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NASA unveiled the first science-quality images from its next-generation James Webb Space Telescope on Tuesday (July 12) during a live event that culminated in the release of this new image of the Carina Nebula.
NASA

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Investigation of User Trends and Recreational Service Relations in the Sample of Kadınçayırı Natural Park

Ayşe Amucaoğlu[1], Betül Tülek[1,2]*, İbrahim Aytaş[1]

Abstract: With the increasing interest in outdoor recreation activities, the demand for national parks and natural parks has also increased. Natural parks, unlike National Parks, are natural parts that have protection, recreation and tourism areas with only natural resource values that are rare nationally and internationally. Today, natural parks are visited by many people for recreational purposes. For this reason, recreational activities in natural parks gain importance as a tourism activity. This study aimed to reveal the recreational potential by evaluating user trends and expert preferences with the surveys conducted in the Kadınçayırı Natural Park which is located between Çankırı and Kastamonu provinces. Analytical Hierarchy Process (AHP) analysis has been applied to the obtained data arranged in line with Gülez Method features. ArcGIS 10.5 software has been used to produce the maps and SPSS 25.0 software has been used to analyse of surveys. It has been determined that the recreational service and potential of the Kadınçayırı Natural Park showed enrichment. There are some criteria that affect the recreational activities in the area and in this context, suggestions have been developed in terms of the Landscape Architecture professional discipline.

Keywords: Recreation, User trends, AHP, Gülez Method, Çankırı, Kadınçayırı Natural Park.

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1. INTRODUCTION

Natural landscapes are natural areas where no human influence is observed and where the land structure, soil structure, air, water, vegetation and animal community create an ecological balance. International Union for the Conservation of Natural (IUCN) published a report on "Protected Areas Management Categories Purposes and Criteria" in 1978, and according to this report, protected areas were divided into 10 categories. These categories are Scientific Reserves/Absolute Nature Reserves, National Parks, Natural Parks, Nature Conservation Areas, Protected Landscapes, Resource Reserves, Natural Biotic Areas, Multi-Purpose Use Areas, Biosphere Reserves, World Heritage Sites. Protected areas are geographical areas defined and managed by legislation in order to ensure the long-term protection and continuity of ecosystem services and cultural values with natural areas. Protected areas include national parks, natural parks, natural monuments, natural protection areas and wildlife development areas (Mert and Kutluca, 2018).

With the increasing interest in tourism and outdoor recreation activities, the demand for natural parks and the variety of activities carried out in natural parks have also increased. There are few studies done on the anthropogenic impacts with user trends on protected areas. This may result from the complexity about the assessment indices. In the context of ecotourism and protected areas, education, technique and ecotourism topics were generally emphasized in the beginning of the researches. TIES (1990) introduced the definition and principles of ecotourism in the book titled “Description and Ecotourism Principles”. TIES provided information on topics such as training and technical assistance in the development of ecotourism. Erdoğan and Uslu (2003) examined the concept of ecotourism in their research titled "Evaluation of Kazdağı National Park in Terms of Ecotourism", revealed the ecotourism potential of Kazıdağı National Park and developed suggestions. Açıksöz,

Topay and Aydın (2006) revealed the potential of Bartın-Arıt Town in terms of trekking activity in their research titled "Determination of the Trekking Potential of Bartın-Arıt Town". Within the scope of the research, it has been suggested that if the determined tracks are evaluated within the scope of alternative tourism, it will contribute positively to the socio-economic structure of the local people. Lai and Nepal (2006) focused on local perspectives of ecotourism development in Tawushan Nature Reserve in Taiwan in their research named "Local perspectives of ecotourism development in Tawushan Nature Reserve, Taiwan".

In recent years, studies have been carried out that reveal the spatial relationship of urban people recreational trends and nature protection areas. Kaya (2007) mentioned the recreational tendencies and demands of the people of the city of Bartın in her research titled "A Research on the Determination of Recreational Tendency and Demands of Bartın Urban Residents" and developed suggestions for meeting these demands and increasing the quality of urban recreation areas. Akten, Yılmaz and Gül (2009) used the AHP method, which allows both quantitative and qualitative factors to be taken into account, in the selection of the best decision alternative in their research titled "Determination of Recreational Land Use Factors for Land Use Planning: Case of Isparta Plain". Kurtoğlu and Duzguneş (2011) explained the possibilities of the urban forest, which forms a part of the Kafkasör Plateau, the oldest recreation area for the city of Artvin and its immediate surroundings, with the research titled "Recreation Opportunities of the Artvin Urban Forest and Examination of User Preferences". Aydınözü, İbret and Aydın (2012) discussed the tourism and recreational potential of the area in the research named "Analysis of Land Use in Kastamonu Ilgaz Mountain National Park". As a result of this study, it was stated that its development for use harmed its natural structure. Polat, Aktaş Polat (2016) handled the nature parks in the sample area within the scope of protected areas in their research titled "Investigation of Recreational Nature Parks in Mersin as Protected Areas" and aimed to identify the recreational potentials of these parks. Surat (2016) highlighted the recreational potential of Deriner Dam Lake and its surroundings, located within the borders of Artvin province, in her research titled "Evaluation of the Recreational Potential of Deriner Dam Reservoir and According to Gulez Method and Development of Land Use Proposals". Genç, Şengel and Işkın (2017) stated in their research titled "Evaluation of the Eco Tourism Potential of Abant Nature Park" that ecotourism is an important tool for sustainable development, especially in underdeveloped and developing destinations, and they defined the types of ecotourism.

In this research, Analytical Hierarchy Method (AHP) was performed as one of the multicriteria decision-making methods (MCDM) and Gülez Method was used to carry out a simple and quantitative analysis in Kadınçayırı Natural Park. It was aimed to examine the user trends and recreational service relations with ecological approaches in the example of Kadınçayırı Natural Park. For this purpose, a survey was conducted involving users of the natural park. It has been concluded that more than one recreation activity is carried out in the area. In the light of the surveys conducted in the area and Gülez Method features, the landscape value, recreational facilities and negative factors were analyzed with AHP and suggestions were made.

This research is important in terms of providing the balance of protection and use of the Kadınçayırı Natural Park, which is one of the important nature conservation areas in the professional discipline of Landscape Architecture, evaluating the users expectations of the area, expert opinions and spatial relations with statistical methods, and in this sense, the first data about the area were produced.

2. MATERIAL AND METHOD

2.1. Research area

Kadınçayırı Natural Park is within the borders of Ilgaz district of Çankırı and forms a border with Kastamonu in the north. There are Kurşunlu in the west and southwest, Korgun and Çankırı city center in the south, Yapraklı district in the southwest, Kastamonu-Tosya district in the east, and Araç, İhsangazi and Kastamonu city center districts in the north of Ilgaz (Figure 1).

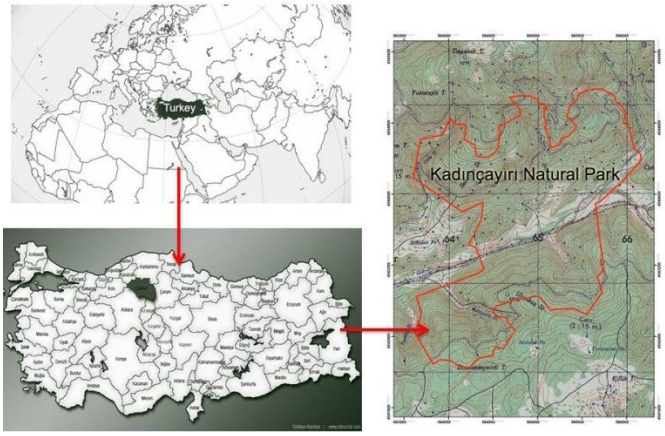

Figure 1. Location of research area

The research area was declared as a Natural Park with the approval of the Ministry dated 5 September 2012. The natural park area is located within the Çankırı Ilgaz Kadınçayırı-Yıldız hill Culture and Tourism Conservation and Development Zone (General Directorate of Natural Conservation and National Parks, 2016). The natural park area, located approximately 17.2 km northeast of Ilgaz district, on the southern slopes of the Ilgaz Mountains and covering an area of 422 ha, is located between 41 º 01′ 42″ – 41º 03′ 22″ northern latitudes and 33º 45′ 27″ – 33º 47′ 09″ eastern longitude. Natural park, which is a high mountainous land, is 63 km from the center of Çankırı. There is Gökçay Stream at the valley plain (Çankırı Kadınçayırı Natural Park, 2014).

2.2. Natural and cultural landscape features

Climate

In order to reveal the climatic characteristics of Kadınçayırı Natural Park, the data collected from two meteorology stations in Ilgaz and Çankırı were used. Since there is no meteorology station in the area, some of the data were interpolated and the climatic characteristics of the natural park area were revealed (Çankırı Kadınçayırı Natural Park, 2014).

The annual average temperature in Ilgaz is 10.6°C. The highest temperature was recorded on July 30, 2000 with 41.4°C. The lowest temperature was measured as -20.8°C on February 2, 2012. When the monthly temperature graph obtained by the interpolation method of Kadınçayırı Natural Park is examined, it is seen that the annual average temperature is 7°C and it drops to -4°C in January and rises to 18.4°C in July. The annual temperature difference is 22.5°C. The highest temperature was calculated in July with 37.8°C, and the lowest temperature was calculated in February with-24.4°C (General Directorate of Meteorology, 2013).

The annual average rainfall in the natural park is 805.0 mm. The highest average amount of precipitation was calculated in May with 103.39 mm, and the lowest average amount of precipitation was calculated in September with 42.47 mm. On a daily basis, the highest rainfall was calculated in June with 108 mm and the least precipitation was calculated in January with 38.05 mm (General Directorate of Meteorology, 2013) (Figure 2).

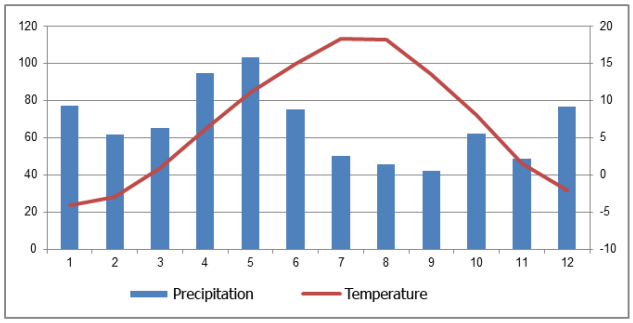

Figure 2. Kadınçayırı Natural Park monthly precipitation (mm), temperature (°C) values (General Directorate of Meteorology, 2013)

Vegetation and Wildlife

In Kadınçayırı Natural Park, mostly coniferous (coniferous) pure or mixed forests, wet and dry meadows, stream ecosystem, riparian ecosystem zone and swamp-peat ecosystem in a small area were observed. Deciduous shrubs and trees have also been observed in some areas where these ecosystems are intertwined. In this way, a rich ecosystem pattern is seen, which is mostly terrestrial, and some of it is seen in the form of rivers, wet pastures and swamps. Forest areas, aquatic ecosystems, grassland and shrub formations, the existence of thin stream branches in forests and open areas with moist and steep valleys are important for plant and animal species that have adapted to such ecosystems. In addition to seed plants, many moss, fungus and lichen species were able to find a living environment in moist-shady and organic matter-rich habitats in these ecosystems (National Parks Directorate, 2020).

