment, Urbanization, and Climate Change, packaging is a valuable material used from raw material to final product for the transportation, storage, preservation, and marketing purposes of various materials made from different raw materials (PWCR, 2021).

Packaging waste refers to the waste of sales, secondary, and transportation packaging discarded or left in the environment after the presentation of products to consumers or any material reaching the final user, excluding production waste and including reusable packaging whose useful life has expired [URL 1].

Plastic packaging is derived from various products processed at petrochemical plants from petroleum refineries. Only 4% of total global oil production is used for plastic production, with a mere 3% of this used specifically for plastic packaging production. Plastic is favored in the industry due to its ability to produce more packaging with less material and its ease of shaping [URL 2]. Plastic packaging is durable, protecting contents from external elements, maintaining hygiene by shielding contents from contact with air and external environments, and preventing spoilage. It is not waste and can be recycled multiple times, contributing to increasing recycling rates globally over time [URL 3].

Metal packaging, particularly used in food and beverage packaging, can be made from metals such as aluminum and steel. Examples include metal cans, tin cans, and aluminum foils [URL 4].

Composite packaging materials are produced by combining at least two different materials (paper, plastic, and aluminum), fully integrating their surfaces. The purpose of using different materials together is to increase durability, flexibility, and combine the unique properties of the materials [URL 5].

Paper and cardboard packaging, widely used for food products, are recyclable and environmentally friendly options. Examples include cardboard boxes, paper bags, and paper cups [URL 6].

After use, glass packaging collected in recycling bins and brought to licensed recycling facilities undergoes a series of processes to be reintroduced into production. Glass fragments are sorted by color, physically processed, and ground into furnace-ready cullet. This cullet, mixed with silica sand and soda, is melted in high-temperature furnaces, molded into desired shapes for packaging, and then cooled and prepared for secondary packaging [URL 2].

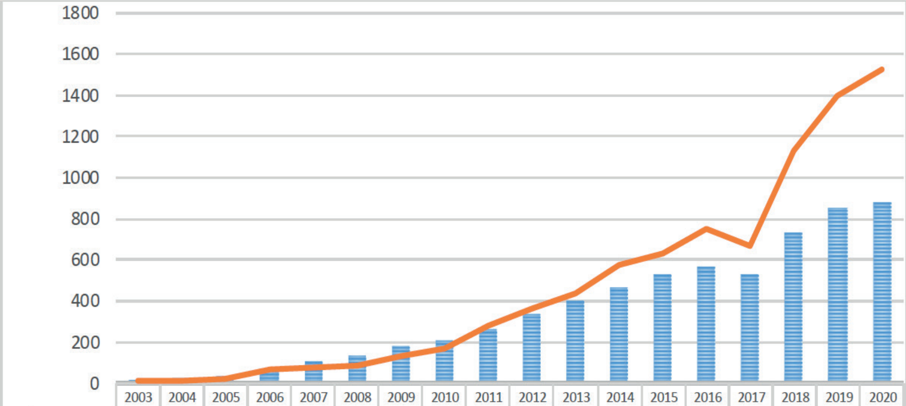
Wooden packaging, one of the oldest packaging materials, is widely used for its strength and durability in packaging fragile and large-size goods, as well as for ventilating fresh fruits and vegetables. Today, it is also used for packaging large machinery, motor vehicles, and a wide variety of other products [URL 2].

Packaging waste holds significant importance for environmental sustainability as an inevitable byproduct of modern life. Today, the management of packaging waste requires substantial effort to both conserve natural resources and reduce environmental pollution. The current literature on packaging waste encompasses numerous studies analyzing the production and recycling processes of various types of waste. In this study, an extensive literature review was conducted through the Higher Education Council (YÖK) Thesis Center and Google Scholar. Data obtained from these sources were used to understand the current status and developments in packaging waste management in Turkey. The performance of packaging waste production and recycling in Turkey between 2010 and 2020 was examined in light of policies and practices implemented during this period. Detailed analysis included the total amount of packaging produced, the amount of packaging introduced to the market, and the amount of packaging recovered. Furthermore, the changes in recycling rates over the years and the underlying reasons for these changes were investigated.

The aim of this study is to reveal the current status of packaging waste management in Turkey and to provide recommendations to achieve future recycling targets. The findings of the study offer significant insights for policymakers, academicians, and industry representatives regarding packaging waste management. In this context, the study aims to contribute to the development of more effective strategies for the management and recycling of packaging waste.

The Ministry of Environment, Urbanization, and Climate Change has established the "Packaging Information System" under the Regulation on the Control of Packaging Waste to create an inventory of packaging and packaging waste. The system's users are defined as the Ministry, Provincial Directorates of Environment and Urbanization, packaging producers, suppliers, businesses that introduce packaged products to the market, packaging waste collection, sorting, recycling and recycling facilities, authorized organizations, and municipalities [URL 7].

According to the Packaging Waste Control Regulation, packaging waste collection-separation facilities and recycling facilities are required to obtain a license from the Ministry of Environment, Urbanization, and Climate Change. The licensing process began in 2003 and has increased over the years. According to the Ministry's 2022 data, as of 2020, there are 882 collection-separation facilities and 1,526 recycling facilities in Turkey. The number of temporary activity-certified/licensed packaging waste facilities is shown in Figure 1 [URL 7].



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
TAT	15	23	31	69	101	137	176	210	266	340	403	465	527	566	527	731	850	882
GDT	13	14	19	70	81	89	134	170	276	366	433	572	627	751	665	1128	1399	1526

Figure 1. *Number of packaging waste processing facilities with temporary activity certificates/licenses (TAT: Collection and Separation Facility, GDT: Recycling Facility)*

Municipalities are obliged to collect or ensure the collection of packaging waste in accordance with the current Packaging Waste Control Regulation. To perform these tasks, they prepare packaging waste management plans specifying who, how, in what manner, and when the collection, separation, and transportation of packaging waste will be carried out separately from other wastes at the source, and submit these plans to the Ministry of Environment, Urbanization, and Climate Change (MoEUCC). The number of municipalities that have prepared and submitted their packaging waste management plans to MoEUCC and whose plans have been found compliant is shown in Figure 2 [URL 7]. In 2008, the number of municipalities that prepared and implemented such plans was 45, which increased to 596 by 2020.

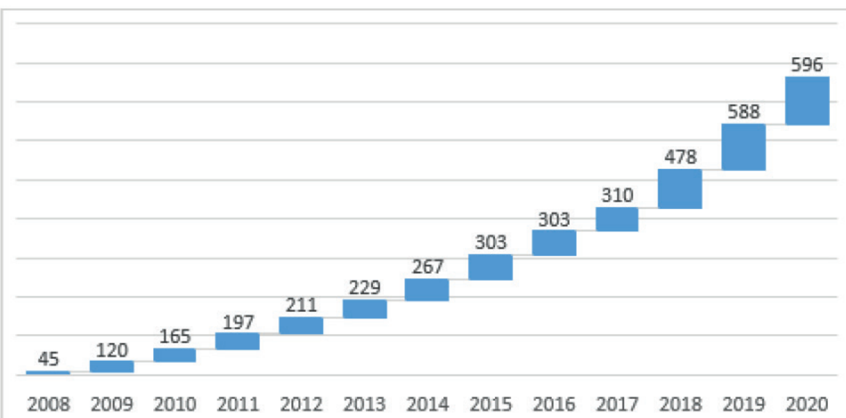


Figure 2. Number of municipalities that have prepared packaging waste management plans.

Evaluation of Packaging Statistics Between 2010-2020

Plastic Packaging Waste Statistics Between 2010-2020

According to MoEUCC data for the years 2010-2020 in Turkey, total plastic packaging production amounted to 27,322,975 tons. The highest production was recorded in 2018 at 4,099,951 tons. During the mentioned years, the amount of packaging released into the market was 10,454,899 tons, with 5,192,615 tons recycled. The achieved recycling rate averaged 50%. Data detailing plastic packaging production, released amounts, recycled amounts, and achieved recycling rates in Turkey are presented in Table 1 (MoEUCC, 2012, MoEUCC, 2013, MoEUCC, 2014, MoEUCC, 2015, MoEUCC, 2016, MoEUCC, 2017, MoEUCC, 2018, MoEUCC, 2019, MoEUCC, 2020, MoEUCC, 2021, MoEUCC, 2022).

Table 1. Plastic packaging data in Turkey between 2010-2020.

Packaging Type	Year	Amount of Packaging Produced (tons)	Amount of Packaging Released to the Market (tons)	Amount Recycled (tons)
Plastic	2010	1.186.213	812.532	242.039
Plastic	2011	1.223.783	706.082	307.549
Plastic	2012	1.377.841	908.674	372.246
Plastic	2013	1.566.809	904.579	472.890
Plastic	2014	3.513.086	1.144.285	506.717
Plastic	2015	2.244.973	1.244.065	501.455
Plastic	2016	3.080.647	911.705	498.887
Plastic	2017	3.150.000	915.301	497.089
Plastic	2018	4.099.951	943.567	590.923
Plastic	2019	3.009.487	1.037.558	586.832
Plastic	2020	2.870.185	926.551	615.988
Total		**27.322.975**	**10.454.899**	**5.192.615**

The graph showing the change in recycling rates over the years between 2010 and 2020 in Turkey is presented in Figure 3.

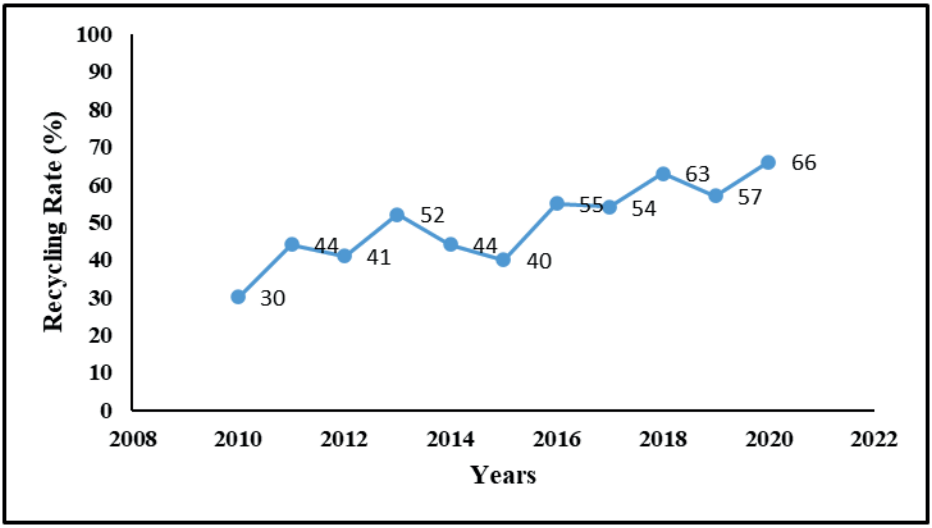


Figure 3. Changes in plastic packaging recycling rates over the years in Turkey between 2010 and 2020.

Statistics of Metal Packaging Waste from 2010 to 2020

According to the Ministry of Environment, Urbanization, and Climate Change (MoEUCC) data for the years 2010-2020, total metal packaging production in Turkey amounted to 3,522,252 tons. The highest production was recorded in 2016 at 394,805 tons. During the mentioned years, the amount of packaging released into the market was 1,545,232 tons, with 891,923 tons recycled. The achieved recycling rate averaged 58%. Data detailing metal packaging production, released amounts, recycled amounts, and achieved recycling rates in Turkey are presented in Table 2 (MoEUCC, 2012, MoEUCC, 2013, MoEUCC, 2014, MoEUCC, 2015, MoEUCC, 2016, MoEUCC, 2017, MoEUCC, 2018, MoEUCC, 2019, MoEUCC, 2020, MoEUCC, 2021, MoEUCC, 2022).

Table 2. Metal packaging data in Turkey between 2010-2020.

Packaging Type	Year	Amount of Packaging Produced (tons)	Amount of Packaging Released to the Market (tons)	Amount Recycled (tons)
Metal	2010	230.945	119.436	64.950
Metal	2011	246.861	137.764	74.669
Metal	2012	270.780	141.333	80.917
Metal	2013	279.177	156.879	82.187

Metal	2014	373.809	160.975	80.747
Metal	2015	261.187	148.112	73.507
Metal	2016	394.805	145.201	120.412
Metal	2017	373.682	142.482	81.146
Metal	2018	179.438	130.981	89.488
Metal	2019	385.941	132.524	71.234
Metal	2020	525.627	129.545	72.666
Total		**3.522.252**	**1.545.232**	**891.923**

The graph showing the change in metal packaging recycling rates produced in Turkey between 2010 and 2020 is presented in Figure 4.

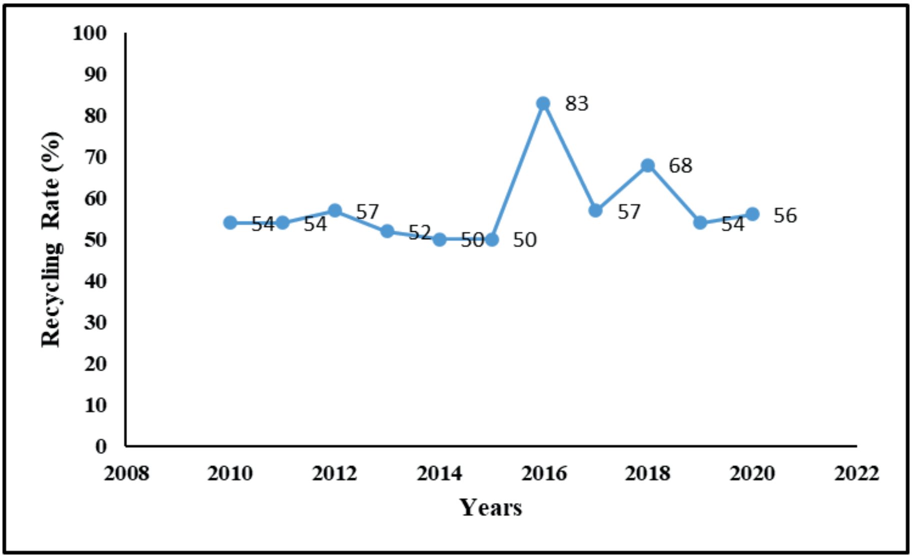


Figure 4. Changes in metal packaging recycling rates over the years in Turkey between 2010 and 2020.

Statistics of Composite Packaging Waste from 2010 to 2020

According to the Ministry of Environment, Urbanization, and Climate Change (MoEUCC) data for the years 2010-2020, total composite packaging production in Turkey amounted to 2,277,545 tons. The highest production was recorded in 2016 at 300,519 tons. During the mentioned years, the amount of packaging released into the market was 1,079,234 tons, with 736,454 tons recycled. The achieved recycling rate averaged 70%. Data detailing composite packaging production, released amounts, recycled amounts, and achieved recycling rates in Turkey are presented in Table 3 (MoEUCC, 2012, MoEUCC, 2013, MoEUCC, 2014, MoEUCC, 2015, MoEUCC, 2016, MoEUCC, 2017, MoEUCC, 2018, MoEUCC, 2019, MoEUCC, 2020, MoEUCC, 2021, MoEUCC, 2022).

Table 3. Composite packaging data in Turkey between 2010-2020.

Packaging Type	Year	Amount of Packaging Produced (tons)	Amount of Packaging Released to the Market (tons)	Amount Recycled (tons)
Composite	2010	91.001	68.756	70.715
Composite	2011	103.093	86.973	76.610
Composite	2012	148.184	97.904	71.524
Composite	2013	140.497	107.721	76.216
Composite	2014	138.282	90.668	74.095
Composite	2015	153.945	104.658	49.386
Composite	2016	300.519	96.385	55.410
Composite	2017	102.636	96.773	62.110
Composite	2018	300.266	104.439	60.749
Composite	2019	273.495	95.412	66.973
Composite	2020	525.627	129.545	72.666
Total		**2.277.545**	**1.079.234**	**736.454**

The graph showing the change in the recycling rates of composite packaging produced in Turkey between 2010 and 2020 is presented in Figure 5.

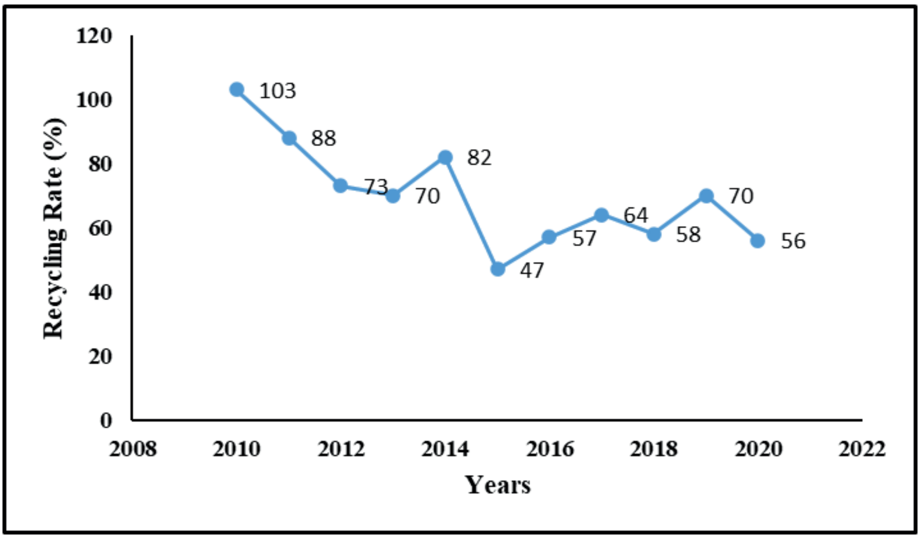


Figure 5. *Changes in composite packaging recycling rates over the years in Turkey between 2010 and 2020.*

Statistics of Paper/Cardboard Packaging Waste from 2010 to 2020

According to the Ministry of Environment, Urbanization, and Climate Change (MoEUCC) data for the years 2010-2020, total paper/cardboard packaging production in Turkey amounted to 29,574,337 tons. The highest production was recorded in 2019 at 4,023,994 tons. During the mentioned years, the amount of packaging released into the market was 14,835,428 tons, with 14,584,432 tons recycled. The achieved recycling rate averaged 98%. Data detailing paper/cardboard packaging production, released amounts, recycled amounts, and achieved recycling rates in Turkey are presented in Table 4 (MoEUCC, 2012, MoEUCC, 2013, MoEUCC, 2014, MoEUCC, 2015, MoEUCC, 2016, MoEUCC, 2017, MoEUCC, 2018, MoEUCC, 2019, MoEUCC, 2020, MoEUCC, 2021, MoEUCC, 2022).

Table 4. Paper/cardboard packaging data in Turkey between 2010-2020

Packaging Type	Year	Amount of Packaging Produced (tons)	Amount of Packaging Released to the Market (tons)	Amount Recycled (tons)
Paper/cardboard	2010	2.590.586	1.024.429	1.423.181
Paper/cardboard	2011	2.389.201	996.076	1.573.511
Paper/cardboard	2012	2.168.614	1.049.428	1.176.088
Paper/cardboard	2013	2.358.591	1.271.906	1.429.091
Paper/cardboard	2014	1.953.208	1.335.603	1.523.253
Paper/cardboard	2015	2.979.101	1.530.578	1.568.855
Paper/cardboard	2016	2.563.665	1.444.047	1.199.606
Paper/cardboard	2017	2.757.848	1.604.823	1.258.128
Paper/cardboard	2018	2.529.403	1.314.154	1.227.249
Paper/cardboard	2019	4.023.994	2.065.781	1.125.613
Paper/cardboard	2020	3.260.126	1.198.603	1.079.857
Total		**29.574.337**	**14.835.428**	**14.584.432**

The graph showing the change in paper/cardboard packaging recycling rates produced in Turkey between 2010 and 2020 is presented in Figure 6.

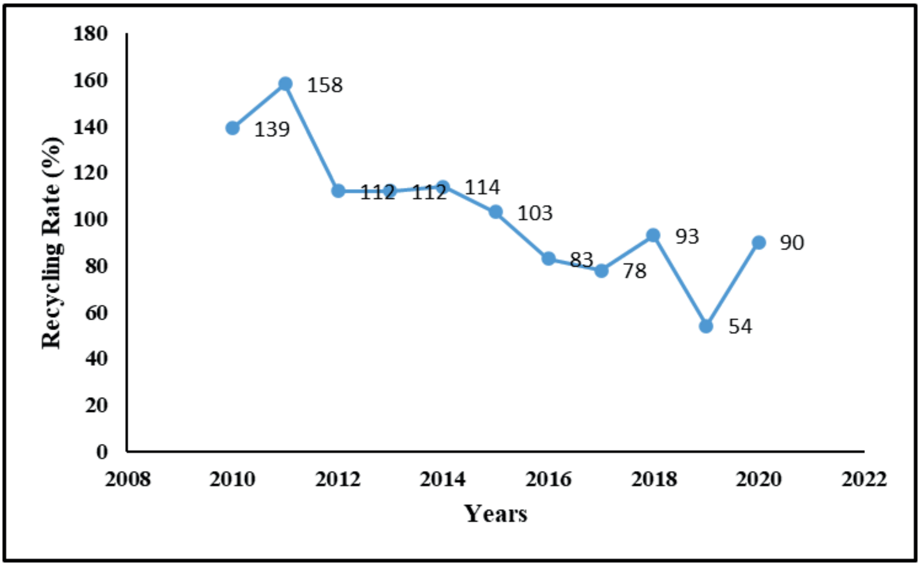


Figure 6. *Changes in paper/cardboard packaging recycling rates over the years in Turkey between 2010 and 2020.*

Statistics of Glass Packaging Waste from 2010 to 2020

According to the Ministry of Environment, Urbanization, and Climate Change (MoEUCC) data for the years 2010-2020, total glass packaging production in Turkey amounted to 10,890,335 tons. The highest production was recorded in 2020 at 1,742,759 tons. During the mentioned years, the amount of packaging released into the market was 7,705,266 tons, with 2,214,947 tons recycled. The achieved recycling rate averaged 29%. Data detailing glass packaging production, released amounts, recycled amounts, and achieved recycling rates in Turkey are presented in Table 5 (MoEUCC, 2012, MoEUCC, 2013, MoEUCC, 2014, MoEUCC, 2015, MoEUCC, 2016, MoEUCC, 2017, MoEUCC, 2018, MoEUCC, 2019, MoEUCC, 2020, MoEUCC, 2021, MoEUCC, 2022).