Kadınçayırı Natural Park, Ilgaz Mountain National Park and Ilgaz Wildlife Development Area (YHGS) are located at the most important transition points between the Central Anatolian steppes and the Black Sea forest vegetation. Transition points are the most ecologically valuable areas. These areas are considered to *be the richest endemic species and biodiversity areas*. The Western and Central Black Sea forest ecosystems as a whole, together with Kadınçayırı Natural Park, Ilgaz Mountains National Park and Ilgaz Wildlife Development Area, are important reserves of biological diversity and wildlife. Roe deer, Red Deer, Lynx, Wolf, Fox, Marten, Weasel and Brown Bear are important species for a sustainable wildlife and forest ecosystem. Most valuable bird species of this special ecosystem are Falcon, Eagle, Eagle, Rooster, Nightingale, Partridge, Stork, Thrush (National Parks Directorate, 2020).

Topography

Ilgaz Mountains, which include natural park area, located in the Western Black Sea Region. In this region, there are Küre Mountains parallel to the coast. There is the Gökırmak gulley in the south of the Küre Mountains, and the Ilgaz Mountains in the same direction with the Küre Mountains are located in the south of the Gökırmak depression (Taş, 2006). The natural park area is located approximately 8 km southwest of Büyükhacet Tepe (2587 m), the highest peak of the Ilgaz Mountains, and approximately 4 km southwest of Küçükhacet Tepe (2546 m), the second highest peak (Kadınçayırı Natural Park Development Plan, 2014).

According to the slope map of the research area, there are high-very high slopes in the area. There is a slope of more than 45% in the areas outside the Gökdere valley plain within the natural park. The lowest slopes are found in the Gökdere valley plain. The hillsides in the north of the natural park generally have south and southeast aspects.

Hydrology

Gökdere Stream is located within the Devrez Sub-Basin of the Kızılırmak River Basin. Gökdere Stream reaches Gökçay Stream, Gökçay joins with Devrez Stream, and Devrez Stream mixes with Kızılırmak River (Çankırı Kadınçayırı Natural Park, 2014). Devrez Stream, which collects the waters of Orta, Kurşunlu, Ilgaz and Tosya and joins with Kızılırmak near Kargı, is one of the most important streams of the Kızılırmak Basin. Devrez Stream Valley stretches along a 140 km depression, roughly east-west parallel, between Ilgaz and Geçmiş Mountains (Taş, 2006).

Gökçay Stream, which is one of the important streams feeding Devrez Stream, starts in the Ilgaz Mountains and continues in the northeast-southwest direction and merges with Devrez Stream near Ilgaz. Approximately 1400 m of Gökdere passes through the natural park and merges with Gökçay Stream near Çomar Village. Gökdere maintains its flow throughout the year. There are valley plains formed from alluvial outcrops accumulated by Gökdere in the area (National Parks Directorate, 2020) (Figure 3).

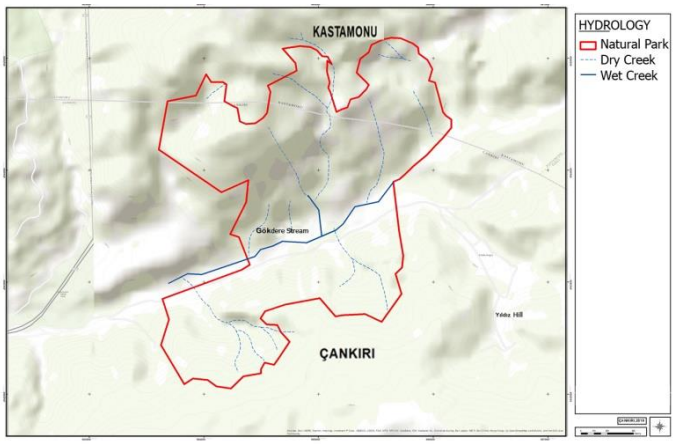

Figure 3. Hydrological characteristics of research area

Stone retaining walls (approximately 150 m long and 1.5 m high) were built on both sides of Gökdere Stream by the Çankırı Directorate of the Ministry of Agriculture and Forestry for the purpose of stream rehabilitation (Forest and Water Affairs Directorate, 2020) (Figure 4).

Figure 4. A view from Gökdere stream (Original, 2020)

Transportation to Kadınçayırı Natural Park

Natural park is connected to the highway transportation network by the Çankırı-Kastamonu State Highway numbered D765. Natural park is reached after 3.5 km (from Çankırı) from the junction near Mülayim-Yenice Village on this state highway. Also, the closest district center to the Natural Park is Ilgaz (Çankırı Kadınçayırı Natural Park, 2014) (Figure 5).

Figure 5. A view from the transportation routes of research area (Original, 2020)

Access to the natural park from the north is provided by the same highway, approximately 55 km after Kastamonu. In addition, it is possible to reach the natural park from different directions (Figure 6).

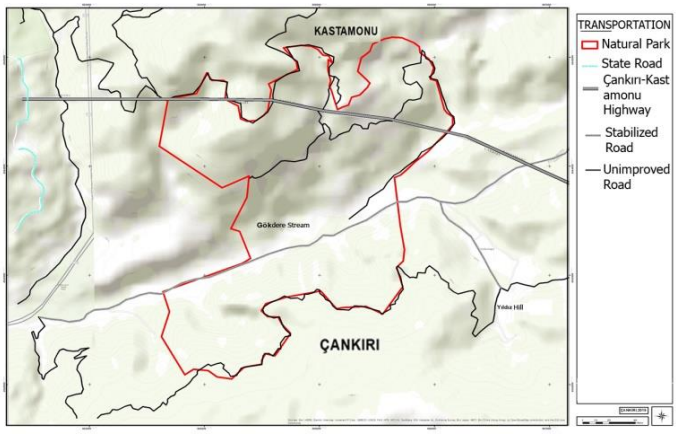

Figure 6. Transportation network in research area

Actual Land Uses and Recreational Opportunities

There is a meadow (approximately 5.1 ha) in the area where the border of the natural park begins and where Eskiyayla Stream valley joins with Gökdere. Along the east and west of the meadow area, there is a mixed forest (mainly Scotch pine, Black pine and Fir). Approximately 700 m from this meadow area, the border of the northern part of the natural park begins. At this point, there is a natural park entrance control point built by Çankırı Special Provincial Administration in 2013. Beginning from this point, meadows and shrubs are seen along the Gökdere (Çankırı Kadınçayırı Natural Park, 2014).

An iron bridge was built to cross the north of Gökdere (Forest and Water Affairs Directorate 2020). The unpaved road deviating from the stabilized road passes through the middle of this area, reaches Gökdere and continues from the north of the stream. At this point, there is a meadow area (approximately 1.6 ha) in the north of Gökdere (Çankırı Kadınçayırı Natural Park, 2014). To the west of this area, there are opened-covered picnic tables, a children's playground on the stream side of the area, and toilet-masjid building built by the Çankırı Special Provincial Administration.

There are skilift and zipline construncions in the Kadınçayırı Natural Park. The skilift has double seat and their carrying capacity are 250 kg. There are 320 seats on the skilift (1560 meters long) in the Kadınçayırı Natural Park. Also, the zipline construction is located in Ilgaz district of Çankırı. This construction (25-meter-high and 530-meter-long) is the longest zipline in Turkey. It has two rope wires and these ropes carry a weight of 100-150 kg depending on the weather conditions. The average time between the start and finish points of the zipline is 30-40 seconds (Yelekçi, 2021) (Figure 7).

Figure 7. Natural park zipline point (Original, 2020)

7 bungalows called *Orman Köşkü* were built in Natural Park in order to develop tableland tourism. These bungalow houses (two-roomed and 72 square meters) have a living room and kitchen on the ground floor and two bedrooms on the upper floor. In addition, the wide meadows in the Yarpınar region and on both sides of Gökdere are suitable areas for recreational activities. Although there is no regular recreational activity within the borders of the natural park, the area is used by the local people for daily picnic activities. Picnic areas are used extensively in all seasons (Figure 8).

Figure 8. Bungalows (Original, 2020)

2.2. Data set

Protected areas, plant richness and geomorphological structure are the main features of the research area. The recreation potential of Kadınçayırı Natural Park is high and it is one of the most important recreation areas of Çankırı province. The research area is regularly visited by many users and provides opportunities for various recreational activities.

Rural recreation areas, trekking, camping-caravan, botanical tourism, photo safari, scientific studies, chairlift, teleski, zipline, winter sports, bungalows, grass fields and picnic areas are used for various purposes in the area. The data sets used in research can be listed as follows:

• 1/25.000 scaled analysis and synthesis reports and maps regarding the research area prepared and updated in 2014 by Çankırı Directorate of Forestry,
• Climatic data taken from Çankırı meteorology stations,
• Materials such as on-site observations, surveys and photographs, and video recordings taken during these observations were analyzed.

In addition, research and publications on physical planning, landscape planning and landscape ecology, interviews with experts and academicians, and informations obtained from institutions and organizations working on natural resources were used as material.

2.3. Research methodology

The research method consists of 5 basic steps. *In the first step*, a literature review was carried out for the purpose and field of the research. National and international resources have been researched about landscape ecology, ecological approaches and recreational potential. Data and maps that may be necessary to determine the recreational potential with ecological approaches have been collected and transferred to the digital data.

In the second step, important environmental features and tourism resources of the research area were determined by field studies and their structural-functional definitions were made. Selection of factors and sub-factors, analysis and evaluation of environmental characteristics and tourism resources constitute process steps. Environmental characteristics and tourism resources were examined in 3 groups. These are;

• Abiotic features (Climate, topography, geology, geomorphology, soil and hydrology)
• Biotic features (Vegetation, wildlife)
• Cultural features (Actual land use, historical and archaeological sites, attraction points)
Maps related to land use capability, land cover, topography, soil, hydrology, geology, protected areas and existing areas were produced with ArcGIS 10.5.

The resampled images were sensetively combined, digitized and transferred to GIS. New maps were created with the help of collected data and satellite images to be used in the analysis of landscape units. In order to produce a map of ecological units in the research area, a parametric method-based structure was generated by examining the Belgian landscape description and evaluation method, French Landscape Atlas studies, CORINE and EUNIS habitat classification methods, which are among the ecological landscape classification methods. Evaluation and separation principles of McHarg (1969), Ndubisi (2002), Erol (2005), Steiner (2008), Koç & Şahin (2008), as well as land cover and ecological unit studies from Coordination of Information

on the Environment (CORINE), European University Information Systems organisation (EUNIS), Belgium and France Land Cover Studies established the principles of the method. Aiming to create homogeneous landscape units;

1. Topography (Slope, Aspect)
2. Geology
3. Major Soil Groups
4. Land Use Capability Classes
5. Land Use values were used.

In order to determine the recreational potential of the research area, the method developed by Gülez (1990) in accordance with the conditions of Turkey and which allows the outdoor potential of a forest recreation area to be determined easily was used. AHP was first introduced by Myers and Alpert in 1968 and was developed as a model by Saaty in 1977 and made usable in solving decision making problems. According to Akten et al. (2009), AHP is a powerful and easy-to-understand multi-criteria decision-making technique in which both quantitative (objective) and qualitative (subjective) factors are taken into account in the selection of the best decision alternative. According to Zahedi (1986), the following steps are applied in solving a decision-making problem using the AHP technique:

Step 1: A decision hierarchy consisting of decision elements is established to define the decision-making problem.
Step 2: Data are obtained by comparing the decision elements among themselves in pairs.
Step 3: By using the eigenvalue method, the relative priority (importance, weight) values of the decision elements are estimated.
Step 4: According to the relative priority values of the decision elements, the overall priority values and ranking of the decision alternatives are obtained.

AHP method brings a very practical way of calculation and is expressed with a simple mathematical formula shown below (Surat 2016).

$$RP\ (\%)=P + I + U + RK + OSE$$

The meaning of the symbols that enter the formula with certain weights and the distribution of the highest (maximum) score (or weights) they can get are shown in Table 1. As seen in the chart, the total score will theoretically be at most 100, so the sum of the scores that the items in the formula can get will give the outdoor recreation potential of an area as a percentage. According to Gülez (1990), the items in the formula get scores according to the following features.

Table 1. Formula items and the scores

Symbol	Meaning	Maximum Score (Item's Weight Score)
P	Landscape value	35
İ	Climate value	25
U	Accessibility	20
RK	Recreational convenience	20
OSE	Negative factors	0 (Min. -10)
ARP	**Recreational potential**	100

To determine user trends, a survey form was designed with the actual informations from local people, experts and field managers. In field surveys, the sample group was selected from the local people of Çankırı. The population of Çankırı in 2020 is 192,428 (TUİK, 2021). Statistical formulas created by Özdamar (2003) were used to determine the sample size (Table 2). The number of surveys to be applied to the local people was determined as 100, taking into account the 95% confidence interval (Özdamar, 2003) and the possibility of data loss. Participants were selected by random sampling technique.

Table 2. Statistical formulas of sample size

Sample Size	±0.03 sampling error (d)			±0.05 sampling error (d)			±0.10 sampling error (d)		
	p=0.5 q=0.5	p=0.8 q=0.2	p=0.3 q=0.7	p=0.5 q=0.5	p=0.8 q=0.2	p=0.3 q=0.7	p=0.5 q=0.5	p=0.8 q=0.2	p=0.3 q=0.7
100	92	87	90	80	71	77	49	38	45
500	341	289	321	217	165	196	81	55	70
750	441	358	409	254	185	226	85	57	73
1000	516	406	473	278	198	244	88	58	75
2500	748	537	660	333	224	286	93	60	78
5000	880	601	760	357	234	303	94	61	79
10000	964	639	823	370	240	313	95	61	80
25000	1023	665	865	378	244	319	96	61	80
50000	1045	674	881	381	245	321	96	61	81
100000	1056	678	888	383	245	322	96	61	81
1000000	1066	682	896	384	246	323	96	61	81
100 million	1067	683	896	384	245	323	96	61	81

In the third step, landscape units were created in the context of the landscape plan. Within this scope, the study area is divided into 5 ecological units including *agricultural areas, inland waters, natural areas, semi-natural areas* and *plant exchange areas* by overlapping climate, geomorphology, large soil groups, land use capability classes and land cover classes.

In the fourth step, AHP analysis developed from the Gülez method was integrated into the surveys conducted in the field and was revealed with the main and sub-criteria that will determine the recreational potentials. In order to determine the suitability of the recreation areas, the land suitability criteria and the suitability values of the sub-criteria of these criteria were examined by AHP analysis. Landscape units are classified according to their suitability for each type of use. In order to determine the suitability of recreation areas, *Landscape value, Recreative Facilities* and *Negative Factors*, which are the features of Gülez Method, were taken into consideration, and these criteria were applied to the surveys as land suitability criteria. Pairwise comparison matrices were filled in by each of the landscape experts (n=10). As a result, criteria priorities were obtained by calculating the *Consistency Rates*, which was carried out to control the consistency of the data (Akten et al., 2009) (Figure 9).

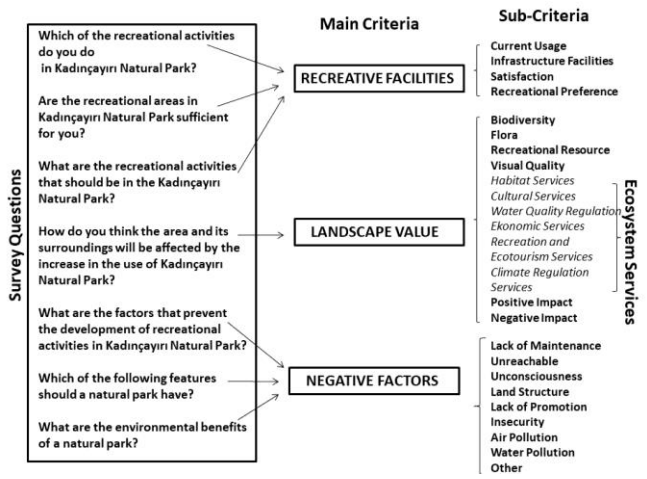

Figure 9. A diagram showing the flow of process (Original, 2021)

In order to support the types of landscape units and ecological units, surveys were practiced on the local people and the Gülez Method and AHP analysis were applied by experts, their use potentials were revealed with main and sub-criteria. Landscape units are classified according to their suitability for each type of use.

In the last step, recreational potentials in Kadınçayırı Natural Park were analyzed by relating with ecological units, and conclusions and recommendations were made.

3. DISCUSSION AND CONCLUSIONS

3.1. Ecological units of reseach area

In order to determine landscape units of the research area 23 Landscape Units were produced as a result of overlapping the topography (slope and aspect groups) and geology (7 groups) layers. The research area was divided into 359 Landscape Units, with the addition of major soil groups (3 groups), land use capability classes (3 groups) and land use layers. Landscape Analysis (Landscape Diagnosis) was carried out in order to better understand the core values of the landscape unit result.

Following the determination of the landscape units, the ecological units in the area were classified as *agricultural areas*, *inland waters*, *natural areas*, *semi-natural areas* and *plant exchange areas* according to the CORINE habitat classification. In this context, it has been observed that natural and semi-natural areas have an important place in the area and inland waters make significant contributions to the ecological structure of the area. Agricultural areas are not actively used in the research area (Figure 10).

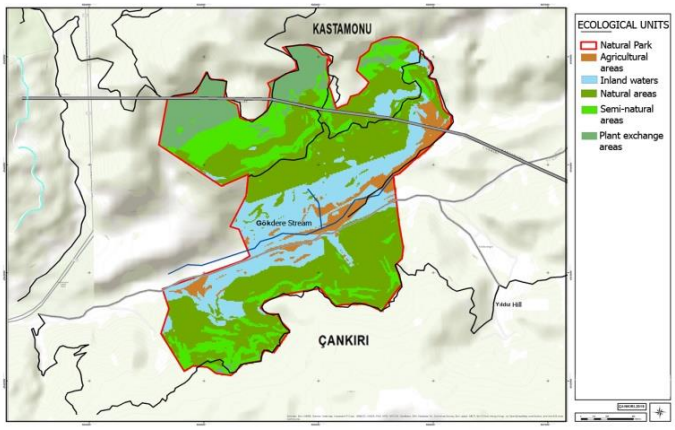

Figure 10. Ecological units of research area

3.2. Survey application

In this research carried out in Çankırı Kadınçayırı Natural Park, the expectations and preferences of the park users (n=100) were revealed. Survey results showed that the area is mostly used by men, the majority of them are between the ages of 21-30, research area is more preferred by married individuals and is visited by all income groups. In addition, natural and recreational features of Çankırı Kadınçayırı Natural Park appeal to all age groups.

The answers to the questions posed to the users are as follows:

- "What is your marital status?" "Married" with a rate of 56%,
- "What is your education status?" "University" with a rate of 43%,
- "What is your job?" "other profession group" with a rate of 46%,
- "What is your average monthly income?" "2000-3000 TL" with a rate of 43%,
- "Where are you coming from now?" "10-50 km" by 55%,
- "Who are you making this visit with?" "with my friends" with a rate of 41%,
- "How many people do you usually visit with?" "5-8 people" with a rate of 44%,
- "Why did you choose to come here today?" "picnic" with a rate of 51%,
- "Which seasons do you come in mostly?" "summer season" with a rate of 69%,
- "Which days do you prefer to visit?" "Weekends" with a rate of 56%,
- "How often do you come?" "1-2 per year" with a rate of 26%,
- "What time do you arrive earliest?" "between 10-12 hours" with a rate of 49%.

3.3. Gülez method application

Gülez method were conducted on an expert group. To apply the method, a total of 10 evaluations were made, including 2 experts from Çankırı Special Provincial Administration and 8 faculty members from Çankırı Karatekin University, Faculty of Forestry, Department of Landscape Architecture. Giving a brief information about the area, experts were asked

to evaluate the field in the light of the criteria in the survey form (Tülek, 2021).

According to the Gülez method, created based on the relationship between *the landscape value, climate value, accessibility, recreational facilities, negative factors and the recreational potential of the area* and *the characteristics of the landscape value* and *the recreational potential of the area* were carried out to experts. The result of the analysis is 66.3%. Despite the value obtained, the landscape value of the research area has been determined as *high* (Tülek, 2021).

4. RESULTS

Among these criteria, *Landscape Value* was the criterion that most affected and determined the recreational potential in the area. Examining the sub-criteria regarding the landscape value, *Visual Quality* was found to be the sub-criteria that determined and increased the landscape value the most (Table 3).

Table 3. Result table of the AHP method

Main Criteria	Sub-Criteria	L Weights	Inconsistency
Recreative Facilities	Current Usage	2,84	3
	Infrastructure Facilities	3,2	
	Satisfaction	2,95	
	Recreational Preference	3,01	
Landscape Value	Biodiversity	3,65	**3,57**
	Flora	3,4	
	Recreational Resource	3,52	
	Visual Quality	3,9	
	Habitat Services	3,88	
	Cultural Services	3,69	
	Water Quality Regulation	3,08	
	Ekonomic Services	3,31	
	Recreation and Ecotourism Services	3,76	
	Climate Regulation Services	3,48	
	Positive Impact	3,61	
	Negative Impact	3,66	
Negative Factors	Lack of Maintenance	3,54	3,37
	Unreachable	3,02	
	Unconsciousness	3,57	
	Land Structure	2,92	
	Lack of Promotion	3,84	
	Insecurity	3,22	
	Air Pollution	3,03	
	Water Pollution	3,68	
	Other	3,55	

Other criteria following this sub-criteria was; *Habitat Services, Recreation and Ecotourism Services, Cultural Services*. Ecosystem services concept was stated in the Millennium Ecosystem Assessment (MEA) report published in 2005 as *benefits that people derive from ecosystems* (MEA, 2005). In MEA (2005) report, ecosystem services are discussed in 4 main categories as resource-providing, regulating, supporting and cultural services (MEA, 2005). According to this research, these services basically constitute ecosystem services. In this context, ecosystem services became prominent in terms of increasing the landscape value of the area.