Table 5. Glass packaging data in Turkey between 2010-2020.

Packaging Type	Year	Amount of Packaging Produced (tons)	Amount of Packaging Released to the Market (tons)	Amount Recycled (tons)
Glass	2010	363.024	492.626	160.238
Glass	2011	477.559	601.962	198.532
Glass	2012	531.330	497.599	127.751
Glass	2013	899.596	641.520	183.053

Glass	2014	878.262	637.045	154.841
Glass	2015	1.025.533	696.176	212.701
Glass	2016	1.076.617	758.991	231.306
Glass	2017	1.331.265	845.615	193.563
Glass	2018	955.721	860.239	234.699
Glass	2019	1.608.669	871.426	276.037
Glass	2020	1.742.759	802.067	242.226
Total		**10.890.335**	**7.705.266**	**2.214.947**

The graph showing the change in the recycling rates of glass packaging produced in Turkey between 2010 and 2020 is presented in Figure 7.

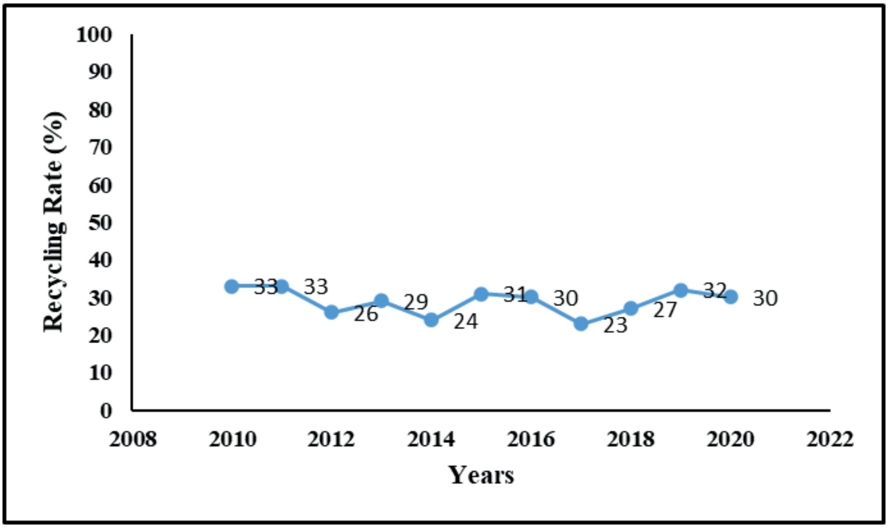


Figure 7. *Changes in glass packaging recycling rates over the years in Turkey between 2010 and 2020.*

Statistics of Wood Packaging Waste between 2013-2020

According to the Ministry of Environment and Urbanization data in Turkey, wooden packaging production totaled 5,259,959 tons from 2013 to 2020. The highest production amount was recorded in 2018 with 1,070,084 tons. During these years, the amount of packaging released into the market was 4,165,908 tons, with a recovered amount of 1,056,574 tons. The achieved recycling rate averaged 25%. Data detailing wooden packaging production, released amounts, recovered quantities, and achieved recycling rates in Turkey are presented in Table 6 (MoEUCC, 2012, MoEUCC, 2013, MoEUCC, 2014, MoEUCC, 2015, MoEUCC, 2016, MoEUCC, 2017, MoEUCC, 2018, MoEUCC, 2019, MoEUCC, 2020, MoEUCC, 2021, MoEUCC, 2022).

Table 6. Wood packaging data in Turkey between 2013-2020.

Packaging Type	Year	Amount of Packaging Produced (tons)	Amount of Packaging Released to the Market (tons)	Amount Recycled (tons)
Wood	2013	655.477	456.057	61.600
Wood	2014	427.322	562.678	80.747
Wood	2015	436.442	473.710	100.051
Wood	2016	504.217	486.110	126.676
Wood	2017	719.741	523.261	113.509
Wood	2018	1.070.084	547.681	171.048
Wood	2019	670.125	561.259	180.229
Wood	2020	776.551	555.152	222.714
Total		**5.259.959**	**4.165.908**	**1.056.574**

The graph showing the change in the recycling rates of wood packaging produced in Turkey between 2013 and 2020 is presented in Figure 8.

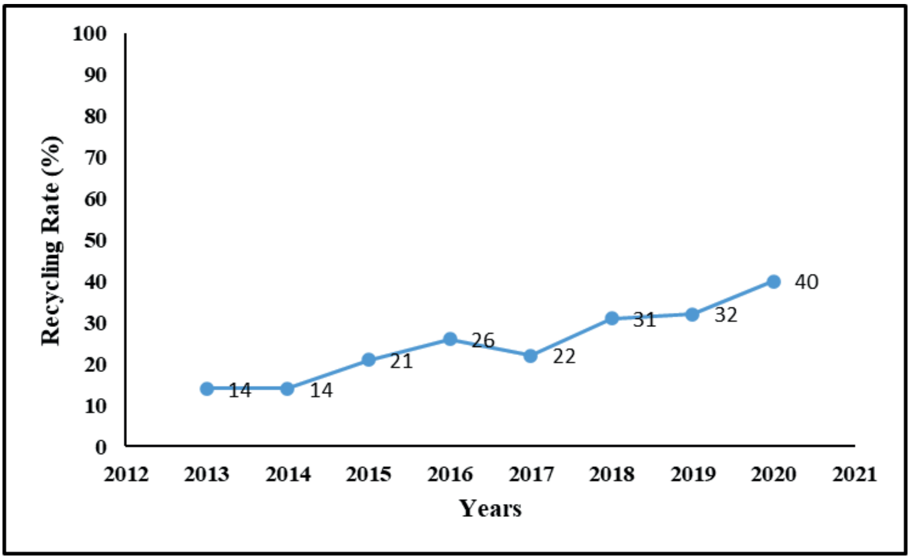


Figure 8. *Changes in wood packaging recycling rates over the years in Turkey between 2013 and 2020.*

When reviewing the bulletins of packaging statistics prepared by the Ministry of Environment, Urbanization, and Climate Change, it is observed that the number of waste collection and separation facilities, as well as recycling facilities, has increased annually since the inception of the licensing system in 2003. In 2003, there were 15 collection and separation facilities and 13 recycling facilities registered in the packaging information system, whereas by 2020, these numbers had grown to 882 and 1536, respectively. The number of municipalities preparing packaging waste management plans in Turkey increased from 45 in 2008 to 596 in 2020.

Until 2020, the Ministry of Environment, Urbanization, and Climate Change published packaging waste data under the packaging statistics section on the General Directorate of Environmental Management's website. However, starting in 2021, they began publishing these statistics under the waste statistics bulletin along with other waste data. Upon reviewing the waste statistics bulletin, it was noted that unlike the packaging statistics bulletin, detailed information on packaging waste and recycling/recycling rates is not provided.

Examining the quantities of packaging produced, released to the market, recovered, and actual recycling rates from 2010 to 2020 reveals that a total of 78,847,403 tons of packaging were produced over the decade, with 39,785,967 tons released to the market. Out of the packaging released to the market, 24,676,945 tons were recovered, resulting in a recycling rate of 63%. Figure 9 illustrates the percentages of different types of packaging produced among the total production from 2010 to 2020. Figure 10 displays the percentages of different types of packaging released to the market among the total released packaging from 2010 to 2020. Figure 11 shows the percentages of different types of packaging recovered among the total recovered packaging from 2010 to 2020.

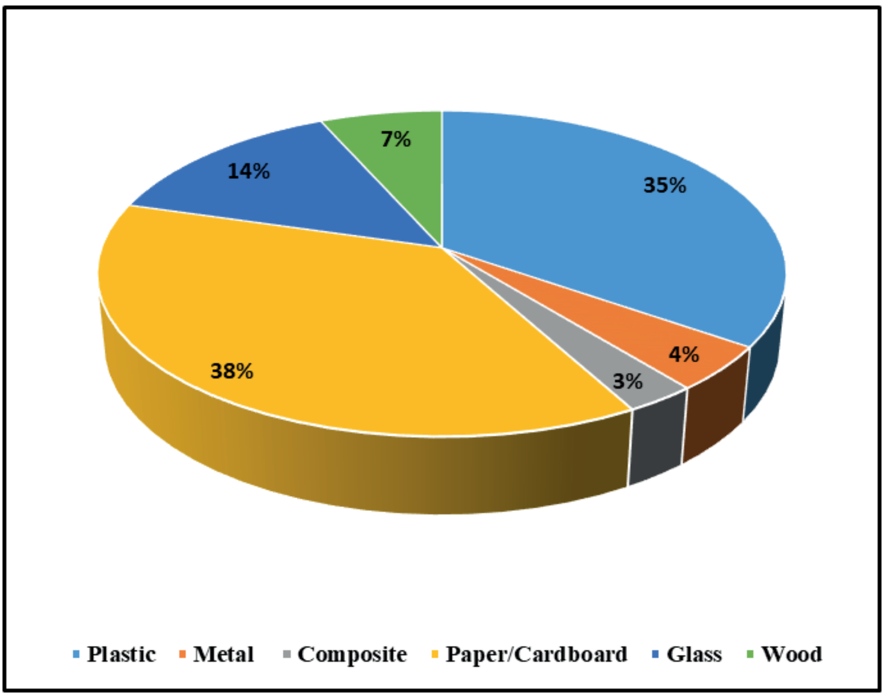


Figure 9. *Ratios of packages produced between 2010 and 2020.*

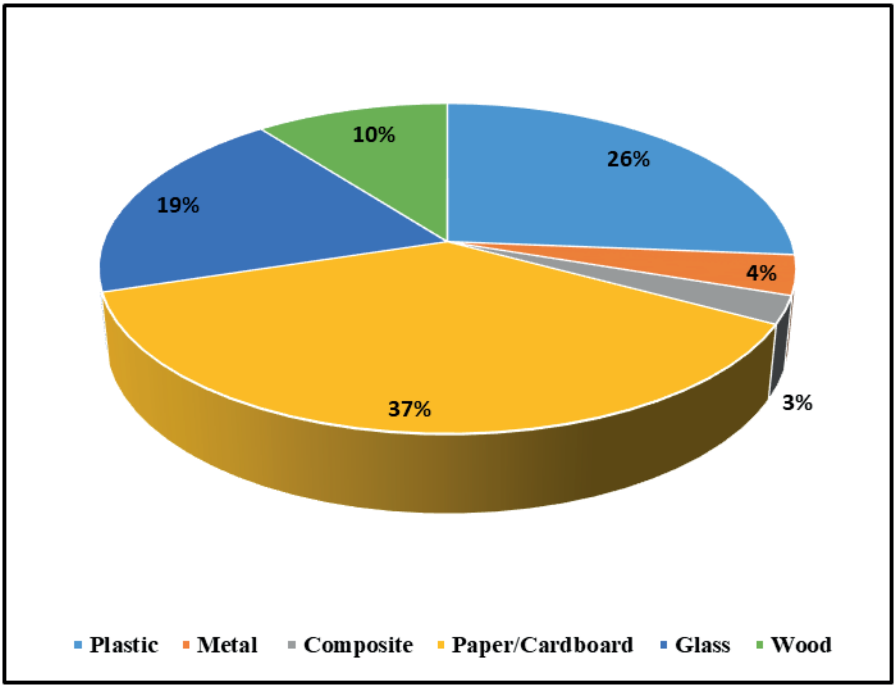


Figure 10. *Percentage of packages released into the market between 2010 and 2020.*

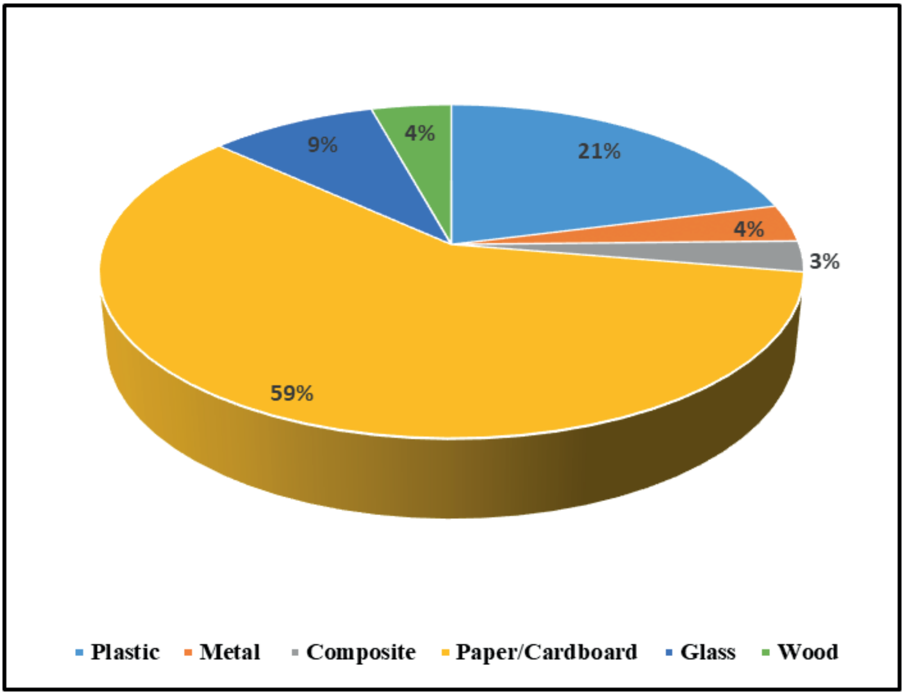


Figure 11. *Recycling rates of packaging waste between 2010-2020.*

Between 2010 and 2020, plastic packaging production totaled 27,322,975 tons, representing 34% of the total packaging produced during the decade. Over the same period, 10,454,899 tons of packaging were introduced into the market, constituting 26% of the total released packaging. The amount of plastic packaging waste recovered over the decade amounted to 5,192,615 tons, achieving a recycling rate of approximately 50%.

Metal packaging production from 2010 to 2020 amounted to 3,522,252 tons, accounting for 4.5% of total packaging production. During this period, 1,545,232 tons of metal packaging were released into the market, with 891,923 tons being recovered, resulting in a recycling rate of 58%.

Composite packaging production reached 2,277,545 tons from 2010 to 2020. Of the 1,079,234 tons of composite packaging released to the market during the decade, 736,454 tons were recovered. Composite packaging constituted 3% of total packaging produced, released to the market, and recovered, achieving a recycling rate of 70%.

Paper/cardboard packaging emerged as the most prominent and highest percentage of all types of packaging produced, released to the market, and recovered within the overall packaging waste category. A total of 29,574,337 tons of paper/cardboard packaging were produced from 2010 to 2020, comprising 38% of the total production during that period. Comparatively, 14,835,428 tons of paper/cardboard packaging were introduced into the market, indicating a significant portion of Turkey's production is exported. Of the paper/cardboard packaging released to the market, 14,584,432 tons were recovered, resulting in an impressive recycling rate of 98%.

Glass packaging production in Turkey from 2010 to 2020 amounted to 10,890,335 tons, with 7,705,266 tons released to the market and 2,214,947 tons recovered. Glass packaging accounted for 13.8% of total packaging production, 19% of packaging released to the market, and achieved a recycling rate of 9%. Of the glass packaging released to the market, 29% was recovered.

The Ministry of Environment, Urbanization, and Climate Change began registering wooden packaging data from 2013 onward, unlike other packaging types documented since 2010. Between 2013 and 2020, Turkey produced a total of 5,259,959 tons of wooden packaging, with 4,165,908 tons released to the market. Of the wooden packaging released to the market, 1,056,574 tons were recovered, resulting in an overall recycling rate of 25%.

Conclusion and Recommendations

Until 2020, the Ministry published bulletins under the packaging statistics detailing the quantities of packaging produced, released to the market, recovered, and recycling rates achieved. According to the Packaging Waste Control Regulation, recycling rates of 55% for 2021-2025, 65% for 2026-

2030, and 70% for years beyond 2031 are targeted. It was determined that a total recycling rate of 62% was achieved between 2010 and 2020.

In conclusion, considering the increasing number of sorting and collection facilities and recycling plants, it is recommended to further elevate the set targets through regulatory enhancements, state incentives, and enforcement measures to increase recycling rates. As of 2020, packaging statistics are incorporated within the "Waste Statistics Bulletin" alongside other waste data, albeit with less detailed coverage compared to the dedicated "Packaging Statistics" bulletin. It is suggested that transparent and readily accessible packaging data should be provided within the waste statistics bulletin for better information dissemination and policy formulation.

Acknowledgements

This study, a part of Msc thesis entitled "INVESTIGATION OF POTENTIAL RECYCLING OF PACKAGING WASTE FROM THE DEMOGRAPHIC ORIENTATION" which was conducted at Istanbul University-Cerrahpaşa, Institute of Graduate Studies.

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Chapter 4

THE OBJECTIVE OF THIS RESEARCH IS TO DEVELOP A NEW LIGHTWEIGHT CONCRETE UTILISING NATURAL FIBRES WASTE

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1.Introduction

Lightweight concrete is a building material that exhibits superior technological properties compared to traditional concrete produced with artificial or natural lightweight aggregates with a unit volume weight between 800 and 2000 kg/m³. It has been increasingly preferred in construction projects in recent years due to its superior properties compared to traditional concrete [1-2]. The growing interest in lightweight concrete has led to the emergence of numerous studies in the literature. These studies have focused on the potential use of alternative lightweight aggregates as an alternative to conventional aggregates. A number of these studies have explored the use of pumice, perlite, fly ash, and rice husk ash, among other materials [3-5].

Aggregates constitute as much as 75% of the concrete volume. Consequently, investigating the use of alternative aggregates is of great importance for the concrete industry. Pumice is a type of rock formed as a result of volcanic activity, with a porous structure, a spongy appearance, a hardness scale of 5-6, a density not exceeding 2000 kg/m³, and is widely used in the production of lightweight concrete. The study examined the unit volume weight, pressure and tensile tests of acidic pumice added concretes intended for use in the production of lightweight concrete. The results indicated that pumice would contribute to the reduction of dead load in buildings due to its low density and would enhance the technological properties of concrete, including heat and sound, due to its porous structure [6]. In a subsequent study, the post-temperature pressure and water absorption values of pumice-added concrete in the production of lightweight concrete for evaluation in non-load-bearing building stock were examined. The results of the study indicated that the water absorption value was within the specified standards and that it also made a positive contribution to the compressive strength after heat [7]. There are a number of studies in the literature which demonstrate that the incorporation of pumice into the production of lightweight concrete has a beneficial effect on the properties of the concrete [8-10]. In addition to the use of pumice as an aggregate, there are also studies on the use of its fibres in lightweight concrete. In this study, lightweight concrete was produced by the addition of fibre reinforcement in addition to pumice aggregate. The study concluded that the optimal mixture ratio was M20, and that the mixture with 40% pumice and 0.5% fibre reinforcement exhibited a positive impact on strength values [11]. In their study, Rai and Joshi examined the behaviour of fibre-reinforced concrete. The study indicated that fibre-reinforced concrete exhibited 16% higher compressive strength and 30% higher flexural strength values than conventional concrete. Furthermore, the presence of fibres was found to enhance the ductility of concrete [12].

In this study, a lightweight concrete was produced by substituting pumpkin fibre, a natural fibre group for pumice aggregate at rates of 1-3-

5% and adding 15% fly ash as a pozzolanic additive. The unit volume weight and compressive strength of the produced lightweight concrete samples were then tested. The data obtained indicate that fibres contribute positively to lightweight concrete samples.

2. Experimental program

2.1 Materials

Four distinct mixture properties were devised, comprising reference samples with and without the inclusion of pumpkin fibre additives. The mixture was composed of CEM I cement supplied by KÇS, pumice sourced from the Kayseri region, fly ash from the Sivas region, and pumpkin fibre from the Hatay region. The physical and chemical properties of the materials employed in the study are presented in Tables 1-4.

Table 1. *Physical properties of pumice aggregate*

Propery	0–4 mm	4–16 mm
Specific gravity	2.71	2.78
Water absorption (%)	1.80	1.03
Fineness modulus	3.75	6.82

Tablo 2. *Physical and chemical properties of materials.*

Compounds (%)	Cement	Fly ash
Chemical analysis results		
SiO_2	18.50	38.25
Al_2O_3	5.33	16.41
Fe_2O_3	2.79	5.12
CaO	64.37	27.36
MgO	3.40	1.55
SO_3	2.45	
Na_2O+K_2O	0.60	0.62
SrO	-	4.45
Loss on ignition (%)	0.52	0.76
Other		5.46
Physical analysis results		
Specific Weight	3.14	2.26
Fineness	3315 cm^2/g	< 40 µm

Table 3. *Properties of chemical additives*

Parameter	Sika Viscosity	Sika Air immersive
Chemical structure	Polycarboxylate based polymer	Synthetic fluid
Intensity	1.064	1.001
PH	5	10
Freezing point	-5°C	-5°C
% solubility in water	TS EN 934-2	TS EN 934-2
Amount of alkali	TS EN 934-2	

Table 4. *Luffa Cylindrica physical and chemical properties*

Physical properties				Chemical composition			
Intensity (gm/cm^3)	Diameter (μm)	Aspect ratio	Mikro Micro fibrils angle(°)	Cellulose (%)	Lignin (%)	Hemicellulose (%)	Ash(%)
0.55-0.91	260±15	330±10	10±2	61.0±2	10.59±1.2	20.44±1.3	0.3±0.10

2.2. Mixture proportions

The study involved the production of four distinct mixtures in accordance with the TS 802 [13] standard. These mixtures incorporated 1-3-5% pumice aggregate as a fibre additive and 15% fly ash as a pozzolanic additive. The mix design for lightweight concrete and the names of the fibre-added samples are presented in Table 5.