Some factors that negatively affect the recreational potential in the area have also emerged as a result of the analysis. The most prominent sub-criteria negatively affecting the recreational potential of the area is *Lack of Publicity of the Area*. This criteria is followed by criteria such as *Water Pollution, Unconsciousness, Negligence* in the study area, respectively. Promoting the natural park as an important natural area for Çankırı and Ilgaz in local, regional, national and international platforms will minimize this negative situation in the natural park.

The criterion that least affects and determines the recreational potential in the area is *Recreational Facilities*. Among the sub-criteria, the *Infrastructure Facilities* is the most determinant; *Current Use* sub-criterion was the least decisive sub-criteria. This result again shows the existence of some negative factors in the area.

In the research, it was revealed that 69% of the users of the area preferred the summer season, while the recreational use remained at a very low level in other seasons.

Due to the low income level of users in Çankırı and the majority of them being students, regular trips to the area are not possible. In field studies, it has been observed that users mostly come to the area with their private vehicles. Poor public transport facility is the main reason for this situation.

Users who come to the area for one day prefer this area because of its magnificent view and quietness. These users aim to get away from the stress and tiredness of the day and to feel good about themselves. Therefore, recreation and picnic activities in the area come to the fore.

The destruction caused by stream improvement and recreational activities in the area has already increased concerns about the future. This area is used as a recreational area with unsustainable methods and without considering the protection-use balance. Despite the destruction caused by the pressure of anthropogenic effects on the area, the area has the potential to renew itself.

When a general evaluation is made about the area, it is concluded that the majority of users find the facilities in the area inadequate. In addition, the lack of publicity of the natural park also affects the user potential.

With its natural resource values and recreational features, Kadınçayırı Natural Park offers various recreational opportunities to the users. Despite this, the park hosts visitors below its physical potential. The main reasons for this situation is that the area allows mostly summer use and remains idle in other months, and the transportation infrastructure is not sufficient.

As a result of the improvement of the transportation infrastructure in the area, more efficient use of the ski center will be ensured. Furthermore, it will provide easy access to the area for the social layers with low income levels.

Activities in the research area include photography, trekking / trekking, camping-caravan, picnic areas, plant research and wildlife (fauna) observation, chairlift, teleski, zipline, bungalows, football fields and winter sports. The intensity of ecotourism activities increases even more especially in summer months. There is a need to protect the research area, to encourage recreational participation, to support tourism investments, to increase environmental awareness, to protect

natural and cultural landscape values and to transfer them to future generations, to disseminate ecotourism planning with the participation and support of responsible and relevant institutions, and to promote the area on a national and international scale.

Infrastructure and facilities for sports activities, as well as the possibility of recreational activities, accommodation and ease of communication/transport increase the recreational attractiveness of the area.

3 main criteria (landscape value, negative factors, recreational facilities) and 25 sub-criteria were evaluated in the field through user surveys and AHP analysis. As a result of the evaluations, it has been determined that the most important main criteria affecting the recreational potential of the area are the landscape values (47%). This criterion was followed by negative factors (25%) and recreational facilities (28%). Among the landscape values, ecosystem service values come to the fore. The prominent ecosystem services are habitat services, recreation and ecotourism services, cultural services, climate regulation services, economic services and water quality regulation services, respectively. The landscape and ecosystem values can be increased by minimizing the effects of the negative factors criteria on the area.

Negative factors in the area are lack of infrastructure, lack of publicity, inadequacy of health facilities, transportation-distance problems, lack of awareness of natural parks-lack of education, lack of security, unsuitable land conditions, climatic conditions, entrance fees, and pollution of water source. The most prominent negative factor according to AHP analysis is the lack of publicity. If the negative factors are eliminated, the number of users of the area will increase (Figure 11).

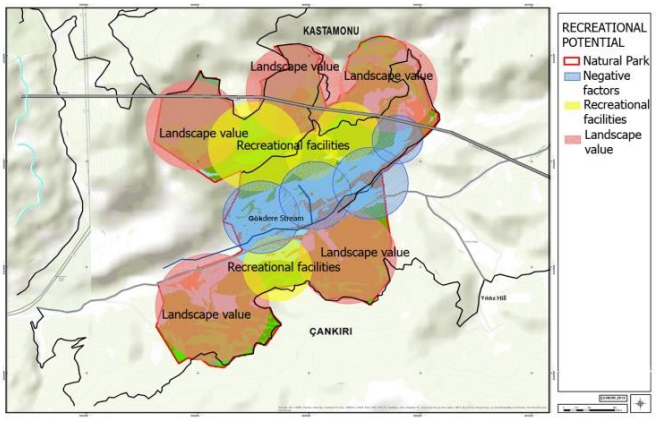

Figure 11. Recreational potential of research area

Akten, et al. (2009) obtained the coefficients of suitability in terms of recreational area use criteria with the AHP method and determined the recreational potential of the area. In our study, it has been revealed that the recreational potential of the area is quite high in line with the data obtained by the Gülez method.

Demir and Demirel (2018) mentioned that the landscape ecology approach should be based on landscape planning, taking land use decisions in landscape management studies, risk management, and abiotic-biotic relationships in the landscape. According to Balık &Türkyılmaz (2021), AHP statistical method is used to prioritize ecological risk factors in Lake Gala National Park. The ecological risk level in the wetland section is higher than the ecological risk level in the terrestrial section. In this context, in the example of Kadınçayırı Natural Park, the necessity of ecological approaches comes to the fore in terms of the recreational potential, the management and planning decisions that affect it.

As a result of the analysis of the data prepared with GIS for Kadınçayırı Natural Park, the ecological unit map of the area was created. Çankırı Kadınçayırı Natural Park Landscape Plan Strategies have been developed as a result of the interpretation of the analysis sheets prepared for the research area and the evaluation of the results of the surveys with the local people and experts. These strategies are:

1. Rare and diverse areas in terms of natural landscape characteristics should be protected. Use areas with endemic species and/or rich biodiversity should be protected by defining appropriate zoning and boundaries.
2. Solution proposals should be developed to increase, protect and improve the quality of valleys, streams and stream beds, which are very important as a resource value. Afforestation areas should be determined for erosion and landslide control purposes.
3. Due to its agricultural character, agricultural types and practices in the region should be supported and their relations with natural and cultural factors should be balanced.
4. Touristic and recreational resources should be evaluated and appropriate activities should be defined for these resources. As recreation types; camping, mountain biking, trekking, botanical tourism, wildlife, trekking, skilift, teleski and zipline should be included in the scope of evaluation. Alternatives should be developed considering the legal regulations in the location and use of tourism facilities and second housing areas.
5. Development directions for residential areas should be proposed.

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The authors have no conflicts of interest to declare.

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Tuning Optical and Electrical Properties of Ultra-Fast Prepared Nanoflower Mg:ZnO Films by MWCNTs Coating

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Abstract: Mg doped ZnO films were decorated by multi-walled carbon nanotubes (MWCNTs) *via* fast chemical bath onto ZnO seed layers. XRD analysis showed preferential orientation shift from high-energy (002) peak to low-energy (101) peak with MWCNTs coating. Average crystalline size of Mg doped ZnO samples were 15 nm. diameter and decreased by MWCNTs coating. SEM images revealed that the presence of accumulative nanoflower-rod forms on Mg:ZnO surfaces and net-shaped coating has been achieved by MWCNTs inclusion. No major difference was detected in optical absorption edge of both films however MWCNTs coating caused an increase direct band gap energy. Calculated band gap values were 3.04 eV and 3.34 eV in Mg:ZnO and Mg:ZnO/MWCNTs films, respectively due to Burstein-Moss effect. Electrical resistance results showed that MWCNTs decreased the resistance of films at room temperature which were calculated as 29.85 and 8.53 kΩ for Mg:ZnO and Mg:ZnO/MWCNTs films, respectively.

Keywords: Chemical bath deposition, ZnO, MWCNTs, electrical properties, optical properties.

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1. INTRODUCTION

Opto-electronic device integration is so essential to produce Uv-photodedectors, CIGS-based solar modules, optical wave guides and LED screens. Chemical-mechanical stability and average crystallite size with shape of the particles have a big impact on the band gap tailoring that affect opto-electronic device performance. In the studies of GaN-replacement material, its useful optical properties are highlighted by its wide optical band gap energy (~3.37-3.82 eV), stimulated excitonic emission probability even above room temperature (RT) and high optical transperancy (>80%) in Uv-Vis region (Tan et.al., 2016; Kim et.al., 2013). The arrangement of the optical band gap energy with using ZnO is widely investigated by different research groups because localized surface defects have been created so recombination of electron-hole may be hindered (Samadi et.al., 2016).

ZnO nanostructures have shown remarkable properties that used in dye sensitized solar cells, pharmaceutical, photocatalysis and room temperature gas sensors (Yao et.al., 2014; Majunder et.al., 2020). The main advantages of ZnO nanostructures are supplying a direct pathway to conduction and transportation of electrons, large surface to volume ratio, creating active polar surfaces, reduce the mass transfer resistance and reduction interface effects (Yang et.al., 2012). VA group elements or transtion metal doping with/without IA/IIA group elements as well as carbon modification which including nanotubes, graphene, carbon fibers have been studied to achieve reproducible properties of the nanostructures (Okeke et.al., 2021). Alkaline earth metals can affect the physical and chemical character of ZnO. As a IIA group element, ionic radius of Mg^{2+} (0.57 Å) is so proper to replaceZn^{2+} ions (0.60 Å) so lattice stability can be ensured (Jaballah et.al., 2020). To obtain high mechanical

stability and functionality, multi-walled carbon nanotubes (MWCNTs) have been studied as a matrix form in nano-structures (Chen et.al., 2012). Functional groups on the surface of the walls can be helpful so physical and chemical properties of matrix structures can be improved.

Thin film production type is very important as being fast, simple and cheap in industrial applications. For this reason, chemical methods are preferred more than physical methods.There are many procedures involving the chemical reaction of precursors proposed and implemented by researcherssuch as hydrothermal, sputtering, atomic layer deposition and spin coating (Sharma et.al., 2015; Sahoo et.al., 2013; Papielarski et.al., 2019). Among them, chemical bath deposition is so attractive due to its easy production and set-up, ability of the storage of wastes. One characteristic of zinc is the tendency of zinc hydroxide to easily undergo dehydration reactions forming the oxide phase, which allows to obtain high ZnO crystal quality even in low-temperature production (Altun et.al, 2021).

Hence, an attempt was made to chemical bath deposition the Mg:ZnO nanoflower/MWCNTs matrix and evaluate its structural, electrical and optical properties in this study. Structural and morphological properties of ZnO seed layer were shown in our previous study (Sarf et.al., 2020).

2. MATERIAL AND METHODS

Mg doped and MWCNTs coated ZnO films were deposited by simple chemical bath onto ZnO nanoflower seed layers (1x4 cm). Nanoflower ZnO seed layer preparation procedure was explained in our previous study (Sarf et.al., 2020). All chemicals were purchased from Sigma Aldrich and used without any further purification. Zincacetate dihydrate ($Zn(Ac)_2.2H_2O$)(99%), magnesium acetate tehtrahydrate ($C_4H_6MgO_4$)(99%) and ammonium hydroxide (NH_4OH) were used as a zinc-source, Mg-source and complex agent, respectively. The total distilled water volume was 100 ml. and [Zn/Mg] molar ratio was arranged as [4/1]. Nanoflower ZnO seed layers were immersed into aqueous solution and pH of this solution was set to 11 with adding ammonia65±5 ºC and 8 min. were chosen as working temperature and working time for mixing the solution in the beaker on the hot plate. 10% metal containing MWCNTs (0.02 g) was added in aqueous solution to obtain Mg:ZnO/MWCNTs. After one day waiting, Mg:ZnO and Mg:ZnO/MWCNTs films were annealed at 450 ºC to remove surface residues.

The structural analysis of the films was performed by Rigaku SmartLab X-ray diffractometer at 1.5406 Å over 2θ range of 20º–80º. The surface morphology studies were carried out by JEOL JSM-7100F- SEM (scanning electron microscope). Chemical composition of the films was determined by FTIR (Fourier Transform Infrared Spectrum) monitoring VERTEX 70 with an attenuated total reflectance (ATR) Bruker, Germany. I-V measurements were carried out by using a computer-controlled system which was included Keithley 2400 source meter, LakeShore 325 temperature controller, test cell and computer.

3. RESULTS AND DISCUSSION

Figure 1 shows the XRD analysis of Mg:ZnO and MWCNTs/Mg:ZnO films. The x-ray patterns were corresponded with JCPDS card No.36-1451 and showed the polycrystalline pure hexagonal wurtzite structure of ZnO (Karaduman et.al., 2019). Three typical ZnO indexed peaks of (100), (002) and (101) were clearly observed (Sarf et.al., 2021). There was no purity peak such as metal, oxide, or any binary zinc alloy phases, or 'Mg' element peak or its compounds. A slightly shift was observed from (002) peak of ZnO seed layer and intensity of this peak can enhanced with Mg doping without changing wurtzite structure due to Mg^{2+} ionic radius (0.57 Å) which was so close Zn^{2+} ionic radius (0.60 Å). There was a very slight rolling of 26.16° and it has confirmed that the samples contained MWCNTs. The reason why there is no obvious characteristic C(002) peak in MWCNTs can be explained by the fact that dispersion is difficult in aqueous solutions and MWCNTs amount was so low and film growth process were too fast. In our prevous study which including ZnO/MWCNTs films, similar x-ray patterns of the unseen C (002) peak were obtained (Özütok et.al., 2019). Although preferential orientation of Mg:ZnO samples had high energy (002) peak along a-axis, MWCNTs/Mg:ZnO samples had low energy (101) preferential orientation peak along c-axis, indicating MWCNTs-ZnO matrix can change severly ZnO lattice parameters. In addition, it can be seen that the Mg element can settle in the ZnO host lattice and the coating of MWCNTs is relative succesfull in fast growth process.

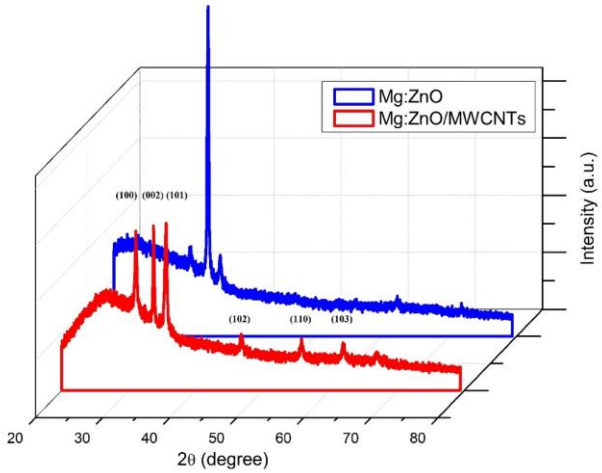

Figure 1. X-ray patterns of of Mg:ZnO and MWCNTs/Mg:ZnO films

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Table 1. Structural parameters of Mg:ZnO and MWCNTs/Mg:ZnO films.

	Lattice parameters		Aspect ratio (c/a)	Bond length 'L' (Å)	Crystallite size D (nm) From XRD	Dislocation density 'δ'	Strain 'ε' (x10^{-4})	APF	Volume of the nanoparticles	Volume of unit cell 'V' (Å)^3	No of unit cells
	'a=b' (Å)	'c' (Å)									
Mg- doped ZnO	3.2236	5.1542	1.5988	1.9662	15	0.0044	24.40	0.7562	1767	46.38	38.09
MWCNTs coated Mg-doped ZnO	3.2163	5.1419	1.5987	1.9567	10	0.01	36.40	0.7563	523	46.06	11.35

Detailed structural parameters were listed in Table 1.

The values of lattice constants 'a' and 'c' are calculated by the following formula as shown by Equation (1) and (2) (Mia et.al., 2017);

$$a = \frac{\lambda}{\sqrt{3}\sin\theta} \quad (1)$$

$$c = \frac{\lambda}{\sin\theta} \quad (2)$$

'a' and 'c' values are compatible with the literature, as shown in Table 1 (Bilgili, 2021). The average crystallite size of the films are measured from X-ray line broadening of the preferential orientation peaks using Debye Scherrer's formula (Mujahid, 2015);

$$D = \frac{0.94\lambda}{\beta\cos\theta} \quad (3)$$

where, λ is the wavelength of x-ray radiation, β is the full width at half maximum (FWHM) and θ is diffraction angle. The average crystallite size of the films were estimated as 15 and 10 nm for Mg:ZnO and Mg:ZnO/MWCNTs films, indicating carbon nanotubes had an improving effect on the crystallinity due to high mechanical stability of tubes. Mujahıd et.al. reported that the average crystallite size of Pt-ZnO/CNT films were found from 14 nm to 24 nm. Umaralikhan et. al. calculated that the average crystallite size of Mg doped ZnO sample is 33 nm by using Debye-Scherrer's Formula (Umaralikhan et.al., 2017). Lattice strain formula is shown by Equation (4) (Sathya et.al, 2018);

$$\varepsilon = \frac{\beta\cos\theta}{4} \quad (4)$$

Due to low concentrated local impurity regions, increasing lattice strain with Mg doping and MWCNTs coating did not have a noticeable effect. A value associated with strain, dislocation density is calculated by Equation (5) (Mariappan et.al., 2014);

$$\delta = \frac{1}{D^2} \quad (5)$$

Dislocation density was relatively high in MWCNTs coated samples with decreasing crystalline size and increasing lattice strain. The following Equation (6) is used to calculate the volume of the unit cell for hexagonal system (Sathya et.al., 2018);

$$V = \frac{\sqrt{3}}{2}a^2c \quad (6)$$

The unit cell volumewas calculated by the above relation and were found to be 46.38 Å^3 and 46.06 Å^3 for Mg:ZnO and Mg:ZnO/MWCNTs samples, respectively. This indicated that Mg^{2+} ions and some C atoms that were difficult to separate reside partially in tetrahedral Zn^{2+} positions. Bond length is calculated by the relation as Equation (7) (Srinivasan et.al., 2007);

$$L = \sqrt{\left(\frac{a^2}{3} + \left(\frac{1}{2} - u\right)^2 c^2\right)} \quad (7)$$

where a and c are lattice parameters, and u is defined as positional parameter of the wurtzite structure which is calculated by Equation (8) (Sathya et.al, 2018);

$$u = \frac{a^2}{3c^2} + 0.25 \quad (8)$$

'u' parameter was 0.38 for both films. Bond length 1.9662 nm. and 1.9567 nm. for Mg:ZnO and Mg:ZnO/MWCNTs samples, respectively. These values were consistent with bulk zinc (1.97 nm.). APF was determined by Equation (9) (Bilgili et.al., 2021);

$$APF = \frac{2\pi a}{3\sqrt{3}c} \quad (9)$$

The APF of commercial ZnO was 74%. However, in our study, it was calculated about 75.6%. It can associate with that nanocrystals was slightly larger than that of bulk materials. The volume of the particles V is calculated from the equation and the volume of hexagonal unit cell has been estimated from ϑ. Then, the ratio (V/ ϑ) gives the number of unit cell present in a grain (Sathya et.al., 2018) ;

$$V = \left(\frac{4}{3}\right)\pi\left(\left(\frac{D}{2}\right)^3\right) \quad (10)$$

$$\vartheta = 0.866a^2c \quad (11)$$

the volume of the particles were 1767 and 523, the volumes of hexagonal unit cell were 46.38 and 46.06 and the numbers of unit cell present in a grain are found 38.09 and 11.35 for Mg:ZnO and Mg:ZnO/MWCNTs films, respectively.

Figure 2 shows the SEM analysis of Mg doped ZnO and MWCNTs coated ZnO films. It could be highlighted from our previous study that, ZnO seed layer had nanoflower forms on the glass surface (Sarf et.al., 2020). With Mg doping, petal density of nanoflowers increased and relative nano-rod forms detect, indicating Mg doping can cause accumulation of petals during fast nucleation of ZnO and the rod froms and some observed agglomerative forms are thought to be associated with Mg assemblage. Dimension of nanoflowers of ~230 nm. increased with Mg doping. Wahyuono et.al. explained that the number of nucleation sites critically affects the self-assembly during nano-flower growth and the low concentration of OH- facilitates relatively high nucleation rates (Wahyuono et.al., 2016). Consistent nanoflower structures were observed in Mg:ZnO films as reported by Sagheer et.al. that explained by ZnO seed layer attribution and acts as the building block for the growth (Sagheer et.al., 2020). Lattice mismatch of ZnO seed layer and Mg doped layer may be also ensure its. When examinig the MWCNT effect, it was seen that it transformed

into relative heterogeneous (due to low solubility of nano-tubes in aqueous solution) nanowire-like structures onto nanoflower Mg:ZnO surfaces, induced pronounced wrinkling. Wrinkle formation is beneficial due to the pre-stress phase because it effectively reduces the intrinsic stress inside the film during functional stress and makes the films very suitable for opto-electronic devices such as touch screens (Liu et.al., 2021).