Table 5. *Lightweight concrete mixing ratios*

Samples	Water kg/m^3	Cement kg/m^3	Fly Ash kg/m^3	Fine aggregate kg/m^3	Coarse aggregate kg/m^3	Luffa fiber (%)	Vdk	Hsk
R	140	350	-	500	220	-	7	4
NFLWC1	140	315	35	500	209	1	7	4
NFLWC3	140	315	35	500	198	3	7	4
NFLWC5	140	315	35	500	187	5	7	4

2.3. Testing procedure

Cube samples measuring 10x10x10 cm were produced for compressive strength testing in experimental studies. The samples were cured in a pool at a temperature range of 21-23°C for 7, 28, and 60 days. Unit weight and compressive strength tests were conducted on the lightweight concrete samples. Figure 1 illustrates the process of sample production.

Figure 1. *Natural fiber added lightweight concrete production scheme*

3. Results and discussion

3.1. The results of the unit weight test

Figure 2 presents the test results, demonstrating the average unit weight values of lightweight concrete samples produced on different days.

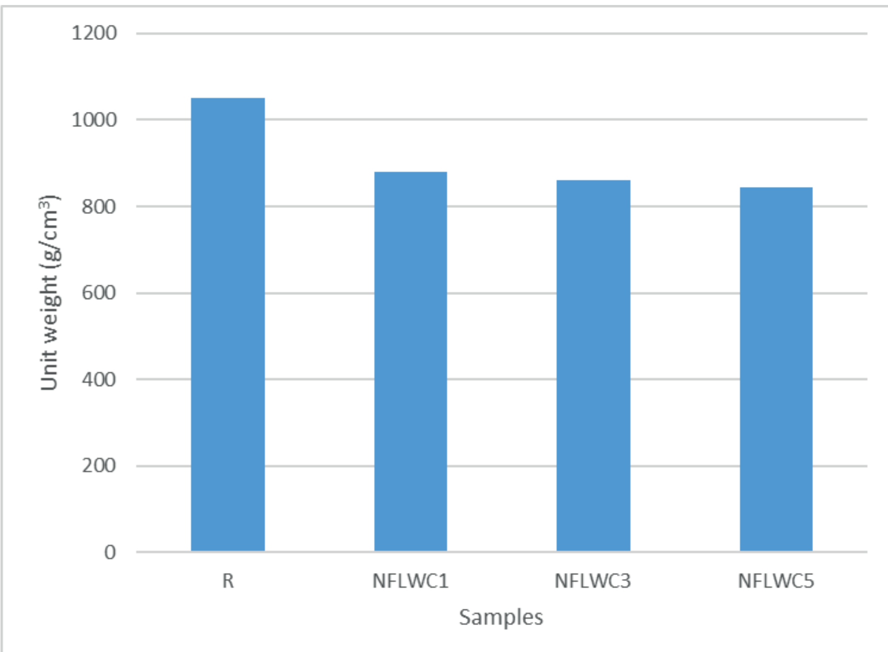

Figure 2. *The experimental data for lightweight concrete samples, expressed in terms of unit volume weight*

The unit volume weight experimental data of the produced fibre-added samples and pure lightweight concrete samples at the end of 7, 28 and 60 days were found to be between 881-844 g/cm^3, with the pure R sample exhibiting a value of 1050 g/cm^3. It was observed that as the fibre additive ratio increased, the unit volume weight values decreased. The fact that the fibre density is lower than the density of pumice demonstrates this phenomenon. The experimental data obtained are also consistent with studies in the literature [14]. Furthermore, the high value of R2: 0.9494 (Figure 3) indicates that the fibre contribution rate of the produced samples is compatible with the unit volume weight reduction.

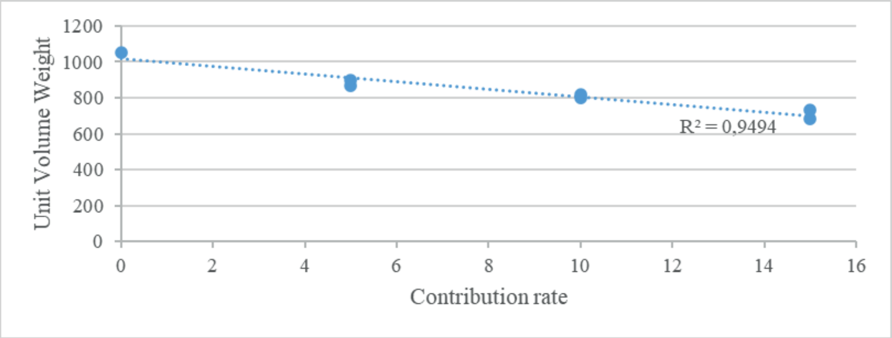

Figure 3. *Lightweight concrete fiber additive ratio density relationship*

3.2. Concrete compressive strength results

Compressive strength test results of lightweight concrete samples that completed 7, 28 and 60 days of curing periods are given in Figure 4.

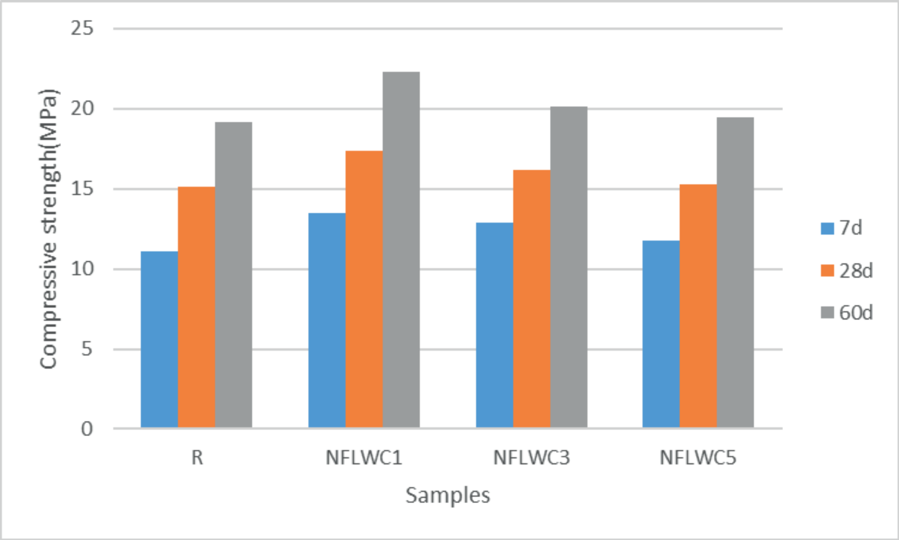

Figure 4. *Compressive strength results of fiber-added lightweight concrete*

Upon examination of the compressive strength values of NFLWC with pumpkin fibre and R samples without additives, it was determined that the fibre-added lightweight concrete samples exhibited values between 11.8 and

22.3 MPa, while the R sample exhibited values between 11.1 and 19.2 MPa. While there was a discernible decrease in compressive strength values as the fibre additive ratio increased, the average compressive strength values of all fibre-added samples were found to be higher than those of the R sample. The NFLWC1-added sample exhibited the highest compressive strength value of 22.3 MPa among the fiber-added lightweight concrete samples. The data obtained from the studies in the literature are consistent with the interpretation that fiber additives improve the mechanical properties of concrete [15-18].

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

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Chapter 5

THE EFFECT OF ARTIFICIAL INTELLIGENCE APPLICATIONS ON THE HEALTH SECTOR

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1. Introduction

As a result of the rapid development of technology in recent years, it can be said that the quality of life of human life has increased significantly. When these technological changes are considered from the perspective of health, treatment processes are accelerating and processes related to health protection are improving with developing technology and new methods. The increasing availability of healthcare data and the rapid increase and development of the amount of big data have recently enabled successful applications of artificial intelligence in healthcare. In particular, powerful artificial intelligence techniques can easily reveal the information hidden in large amounts of data and consequently enable improvement. In addition, these technological innovations play an important role in improving service quality while managing cost and time in issues such as data storage, diagnosis, patient follow-up and treatment [1].

Artificial intelligence is the systems used to solve complex business and operations with the help of computers, which arise by bringing human thinking ability to machines. Artificial intelligence is used in many fields such as automotive, defense industry, banking, as well as in health institutions and organizations, especially in administrative and clinical processes to speed up the process, increase efficiency and reduce costs. The first emergence of artificial intelligence was the famous computer scientist Alan Turing created a test on machine intelligence, where he aimed to find a meaningful difference between a computer and a human, and if not found, the computer should be considered as intelligent as a human. In this context, in 1950, Alan Turing literally put forward the idea of artificial intelligence and designed the Turing test, which is the ability of a machine to exhibit intelligent behavior that is equivalent to a human or indistinguishable from a human [2]. However, artificial intelligence studies in medicine overlap with the emergence of artificial intelligence in the modern era. The biggest proof of this is that in the 1980s, Gunn investigated the diagnosis of abdominal pain by computer analysis and achieved a successful result [3].

Machine learning, which is a subset of artificial intelligence, is a system that investigates the architectures of algorithms that can make predictions based on self-learning models. Machine learning includes different algorithms that help to solve many different types of problems. However, there are many studies on Deep learning and Image processing, which is an area of machine learning. These are generally focused on image inference, classification and object detection. In order to be able to infer correctly from the image, the image must be evaluated correctly. This usually requires expert knowledge [4].

Deep learning methods, which consist of a multi-layered structure compared to machine learning methods, use many non-linear processing layers during feature extraction and transformation processes from data. In this way, a hierarchical order is created and high-level features are obtained from the features in the lower layer. Here, the basic learning principle is based on learning from the representation of the data. In addition, the most important reason for the successful application of deep learning in many fields in recent years is that the required data size is easily obtainable [5].

Artificial intelligence is being used in a variety of settings such as healthcare delivery, clinical laboratories and research facilities. AI approaches have opened previously untapped or unrecognized opportunities such as analyzing unstructured data such as photos, videos, physician notes to support clinical decision-making; using intelligent interfaces to improve patient adherence and treatment adherence; and predictive modelling to manage hospital capacity/resource allocation. [6]. These expanding use cases make the role of AI in healthcare even more important and offer an exciting perspective on how this technology could transform healthcare in the future.

AI will have a central role in the future of healthcare and has the potential to revolutionize areas such as early diagnosis, personalized treatment plans and improving patient outcomes. This technological advancement is a critical step towards reducing costs while improving the quality of healthcare services. The aim of this study is to provide information about the concept of artificial intelligence and to evaluate the usage areas, potential benefits and aspects that need to be developed in all healthcare services through various application examples.

2. Artificial Intelligence (AI)

Artificial intelligence is the name of intelligence developed by machines as an alternative to natural human intelligence. Artificial intelligence refers to a machine that has the ability to make decisions by analyzing the information it obtains by perceiving its environment similar to that of a human being. While training and experience develop human intelligence, machines can also develop a special intelligence with appropriate "training" and enough "experience" [7].

Artificial intelligence algorithms define the steps to be followed in solving any problem. Artificial intelligence consists of complex algorithms based on simple conditional statements. In a simple algorithm, the machine is given a condition "a" and determines what to do when this condition is and is not fulfilled. Machine learning is based on patterns and inferences created with the help of models and algorithms. In this case, the programmer does not write all the algorithms one by one. Instead, the machine is taught a "training" set of data and inferences, and a model is created to make predictions. Deep learning, an advanced stage of machine learning, aims to learn in a similar way to the nervous system [8]. The machine is taught information in layers, which gives it the ability to analyze the relationships of the information and then develop its own algorithm. This provides the machine with its own solution, even in situations that the programmer cannot identify. Deep learning provides results such as face recognition, voice recognition and medical image analysis. As can be understood from these definitions, artificial intelligence enables computers to learn through the automatic extraction and analysis of complex data. No explicit coding is needed to do this. The computer almost learns from its mistakes and continuously improves. It also has the ability to test new information, self-monitor its success rate, and self-correct by forgetting, given the appropriate data [9]. The biggest concern about the use of artificial intelligence in medicine is that it cannot replace physicians in the decision-making process. The main purpose of the use of artificial intelligence here is to assist physicians in the decision-making process rather than making decisions instead of physicians like other technological developments [10].

2.1 Artificial Intelligence Algorithms Applied in Healthcare

- ***Convolutional Neural Networks (CNN)***

When the studies in the field of health are examined, Convolutional Neural Networks (CNN) are one of the most preferred methods in solving many problems so far. Although CNN algorithms are feed-forward artificial neural networks, they give very successful results especially in the processing of two-dimensional data. CNN architectures basically consist of three layers. Convolutional Layer, Pooling Layer and Fully Connected Layer. With CNN, images can be directly transferred to the network structure as raw input. In this way, there is no need for the feature extraction procedure in standard learning algorithms. CNN architecture reduces the parameter values in the network by using a number of spatial relationships and

improves standard back propagation algorithms. With the rapid development of CPUs and GPUs of workstation computers in recent years, computational techniques have been used to train CNNs more efficiently [11].

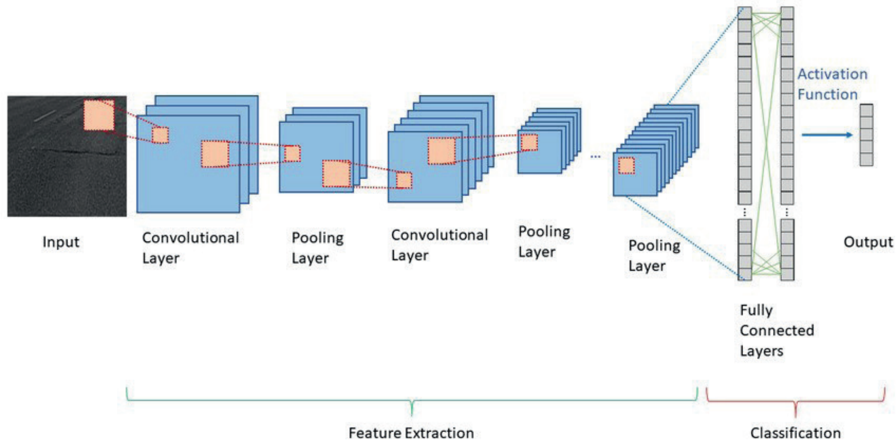

Figure 1. *General Structure of CNN Algorithm*

CNNs are widely used in image recognition and classification tasks. Especially in the field of radiology, the ability of CNNs to automatically and adaptively learn radiological images plays an important role in supporting diagnostic processes and improving patient care.

- ***VGG (Visual Geometry Group) Architecture***

VGG (Visual Geometry Group) is a deep learning algorithm and one of the many network models that emerged especially after the success of AlexNet. It is a network consisting of 13 convolutional, 3 fully connected layers used by the Oxford University Visual Geometry Group to achieve higher success percentages in the ILSVRC-2014 competition. There are a total of 41 layers in the network structure, including Maxpool, Relu layer, Fullconnected layer, Dropout layer and Softmax layer layers. In this architecture, the image to be included in the input layer is 224x224x3 in size and the last layer is the classification layer [12].

Thanks to its deep architecture, VGG provides effective results in image recognition and classification tasks. In particular, it has been observed that VGG can achieve high accuracy rates in medical image analysis. In lung, colon and breast cancer diagnosis, VGG-16 and VGG-19 models provided high accuracy rates in the classification of histopathological images.

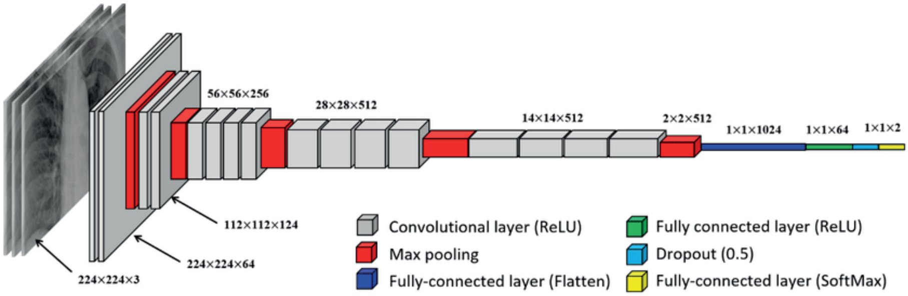

Figure 2. *General Structure of VGG Algorithm*

- ***ResNet Architecture***

ResNet architecture has a different structure from architectures such as VGG and AlexNet. Although ResNet differs from other architectures with its microarchitectural module structure, transitions between some layers can be ignored and transitions to the lower layer can be performed. With these features, ResNet architecture has managed to increase the success rates to higher levels [13].

ResNet is an architecture that offers a solution to the vanishing gradient problem in deep learning models. ResNet-50 and ResNet-101 models have achieved high accuracy, sensitivity and specificity rates in time-independent estimation of the depth of burns, which shows that ResNet is a powerful tool in medical image analysis.

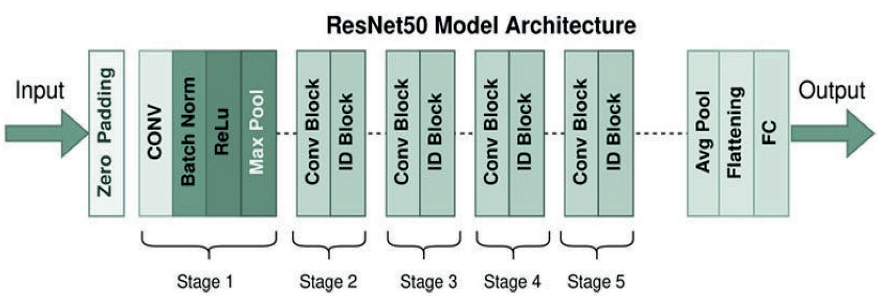

Figure 3. *General Structure of ResNet Algorithm*

- ***DenseNet Architecture***

During neural network training, feature extraction maps are reduced due to convolution and sub-sampling processes. In addition, image features are lost in transitions between layers. DenseNet architecture has been developed to utilize image features more effectively. DenseNet connects each layer forward to other layers in terms of feature structure. In this architecture, each layer uses the features of all previous layers as input and gives all the features as input to all subsequent layers. Another important feature of DenseNet is that it reduces the number of parameters to ensure feature propagation. DenseNet is one of the architectures that makes the best use of the transfer function, but the feature structure of the network

The rate of dissemination is quite high [14]. DenseNet has a dense structure where each layer is connected to all previous layers. This facilitates feature transfer and reuse. In the healthcare sector, DenseNet performs particularly effectively in medical image classification and analysis.

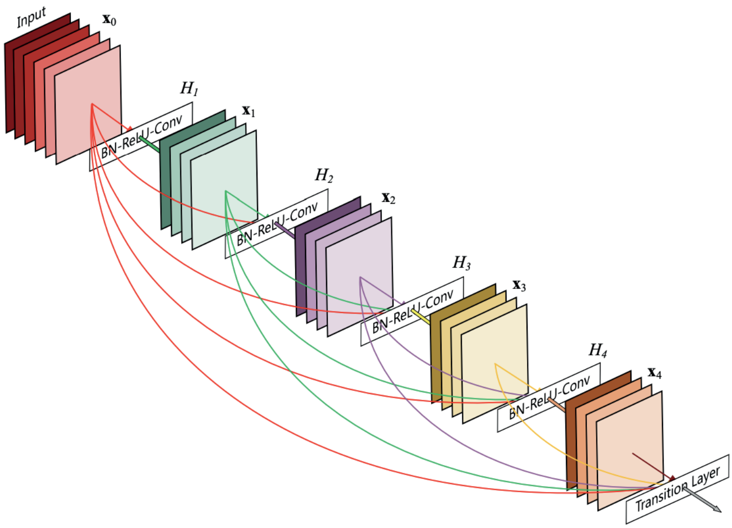

Figure 4. *General Structure of DenseNet Algorithm*

- ***U-Net Architecture***

U-Net is an artificial neural network algorithm developed specifically for medical image segmentation tasks. Originally designed for biomedical image segmentation, U-Net has a broad and deep structure and is particularly known for its ability to perform highly accurate segmentation even with a small amount of training data. This algorithm is designed to learn complex structures from an input image and perform pixel-wise segmentation [15].

The U-Net architecture mainly consists of two main parts, a narrowing (encoder) path and an expansion (decoder) path. The narrowing path consists of a set of convolutional and max pooling layers to extract features and reduce size, while the expansion path consists of a set of convolutional layers and up sampling to rescale the feature maps and produce a more detailed output. The connections between these two paths allow features from the collapse path to be transferred to the corresponding layers in the expansion path, thus allowing the network to produce more precise segmentations [16].