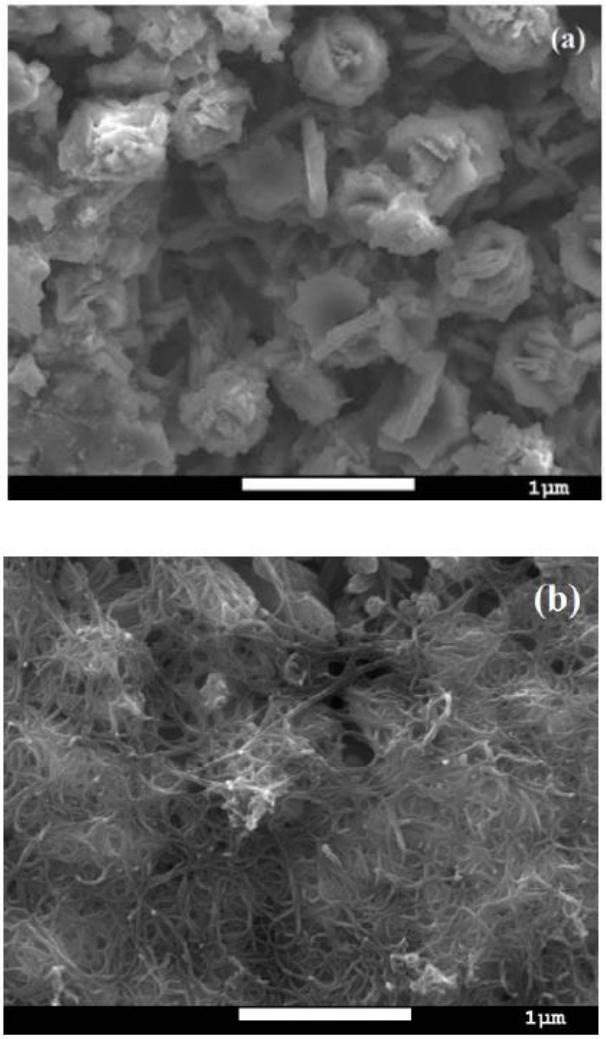

Figure 2. The SEM analysis of Mg:ZnO (a) and Mg:ZnO/MWCNTs films (b)

Uv-Vis absorption spectra of the samples as a function of the wavelength is shown in Figure 3 between 300-900 nm range. No impurity or defect related absorption was detected in the both films, indicating all films had high quality although fast grown of particles. Optical absorption edge at ~345 nm which was nearly similar for both films however MWCNTs coated samples had higher optical transparency which was a result of severe surface change with MWCNTs decoration and increasing homogeinity (Cwirzen et.al., 2008). The sharp absorption edge, which indicated a direct bandgap material, exhibited blue shifts with the increase of Mg content and MWCNTs coating. The phenomenon of absorption edge shifting to lower wavelength (as known blue shift) can be attributed to the Burstein-Moss effect and it is beneficial for optoelectronic applications due to a facilitation of phonon scattering from interfaces (Mohar et.al, 2020).

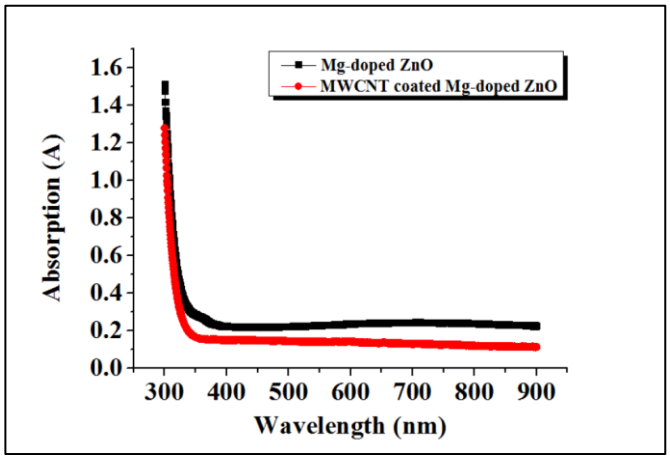

Figure 3. UV-Vis absorption spectra of Mg:ZnO and Mg:ZnO/MWCNTs films

Tauc relation was used for determining the optical direct bandgap, given by Equation (12) (Siregar et.al., 2020);

$$\alpha = \frac{A}{h\nu}\,(h\nu - E_g)^{1/2} \qquad (12)$$

where A is a constant, α is the absorption coefficient, E_g is the optical bandgap and hν is a photon energy. The optical band gap Eg of ZnO values were determined by the absorption spectra, as exhibited in Figure 4. Calculated Eg was 3.04 eV and 3.34 eV for Mg:ZnO and Mg: ZnO/ MWCNTs films, respectively. This increase indicated carbon nanotubes absorbed radiation in the Uv-Vis area, similar results was reported by Ramos-Corona et.al (Romas-Corona et.al., 2019).

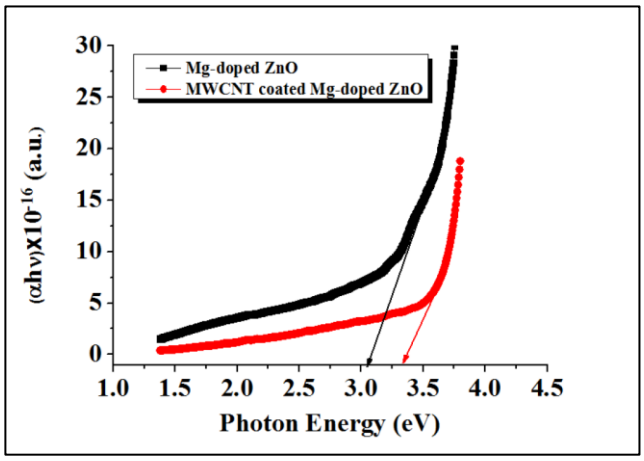

Figure 4. The optical band gap Eg of Mg:ZnO (a) and Mg:ZnO/MWCNTs films

Bandgap width and transition mechanisms were directly affected by the distribution of localized states in the bandgap which was known as the exponential Urbach tail. The Urbach tail of the films can be determined by the following relation (Ilican et.al., 2008);

$$\alpha = \alpha_o \exp\left(\frac{E}{E_U}\right) \qquad (13)$$

where E is the photon energy (hν), α_o is constant and E_U is the Urbach energy which refers the width of the exponential absorption edge. The E_U value was calculated from the slope of Equation (12) using relationship (14);

$$E_U = \left(\frac{d(\ln\alpha)}{d(h\vartheta)}\right)^{-1} \quad (14)$$

Eu values were calculated as 77 meV and 73 meV for Mg:ZnO and Mg:ZnO/ MWCNTs films. Urbach energy decrease indicated the decrease in the disorderliness of the film (Asikuzun et.al., 2018). The refractive index was calculated according to the five five different methods using band gap energies. According to the findings of Naccarato et. al., 2019, our material with (n > 2 and Eg > 3) considered in this research is classified as Transition Metals (TMs) with empty d shell (e.g. V^{5+}). Table 2 gives the refractive indexes that calculated by five different methods using band gap energies and detailed equations were revealed by Pattanaik et.al. (2020).

Table 2. Refractive index calculated by five different methods using band gap energies (Pattanaik, 2020).

Sample	Ravindra	Moss	Herve and Vandamme	Reddy and Anjayenulu	Kumar and Singh	Eg
Mg-doped ZnO	2.1868	2.3604	2.3102	2.7342	2.1240	3.06
MWCNTs coated Mg-doped ZnO	2.0132	2.3093	2.2333	2.6689	2.1815	3.44

Figure 5 represents FTIR spectrum of Mg:ZnO and Mg:ZnO/MWCNTs films to determine chemical composition of functional groups that was taken between 4000 cm^{-1} and 650 cm^{-1}. Typical OH^- group stretching vibration peak was observed around at 3746 cm^{-1} and 3392 cm^{-1} for Mg:ZnO and Mg:ZnO/MWCNTs films, indicating adsorbed water from film surface. The streching vibrations of carboxyl groups were detected at 2324 and 2343 cm^{-1} for Mg:ZnO and Mg:ZnO/MWCNTs samples. C-OH^- streching vibration related bands at ~1374 cm^{-1} were found in Mg:ZnO/MWCNTs samples (Srinet et.al., 2013). Asymmetric stretching of C=O bonds of the carboxylate ions were shown at 1396 cm^{-1} and 1374 cm^{1} in Mg:ZnO and Mg:ZnO/MWCNTs films. The peak at 865 cm^{-1} and 892 cm^{-1} are assigned to O-C-O stretching vibrations of the monodentate carbonate species (Etacheri et.al., 2012).

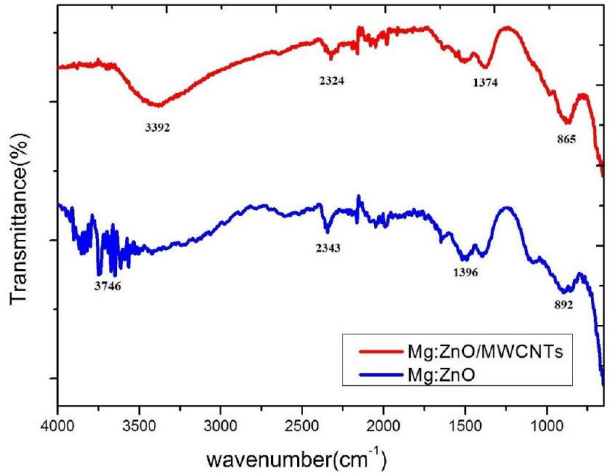

Figure 5. FTIR spectra of Mg:ZnO and Mg:ZnO/ MWCNTs films.

I-V characteristics of Mg:ZnO and Mg:ZnO/ MWCNTs films are shown in Figure 6 at room temperature. I-V characteristics were recorded with a sweep rate of 50 mV/s starting from +1 V to –1 V in a cycle at room temperature. These curves were not affected with the type of electrodes used (gold), and it was clear that, no non-linear behaviour was observed in the indicated voltage interval. The resistance of films at room temperature were calculated as 29.85 and 8.53 kΩ for Mg-doped ZnO and MWCNTs coated Mg-doped ZnO films, respectively (Kılınç et.al., 2010). Similarly, Chen et.al. has reported that the resistivity of the Mn doped ZnO increased with increasing Mn concentration (Chen et.al., 2007). Also, a decrease in resistance was observed with the MWNTS effect (Barthawala et.al., 2020). Particle size decrease could improve effect on the charge transfer and mobility. With MWCNTs coating, resistivity decrease was observed due to the presence of multi-walled carbon nanotubes in the samples produced a more significant number of charges (Diaz-Corona et.al. ,2019). In addition, the deviant of resistance values could be the result of the defect concentration by Mg-doping and MWCNT coating.

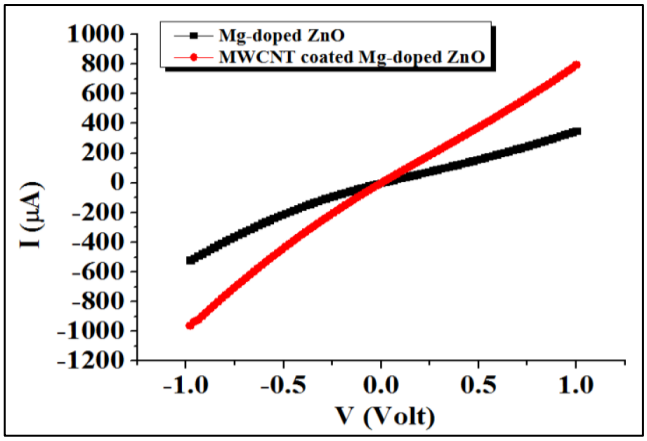

Figure 6. I-V characteristics of Mg:ZnO and Mg:ZnO/ MWCNTs films at room temperature.

4. CONCLUSIONS

The fabrication of Mg:ZnO with/without multi wall carbon nanotube (MWCNT) composite films and a study of their detailed structural analysis as well as optical and electrical properties have been reported. The nanocomposite films were deposited by ultra-fast (less than 10 minutes) chemical bath. The formation of the wurtzite-type hexagonal structure were observed in both of the ZnO and ZnO/MWCNTs composite thin films. Average crystallite size and crystal quality of the nanoflower ZnO seed layers exhibited noticeable improved change with Mg doping and MWCNTs coating. Electrical resistance of the samples decreased with

an increase was detected optical band gap by MWCNTs coating.

Ethics Committee Approval
N/A

Peer-review
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Author Contributions
All authors have read and agreed to the published version of manuscript.

Conflict of Interest
The authors have no conflicts of interest to declare.

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Investigation of Changes in Proteolysis and Lipolysis of Traditional Çanak Cheese Maturing Under the Soil

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Abstract: Çanak cheese which is matured in earthen were containers, is a common cheese type produced widely in Yozgat province of Turkey. Thirty Çanak cheese samples were investigated for routine chemical composition, lipolysis, proteolysis, and free fatty acids (FFAs). Dry matter, salt, salt in dry matter, fat, fat in dry matter, and acidity values in the analyzed samples were determined to be between 45.01 and 66.27 %; 2.11 and 8.89 %; 3.70 and 19.76 %; 13.00 and 40.00 %; 26.23 and 69.30 % and, 0.05 and 0.25%, respectively. WSN, TCA-SN, PTA-SN and lipolysis values were detected to be high in Çanak cheeses. Also, C14, C16, and C18:1 fatty acids were found to be higher than other fatty acids in all cheese samples.

Keywords: Çanak cheese, Fatty acids, Lipolysis, Proteolysis.

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1. INTRODUCTION

Çanak (Pan) cheese, which is matured in earthenware containers, is a common cheese type unique to the district of Sarıkaya, Sorgun, Boğazlayan, Çayıralan, Yerkoy and Şefaatli in Yozgat province in the Anatolia Region. Traditional Çanak cheese is commonly made by small-scale dairies using raw milk and traditional techniques. Fermentation relies on activities of indigenous milk microflora. The production methods of Çanak cheese and the ineffective control of temperature and relative humidity during storage cause differences in the quality of the final product. These variation changes in Çanak cheese show that there is no standardized method in the production of this cheese variety (Kamber, 2008a; Kirdar and Kursun, 2011).
Çanak cheese is white in color, slightly salty and has a homogeneous grain structure (Fig.1). This cheese variety is usually produced in June, July and August and is kept buried underground until September and November to fully mature (Kirdar and Kursun, 2011). It can be classified as a fat (fat content in dry matter <57 %) and hard cheese (Turkish Food Codex, 2015).

Traditional Çanak cheese is made from raw goat or sheep milk without the use of starter culture. Firstly, milk is coagulated using homemade calf rennet (for 30 kg of milk per quarter tea glass) in approximately 60-90 minutes (min.) at 32-35 °C. The curd is divided into four large pieces with a scoop, rested for 15-20 min. and transferred to cloth bags. After filtering, pressure is applied to the clot and left to rest for one hour. At the end of the straining process, the curd is cut into pea-sized pieces by hand on the cloth in the tray and salted. This cloth bag is placed on a rocky surface in a cool place (12–16°C) and pressure is applied with regularly shaped stones to create a weight of 10 kilograms for each kilogram of cheese, and the cheese is cut into potato wedges and crumbled. The pans are filled with a layer of potato slices and one layer of crumbling in alternating order until it is full. Finally, the lid of the pan is closed tightly as before and turned upside down; It sinks into the sand again, this time completely. Maturation is achieved in a cool and slightly moist environment, either by burial directly under the ground or by placing in a box filled with sand. The Çanak (Pan) is then buried underground for ripening for three months (Kirdar and Kursun, 2011).

Figure 1. Çanak cheese

Proteolysis is probably the main biochemical event during ripening for most cheese varieties. Nitrogen fractions are essential parameters for determining the extent of proteolysis (Fox, 1988). Proteolysis can vary greatly depending on the cheese type. The geographical region of the cheese, the season of production, the temperature and time of ripening, and the type of milk used in its production are factors that affect the proteolysis levels in cheese (Di Cagno et al., 2003).

Lipolysis is a biochemical parameter of great importance that is frequently used in the analysis of short and medium chain (ie, C4-Cl2) free fatty acids (FFA) and in the chemical characterization of cheese ripening (Woo et al., 1984; De La Fuente et al., 1993). This type of FFA makes significant contributions to the flavor of different types of cheese, as it is reported that the characteristic flavor of cheese is provided by a well-balanced concentration of chemical compounds. The lipolysis values vary significantly between different cheese types, from Dutch low-grade cheeses (Walstra et al., 1993) to mold-ripened, surface-ripened and Italian hard cheeses (Battistotti and Corradini, 1993). Many studies have been conducted on the composition of fatty acids and sensory properties of various cheese types (Kondyli et al., 2002; Guler and Uraz, 2003; Mallatou et al., 2003; Perotti et al., 2005; Atasoy and Turkoglu, 2008; Atasoy et al., 2008; Atasoy and Turkoglu, 2009; Georgala et al., 2016; Fusaro et al., 2019; Serrapica et al., 2020). In recent years, different types of cheese have been studied in Turkey in order to increase the studies on the effect of proteolysis on the ripening of some cheeses (Cinbas and Kılıc, 2006; Hayaloglu and Karabulut, 2013; Tuncturk et al., 2014; Salum et al., 2018; Ozer and Kesenkas, 2019). The knowledge about Çanak cheese technology and chemical composition is inferior. In contrast, there has been no study on the proteolysis and lipolysis of Çanak cheese.

There have been few studies on the gross composition and microbiological characteristics of Çanak cheese (Akyuz and Gulumser, 1984; Coskun et al., 2002; Kirdar and Kursun, 2011).

The aim of this investigation was to obtain information about fat hydrolysis, proteolysis degree and fatty acids in Çanak cheese and to determine the correlation between chemical and biochemical properties of this cheese.

2. MATERIAL AND METHOD

2.1. Materials

Thirty ripened Çanak cheeses (~250g each) from different towns located near Yozgat in Turkey were purchased and quickly brought to the laboratory at 4 °C. The samples were storaged at 4±1 °C during the analysis.

2.2. Chemical analyses

The pH values of the cheeses were determined using a pH meter (HANNA). Acidity of samples was detected according to the AOAC method by titration (AOAC, 2000) and the fat content (%) was analyzed by the Gerber method (IDF, 1997). The total solids content was found by gravimetric (IDF, 1982) and the salt content was determined by the Mohr method (IDF, 1979). The amount of salt and fat in the dry matter was obtained by calculation.

2.3. Determination of proteolysis

The total nitrogen (TN) content was determined using the Kjeldahl method (IDF, 1993). The total protein, water-soluble nitrogen (WSN), 12% trichloroacetic acid soluble nitrogen (TCA-SN) and 5% phosphotungstic acid soluble nitrogen (PTA-SN) were detected using the Kjeldahl method (Bütikofer et al., 1993). The ripening index (RI) was also calculated by taking the percentage of WSN to TN ratio.

2.4. Determination of lipolysis

The lipolysis in cheese samples was evaluated by determining the acid degree value (ADV) and free fatty acid (FFA) content. Determination of ADV was done using the BDI method. In order to determine the ADV (mM/100 g fat) in cheese samples, finely ground 10 g samples were placed in special butyrometers. 20 mL reagent (obtained by dissolving 30 g Triton X-100 and 70 g sodium tetra phosphate in 1 L of distilled water and adjusting the pH to 6.6 with o-phosphoric acid) was added to it, and the oil was released by placing the butyrometers in boiling water. The mixture was then centrifuged for 1 min. and enough aqueous methanol (1 water: 1 methanol) was added to bring the oil column to the butyrometer neck. The samples were centrifuged again for 1 min. and incubated in a water bath. All of the upper oil was withdrawn with a syringe, 5 mL of oil solvent (4 petroleum ether: 1 n-propanol) containing 0.1 g/L thymol blue indicator was added and titrated with 0.01 N tetra n-butyl ammonium hydroxide. As a result, the ADV ratios were calculated and determined according to Case et al. (1985).

The fatty acids extracted from cheese were determined according to the Deeth et al. (1983) method (Table 1) by gas chromatography (Agilent 6890 Series GC system). The cheese samples (1.5-2.0 g) were weighed into the test tube. Then 2.5 g of sodium sulfate, 5 mL of heptanoic acid and 300 µL of 4 N H2SO4 were added. The mixture was stirred in the vortex for 30 sec. 5 mL of hexane was added over and stirred again. After the covers of the samples are wrapped with parafilm, they were kept on hold for 2 hours in a dark environment. At the end of the period, in the top layer of the sample in the test tubes the hexane / diethyl ether layer containing the lipids is carefully transferred to each biorad column (100 mm height and 10 mm diameter) which with 1 g of deactivated alumina and glass wool is washed once with 5 mL of diethyl ether / hexane (1/1 v / v) mixture. The column is washed twice with 5mL of 1: 1 diethyl ether /

hexane solution, the wash solution is poured into the waste tray. After the diethyl ether / hexane solution was completely filtered, the air was given to the upper part of the columns by a fan and allowed to dry for 60 min. The dried alumina was transferred into 13 mm closure glass tubes. 2 mL formic acid (6%) prepared in diethyl ether was added to the test tube, the tubes were closed for 15 seconds after mixing and centrifuged for 10 min. at 2000 rpm. The clear part collected on the upper surface was transferred to the colored vials using a Pasteur pipette and closed with a unique sealing device. Samples were stored at -18ºC until GC analysis. The samples were allowed to dissolve free fatty acids for 30 min at room temperature before being injected into the GC, and 5 µL of the vials were injected from the vials under appropriate GC conditions.

Table 1. The working conditions of Gas Chromatography

Detector	Flame ionization detector (FID-Flame Ionization Detector)
Column	Agilent –FFAP Capillary 300x250 µm x 0.25 µm
Detector temperature	230ºC
Injector temperature	220ºC
Split ratio	1:20
Injection volume	1 µL
Mobile phase	Nitrogen (N2) flow rate: 2 mL / min Hydrogen (H2) flow rate: 33 mL / min
Air flow rate:	370 mL / min

2.5. Statistical analysis

The mean, minimum, maximum and standard deviation values for all parameters were obtained using SPSS v.19 (IBM Corp., Armonk, NY, USA). Significance assessment was done by analyzes of variance followed by Spearman correlation (Draper and Smith, 1998).

3. RESULTS AND DISCUSSIONS

3.1. Gross composition

The chemical content of the Çanak cheese samples is shown in Table 2. The mean value of fat, salt, pH, titratable acidity, and total dry matter was determined 22.92%, 4.22%, 5.34, 0.14 and 52.10%, respectively.

Dry matter of samples contents vary according to the type and duration of syneresis, salting type, curd size, pre-ripening (Ucuncu, 2004). The dry matter content of Çanak cheese showed to be similar to Sıkma cheese, Tulum cheese, and Küp cheese. For the rates of fat in dry matter in the samples of Çanak cheese, 30% and 50% were more concentrated. Five samples fat rate in dry matter have been detected to contain more than 50%.