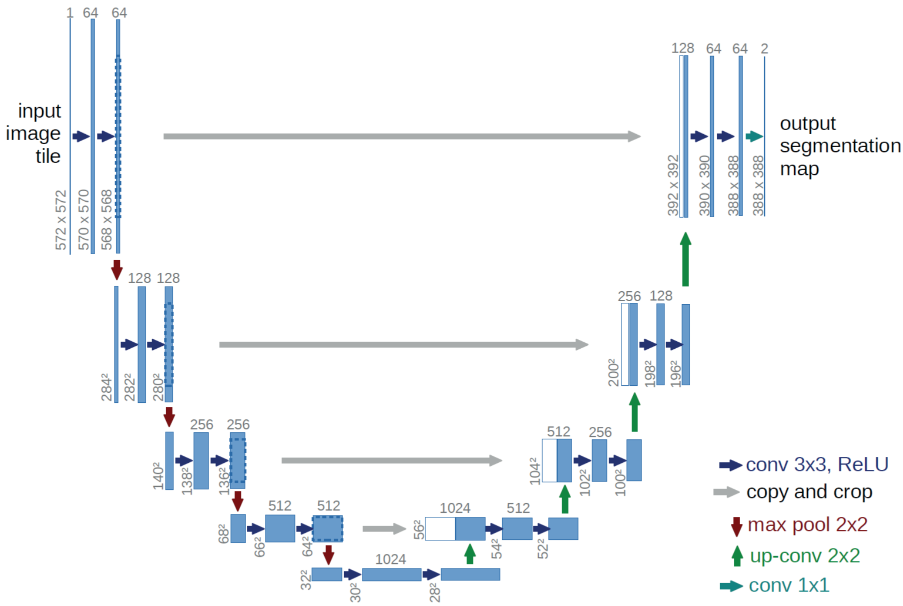

Figure 5. *General Structure of U-Net Algorithm*

2.2 Artificial Intelligence Applications in Healthcare

Artificial intelligence is transforming many processes in the medical field, such as diagnosis, treatment and patient care. Research in this field shows that AI is effective in areas such as medical imaging, disease diagnosis, treatment recommendations, patient monitoring and management of healthcare services. Thanks to big data analysis and learning algorithms, AI applications enable faster, more accurate and personalized delivery of healthcare services. For example, AI algorithms used in medical imaging can help radiologists diagnose diseases such as cancer earlier and more accurately. In addition, AI-powered chatbots and virtual health assistants make it easier for patients to access healthcare services by answering their questions and performing pre-assessments. These technological advances have the potential to reduce costs while improving the quality of healthcare.

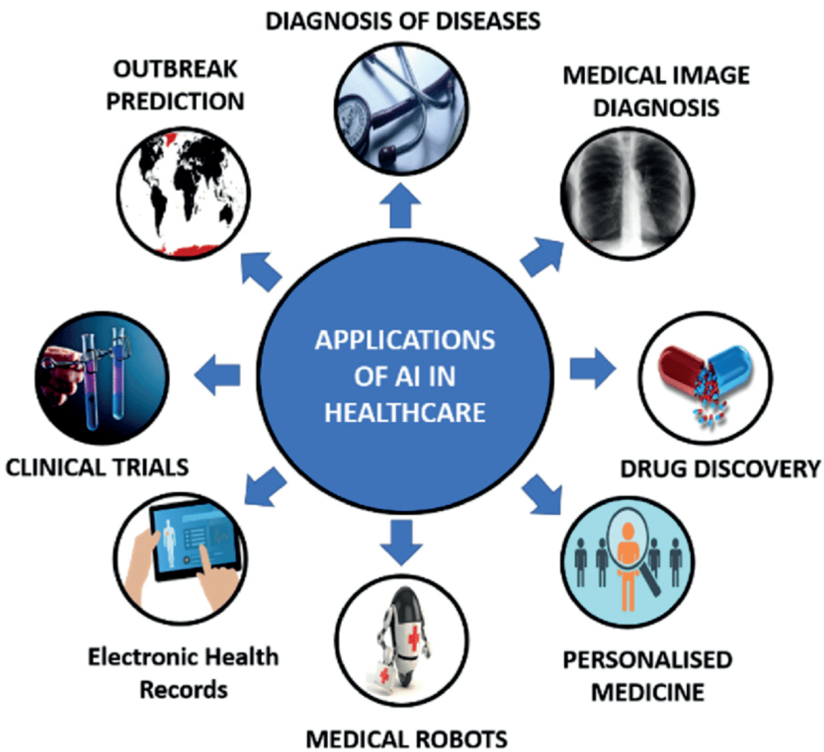

Figure 6. *Applications of AI in Healthcare*

Figure 6 show that how artificial intelligence applications are applied in the field of health. To mention these areas in order;

- **Diagnosis of Diseases:** The use of artificial intelligence for disease diagnosis. Artificial intelligence for disease diagnosis often uses methods such as deep learning and machine learning. These processes are based on analyzing large amounts of medical data and identifying patterns. Many methods and algorithms are used here. These include Convolutional Neural Networks (CNN), DenseNet, ResNet, ResNet, VGG and MobileNet, which use pre-trained deep learning models to select high-level features and improve classification performance [17].

- **Medical Image Diagnosis:** Medical image diagnosis with artificial intelligence methods is the process of analyzing medical images such as X-ray, MRI, CT and ultrasound using deep learning and machine learning techniques. This process consists of data collection and preparation, preprocessing, model training, feature extraction and classification, evaluation and validation, and clinical application. In particular, deep learning models such as Convolutional Neural Networks (CNNs) learn to recognize disease-specific features in medical images during training and are capable of diagnosing new images using these features. Medical image diagnosis with AI has the potential to speed up the diagnostic process, improve accuracy and reduce the workload of doctors, but accurate training, sufficient data and clinical validation are required for effective use of these systems. Advances in this field are supported by academic studies that include topics such as evaluating the performance of the model and its use in the clinical setting [17].

- **Drug Discovery:** Artificial intelligence drug discovery is a process used to rapidly screen and develop drug candidates by identifying potential therapeutic targets. This technology extracts meaningful information from large biological and chemical data sets using methods such as data mining and machine learning. Artificial intelligence can speed up the drug development process, reduce research costs and lead to the discovery of more effective drugs. This process allows for a better understanding of disease mechanisms, the development of targeted therapies and the advancement of personalized medicine. AI-based drug discovery methods have made significant advances in areas such as genetic sequencing, molecular simulation and biomarker analysis. The application of this technology has the potential to revolutionize drug discovery and development processes, thus contributing to human health by providing faster and cost-effective solutions [18].

- **Personalized Medicine:** By analyzing large data sets, such as genetic information and disease history, artificial intelligence plays a critical role in developing tailored treatments for patients. This is particularly important in the treatment of complex diseases such as cancer, as AI algorithms can determine the most appropriate treatment for the patient's genetic makeup and disease characteristics. Furthermore, AI-based systems can monitor patients' health status in real time, assessing their response to treatment and personalizing it if necessary. Another important application of this technology is in the early diagnosis of diseases [19].

- **Medical Robots:** Medical robots provide significant benefits to doctors in medical applications. These robots enable surgical procedures to be performed in a more precise and controlled manner, shorten operation times and accelerate patient recovery processes. Especially in the field of laparoscopic and robotic surgery, medical robots allow doctors to get better visibility in tight spaces and perform less invasive procedures. Robot-assisted surgeries reduce the physical impact on the patient, minimizing postoperative complications such as pain, risk of infection and scarring. Furthermore, medical robots make it possible to perform complex surgical procedures more safely, thanks to advantages such as repeatability and high accuracy. Robotic surgical systems provide doctors with a working environment supported by technologies such as 3D imaging and augmented reality, contributing to more effective and efficient surgeries. These developments have the potential to improve the quality of healthcare services while at the same time reducing healthcare costs [20].

- **Electronic Health Records:** Artificial intelligence provides significant benefits in the management of electronic patient records and improves the efficiency of healthcare. By extracting complex patterns from large data sets, AI algorithms speed up the analysis of patient records and improve diagnostic processes. This allows for earlier diagnosis of diseases, personalizing treatment processes and improving the overall quality of healthcare.

- **Clinical Trials:** AI improves efficiency in the design, management and analysis of clinical trials, providing faster and cost-effective solutions. In particular, in data management and analysis, AI facilitates the processing of large and complex data sets so that researchers can gain deeper insights into diseases and potential treatments. In patient selection and stratification, AI can improve the success rate of clinical trials by enabling more accurate targeting, especially in heterogeneous patient populations. Furthermore, AI-based algorithms can monitor side effects and treatment efficacy in real time, thus enabling early intervention [21].

- **Outbreak Prediction:** By processing information from large data sets, artificial intelligence can predict the spread and impact of outbreaks. In this process, AI algorithms analyze various data sources such as disease cases, travel data, social media data and environmental factors. By processing this data, AI can predict the starting points of outbreaks, the speed of their spread, and the regions they potentially affect. Furthermore, AI methods can also be used to predict demand and resource needs for healthcare systems during outbreaks. For example, AI-based modeling can provide early warnings of disease spread, helping to plan public health interventions in a timely and effective manner. These technologies also play an important role in optimizing vaccine distribution and treatment modalities. The success of AI in outbreak prediction depends on data quality, algorithm accuracy and cross-disciplinary collaboration. In this context, applications of AI in the healthcare sector have the potential to revolutionize the management and control of outbreaks [22].

Theoretically and practically, many artificial intelligence methods can be applied in almost all processes in healthcare. Today, in many health institutions, it is quite clear how artificial intelligence has made an impact in the field of medicine and how this technology has improved health services.

3. Artificial intelligence in healthcare in the world

In order for healthcare organizations to survive and remain competitive, they must reduce the costs they have to bear every day and increase the quality of treatment and service. In this context, healthcare organizations should provide excellent healthcare services by reducing their costs by using artificial intelligence technologies. In this way, they can provide both fast and quality healthcare services to patients. Considering that human health cannot be equated with anything on earth, it is very important that this cutting-edge technology is used to save and improve human life. To illustrate with examples from around the world, the Intel IT company and the Montefiore Health System in the United States have developed artificial intelligence solutions to provide patients with more efficient healthcare and to investigate common patterns of patients. This makes it possible to reduce human errors, reduce medication waste due to errors in calculating drug doses, and reduce the financial and moral damage of incorrect treatments recommended and administered to patients [23]. In a study conducted by the Centerstone Research Institute in the United States, it was determined that diagnosing patients using artificial intelligence technology is much less costly than traditional methods. In this study, using artificial intelligence algorithms, the physical findings and disease outcomes of approximately 500 randomly selected patients were compared. The study showed a significant difference between the costs per unit [24]. In addition, today, dozens of surgeries are performed by specialist doctors with remote access and artificial intelligence support. In this context, robots provide assistant support to doctors. Therefore, robotic surgery systems are frequently preferred by physicians. As a result, it becomes possible for an expert doctor from one end of the world to reach a patient on the other end of the world by minimizing time and transportation costs.

Watson is a world-renowned artificial intelligence system that uses machine learning, data mining and natural language processing to help physicians review their patients' electronic health records, access disease-related academic publications and review disease-related documents. A study in India showed that the treatment recommended by the Watson oncology system to 638 patients with breast cancer was 90% identical to the treatments recommended by the tumor detection board, saving significant time. The researchers used both the Watson system and the manual method to collect and analyze data to create recommendations and compared the elapsed times of the two methods. The result was a significant improvement in both time and cost [25]. From research to delivery to patients, drug production in research laboratories is very costly and takes a very long time. A biomedical company in the United States reports that it takes approximately eight years to get a drug from the research laboratory to the patient. Only a fraction of the drugs that enter preclinical testing during drug production are approved for human use. However, a pharmaceutical company needs to spend around 250 million US dollars to develop a new drug in research laboratories to make it available to patients [26]. As a rival to the work done in America, a lot of work is being done in the field of artificial intelligence in China. Especially in recent years, an artificial intelligence algorithm developed in China makes predictions about when patients in a coma will wake up and the subsequent processes. In this regard, the software applied to 10 different patients predicted better than the doctors whether these patients would wake up and, if so, when they would wake up. As a result, the tasks to be done were determined without wasting time and the resources were used at the right time [27].

Scientists at a research institute in the United States have designed an application that uses artificial intelligence to determine the likelihood of breast cancer. This new application has the ability to identify breast cancer potential by reviewing millions of records using mammography images of patients. The researchers who developed the application used artificial intelligence to evaluate mammography and pathology reports from thousands of patients. Research has shown that artificial intelligence can diagnose 30 times faster and 99% more accurately than a doctor. As a result, this method can be used as an effective method for both time and cost optimization in a few medical institutions [28].

4. Discussion and Result

In recent years, the importance of health services in global economies has increased. The rapid development of technology and information systems has also pushed the healthcare sector into the process of digitization. The rapid development of technology and information systems and increasing competition have also driven the healthcare sector. However, it has enabled the rapid integration of artificial intelligence (AI) technologies into the health sector. Artificial intelligence is being used across a wide range, from diagnosis to treatment, to protective health services to administrative processes, accelerating processes and reducing costs. However, the use of incorrect or unsafe AI systems can threaten human employment and lead to misdiagnosis and treatment. Analyses show that AI technologies have the potential to reduce labor force and access problems in healthcare, reduce costs and speed up processes. However, the importance of ethical principles, policy development, measurement and monitoring mechanisms for managing risks such as autonomous attacks, unreliable diagnoses and medical errors that may be encountered during the use of AI is stressed. In this context, the responsible and ethical use of AI technologies in the health sector is critical to maximizing the benefits of these technologies. The use of artificial intelligence in healthcare can help doctors diagnose, monitor, classify, make decisions, make treatment choices and make recommendations. For example, artificial intelligence-based methods can reduce errors in cancer diagnosis, listen to patients' symptoms to guide the treatment of the disease, and generate automated medical reports by diagnosing IT images. As doctors and other health workers have to provide their health services, it is becoming increasingly important for them to adopt and use new technologies. Consequently, healthcare providers should be informed of the key issues or potential risks associated with the use of artificial intelligence in health services. In the healthcare sector, where such expensive and complex technologies are used, these technologies undoubtedly provide benefits such as effective diagnosis and treatment, reducing errors and costs, making the right decisions, saving labor and time, but also bringing about problems such as investment costs and the technology's persistence. In terms of commitment to technology, it is known that technology transferred, especially from developed countries to underdeveloped countries, creates a huge gap. However, the idea that human life is more valuable than material elements make it possible to ignore the economic aspect of the situation. However, it is possible to evaluate and ensure the sustainability of technologies used in the health sector by developing adequate numbers and quality human resources. Otherwise, unreasonable technology transfers can lead to waste of resources and excess technology capacity. It is essential to have informed professionals to build an AI-oriented health system, to ensure a high level of data protection and privacy, to maintain a high standard of cyber resilience and cyber security, an adequate level of transparency, regulatory supervision and high security. In this case, it is very important to review the existing regulatory framework and to follow the process in line with new technological developments. In order to ensure that artificial intelligence is used ethically and legally in healthcare, the co-operation of all stakeholders, including AI professionals, patients, clinical teams, healthcare managers and regulators, is essential. To develop a common vision, stakeholders should be informed about the advantages, disadvantages and opportunities of integrating artificial intelligence into health services.

Our future may be heavily influenced by technological developments such as artificial intelligence, medicine and big data. As these technologies become more widespread and integrated into health services, the role of health professionals is thought to change. Will medical diagnosis replace artificial intelligence in the future? Will the future tasks of health professionals shift to case management? Or questions will arise as to whether scanning, detection and identification areas will go to smart machines. However, it is believed that artificial intelligence should be used as an auxiliary to doctors and could not replace them. Because something that seems emotionally impossible is smart machines taking over the doctor-patient relationship. It is unacceptable that the delivery of health services, especially verbal, tactile, auditory and emotional communication, should be transferred to digital technologies.

As a result, artificial intelligence technologies have the potential to revolutionize the health sector, and responsible use of these technologies can create a safer and more accessible health system for patients, while improving the quality of health services. In this context, governments and health institutions need to develop policies that support the implementation of AI, implement ethical and legal regulations, and establish a permanent monitoring mechanism. This will maximize the potential of AI in the health sector, while preventing potential risks.

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Chapter 6

OXYGEN AND CARBON ISOTOPE GEOCHEMISTRY OF ÇALTEPE FORMATION LIMESTONES AROUND GÖÇERI VILLAGE (HÜYÜK, KONYA, TÜRKIYE)

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1. Introduction

Çaltepe Formation limestones (Lower-Middle Cambrian) hold an important place in the geological development of Turkey. The study area is located around Göçeri Village (Akşehir, Konya) in the southeast of the Sultandağları Massif, located within the Taurids Main Tectonic Unit (Figure 1). The purpose of this study is to determine the $\delta^{18}O$ and $\delta^{13}C$ isotope properties of Çaltepe Formation limestones. A measured stratigraphic section was taken from the Çaltepe Formation and 58 limestone samples were collected (Figures 2, 3). The $\delta^{18}O$ and $\delta^{13}C$ isotope analyses were performed on 39 limestone samples collected from the study area, selected from appropriate levels for the purpose, at the UC-Davis Laboratory of the University of California. The obtained isotope values were evaluated by dropping them in various diagrams.

Figure 1. Location map of the study field (Google Maps).

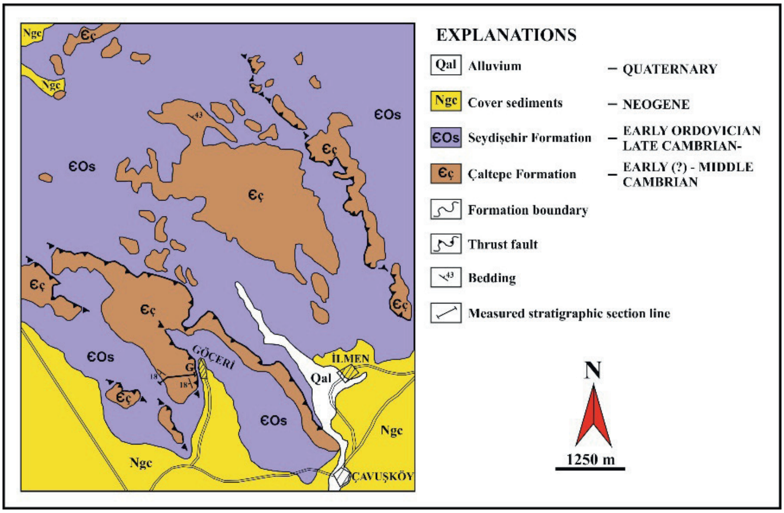

Figure 2. Geological map of the study field (modified from Özkan and Küpeli, 2017).

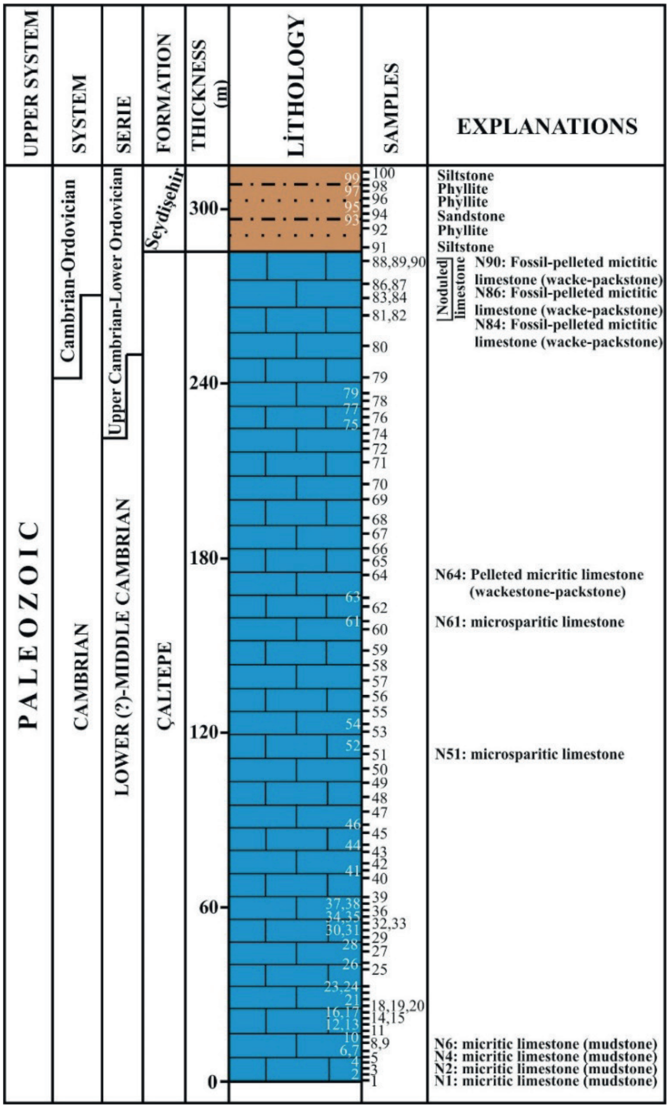

Figure 3. Measured stratigraphic section of the Çaltepe Formation (modified from Özkan and Küpeli, 2017).

Özgül (1997), in his study outside the study area, stated that the Çaltepe Formation consists of dolostone, dolomitic limestone, and neritic limestone at the base and that it consists of variegated colored nodular limestones with thin shale interlayers at the upper levels. In the study area, the Çaltepe Formation does not contain dolostone and only features limestone and nodular limestone (Figure 4A-D).

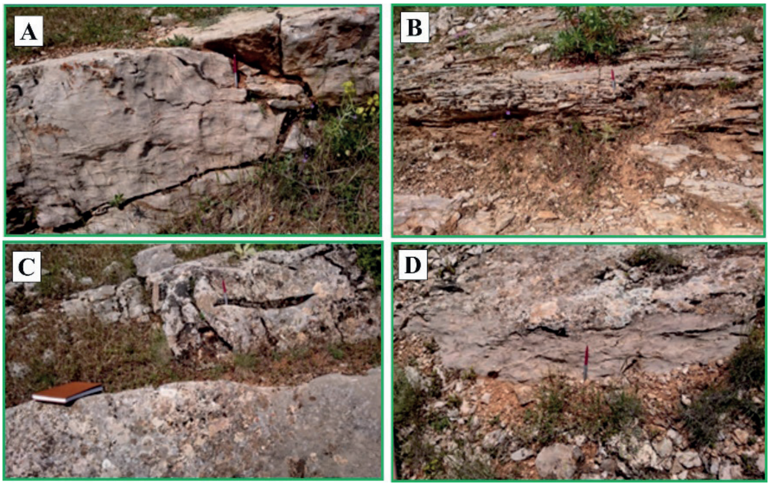

Figure 4. A) Limestone of the Çaltepe Formation (northwest of Göçeri Village), B) Limestone with calcschist characteristics belonging to the Çaltepe Formation (northwest of Göçeri Village), C) Medium-thick layered and compact limestone belonging to the Çaltepe Formation (northwest of Göçeri Village), D) Nodular limestone belonging to the Çaltepe Formation (northwest of Göçeri Village).

Since the Çaltepe Formation is the oldest unit forming the foundation in the study area, it could not be determined which unit it overlies, but in the study conducted by Özgül (1997) outside the study area, it was stated that the Çaltepe Formation overlies the Hamzalar Formation with a conformity contact. In the study area, in some places the Çaltepe Formation overlies the Seydişehir Formation with a tectonic contact, while in some places it is covered by the Seydişehir Formation with a conformity contact from the top (Figure 2). The thickness of the Çaltepe Formation was measured as 290 meters according to the measured stratigraphic section (Figure 3).

In this study, no fossils that could give an age were found from the limestones of the Çaltepe Formation. Dean and Monod (1970) gave the unit an Early-Middle Cambrian age because they found trilobite fossils indicating the Early Cambrian in the lower levels and the Middle Cambrian in the upper levels of the upper part of the dolomitic limestone member of the Çaltepe Formation, where they worked around Seydişehir. This age was also accepted in this study.

Çaltepe Formation limestones were deposited in a shallow-deep shelf environment dominated by carbonate development, according to their paleontological and microfacies characteristics.

According to the measured stratigraphic section, Çaltepe limestones start with gray-colored, thick-layered micritic limestones (mudstone) at the base and end with wackestone-packstone at the ceiling (Figure 3). The nodular limestones in the upper level are in the form of sandy, micritic matrix limestone layers and contain opaque minerals, quartz, plagioclase, and sparicalcit stylolite.

Considering the microscopic features of the samples collected from the limestone of the Çaltepe Formation, it was determined that they were largely in the mudstone, wackestone, and packstone microfacies according to the Dunham (1962) classification (Özkan and Küpeli, 2017).

2. Oxygen and Carbon Isotope Characteristics of the Çaltepe Formation Limestones

$\delta^{13}C$ and $\delta^{18}O$ isotope values of Çaltepe limestone samples are given in Table 1.

Table 1. $\delta^{13}C$ and $\delta^{18}O$ isotope analysis results of Çaltepe limestone samples (‰; VPDB)

Sample	$\delta^{13}C$	$\delta^{18}O$	Diagenetic temperature (°C)	Gömülme derinliği (m)	Mn/Sr (Özkan and Küpeli, 2017)
G90	1.01	-9.90	53	1767	2.80
G89	0.38	-9.82	53	1767	0.77
G88	0.96	-12.52	74	2467	2.77
G87	-2.90	-9.17	48	1600	4.14
G86	0.77	-10.10	55	1833	2.05
G85	-1.10	-9.85	53	1767	1.74
G84	0.39	-9.77	52	1733	1.60
G83	-0.09	-9.91	53	1767	1.24
G82	-0.22	-9.51	50	1667	1.49
G80	0.21	-10.61	58	1933	1.68
G78	0.02	-11.23	63	2100	1.02
G76	1.01	-11.71	67	2233	1.30
G72	0.97	-12.18	71	2367	0.56
G69	0.61	-12.19	71	2367	1.78
G66	-0.35	-13.78	84	2800	3.05
G64	0.86	-14.32	91	3033	0.73
G61	0.42	-13.53	82	2733	2.49
G57	-0.55	-11.70	67	2233	1.78
G54	-0.90	-11.69	67	2233	1.70
G51	0.77	-14.14	87	2900	2.33

Table 1. Continued.

G46	0.39	-15.00	95	3167	1.43
G43	0.80	-15.00	95	3167	2.19
G39	0.77	-15.01	95	3167	1.52
G35	0.30	-14.82	94	3133	1.74
G32	0.52	-15.03	95	3167	2.99
G29	0.50	-14.87	94	3133	1.65
G23	0.80	-15.08	96	3200	1.47
G19	0.80	-15.02	95	3167	1.92
G16	0.64	-14.90	94	3133	1.68
G13	0.43	-15.01	95	3167	2.47
G11	0.42	-12.71	75	2500	2.18
G9	0.58	-13.38	81	2700	1.75
G7	0.84	-15.35	98	3267	1.55
G6	0.22	-12.62	84	2800	1.74
G5	0.00	-13.99	86	2867	1.93
G4	0.01	-13.91	85	2833	1.97
G3	0.25	-14.15	87	2900	2.46
G2	0.35	-12.21	71	2367	2.06
G1	0.56	-12.88	77	2567	2.49

According to these values, $\delta^{13}C$ isotopes of Çaltepe limestone samples vary between -2.90 and 1.01‰, while $\delta^{18}O$ isotopes vary between -15.35 and -9.17‰ (Table 1). Additionally, a weak negative correlation was observed between $\delta^{13}C$ versus $\delta^{18}O$ values of Çaltepe limestone samples (Figure 5). In addition, the distribution patterns of $\delta^{13}C$ and $\delta^{18}O$ isotope values of limestone samples belonging to the Çaltepe Formation from bottom to top are in the form of decreases and increases (Figure 6).

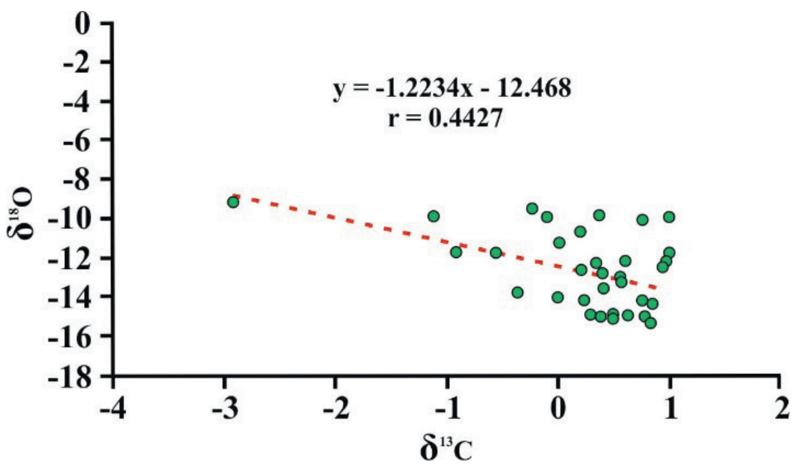

Figure 5. $\delta^{13}C$ versus $\delta^{18}O$ isotope diagram of Çaltepe limestone samples.

The diagenetic temperatures of Çaltepe carbonates calculated according to the formula of Anderson and Arthur (1983) (with $\delta^{18}O$ values) vary between 48-98°C (average 77°C) (Table 1).

$$T^{o}C = 16.0 - 4.14(\delta c - \delta w) + 0.13(\delta c - \delta w)^2$$

In this equation δc is $\delta^{18}O$ of the carbonate compared to the PDB international standard and δw is $\delta^{18}O$ of the water compared to the SMOW international standard.

In the $\delta^{18}O$ and $\delta^{13}C$ isotope diagram, Çaltepe carbonate samples show climatic and diagenetic changes (Figures 7, 8). In addition, Çaltepe carbonate samples in Figure 9 indicate mostly low and less often high rock-water interaction.

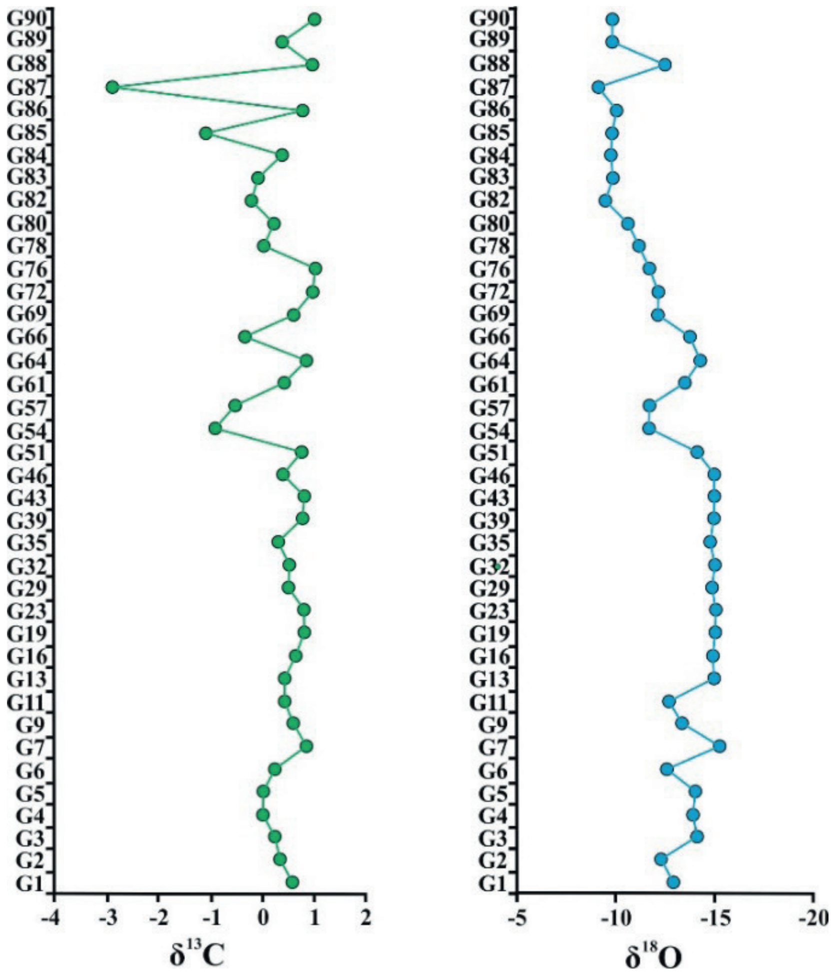

Figure 6. Distribution of $\delta^{13}C$ isotope and $\delta^{18}O$ isotope values of Çaltepe limestone samples.

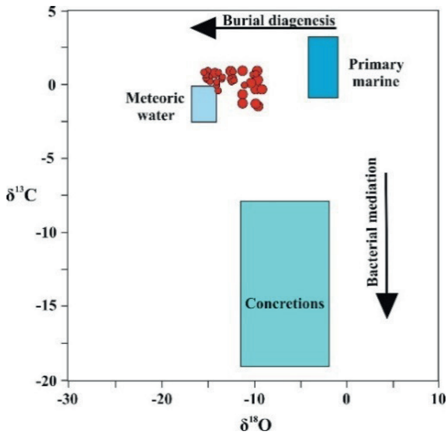

Figure 7. $\delta^{18}O$-$\delta^{13}C$ cross plot of the Çaltepe carbonate samples.

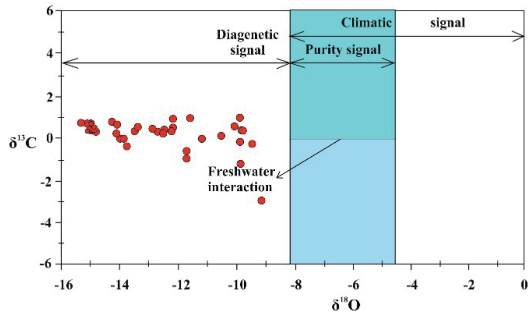

Figure 8. Position of Çaltepe carbonate samples in the weak negative correlation $\delta^{13}C$ versus $\delta^{18}O$ diagram. All samples fall within the diagenetic influence area.

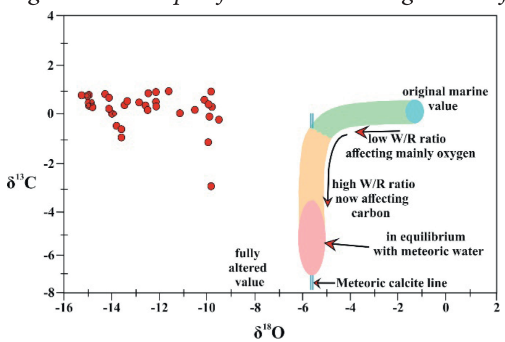

Figure 9. Graph of changes in $\delta^{18}O$ and $\delta^{13}C$ that accompany modification of a marine carbonate by meteoric water (Lohmann, 1988). Initial dissolution and reprecipitation by interaction with pore water fluids with a small meteoric component will shift carbonates to lower $\delta^{18}O$ values but leave $\delta^{13}C$ values relatively unchanged. Only after water-rock (W/R) ratios become very large, will $\delta^{13}C$ values decrease. The vertical line defined by increasing water-rock (W/R) interaction is the 'meteoric calcite line', which defines the $\delta^{18}O$ value of meteoric water responsible for precipitates of late calcite cement (from Lohmann, 1988).

Figure 10 shows which organisms were effective in the deposition of Çaltepe limestones. However, due to the effect of diagenetic alteration, the fact that our samples fell in areas far from areas indicating organisms prevented this distinction from being made. In the petrographic examination of Çaltepe carbonates, trilobite shell fragments, and crinoid discs were encountered. Dean and Monod (1970) found trilobite and brachiopod fossils in Çaltepe limestone. These data indicate that Çaltepe limestones were deposited in a carbonate-dominated shelf environment.

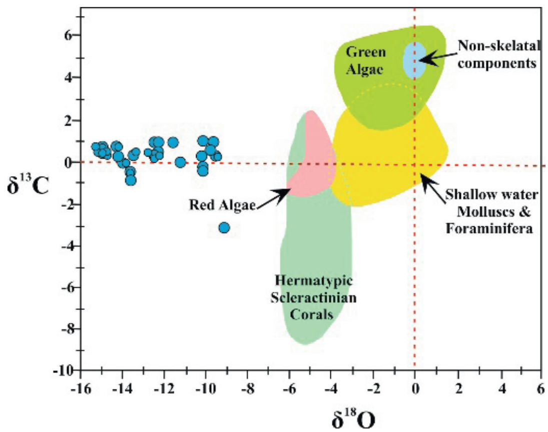

Figure 10. Diagram of $\delta^{18}O$ versus $\delta^{13}C$. Explanation of the range of imbalance oxygen and carbon isotope offsets for selected modern organisms based on biotic impact. After Anderson and Arthur (1983).

In another $\delta^{18}O$ and $\delta^{13}C$ graph, Çaltepe carbonates show the development from seawater and exposure to the effect of hydrothermal fluids (Figure 11). Again, in another $\delta^{18}O$ and $\delta^{13}C$ graph (Figure 12), it is seen that Çaltepe limestone samples are under the influence of medium-deep burial and hydrothermal diagenetic environment, and supergene freshwater diagenetic environment.

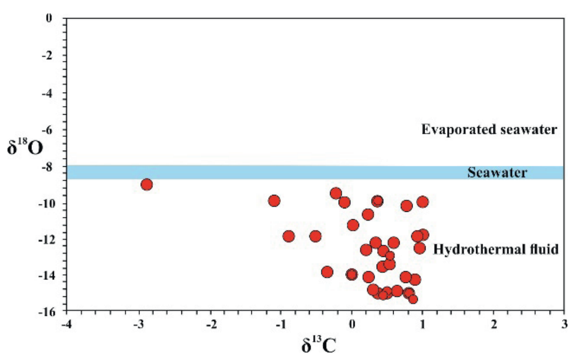

Figure 11. Diagram of $\delta^{18}O$ versus $\delta^{13}C$.

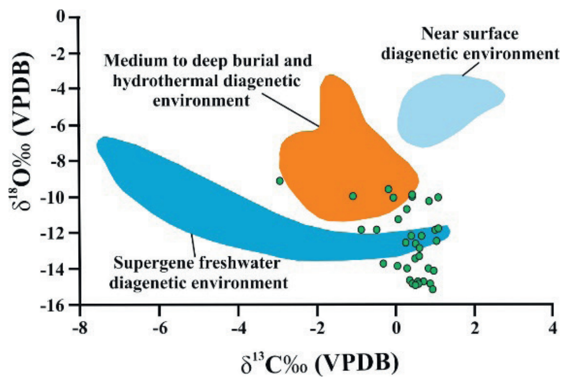

Figure 12. Graph of carbonate rock values of δ18O versus δ13C.

3. Discussion

Çaltepe Formation limestones, according to their paleontological and sedimentological characteristics, indicate deposition in a carbonate-dominated shelf environment.

$\delta^{18}O$ of the seawater is checked up by the global ice volume associated with eustatic sea level, and $\delta^{13}C$ is affected by the degree of the biological uptake of light carbon from the dissolved ΣCO_2 in the ocean (e.g., Broecker and Peng, 1982; Niitsuma et al., 1991). Heavier value of $\delta^{13}C$ corresponds to higher degree of the uptake and the smaller amount of ΣCO_2 in the ocean (Niitsuma et al., 1991). The adverse correlation between $\delta^{18}O$ and $\delta^{13}C$ proposes that glacial phases with low sea levels had larger amount of ΣCO_2, and interglacial phases with high sea levels had smaller amount of ΣCO_2 in the ocean (Niitsuma et al., 1991). Therefore, we can say that the negative correlation between $\delta^{18}O$ and $\delta^{13}C$ observed in Çaltepe carbonates (Figure 5) is due to the fact that glacial phases with low sea levels in the basin have a greater amount of ΣCO_2 and interglacial phases with high sea levels have a smaller amount of ΣCO_2. The Cambrian world was located between two ice ages, one during the late Proterozoic and the other during the Ordovician (Britannica, 2024). However, during the Cambrian there was no significant ice occurrence. None of the continents were present at the poles so land temperatures remained mild. Essentially, across the world climate was presumably warmer and more uniform than it is today (Britannica, 2024). During the Cambrian period, sea levels increased significantly, but fluctuations also developed.

The carbonate paleotemperature equation has three variables; $^{18}O_{carbonate}$, $^{18}O_{water}$, and temperature (t). We estimate t from the measured $^{18}O_{carbonate}$ value and an assumed $^{18}O_{water}$ value. Assuming ice-free conditions for the Cambrian Ocean and no change in $\delta^{18}O$ seawater (-1.4‰ to -1‰; V-SMOW) over time (Wotte et al., 2019), a V-SMOW value of -1.4 was used in the diagenetic temperature calculation of the Çaltepe carbonates. Çaltepe carbonate samples have values considerably higher than the critical temperature of 50°C. This is consistent with a strong diagenetic alteration (medium-deep burial and hydrothermal fluid effect) (Table 1; Figures 7-9, 11, 12).

Post-depositional alteration causes increases in Mn^{2+} and Fe^{2+} contents and decreases in Sr^{2+}, Na^{+}, ^{18}O, and possibly ^{13}C contents in carbonate components (Brand and Veizer, 1981; Colombié et al., 2011). Sr^{2+} and Mn^{2+} are useful diagenetic tracers due to their widely divergent partition coefficients, their association mostly with the carbonate lattice, and their large compositional differences in marine and meteoric water (Kinsman, 1969; Turekian, 1972; Colombié et al., 2011). Çaltepe limestone samples collected from the measured stratigraphic section show Mn/Sr ratios ranging from 0.56 to 4.14 (1.90 on average) (Özkan and Küpeli, 2017). Thus, while 2 samples exhibit strong diagenetic alteration, 37 samples exhibit low diagenetic alteration, indicating a high degree of preservation of primary geochemical traces (Table 1).

It has been observed that there are different correlation relationships between Mg/Ca ratios, $\delta^{13}C$, $\delta^{18}O$ isotope values, and Mn/Sr ratios of Çaltepe limestone samples (Özkan and Küpeli, 2017). Accordingly, while no correlation is observed between Mg/Ca and Mn/Sr ratios, a moderate positive correlation is observed between Mg/Ca ratios and $\delta^{18}O$ isotope values. Additionally, no correlation was observed between Mg/Ca ratios and $\delta^{13}C$ isotope values (Özkan and Küpeli, 2017). Considering these data, it was observed that the $\delta^{18}O$ isotope values became heavier as the Mg content of the limestone samples increased. Therefore, the factor that causes the Mg content to increase in the water mass also causes the $\delta^{18}O$ isotope values to become heavier. This can be explained by the mixing of cold Mg-rich waters with heavier $\delta^{18}O$ isotope contents into relatively high-temperature shallow marine waters (Özkan and Küpeli, 2017).

When looking at the relationships between diagenetic temperatures and $\delta^{13}C$ and $\delta^{18}O$ isotope ratios, no significant correlation is observed between temperature and $\delta^{13}C$ isotope ratios, while a strong negative (r=-0.99) correlation is observed between temperatures and $\delta^{18}O$ isotope ratios. This shows that diagenetic processes and increasing temperatures do not cause any alteration at $\delta^{13}C$ isotope ratios, but $\delta^{18}O$ isotope values undergo alteration and become lighter.

The diagenetic environment of carbonate rocks is the sum of various environmental factors, such as salinity, temperature, and redox properties. Sea level influences diagenesis by controlling the movement state of underground fluid thus designating the diagenetic environment and diagenetic process (Xiaofeng et al., 2023). The environment specifies the fabric of matter, and different diagenetic environments destinably bring about differences in carbon and oxygen isotope characteristics in their sediments (Xiaofeng et al., 2023).

Analyzing the diagenetic environment has formed a key link in carbonate rock research, and identifying the diagenetic environment through the connection of carbon and oxygen isotopes has become an effective method (Xiaofeng et al., 2023). Jiang et al. (2008) discriminated the diagenetic environments of carbonate rocks into seawater environments, atmospheric freshwater environments, mixed water environments, burial environments, and epigenetic environments (Xiaofeng et al., 2023). Huang (2014) discriminated the diagenetic environments of carbonate rocks into early near-surface, epigenetic atmospheric freshwater, late mid-deep burial, and hydrothermal diagenetic environments (Xiaofeng et al., 2023). The carbon and oxygen isotopes of the Çaltepe carbonates in this study mostly display the meso diagenetic environment and the medium–deep burial and hydrothermal diagenetic environments.

Considering the thermal limit of 38°C as a critical threshold, secular changes in the oxygen isotopic composition of ocean seawater are requisite to express the presence of marine life in the Paleozoic (Wotte et al., 2019). Wotte et al. (2019), based on their interpretation of Siberian data, stated that the minimum decrease in the oxygen isotope composition of early-middle Cambrian seawater compared to today would be approximately -3 ‰. They have stressed that with this assumption calculated subtropical sea surface temperatures vary between 28°C and 32°C. These sea surface temperatures would be clearly below the upper lethal limit of 38°C marine organisms (Wotte et al., 2019).

Using a surface temperature of 28 to 32°C (average 30°C) for the Cambrian Sea, burial depths of the Çaltepe limestones were estimated to range from 1600 to 3267 m (Tablo 1).

Usually, the oxygen isotope values in marine sediments increase with increasing paleosalinity because pending the evaporation process, $\delta^{16}O$ is first transported by atmospheric precipitation, leading to the enrichment of $\delta^{18}O$ in evaporated seawater (Xiaofeng et al., 2023). Keith and Weber (1964) recommend a classic salinity formula for distinguishing marine limestone from freshwater limestone during the Jurassic period and beyond based on the analysis and summary of a large amount of carbon and oxygen isotope data:

$$Z = 2.048 \times (\delta^{13}C_{PDB} + 50) + 0.498 \times (\delta^{18}O_{PDB} + 50)$$

(Xiaofeng et al., 2023). It is trusted that when the carbonate rock value of Z >120, it was by marine sedimentation, and when Z <120, it formed by freshwater sedimentation (Xiaofeng et al., 2023). This proposed formula has been widely used in determining the paleosalinity of carbonate sedimentary environments in different geological histories.

The Z value of Çaltepe limestone samples varies between 116.8 and 124.4 (average 121.5), with 4 samples being <120, indicating a brackish water environment, and 35 samples being >120, indicating a marine water environment. This indicates the inflow of fresh water into the basin during the interglacial period, and therefore the change in sea water salinity.

In the binary diagrams of Z-values and $\delta^{13}C$ and $\delta^{18}O$ isotope values of Çaltepe limestone samples: while a strong positive (r=0.76) correlation is observed between the Z-value and $\delta^{13}C$, a very weak positive (r=0.25) correlation is observed between the Z-value and $\delta^{18}O$ (Figure 13). This suggests that this situation is probably closely related to the growth of algae and the rise and fall of sea levels.

As a result, we can say that the Çaltepe limestones were deposited under oxic-anoxic shallow-open marine environment conditions in a marine basin of the Early-Middle Cambrian period with fluvial and hydrothermal solution input, which developed as a result of the melting of the Baykonurian glaciers.

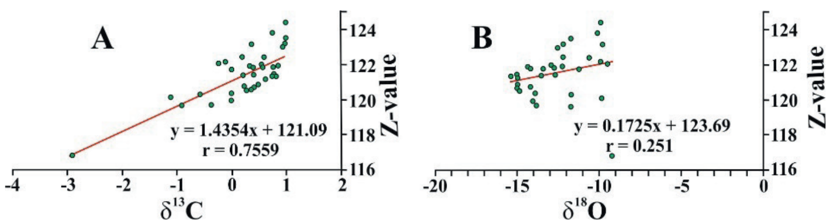

Figure 13. Diagrams of $\delta^{13}C$ (A) and $\delta^{18}O$ (B) versus Z-values of Çaltepe limestones.

4. Conclusions

Çaltepe limestones were deposited under oxic-anoxic shallow-open marine environment conditions in a marine basin of the Early-Middle Cambrian period with fluvial and hydrothermal solution input, which developed as a result of the melting of the Baykonurian glaciers.

Çaltepe carbonate samples have values considerably higher than the critical temperature of 50°C. This is consistent with a strong diagenetic alteration (medium-deep burial and hydrothermal fluid effect).

The carbon and oxygen isotopes of the Çaltepe carbonates in this study mostly display the meso diagenetic environment and the medium–deep burial and hydrothermal diagenetic environments.

Using a surface temperature of 28 to 32°C (average 30°C) for the Cambrian Sea, burial depths of the Çaltepe limestones were estimated to range from 1600 to 3267 m.

The Z value of Çaltepe limestone samples varies between 116.8 and 124.4 (average 121.5), with 4 samples being <120, indicating a brackish water environment, and 35 samples being >120, indicating a marine water environment.

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Chapter 7

ELECTROSPUN POLYBUTYLENE TEREPHTHALATE FIBERS

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1. Introduction

Poly(butylene terephthalate) (PBT), is one of the semicrystalline thermoplastics used in various applications. It is a promising material for fiber production and injection molding of automotive and electronic parts due to its superior properties. From the day it was launched on the market, it has become one of the popular commercial polyesters due to its stable mechanical, rheological, electrical (insulation), dielectric and thermal properties, chemical resistance, easy moldability, dimensional stability, quick crystallization behavior without nucleating agents. The degree of crystallinity of PBT is generally reported as between 35-40 % that was reported as the reason for robust structure and good mechanical properties. The glass transition temperature and melting temperature of PBT were reported around 30-50 °C and 220-230 °C respectively. Due to its quick crystal formation performance, its mechanical properties such as strength, toughness, stiffness, wearing resistance were reported to high compared to other thermoplastics (Thomas & P. M., 2011).

Electrospinning is a unique fiber formation process that is performed under electrical field through the use of a polymer solution. Various types of fibers can be spun including microfibers, nanofibers, composite fibers, nanocomposite fibers, bicomponent fibers and so on. The fiber morphology can be tuned by changing the polymer solution properties, spinning-environmental conditions, and set-up properties (Bagheri, Najafi Mobara, Roostaie, & Baktash, 2017; Catalani, Collins, & Jaffe, 2007; Chen et al., 2017; Danti et al., 2015; Forouharshad, Saligheh, Arasteh, & Farsani, 2010; Gardella, Fina, & Monticelli, 2015; Grande et al., 2018; Khalid Saeed, Soo Young Park, & Nauman Ali, 2009; Liguori et al., 2022; Mathew, Hong, Rhee, Lee, & Nah, 2005; Moroni, Licht, de Boer, de Wijn, & van Blitterswijk, 2006; Ramakrishna, Fujihara, Teo, Lim, & Ma, 2005; Saligheh, Arasteh, Forouharshad, & Farsani, 2011; Thomas & P. M., 2011; Wang, Fang, & Wang, 2015).

In this chapter electrospinning process is explained with basic system requirements. The process parameters and their effects on fiber formation and morphology were also discussed. Electrospinning of PBT fibers was reviewed by considering the most impactful studies and future recommendations and conclusions were given for PBT fibers.

2. Electrospinning

The electrospinning system consists of a feeding system, a collector and a power supply. All components have different functions as given below (Ramakrishna et al., 2005):

Feeding System: Feeding system is consisted of a syringe and a motor. Syringe is used to feed the polymer solution for fiber formation. It is generally work with a pumping system or a driver. Needle is used for a precise feeding of the electrospinning solution and formation of electrical field between syringe and collector. As given in Figure 1, syringe plunger is moved by a simple motor and spinning solution is fed. Pump system can be controlled by changing feed rate. The main function of the feeding system is to supply spinning solution between the needle and collector at a continuous, constant and controlled flow rate.

Collector: Collector is a plate that can be found in different geometries including rectangular, circular, grid, constant or rotary. Its basic function is to collect the fiber on its surface. It is grounded during spinning process for safety.

Power Supply: Power supply is used to generate electrical field between the collector and needle. Its main function is to enable stretching of fiber solution under electrical field. For electrospinning high voltage is required and it can be tuned to prepare different fibers with various morphologies.

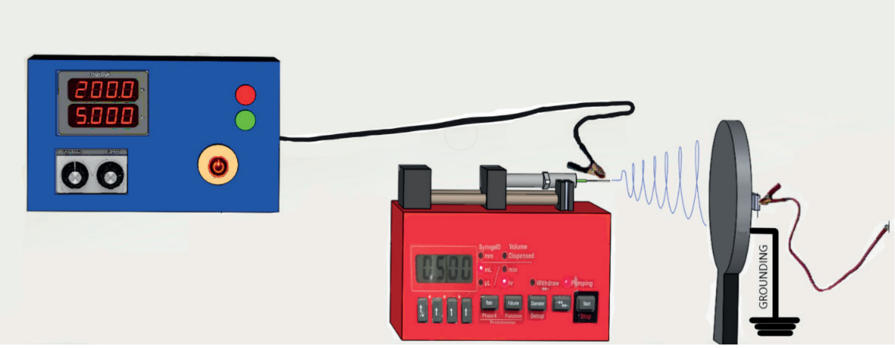

Figure 1. *Electrospinning set-up*

There are various factors that affect the fiber properties including polymer properties, solvent properties, solution properties, electrospinning conditions, mechanism of electrospinning system and environmental conditions. Fiber morphology can be tuned easily by changing only one parameter (Ramakrishna et al., 2005).

3. Electrospinning of PBT fibers

Depending on the composition, morphology and preparation methods, PBT fibers can be evaluated as;

- Electrospun PBT fibers
- Electrospun PBT composite fibers
- Electrospun PBT-based copolymer fibers

- Electrospun PBT bicomponent fibers

Electrospinning solutions were prepared by using different solvents including chloroform (Chen et al., 2017; Danti et al., 2015; Grande et al., 2018; Moroni et al., 2006), trifluoroacetic acid (TFA) (Bagheri et al., 2017; Catalani et al., 2007; Forouharshad et al., 2010; Gardella et al., 2015; Khalid Saeed et al., 2009; Saligheh et al., 2011; Wang et al., 2015), dichloromethane (DCM) (Forouharshad et al., 2010; Gardella et al., 2015; Moroni et al., 2006; Saligheh et al., 2011), hexafluoroisopropanol (HFIP) (Chen et al., 2017; Danti et al., 2015; Liguori et al., 2022; Mathew et al., 2005; Moroni et al., 2006) dichloroethane (DCE) (Moroni et al., 2006), dioxane, (Moroni et al., 2006) and/or their mixtures (Chen et al., 2017; Danti et al., 2015; Forouharshad et al., 2010; Gardella et al., 2015; Grande et al., 2018; Moroni et al., 2006; Saligheh et al., 2011). In the following sections, some impactful studies will be given as categorized below.

3.1 Elecrospun PBT Fibers

There are a few studies about PBT fibers. The studies were summarized in Table 1 by considering polymer type, solution concentration, filler type, filler concentration, solvent type, spinning conditions, fiber properties and application.

Forouharshad et al. electrospun PBT fibers by a traditional electrospinning set up. The study was performed based on changing process parameters and investigating their relationship with fiber properties. For this aim, various parameters were investigated that influence the electrospinning process, including the concentrations of the polymer and solvents, feed rate, applied voltage, tip-collector distance. In order to dissolve PBT, trifluoroacetic acid (TFA) and dichloromethane (DCM) 50/50 v:v were used. Concentrations of PBT were ranged from 12, 14 and 16 wt%. Process conditions were set as: 0.5 mL/h, 15 cm, 20 kV and 30 kV that were given as feed rate, tip-collector distance and applied voltage, respectively. Bead-fiber morphology was observed at 12 wt% polymer concentration. Smooth, solid fiber morphology was obtained at 14 wt% PBT concentration. Average fiber diameter values of 14, 16 wt% were measured as 549 nm at 20 kV, and 736 nm at 20kV, respectively. The study concluded that the concentration of the PBT solution and the applied voltage are critical parameters that determine the morphology of the electrospun fibers. While increased polymer concentration led to higher fiber diameter due to higher viscosity, increased applied voltage led to lower fiber diameter due to higher stretching of fibers. The electrospun PBT nanofibers exhibited higher degree of crystallinity and mechanical performance at 14 wt% polymer concentration and 30 kV. As obvious from these outcomes, polymer concentration and applied voltage significantly affected the morphology and mechanical properties of PBT nanofibers (Forouharshad et al., 2010).

In another study, Catalani et al., electrospun PBT fibers by conventional electrospinning techniques, using as trifluoroacetic acid (TFA) and hexafluoropropanol (HFIP) solvents. Electrospinning parameters were determined as: 4% w/w, 20 μL/min, 20 kV and 20 cm which were given as polymer concentration, feed rate, applied voltage and tip-collector distance, respectively. The fiber diameter was determined around 100-250 nm. As reported in the study, both solvents were found successful for electrospinning of the PBT. Fiber diameter could be tuned by changing solvent type, polymer concentration feed rate, needle diameter, applied voltage, needle-collector distance and so on. Additionally, PBT electrospun fibers showed high molecular orientation and residual charges, that were reported to influence their thermal and electrical properties. These findings enhance the understanding of the electrospinning process and its impact on the properties of PBT fibers, potentially informing their optimization for various applications, including tissue engineering (Catalani et al., 2007).

Wang et al., investigated the effects of entanglement density on the fiber diameter. In the first step, PBT fibers were obtained by dissolving PBT in TFA. A syringe pump was used at a flow rate of 1 mL/h. The distance between the tip and the collector was maintained at 14 cm. An applied voltage of 9.3 kV was used to create a sufficient electric field for the electrospinning process. Different concentrations (9, 10, 12, and 14 wt.%) of PBT solutions were used to study the effect on fiber diameter. Higher concentrations resulted in larger fiber diameters due to increased solution viscosity. Fiber diameters were influenced by solution concentration and viscosity. For example, a 9 wt% solution produced fibers with an average diameter of 354 ± 102 nm, while a 14 wt.% solution resulted in fibers with an average diameter of 1.13 ± 0.23 μm. In the second part of the study, nucleating performance of electrospun PBT fibers were compared with poly(ethylene terephthalate) (PET) and poly(trimethylene terephthalate) (PTT) fibers by using isotactic polypropylene (iPP). Electrospun PBT fibers were reported as effective nucleating agents for iPP, significantly enhancing its crystallization rate compared to PET and PTT fibers (Wang et al., 2015).

3.2 Elecrospun PBT Composite Fibers

Composite fibers are materials that consist of at least two components. The matrix is the polymer phase, and it provides fiber formation. The other phase is the filler that is generally used for obtaining additional functions. In the literature various fillers such as TiO_2 (Khalid Saeed et al., 2009), single wall carbon nanotubes (SWCNTs) (Saligheh et al., 2011), multi wall carbon nanotubes (MWCNTs) (Mathew et al., 2005), were used for preparation of PBT composite fibers. The studies were summarized in Table 2.

In one of these studies, electrospun PBT and TiO_2/PBT composite nanofibers were prepared and characterized using by scanning electron microscopy (SEM), transmission electron microscopy (TEM), X-ray diffraction analysis (XRD), Instron, and thermogravimetric analysis (TGA). In order to dissolve PBT, TFA was used and mixed in a magnetic stirrer. The polymer concentration was 10 wt% and the amount of TiO_2 was % 5 wt with average diameter less than 50 nm. Processing conditions were set as: 0.2 ml/h, 20 kV, 20 cm that were given as feed rate, applied voltage and tip-collector distance respectively. The observed diameter of PBT and TiO_2/PBT nanofibers were in the range of 500-100±50 nm. The mechanical, thermal and morphological properties were investigated. XRD analysis point that the electrospinning process successfully incorporated TiO_2 nanoparticles into the PBT polymer matrix, resulting in organic-inorganic composite nanofibers without altering the PBT's structure. To analyze the mechanical properties tensile tests were performed. The elongation at -break values of PBT and TiO_2 (5 wt%)/PBT were 51.01 ± 8.3 and 46.2 ± 7.1 respectively. The results indicate that adding TiO_2 made nanofibers stronger but less flexible. It was also observed that TiO_2 particles in nanofiber composites remained at high temperatures due to the presence of thermally stable TiO_2 nanoparticles. According to TEM analysis, TiO_2 particles were adequately dispersed and encapsulated (Khalid Saeed et al., 2009).

In another study, single wall carbon nanotubes (SWCNTs) were used as the fillers and TFA, DCM were used as the solvents to prepare electrospun PBT/SWCNT composite nanofibers. Polymer concentration was determined as 15 wt% and processing conditions were set as: 0.5 ml/h, 20 kV, 15 cm that were given as feed rate, applied voltage and tip-collector distance respectively. Various amounts of SWCNTs were used: 0.5, 1, 2, and 4 wt%. The effects of different amounts of SWCNTs on morphological, crystallization and mechanical properties were examined by SEM, DSC, and tensile testing, respectively. SEM analysis revealed that lower SWCNT content resulted in finer fibers, while higher filler content led to broader fiber diameter distribution. Additionally, the average fiber diameter of 0.5, 1, 2 and 4 wt % were 473, 422, 462 and 651 nm, respectively. The presence of SWCNTs acted as a nucleating agent, promoting faster crystallization and increasing the degree of crystallinity at moderate SWCNT levels. However, this effect diminished at higher SWCNT content. Mechanical testing showed enhanced specific tensile strength and elastic modulus for the composite fibers compared to electrospun PBT fibers. 1 wt% SWCNT filled composite fibers showed the highest mechanical performance compared to PBT fibers. Conversely, the elongation at break decreased, indicating that the addition of SWCNTs made the fibers stronger and stiffer but less flexible. Although morphological and mechanical properties were reported in the study, electrical properties of the samples were not mentioned (Saligheh et al., 2011).

Mathew et al., fabricated PBT composite fibers by electrospinning and multi-walled carbon nanotubes (MWCNTs) were used as the filler. Polymer concentration and MWCNT concentration were 8 and 5 wt% respectively. The characterization of nanofibers investigated by SEM, TGA and atomic force microscopy analysis (AFM). The incorporation of carbon nanotubes resulted in nanofibers with a wider fiber diameter distribution, rougher surface morphology, and enhanced thermal stability. MWCNTs were reported to be homogeneously dispersed in the PBT fiber preferably oriented in the fiber axis. The fiber diameter was reported between 250 – 4000 nm due to increase solution viscosity. The addition of MWCNTs into PBT led to a slight broadening of the diameter distribution of the fibers and an increase in surface roughness due to the protrusion of MWCNTs onto the fiber surface. Additionally, AFM analysis indicated that the modulus of the nanofibers increased by nearly three times after incorporation of MWCNTs. The thermal stability of PBT fibers was also reported to increase around 8–9°C. Although morphological, thermal and mechanical properties were reported in the study, electrical properties of the samples were not mentioned (Mathew et al., 2005).

Bagheri et al., used Fe_3O_4 as the filler for PBT composite fibers. The concentration of polymer and Fe_3O_4 were determined as 16, 0–7% w/v, respectively. Electrospinning conditions were set as 0.5 ml/min and 16 kV that were given as feed rate and applied voltage respectively. Electrospun composite PBT mats were used for isolation of some selected triazines. As reported in the study, incorporation of magnetic nanoparticles within the PBT nanofiber matrix enhanced the efficiency of the analyte extraction due to increased affinity. Although composite PBT fibers were reported to be effective in terms of isolation performance no details were given in the study regarding fiber morphology, mechanical properties and their effects on performance (Bagheri et al., 2017).

3.3 Electrospun PBT-based Copolymer Fibers

PBT copolymers were also reported to be proper polymers for electrospinning that can be seen from Table 3. Grande et al. used PEOT/PBT (300PEO, Polyactive) block co-polymer (PEOT/PBT 55/45 wt%). Three different PEOT/PBT spinning solutions were prepared by using $CHCl_3$ + DMF, $CHCl_3$ + MeOH, and $CHCl_3$ + HFIP. Primary and secondary solvents were mixed in a ratio of 9:1 v/v. In this study applicability of atmospheric pressure plasma jet (APPJ) treatment was investigated to enhance the electrospinning performance of PEOT/PBT. Samples were prepared with and without plasma treatment. Plasma treatment was performed before the electrospinning at different time intervals from 1 to 7 minutes was applied to the polymer solutions. Electrospinning was carried out by a rotating drum collector. Process parameters were adjusted to 0.1 mL/h, 30 kV and 20 cm that were given as feed rate, applied voltage and tip-collector distance respectively.

5-minute APPJ treatment was determined as the optimum for performance of electrospinning in terms of bead formation rate and finer fiber diameter for almost all solvent mixtures except $CHCl_3$ + DMF. However, $CHCl_3$ + HFIP resulted in fibers with the average diameter of (630 ± 200 nm). after 3 min. of APPJ treatment. As reported in the study, APPJ treatment led to increase in solution conductivity that resulted in better electrospinnability. MeOH incorporation led to formation of finer fibers (290 ± 100 nm). Additionally, according to cytotoxicity tests, nanofibers were found nontoxic, and samples obtained from solutions with MeOH or HFIP secondary solvents showed enhanced cell adhesion after plasma modification (Grande et al., 2018).

Moroni et al. prepared electropun PEOT/PBT (55/45) fibers by using various solvents such as chloroform, DCM, DCE, dioxane, $CHCl_3$+HFIP, $CHCl_3$+MeOH to investigate the fiber morphology The polymer concentrations varied between 10-20%. Process conditions were determined as 0.19, 1.8 ml/min, 15, 25 cm and 12 kV feed rate, needle-collector distance and applied voltage respectively. As reported in the study, irregular pore morphology was observed in the case of decrease in solvent's boiling point. For the solvents with higher boiling points, decrease was observed in the pore size. Polymer concentration was found to affect the pore formation and morphology. Pore formation was observed for the needle-collector distance and polymer concentrations higher than 16% conditions. Various and tunable fiber morphologies with or without pores at different combinations of polymer concentration and needle-collector distance were obtained. Flow rate was also found to increase the fiber diameter of the fibers due to higher amount of solution fed in a given time. Additionally, fibers with the average diameter around 10 μm showed good cell attachment and proliferation. The electrospun scaffolds were covered with cells in 14 days and the biomedical applicability of PEOT/PBT fibers were also shown (Moroni et al., 2006).

3.4 **Electrospun PBT Bicomponent Fibers**

Bicomponent fibers is another morphology that can be obtained by electrospinning. In this morphology at least two different components are used, and two layers known as core and shell are obtained. Core is the inner component and covered, encapsulated by the outer shell layer. Although, there are many studies about bicomponent fibers, there are limited studies for PBT-based bicomponent fibers that can be seen from Table 4. Bagheri et al. electrospun polyvinylpyrrolidone polybutylene terephthalate/polypyrrole (PVP–PBT/PPy) bicomponent fibers and PVP phase was removed, and hollow fibers were obtained. Electrospun fibers were used as a sorbent for μ-SPE of some selected triazines. Polymer solutions were prepared at different concentrations between 10–16% w/v in TFA and ferric chloride was mixed; following that, pyrrole monomers (0–2% w/v) were added and mixed until polymerization was completed. PVP/TFA solution prepared, and two spinning solutions were fed by a pump through a coaxial, core–shell nozzle on the syringe. Additionally, PBT/PPy blend electrospun fibers were also prepared for comparison. Needle-collector distance, applied voltage, feed rate were given as 12 cm, 15 kV and 0.5 mL/h respectively. Depending on the composition, the fiber diameter varied between 100–2000 nm. After removal of PVP core component, hollow fiber morphology was obtained, and inner porosity of the fibers increased, and extraction performance of hollow fibers were higher than PBT/PPy blend fibers (Bagheri, Rezvani, & Banihashemi, 2016).

4. Conclusions

PBT is one of the semicrystalline thermoplastics mostly used in injection molding of automotive and electronic parts due to its stable electrical, thermal and mechanical properties. Electrospinning is a process for preparation of ultrafine or nanofiber formation that is performed under electrical field through the use of a polymer solution. Different types of morphologies can be prepared such as microfibers, nanofibers, composite fibers, nanocomposite fibers, bicomponent fibers and so on. The tunable fiber morphology increases applications of electrospun fibers. In this chapter electrospinning process is explained with basic system requirements. The process parameters and their effects on fiber formation and morphology were also discussed by considering the applications of PBT electrospun fibers.

Acknowledgment

This study was supported by The Scientific and Technological Research Council of Turkey (TUBITAK), 2209-A, University Students Projects Support Program 2023/2.

Table 1. *Electrospinning conditions and properties of PBT fibers*

Polymer	Solution Properties	Electrospinning Conditions			Fiber Properties	Reference
		Feed Rate (mL/h)	Applied Voltage (kV)	Tip-Collector Distance (cm)		
PBT	**C*:** 12, 14, 16 wt % **S*:** DCM +TFA 1/1 (v/v)	0.5	20	15	**12 wt%:** A mixture of large beads and fibers **14 wt%:** 300-800 nm, AD*: 549 nm **16 wt%:** 400–1000 nm, AD*:736 nm	(Forouharshad et al., 2010)
PBT	**C*:** 4% w/w **S*:** TFA	0.12	20	20	AD*: 100 – 250 nm	(Catalani et al., 2007)
PBT	**C*:** 9, 10, 12, 14 wt.% **S*:** TFA	1	9.3	14	**9 wt %:** AD* of 354 ± 102 nm **14 wt %:** AD* of 1130 ± 230 nm	(Wang et al., 2015)

C*= Concentration, S*= Solvent(s) *Average Diameter= AD

Table 2. *Electrospinning conditions and properties of PBT composite fibers*

Polymer	Solution	Filler	Electrospinning Conditions			Fiber Properties	Application	Reference
			Feed Rate (mL/h)	Applied Voltage (kV)	Tip-Collector Distance (cm)			
PBT	**C*:** 10 wt% **S*:** TFA	**C*:** 5 wt % TiO_2 (AD*: <50 nm)	0.2	20	20	500-100±50 nm	N/A	(Khalid Saeed et al., 2009)
PBT	**C***:14%wt **S*:** DCM + TFA 1/1 (v/v) + SWCNT	**C*:** 0.5, 1, 2, and 4 wt% SWCNT (AD*:<2 nm, length<20μm)	0.5	20	15	**0.5 wt% SWCNT** AD*: 473 nm **1 wt% SWCNT:** AD*: 422 nm **2 wt% SWCNT:** AD*: 462 nm **4 wt% SWCNT:** AD* 651 nm	N/A	(Saligheh et al., 2011)
PBT	**C***: % 8 wt **S***: CNT + HFIP	**C*:** 5 wt% MWCNT (AD*: 15–30 nm)	-	20	18	250- 3500 nm AD* : 1350 nm	N/A	(Mathew et al., 2005)
PBT	**C***: 15 wt % **S*:** DCM + TFA (1/1) + POSS-OH	**C*:** 2 - 10 wt % POSS-OH (M = 959.7 g/ mol)	0.18	-	N/A	300-700nm AD* = 400 nm	N/A	(Gardella et al., 2015)
PBT	**C***: 16 % w/v **S*:** TFA	**C*:** 0–7% w/v Fe_3O_4	30	16	N/A	N/A	Thin film micro extraction	(Bagheri et al., 2017)

C*= Concentration, S*= Solvent(s), AD*=Average Diameter

Table 3. *Electrospinning conditions and properties of PBT-based copolymer fiber*

Polymer	Solution Properties	Electrospinning Conditions			Fiber Properties	Application	Reference
		Feed Rate (mL/h)	Applied Voltage (kV)	Tip-Collector Distance (cm)			
PEOT/ PBT block copolymer (55/45 w%)	**C* :** 14.4 , 17.0 wt % **S*:** $CHCl_3$+DMF **C*:** 9, 11.2, 13.5, 14.6 wt % **S*:** Chloroform + MeOH **C*:** 9 , 11.1 ,11.8 ,15 wt % **S*:** Chloroform + HFIP	6	30	20	250-1700 (w/o Atmospheric Pressure Plasma Jet Treatment)	Tissue Engineering	(Grande et al., 2018)
PEOT/ PBT block copolymer (55/45 w%)	**C*:** 10-20 % **S* :** •Chloroform ($CHCl_3$) •Dichloromethane (CH_2Cl_2) •Dichloroethane ($C_2H_4Cl_2$) •Dioxane ($C_4H_8O_2$) •Chloroform + HFIP •Chloroform + Methanol (CH_3OH)	2.34	12	-	AD*: 500 - 21400 nm	Cell attachment	(Moroni et al., 2006)

PEOT/ PBT block copolymers (70/30 w%) & (30/70 w%)	**C* :** 20 % w/v **S*:** HFIP	19	20	N/A	AD*: 760±150 nm for 30/70 AD*: 870±260 nm for 70/30	Drug Delivery	(Liguori et al., 2022)
PEOT/PBT	**C* :** 26 – 30 % w/v **S*:** 70:30 – 80:20 v/v Chloroform/HFIP	0.05 – 2	2- 16	2-16	AD*: 35.7 – 190.8 μm	Human mesenchymal stromal cells	(Chen et al., 2017)
PEOT/PBT	**C* :** 20% v/v **S* :** Chloroform/ HFIP (90/10 v/v)	5	15	15	AD*: 1.9 ± 0.9 μm	Tympanic membrane	(Danti et al., 2015)

C*= Concentration, S*= Solvent(s), AD*=Average Diameter

Table 4. *Electrospinning conditions and properties of PBT bicomponent fibers*

Polymer	**Solution Properties**	**Filler**	**Electrospinning Conditions**			**Fiber Properties**	**Application**	**Reference**
			Feed Rate (mL/h)	**Applied Voltage (kV)**	**Tip-Collector Distance (cm)**			
PBT/PPy (Shell) – PVP (Core)	C*: 10-16 % w/v PBT and 0-2 % w/v PPy **S*:** TFA (16 % w/v) + PVP	$FeCl_3$ (0.05g)	0.5	15	12	**AD*:** 100-2000 nm	Hollow nanofibers	(Bagheri et al., 2016)

C*= Concentration, S*= Solvent(s), AD*=Average Diameter

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Chapter 8

OXIDATION IN FERMENTED MEAT PRODUCTS

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Introduction

Meat and meat products are foods with high bioavailability and are consumed worldwide due to their unique aroma and taste (Nawaz et al., 2022). The American Meat Science Association (AMSA) defines meat as skeletal muscles and related tissues obtained from mammalian, bird, reptile, amphibian, and aquatic species generally harvested for human consumption. The USDA (US Department of Agriculture) defines it as the meat of animals (including fish and birds) used as food that can be part of a healthy diet (USDA, 2023). The existence of different definitions does not change the fact that meat contains high biological value protein and important micronutrients necessary for good health throughout life (Williams, 2007), such as vitamins (pantothenic acid, niacin, and vitamins B2, B6, B12) and minerals (phosphorus, iron, selenium, and zinc) (Ahhmed & Muguruma, 2010; Milan et al., 2014). Furthermore, it contains various fatty acids, including essential omega-3 polyunsaturated fats (Williams, 2007).

Fermented Meat Products

Various raw and processed meat products are available, including cooked, dry-cured, fermented, and smoked (Geeraerts, Stavropoulou, Vuyst & Leroy, 2019). Fermented meat products, which take a significant place among meat products, are produced by fermenting raw meat with certain enzymes or microorganisms under natural or artificial intervention conditions, causing a series of biochemical reactions and physical changes (Wang et al., 2022). The principles of meat fermentation have been understood very slowly, and the process has not been scientifically based to achieve a higher degree of automation when manufacturing such products. However, when it has been understood that large-scale and low-cost industrial production requirements are not met, intensive research has been started to obtain standard products with a short maturation time. Nevertheless, even today, fermentation occurs spontaneously in some countries, and the success of the process is attributed to the climatic conditions of the geographical region where the product is manufactured (Fernandez, Ordonez, Bruna, Herranz & de la Hoz, 2000).

Fermented meat products contain high amounts of protein, fat, and various additives and have a higher nutritional value than fresh meat since they are consumed after a certain period of maturation (Steinkraus, 1994). Additionally, such products are considered safe for human consumption because the growth of pathogenic and spoilage microorganisms is inhibited (Singh, Pathak & Verma, 2012).

Fermented sausages are usually produced in three stages: ingredient mixing, fermentation, and ripening/drying. During ripening, biochemical, microbiological, and physicochemical changes occur, which are responsible for the product's sensory properties and safety (Fernandez et al., 2000). During fermentation, the Micrococcaceae family produces nitric oxide, while lactic acid bacteria reduce pH values through glycolysis (Martin, Colin, Aranda, Benito & Cordoba, 2007). During ripening/drying, the characteristic taste and texture develop, the product's water content decreases, and various chemical and biochemical reactions occur, primarily in proteins and oils. Furthermore, characteristic aroma compounds are formed through many secondary reactions (Berardo, Claeys, Vossen, Leroy & De Smet, 2015).

Fermented meat products are produced in many parts of the world, especially in Europe, and countries have products with unique tastes and aromas (Gökalp, Kaya & Zorba, 2012). Depending on the processing conditions and composition, fermented sausages are divided into three groups: dry (20-35% moisture), semi-dry (35-50% moisture), and moist/non-dried/spreadable sausages (50-60% moisture) (Kumar et al., 2017). Dry fermented sausages are made from various types of meat across a wide geographic area. However, this product type has the oldest tradition and is still the most widespread in Southern and Central Europe (Fernandez et al., 2000). pH values usually vary between 5.3 and 6.0 (Pearson & Gillet, 1997), and production has two important stages: fermentation and drying/ripening (Kaya & Kaban, 2016). Sausage, Italian salami, saucisson (France), pepperoni (Canada and the United States), salchichon, and chorizo (Spain) are typical examples of dry fermented sausages (Vignolo, Fontana & Fadda, 2010). The pH values of semi-dry fermented sausages range from 4.8 to 5.3 (Pearson & Gillet, 1997), and these types of products are mostly smoked and undercooked. Summer sausages, Holsteiner, cervelat (Switzerland and France), and thuringer (Germany) are examples of semi-dry fermented sausages (Kumar et al., 2017). Sobrasada (Spain), mettwurst, and teewurst (Germany) can be given as examples of fermented sausages with a soft consistency and high moisture content (Kaya & Kaban, 2016).

Oxidation

Although oxidation is among the main causes of quality deterioration in meat and meat products, it is reported to be caused by meat, high amounts of metal catalysts, unsaturated lipids, several oxidizing agents, and heme pigments in muscle tissue (Falowo, Fayemi & Muchenje, 2014). With the storage and/or processing of meat and meat products, free oxygen radicals are formed, and the internal antioxidant defense system is damaged, causing oxidative damage to lipids and proteins (Santé-Lhoutellier, Astruc, Marinova, Greve & Gatellier, 2008; Moylan et al., 2014). In addition to the depletion of antioxidants (vitamins E and C) in muscles after slaughter, the type of animal, fattening type, muscle type, and fattening environment also affect oxidation. Furthermore, the presence of oxygen in the environment, light, temperature, additives, processing techniques, cooking, high pressure, and packaging are also important factors in oxidation (Nacak, 2015). Oxidative processes are the main cause of deterioration in meat quality products' color, flavor, and nutritional value (Santé-Lhoutellier et al., 2008).

Lipid oxidation is the primary cause of chemical degradation in meat. It probably starts in livestock muscles and intensifies after slaughter due to environmental changes and loss of antioxidant capacity (Amaral, Da Silva & Da Silva Lannes, 2018). During lipid oxidation, lipids with any number of carbon-carbon double bonds are oxidatively degraded and occur in multiple stages, mainly initiation, propagation, and termination. Various primary and secondary by-products that impact meat quality and human health are formed as a result of the reaction (Johnson & Decker, 2015). For this reason, preventing lipid oxidation in meat is essential for meat quality and human health (Falowo et al., 2014).

Lipid oxidation is examined in three classes: photo-oxidation, free radical oxidation, and enzyme-catalyzed oxidation. Photo-oxidation can lead to the degradation of unsaturated fatty acids and proteins. Enzyme-catalyzed oxidation is important for the synthesis of eicosanoids from long-chain fatty acids, such as eicosapentaenoic acid, docosahexaenoic acid, and arachidonic acid. Hence it is essential for biological systems. Free radical oxidation, on the other hand, is the most important form of lipid oxidation in meat, called autoxidation, and Figure 1 displays the reaction steps (Huang & Ahn, 2019). At the initial stage of lipid oxidation, lipid molecules (LH) are transformed into lipid radicals (L•). At the propagation stage, the lipid radical is transformed into another lipid radical. At this stage, lipid radicals react with oxygen, and the hydrogen atom is removed from the lipid molecule or oxygen is added to the alkyl radical. Furthermore, lipid hydroperoxides (LCOOH) are formed during the propagation stage. Thus, peroxide radicals (LOO•) and alkoxyl radicals (LO•) are formed. Products such as free radicals, aldehydes, and ketones are formed at the finishing stage. The alkyl radicals (L'CH2•) formed are converted into products such as ethane and pentane as a result of chain reactions; aldehydes can be converted into oxidation products such as hexanal and malondialdehyde. Bad odor and toxic compounds are formed as a result of the reaction, the meat color changes, and functional properties and nutritional value are lost (Guyon, Meynier & Lamballerie, 2016). Additionally, when malondialdehyde, which is formed as a result of lipid oxidation, reaches high levels, sensory quality deteriorates, which is associated with a rancid taste (Wood et al., 2008).

1) Initial stage (Free radical formation)

$LH + HO\bullet \rightarrow L\bullet + H_2O$

2) Propagation (Free radical chain reaction)

$L\bullet + O_2 \rightarrow LOO\bullet$

$LOO\bullet + LH \rightarrow LOOH + L\bullet$

3) Termination (Formation of non-radical products)

LOO• +LH → LOOH + L•

LO•+LH → LOH + L• LO• → L'CH_2• + L"CHO

Figure 1: Reaction steps of lipid oxidation (Huang & Ahn, 2019)

In addition to lipid oxidation, protein oxidation also deteriorates the quality of meat and meat products (Vuorela et al., 2005). Protein oxidation is the covalent modification of a protein that is induced directly by reactive oxygen species and indirectly by secondary by-products of oxidative stress (Shacter, 2000). During protein oxidation, proteins' functional properties are lost, and aggregation and solubility occur in proteins. Accordingly, the product's nutritional value and sensory properties are lost (Zhang, Lin, Leng, Huang & Zhou, 2013; Falowo et al., 2014). With the oxidation of myofibrillar proteins, essential amino acids are lost and protein digestibility decreases, reducing the nutritional value of meat (Armenteros, Heinonen, Ollilainen, Toldrá & Estévez, 2009). In addition to the reduced nutritional value of meat, protein oxidation is also associated with color and texture deterioration in meat and meat products (Estévez, Ventanas & Cava, 2005). It is also stated that the sulfur compounds formed as a result of the reaction are important for the flavor of meat (Roldan et al., 2015). Additionally, tenderness and juiciness of meat and meat products may decrease due to protein oxidation (Lund, Heinonen, Baron & Estevez, 2011). Oxidized proteins are important for human health since they exhibit mutagenic, carcinogenic, and neurotoxic activities, cause damage to foods and human proteins, and promote various diseases (Cruz-Hernandez et al., 2018; Wu et al., 2021). It has been reported that internal and external factors such as water activity, temperature, processing and packaging conditions, pH, meat type, fat amount, fatty acid composition, storage, metal ions, and catalyst/inhibitor substances in the environment affect protein oxidation in meat and meat products (Estevez, 2011; Poljanec et al., 2021; Dominguez et al., 2022).

The formation of carbonyl groups is among the most important changes in oxidized proteins and occurs due to oxidative deamination of alkaline amino acids, such as lysine, arginine, and proline (Cheng, Sun, Pu & Wei, 2018). Carbonyl groups are formed through diverse pathways (direct oxidation of amino acid side chains, reaction with reducing sugars, fragmentation of the peptide backbone, and binding to non-protein carbonyl compounds) (Vuorela et al., 2005). In meat, amino acids with reactive side chains such as amino and sulfhydryl groups (cysteine, glutathione, etc.) are also sensitive to oxidation and cause the formation of disulfide bonds (Lund et al., 2011).

Protein oxidation is similar to lipid oxidation but is more complex (Ergezer, Gökçe, Hozer & Akcan, 2016). Especially the three-dimensional structure of proteins and the composition of amino acids complicate the oxidation mechanism (Stadtman & Levine, 2000). Protein oxidation reactions occur, as shown in Figure 2. The reaction starts with the reaction of free radicals with protein side chains, and protein-free radicals (P•) are formed. Then, protein-free radicals react with oxygen to form protein peroxide radicals (POO•). Protein peroxide radicals, on the other hand, take hydrogen atoms from the environment and cause the formation of protein hydroperoxides (POOH) and protein radicals (P•). Due to the unstable structure of hydroperoxide radicals, they decompose into carbonyl derivatives (Dominguez et al., 2022). In addition to free radical-induced protein oxidation, there are different types of protein oxidation, including protein photo-oxidation, enzyme-catalyzed protein oxidation, and metal-catalyzed protein oxidation (Hellwig, 2019). In protein photo-oxidation, tryptophan, tyrosine, and cysteine, which are chromogenic amino acids, can be directly oxidized by ultraviolet radiation. On the contrary, the singlet oxygen pathway is regarded as another mechanism for photo-oxidative reactions (Pattison, Rahmanto & Davies, 2012). Chains of amino acids, such as lysine, histidine, and threonine, are more sensitive to metal-catalyzed protein oxidation, which is common in protein foods (Stadtman & Levine, 2000). Enzyme-catalyzed protein oxidation involves the catalytic production of reactive radicals and their effects on proteins (Wang, Xiong, Sato & Kumazawa, 2016).

1) Free radical formation

$PH + OH\bullet \rightarrow P\bullet + H_2O$

2) Free radical chain reaction

$P\bullet + O_2 \rightarrow POO\bullet$

$POO\bullet + PH \rightarrow POOH + P\bullet$

3) Formation of non-radical products

$2POO\bullet \rightarrow 2PO\bullet + O_2\bullet$

$2POO\bullet + HO\bullet \rightarrow PO\bullet + O_2\bullet + HO\bullet$

Figure 2: Protein oxidation reaction steps (Dominguez et al., 2022)

Oxidation in Fermented Meat Products

In addition to acidification and proteolysis that occur during the production of fermented meat products, lipid and protein oxidation also have important effects (Wood et al., 2008). It is well known that the typical properties of dry sausages occur as a result of chemical, biochemical, physical, and microbiological changes during ripening, drying, and storage. Changes in protein and lipids are essential for determining the product's final properties (Zhao et al., 2019). However, lipid oxidation has been studied much more comprehensively than protein oxidation, and the impacts of protein oxidation on fermented sausages are still not clearly explained and studies on this subject continue (Fuentes, Estévez, Ventanas & Ventanas, 2014; Ge et al., 2019). Therefore, the current research compiled lipid and protein oxidation mechanisms in fermented meat products and oxidation factors effective on these types of meat products in light of the literature. In this regard, Table 1 lists examples of the effect factors of protein and lipid oxidation in fermented meat products consumed worldwide.

Table 1. *Examples of studies on the effects of protein and lipid oxidation in fermented meat products*

Product	The Effect of Investigated Parameter on Oxidation	Results	Reference
Fermented and heat-treated sucuk	Production procedure difference and storage	In both methods, TBA and carbonyl values of sausages increased during production and storage, and the amount of sulfhydryl decreased. However, heat treatment caused an increase in protein and lipid oxidation markers.	Dalmış, 2007
Dry-cured hams/ Dry-cured loins	Maturation	The TBARS value showed high oxidation indices due to prolonged dehydration, high temperatures, tissue deterioration, and a salting process that increased oxidative reactions.	Armenteros et al., 2009
Dry-cured Iberian ham	High-pressure application (HP) (200 MPa 15 min, 200 MPa 30 min, 300 MPa 15 min, 300 MPa 30 min) and storage time (90 days, 4°C)	While pressure level and time increased lipid oxidation, it did not affect protein oxidation. Storage time increased both lipid and protein oxidation.	Cava et al., 2009
Vacuum-packaged Iberian dry-cured ham	The effect of high hydrostatic pressure treatment (600 MPa)	It has been observed that the use of high pressure increases protein oxidation.	Fuentes et al., 2010
Pork ham	NaCl replacement with KCl, $CaCl_2$ and $MgCl_2$	There was no difference in lipid oxidation between the control group using pure NaCl and the groups using other salts.	Ripolles et al., 2011
Hams	Cooked hams from fresh and pre-frozen (frozen/ thawed)	Protein oxidation by cooking frozen/thawed ham caused quality losses in the product. However, lipid oxidation played a negligible role in their amount.	Utrera et al., 2012
Fermented sausages	Lipid content (4, 10 and 15%) and composition (different lipid sources; animal fat and sunflower oil)	Increasing the oil content increased the susceptibility to lipid oxidation but did not significantly affect the carbonyl content. Using different oils affected the susceptibility to lipid and protein oxidation.	Fuentes et al., 2014
Heat-treated sucuk	Different fat (beef fat, olive oil) formulation	A decrease in TBA values and an increase in carbonyl amounts were detected with the use of olive oil.	Nacak, 2015

Harbin dry sausages	Different starter cultures (*Pediococcus pentosaceus*, *Lactobacillus curvatus*, *Lactobacillus sakei*, and *Staphylococcus xylosus*)	With the fermentation time, the carbonyl content of the samples increased and the sulfhydryl content decreased. The amount of protein oxidation decreased with the use of a mixed starter.	Chen et al., 2016
Fermented and heat-treated beef and turkey sucuk	Different fat combinations (100% beef fat, 85% beef fat+15% olive oil, 70% beef fat+30% olive oil, and 55% beef fat+45% olive oil) and meat types (beef and turkey meat)	Lipid/protein oxidation is higher in heat-treated sucuks. The type of meat used in production also affected oxidation; higher oxidation values were observed in the use of turkey meat. In addition, the use of olive oil in the formulation caused the oxidation properties of the samples to change.	Zungur Bastıoğlu, 2019
Chinese dry sausage	Use of antioxidants (tea polyphenol)	Protein oxidation decreased considerably with the use of antioxidants.	Zhao et al., 2019
Fermented sausages	Different concentrations of *Lactobacillus plantarum* NJAU-01 (10^5 CFU/g, 10^7 CFU/g and 10^9 CFU/g) strain	The use of strains at 10^7 CFU/g and 10^9 CFU/g significantly reduced the carbonyl content of the samples. The sulfhydryl content of the samples using starter culture was significantly higher than the control group without starter culture.	Ge et al., 2019
Heat-treated sucuk	Different lipid formulations (15 and 30% olive oil, beef fat)	While the increased amount of olive oil increased the primary lipid oxidation products, it decreased the secondary ones. The use of olive oil increased the carbonyl content.	Öztürk-Kerimoğlu et al., 2019
Spanish dry-cured ham	Different ripening times (9, 12, 15, 18, and 24 months of processing)	As the maturation time increased, the TBARS value increased, and the 12-month maturation caused the highest carbonyl value formation.	Li et al., 2020
Mutton ham	Storage times (0, 30, 60, 90, 120, 150, and 180 days)	During storage, the carbonyl content increased while the sulfhydryl content decreased.	Guo et al., 2021
***Biceps femoris (BF)* and *Semimembranosus (SM)* muscles ham**	Salting+cold smoking + drying+ripening	Protein oxidation in BF muscle is higher than in SM muscle. In addition, the smoking process did not have a significant effect on proteolytic and lipolytic processes.	Poljanec et al., 2021
Beef jerky	Different starter cultures (*Lactobacillus sakei* BL6, *Pediococcus acidilactici* BP2, and *Lactobacillus fermentum* BL11)	Protein and lipid oxidation values were determined at lower levels with the use of a starter culture.	Wen et al., 2021
Heat-treated sucuk	Different fat (beef fat and/or sheep tail fat), different times cooking (1, 3, 5 min)	While the use of beef fat and/or sheep tail fat was not effective on TBARS, total sulfhydryl, and carbonyl results, the cooking process had a significant effect. In addition, as the cooking time increased, protein and lipid oxidation increased.	Anlar, 2022

Conclusion

Fermented meat products represent a group of important meat products consumed worldwide. However, the raw materials used in production and production procedures differ significantly. Due to these differences, oxidative changes occur in lipids and proteins, and with these changes, the sensory and functional properties of the products are lost. Furthermore, oxidation reactions are important due to the formation of compounds that may adversely impact human health. Hence there is a need for studies on oxidation in fermented meat products. In particular, studies on protein oxidation are considerably more limited than those on lipid oxidation, and there is a need for more detailed studies on this subject. When the studies in the literature are examined, it has been determined that the production process of fermented meat products, the raw materials and additives used, storage conditions and duration, light, temperature, processing techniques, and packaging are important factors in oxidation. Based on these results, it seems possible to ensure that products are exposed to less oxidation by paying attention to internal and external factors affecting oxidation. However, detailed studies on the subject are needed.

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Chapter 9

FIRE SAFETY IN KINDERGARTENS

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Introduction

It is well known that the importance of fire safety in kindergartens cannot be overstated. This is in association with the fact that there are several critical reasons including the protection of young children, adherence to regulatory standards and the maintenance of a secure educational environment. Kindergartens where represent the inaugural educational setting for children aged 3-5 years, the kids are engaged in social interaction with their peers and educators outside the familial context. Given their age and developmental stage, young children are particularly vulnerable during emergencies such as fires due to the lack of the capacity to foresee and protect themselves from potential dangers. It is therefore imperative that robust fire safety measures are put in place both to mitigate risks and to ensure the well-being of children in these environments.

The primary objective of fire safety in kindergartens is to safeguard the lives and physical integrity of the children attending these facilities. Young children are naturally inquisitive and may not fully comprehend the dangers posed by fire or the necessary actions to take in the event of an emergency. Effective fire safety protocols, including regular drills and staff training, are crucial to ensuring educators and children are prepared to respond calmly and effectively during such incidents, thereby minimizing potential harm.

Kindergarten administrators and governing bodies are legally and ethically obliged to comply with fire safety regulations and standards. Regulatory frameworks stipulate specific requirements for fire prevention, detection, and evacuation procedures in educational facilities. Adherence to the regulations not only ensures legal compliance but also reflects a commitment to maintaining a safe and secure learning environment for children, educators, and visitors. In this respect, the design and construction of kindergarten buildings is of critical importance with regard to fire safety. The selection of fire-resistant materials for structural components such as walls, doors, and floors can significantly impede the spread of fire and smoke, thereby providing valuable time for evacuation. Furthermore, the installation and maintenance of fire detection and alarm systems are essential for early warning and prompt evacuation in the event of a fire, which serves to reduce potential casualties and property damage.

Kindergarten staff members, including teachers and administrative personnel, play a pivotal role in fire safety preparedness. Comprehensive training programmes ensure that staff are well-equipped to handle emergency situations calmly and efficiently, guiding children through evacuation procedures and coordinating with emergency responders as necessary. Regular drills and simulations reinforce these protocols, helping to instill confidence and readiness among staff and children alike. By prioritising safety and emergency preparedness, educators can establish a conducive learning environment where children feel secure and supported. This holistic approach fosters a sense of trust and well-being among parents and guardians, who entrust their children to the care of kindergarten facilities.

In addition to physical safety, fire safety initiatives in kindergartens promote valuable life skills and civic responsibility among children. Educating young learners about fire hazards, prevention strategies, and emergency response protocols empowers them to become proactive participants in their own safety and that of their peers. These foundational lessons extend beyond the classroom, influencing their behavior and decision-making in various settings throughout their lives. Furthermore, community engagement and collaboration are integral components of effective fire safety in kindergartens. The establishment of partnerships with local fire departments, emergency services, and community organizations facilitates ongoing support, training opportunities, and resources for kindergarten staff and administrators. The partnerships enhance preparedness efforts and ensure a coordinated response in the event of a fire or other emergencies. Additionally, technological advancements in fire safety systems and equipment continue to enhance the resilience and effectiveness of fire prevention measures in kindergartens. The implementation of advanced smoke detection technologies, automated fire suppression systems, and integrated emergency communication platforms has led to an improvement in the early detection, rapid response, and overall outcomes during fire incidents.

Fire safety in school buildings

The importance of fire safety in school buildings cannot be overstated. It is of critical concern to ensure the protection of students, educators, and staff, as well as the preservation of educational facilities. Effective fire safety measures in schools must therefore encompass a comprehensive approach integrating a number of key elements as regards preventive strategies, robust detection and alarm systems, evacuation procedures, and ongoing training and education.

Preventive measures play a pivotal role in reducing the risk of fire within school buildings. This encompasses adherence to building codes and regulations that mandate the use of fire-resistant construction materials, the storage of flammable materials in a safe manner, and the maintenance of electrical systems. Regular inspections and audits ensure compliance with these standards, identifying potential hazards and implementing corrective actions to mitigate the potential risks.

The installation and maintenance of sophisticated fire detection and alarm systems are fundamental elements of active fire safety in educational institutions. Contemporary fire alarm systems comprise a network of smoke detectors, heat sensors and manual pull stations, strategically positioned throughout the building, which are designed to detect early the indications of a fire. Upon detection of a fire, the systems activate audible and visual alarms to alert occupants and initiate emergency response procedures, facilitating rapid evacuation and firefighting efforts.

It is of the greatest importance that effective emergency egress planning is in place to ensure the safe evacuation of students, educators and staff in the event of a fire emergency. Building codes stipulate the necessity for multiple exit routes, clear exit signage, and unobstructed pathways leading to designated assembly areas outside the building. Regular drills and exercises simulate fire scenarios, familiarising occupants with evacuation procedures and reinforcing the importance of orderly evacuation practices under simulated emergency conditions.

Passive fire protection measures are integral to containing fires within localized areas and limiting their spread throughout school buildings. Fire-rated walls, doors, and floors serve as barriers that resist the passage of flames and smoke, creating fire compartments that facilitate safe evacuation routes and protect adjacent areas from fire damage. Proper compartmentation strategies ensure that fires are isolated and confined until extinguished by emergency responders.

Furthermore, educational and training programmes are crucial elements of fire safety in educational institutions, equipping students, educators and staff with the requisite knowledge and skills to respond effectively during fire emergencies. The subject of fire safety encompasses a range of topics, including the prevention of fires, the identification of potential fire hazards, the correct utilization of fire extinguishers, and the procedures to be followed in the event of an evacuation. Training sessions and drills serve to reinforce the skills, hence promoting a culture of safety and preparedness within the school community.

It is of the vital importance that local fire departments and emergency responders collaborate with schools to enhance fire safety preparedness. Fire safety professionals are able to provide expertise in the areas of risk assessment, the development of emergency response plans and the conduct of joint training exercises with school personnel. This partnership facilitates effective communication and coordination during emergencies, thus ensuring a prompt and unified response to fire incidents.

The role of teachers in protecting children from fire

The fire education provided by teachers has a considerable effect on both the occurrence and prevention of fires in educational settings. This is attributable to their pivotal role in student supervision, delivery of fire safety education, and coordination of emergency responses. The influence is observed across several key aspects. Teachers' knowledge and awareness of fire hazards and prevention strategies with together directly impact their ability to form a safe learning environment. Teachers receiving fire safety training are able to identify potential fire hazards in classrooms, laboratories, and common areas. These include overloaded electrical outlets, improperly stored flammable materials, and blocked evacuation routes. By proactively addressing these hazards and implementing preventive measures, such as regular inspections and safe storage practices, teachers contribute to reducing the likelihood of fires.

Teachers act as the primary educators, responsible for imparting fire safety knowledge and skills to students. The implementation of efficacious fire safety education programmes, delivered by knowledgeable teachers, equips students with essential information on fire hazards, emergency procedures, and evacuation protocols. Such education enables students to identify potential fire hazards, respond appropriately during emergencies, and contribute to the establishment of a culture of safety within the school community.

Teachers are superstars under fire drills and emergency evacuation exercises. They make sure that students know all the evacuation routes, assembly points, and safety procedures in a calm and orderly manner. Accordingly, teachers are great leaders and communicators, which helps everyone stay prepared and respond quickly and safely to fire alarms or emergencies.

That teachers also get to take part in ongoing professional development in fire safety helps them become even more competent at handling fire-related incidents effectively. Training sessions and workshops are a great way for teachers to get up to speed with the latest fire safety tips, emergency response strategies, and how to use firefighting equipment. This ongoing learning helps teachers to respond quickly and calmly during actual fire emergencies, keeping everyone safe and calm.

Teachers also work closely with school administrators, fire safety professionals, and local authorities to determine and put in place comprehensive fire safety policies and procedures. The input in fire safety planning, risk assessments, and policy reviews is really valuable. It helps us to put in place strong prevention measures and emergency protocols that are just right for the specific needs and dynamics of the school environment.

It is so important for teachers to be aware of and follow fire safety regulations and codes. This helps to keep our educational facilities safe and secure. Teachers who know their stuff understand the importance of sticking to building codes, keeping an eye on occupancy limits, using fire-resistant construction materials, and making sure that fire safety systems are in tip-top shape. Their proactive approach to compliance is great because it means that school buildings are equipped with adequate fire detection, alarm, and suppression systems to effectively detect and contain fires in their early stages.

In conclusion, fire education of teachers significantly influences the occurrence or prevention of fires in educational settings by enhancing their knowledge, preparedness, and proactive engagement in fire safety. Empowered teachers play a critical role in creating and maintaining a safe learning environment where fire hazards are minimized, emergency responses are swift and effective, and students are equipped with essential life-saving skills. Their ongoing commitment to fire safety education and collaboration with stakeholders ensures the holistic protection and well-being of everyone within the school community.

A Sample Application

Our sample application was carried out in Bolu province with the participation of 11 Class Teachers, 2 administrative and support personnel. It consists of two floors. On the ground floor; 1 kitchen, 1 nutrition room, 1 material storage, 1 assistant principal's room, 1 classroom, 1 support education room, 1 toilet. On the first floor; 4 classrooms, 1 principal's office, 1 electrical room, 1 toilet. On the second floor; 1 library, 1 game room, 1 multi-purpose hall, 1 story room, 1 guidance service room, 1 toilet. In addition, 2 material rooms and a fuel room are located at the back, connected to the building. Our school has a garden area of approximately 150 square meters. The Emergency Assembly area is also indicated in the evacuation plan and marked in the school yard. Emergency exit doors and interior doors open in the direction of the exit in accordance with the regulation. Since our school is 2 floors, there is no fire escape.

There are 2 portable fire extinguishers on each floor in the building and the maintenance and checks of these extinguishers have been carried out at appropriate times. Fire evacuation signs are appropriately hung on the floors. Fire alarm buttons and smoke detectors are available on each floor. Fire extinguishing hoses are available on each floor. The form prepared for the fire safety assessment of the school building (Table 1) was filled out by the fire safety expert. According to the responses received, the school administration was informed to eliminate the deficiencies.

Table 1. Kindergarten Fire Safety Assessment Form

	Yes	No
Is there a Fire Safety Plan/up-to-date?	+	
Does the staff know the location and use of the equipment?	+	
Are the Fire Safety Equipment active and visible?	+	
Are the staff familiar with the evacuation plan?	+	
Are there emergency response teams?	+	
Are there fire directives and fire instructions?	+	
Have fire awareness and fire drills been conducted?	+	
Is there a fire relay in the electrical installation, is the installation appropriate?	+	
Does the boiler room comply with the standards, is there a gas detector?		+
Is there a hood extinguishing system and gas detector in the kitchen?		+
Is there an automatic extinguishing system for the electrical panel and transformer?		+
Are there portable fire extinguishing devices?	+	
Is there a water tank to support the fire system?	+	
Is there a fire pump?		+
Is there a fixed water sprinkler extinguishing system?		+
Are there fixed fire piping and extinguishing cabinets?	+	
Is there a fire alarm detection notification system?	+	
Is there a fire escape?		+
Is there an emergency sign?	+	
Is there emergency lighting?		+
Are the fire exit doors appropriate?	+	
Is the zoning status of the building suitable for its intended use as a school?		+

Following the training and exercise with the fire safety expert, a visit was arranged to the fire department for our school's teaching staff, administrative personnel and students. The aim was to receive educational information and observe the working environments of the intervention teams and their fire response situations. The results obtained from this study are presented in Table 2.

Table 2. Knowledge levels of teachers and other employees concerning fire in school buildings

Before fire training	After fire training	Rate of change	
Do you know the fire triangle?			
Evet	27,8	100	72,2
Hayır	72,2	0	
Do you have information about fire types?			
Evet	16,7	100	83,3
Hayır	83,3	0	
Do you know about fire extinguishers?			
Evet	22,2	100	77,8
Hayır	77,8	0	
Do you have knowledge about fire control methods?			
Evet	5,5	83,3	77,8
Hayır	94,5	16,7	
Do you have information about fire safety risk assessment in schools?			
Evet	55,6	55,6	0
Hayır	44,4	44,4	
Do you know what number to call if there is a fire?			
Evet	100	100	0
Hayır	0	0	
Do you think your school building is fire resistant?			
Evet	5,5	11,1	5,6
Hayır	94,5	88,9	
Do you feel safe in terms of fire risk in your school environment?			
Evet	44,4	5,6	-38,8
Hayır	55,6	94,4	
Do you know about fire safety?			
Evet	16,7	66,7	50
Hayır	83,3	33,3	
Do you know what a fire evacuation is?			
Evet	16,7	61,1	44,4
Hayır	83,3	38,9	
Do you know how to evacuate plan a fire?			
Evet	16,7	83,3	66,6
Hayır	83,3	16,7	
Do you know what precautions you need to take to avoid fire?			
Evet	33,3	77,8	44,5
Hayır	66,7	22,2	
Do you know the fire risks in your school?			
Evet	22,2	72,2	50
Hayır	77,8	27,8	

Table 2 shows that the staff's knowledge of the fire triangle increased by 72.2%, their knowledge of fire types increased by 83.3%, their knowledge of fire extinguishers increased by 77.8%, their knowledge of fire control methods increased by 77.8%, their knowledge of fire safety risk assessment increased by 0%, and their knowledge of the number to call in case of fire increased by 0%. The proportion of staff who felt the building was fire resistant increased by 5.6%. The proportion who felt safe in the work environment decreased by -38.8%. The proportion of staff with knowledge about fire safety increased by 50%. The proportion with knowledge about fire evacuation increased by 44.4%. The proportion with knowledge about how to behave in a fire increased by 66.6%. The proportion with knowledge about precautions to be taken to prevent fire increased by 44.5%. The proportion with knowledge about fire risk areas in the school increased by 50%.

Conclusion

Fire safety education within the pedagogical community plays a pivotal role in ensuring the safety and well-being of children. By disseminating knowledge effectively, educators can empower themselves and their students to prevent, recognise, and respond to fire hazards in an effective manner. Integrating fire safety into the school curriculum across different grade levels is a proactive approach that embeds these critical lessons into the fabric of everyday learning. Such integration serves to emphasise the importance of fire safety while simultaneously cultivating a culture in which safety practices become second nature to students, thereby mitigating risks and potential emergencies. The incorporation of these topics into lesson plans allows teachers to educate students and reinforce crucial skills consistently throughout the academic year. This systematic approach ensures that fire safety becomes ingrained in the school's culture, thereby creating a safer environment for all. The involvement of local fire departments in these initiatives confers considerable benefit, offering practical demonstrations, expert guidance and insights into local fire safety regulations. Such collaborations facilitate the establishment of robust partnerships between schools and emergency responders, thereby enhancing the efficacy and relevance of fire safety education within the educational community.

In addition to curriculum integration and training programs, the utilization of technology can further enhance fire safety education. Interactive simulations, virtual reality tools, and online courses can provide immersive learning experiences for both students and educators. These technological advancements allow for realistic scenarios and practical exercises, which are instrumental in preparing individuals to respond confidently and effectively during fire emergencies. Furthermore, establishing clear communication channels and emergency response protocols within schools is essential. It is imperative that educators collaborate closely with administrators, support staff, and parents to ensure comprehensive awareness of fire safety procedures and expectations. Regular drills and simulations facilitate reinforcement of these protocols, allowing the school community to practice and refine their responses in a controlled environment. Moreover, fostering a culture of vigilance and accountability contributes significantly to the success of fire safety initiatives. Encouraging students to participate in discussions about fire safety, reporting potential hazards, and adhering to safety guidelines reinforces the collective responsibility for maintaining a safe learning environment. Celebrating achievements in fire safety awareness and preparedness can further promote positive behaviours and attitudes towards safety within the school community.

It is of great importance for educational institutions to conduct ongoing assessments and modifications to fire safety strategies, as this enables the continual advancement in this field. Schools are encouraged to undertake periodic reviews of their fire safety policies, procedures, and educational initiatives, with the aim of addressing emerging risks and incorporating the insights gained from drills and real-life incidents. By maintaining a proactive approach and demonstrating adaptability, educators can guarantee that their endeavours in fire safety education remain pertinent, effective and responsive to the evolving requirements of their students and the community at large.

In conclusion, the integration of fire safety education into the pedagogical community through curriculum integration, training programmes, technology, clear protocols, community engagement, and continuous evaluation is essential for safeguarding the lives of children and promoting a proactive safety culture within schools. By working together with local stakeholders and leveraging educational resources effectively, educators can empower students with the knowledge and skills necessary to mitigate fire risks and respond confidently in emergencies.

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