Fat is the main nutrient of milk, also has important functions in cheese which is the and affects the hardness, stickiness, mouthfeel and flavor of the cheese (Fox et al., 1993; Fox et al., 1999). It was change that fat content of the Çanak cheese samples varied in a wide range.
The fat ratio of Çanak samples showed significant variations. The differences in fat content may be due to the fact that this product does not have a standard production technique. The fat content of Çanak cheese was similar found to that of Sıkma cheese and higher than the other similar cheeses (Kamber, 2008b; Guven and Karaca, 2004).

Table 2 shows that the minimum, maximum and average pH values of Çanak cheese are 4.54, 6.22 and 5.34, respectively. Kinik et al. (1999) determined that the values of 5.22 and 5.46 pH in Sepet cheese were found to be similar and higher than the value of 4.68 pH found by Polat and Yetismeyen (2004) in Civil cheese. In addition, TS591 (2006) stated that the minimum pH value should be 4.5 in white cheeses and it was determined that the results obtained in the study were higher than this value.

The pH values of Çanak cheeses have a significant negative correlation with the acidity values (Table 3). Accoding to the TS 591 standard (2006) recommends that titratable acidity as lactic acid in cheeses should not exceed 3%. As a matter of fact, when the acidity values obtained in the study were examined, it was seen that the titratable acidity values of cheeses did not exceed 3%.

Salt is an important ingredient that contributes to flavor and taste development. When Table 2 is examined, it is seen that the average salt content of Çanak cheeses is 4.22%, the maximum salt content is 8.89% and the minimum salt content is 2.11%. There are significant differences in salt content between both producers and production periods. Since Çanak cheese is salted by hand, inhomogeneously after cheese making, salt distribution is observed immediately, causing limitation of rate of proteolysis in cheeses during ripening (Thomas and Pearce, 1981). In addition, the high salt in moisture (S/M) contact of the cheeses may have reduced the acidity of lactic acid bacteria (Prasad and Alvorez, 1999). Similar results were obtained by Cinbas and Kiliç (2006).

Table 2. Biochemical properties of Çanak Cheese

Parameters	Mean±SD	Minimum	Maximum
pH	5.34±0.44	4.54	6.22
Titratable asidity(LA %)	0.14±0.07	0.05	0.25
Fat[b]	22.92±5.92	13.00	40.00
Dry matter[b]	52.10±4.68	45.01	66.27
Salt[b]	4.22±1.99	2.11	8.89
Fat in dry Matter[b]	43.72±8.30	26.23	69.30
Salt in Dry matter[b]	8.25±4.05	3.70	19.76
Total nitrogen[b]	1.93±0.11	0.49	4.42
Total protein[b]	12.11±6.22	3.13	28.21
WSN[c]	0.33±0.13	0.09	0.68
RI[c]	24.49±16.16	7,38	60,42
TCA	0.26±0.12	0.08	0.64
TCA-SN[c]	17.95±1.71	2.64	59.71
PTA	0.06±0.00	0.01	0.16
PTA-SN[c]	3.85±0.34	0.54	18.86
ADV value	10.34±11.01	1.04	46.24

[*a] [*]Mean data of Çanak cheese analysed in triplicate
[a] All data are expressed as means± standard error
[b] Values for moisture, protein, total nitrogen, total protein, fat and sodium chloride, are g 100/gof cheese.
[c]WSN: water-soluble nitrogen; TCA-SN: 12% trichloroacetic acid-soluble nitrogen; RI: ripening index; PTA-SN: 5% phosphotungstic acid-soluble nitrogen.

Table 3. The correlation between chemical and ciochemical properties of Çanak cheese

	pH	Titratable acidity	Fat	Dry matter	Salt	Fat in dry matter	Salt in dry matter	Total nitrogen	protein	WSN%	TCA%	PTA%	ADV value
pH	1.000												
Titratable acidity	-0.727**	1.000											
Fat	-0.096	0.216	1.000										
Dry matter	-0.315**	0.420**	0.667**	1.000									
Salt	0.442**	-0.370**	-0.034	-0.30	1.000								
Fat in dry matter	-0.028	0.055	0.917**	0.397**	0.08	1.000							
Salt in dry matter	0.442**	-0.403	-0.131	-0.140	0.980**	-0.063	1.000						
Total nitrogen	-0.485**	0.497**	0.507**	0.556**	0.068	0.375**	0.031	1.000					
Total protein	-0.457**	0.460**	0.514**	0.572**	0.085	0.390**	0.043	0.979**	1.000				
WSN%	0.354**	-0.318**	-0.495**	-0.601**	-0.246**	-0.413**	-0.116	-0.789**	-0.800**	1.000			
TCA%	0.175	-0.115	-0.420**	-0.470**	-0.255**	-0.365**	-0.219*	-0.668**	-0.703**	0.854**	1.000		
PTA%	0.341**	-0.258*	-0.282**	-0.280**	-0.025	-0.241*	0.082	-0.524**	-0.554**	0.701**	0.670**	1.000	
ADV value	-0.044	0.078	-0.241*	-0.121	-0.076	0.299**	-0.028	-0.129	-0.162	-0.440**	0.470**	0.399**	1.000

*= Significant at ($p< 0.05$) ** = Significant at ($p< 0.01$)

Total nitrogen was used to determine the evolution of the total protein content and the specify of the maturation index. Total nitrogen was negatively correlated with pH, and positively correlated with dry matter, total acidity, fat and fat in dry matter (Table 3) ($p < 0.01$).

One of the parameters used to determine the level of proteolysis in cheese is the water-soluble nitrogen content. The water-soluble nitrogen ratio, which is considered as an indicator of ripening, is a value that mainly explains the environment of ripening, and therefore the level of large and medium molecular weight nitrogen fractions formed by the hydrolysis of casein (Koçak et al., 1997). WSN/TN, TCA-SN and PTA-SN levels were detected to be high in Çanak cheese.

TCA-SN and PTA-SN values also differed among the Çanak cheese samples. Only small peptides and amino acids are soluble in 12% TCA used in the extraction of nitrogen dissolved in 12% trichloroacetic acid. Therefore, this fraction is also called the non-protein nitrogen (NPN) fraction and can be evaluated as an indicator of proteinase activity in cheese (Tuncturk, 1996). The average TCA-SN values obtained in our study (17.95%) are higher than the results (7.08%) determined by Tarakci et al. (2004) for Van herby cheese and lower than (19.35%) determined by Durmaz et al. (2004) for Surk cheese.

The average of PTA-SN values were found in this study was 4.46%, and the lowest and highest values ranged between 0.54% and 28.81%. These results were higher than the values obtained by Tarakci et al. (2004) in Van herby cheese (3.85%). This can be elucidated by the different compositions of raw milk or the lack of current standard production methods (composition and quality of milk) and production stages (packaging and ripening conditions).

A significant negative correlation was observed between salt in dry matter and TCA-SN values at $p<0.05$ level. Similar results were found in the study by Ercan et al (2012). The cheese ripening coefficient is between 33-66% for fully mature , from 33% in younger cheeses described as less mature. According to this analysis, twenty Çanak cheese was less mature. Using the maturity level of proteolysis to determine the coefficients of the Çanak cheese samples by considering the classification criteria, it was found that 6 of them were less than 10% of the maturation factor, 3 of them 10-20%, 3 of them between 20-30%, and 8 of them between 33-66%.

Table 4. Fatty acid values of Çana cheese samples

Fatty acids										
Saturated fatty acid[1]										
	C4:0	C6:0	C8:0	C10:0	C12:0	C14:0	C15:0	C16:0	C17:0	C18:0
Min	0.00	0.12	0.28	0.95	2.55	0.58	0.31	35.62	0.37	0.28
Max	1.90	1.65	1.17	4.60	6.10	14.72	2.35	46.06	11.69	10.84
Mean	0.94±0.25	1.03±0.21	0.86±0.13	2.81±0.50	3.65±0.51	7.78±2.14	1.13±0.32	41.24±1.64	2.93±1.80	6.09±1.76

Unsaturated fatty acids [2]							
	C14:1	C15:1	C16:1	C17:1	C18:1	C18:2	C18:3
Min	0.10	0.12	0.22	0.05	4.80	0.5	0.16
Max	12.99	2.68	2.47	1.27	23.56	8.27	13.93
Mean	2.63±2.08	0.73±0.40	1.06±0.38	0.36±0.28	17.51±2.99	4.48±1.65	2.65±2.56

[1]C4:0 = Butiric, C6:0 = Caproic, C8:0 = Caprilic, C10:0 = Capric, C12:0 = Lauric, C14:0 = Myristic, C15:0 = Pentadecanoic, C16:0 = Palmitic, C17:0 = Margaric, C18:0 = Stearic acids.
[2]C14:1 = Myristoleic, C16:1 = Palmitoleic, C17:1 = 10-heptadesenoic, C18:1 = Oleic, C18:2 = Linoleic, C18:3 = Linolenic acids.

Lipolysis is the separation of milk fat into mono- and diglycerides and fatty acids as a result of hydrolytic decomposition with natural lipase of milk or lipases secreted by bacteria contaminated with milk, or with the combined effect of both (Coskun, 2005). All factors that have a positive/negative effect on fungal growth (water activity, NaCl, fat ratio, salting pattern, salt gradient in the mass, pH and pH gradient in the mass, O_2 and CO_2 concentration of the cheese environment, temperature, presence and concentration of antimicrobial substances produced by other microorganisms), antifungal agent(s) produced during cheese production and its concentration, cheese variety, and other conditions during cheese production and ripening) affect lipolysis in cheese (Cantor et al., 2004). Table 2 shows that the ADV values of Çanak cheese vary in a wide range between 1.04 and 46.24 and this is thought to be due to the reasons mentioned above.

Table 4 demonstrate the fatty acid composition of the cheeses. There is no information about fatty acid (C4:0 to C18:1) concentrations in Çanak cheese, which has high lipolysis values. In general, the FFA content of Çanak cheese was lower than other cheese varieties. These results can be attributed to the type and composition of milk used in cheese production, heat treatment applied to milk, production methods, ripening and storage temperatures. Long chain fatty acids found in cheeses are mainly myristic (C14:0), palmitic (C16:0), stearic (C18:0) and oleic (C 18:1) acids. The major fatty acids were palmitic (C16:0) and oleic (C18:1) acids and other predominant fatty acids were myristic (C14:0) and stearic (C18:0) acids. A similar situation was reported by Perotti et al. (2005) for "Reggianito and Parmigiano Reggiano" cheese, Cakır et al. (2009) for Keş cheese and Yılmaz et al. (2005) and Guler and Uraz (2003) for Tulum cheese. Palmitic and oleic acid were found

to be the major FFAs in other hard cheese types (Kondyli and Katsiari, 2001).

One of the important features of the quality of dairy products is the determination of the fatty acid profile (Ivanova et al., 2009). The myristic (C14:0), palmitic (C16:0) and stearic (C18:0) acids were found to have the highest values among saturated fatty acids, and oleic acid (C18:1) among unsaturated fatty acids. The oleic acid

(C18:1) and palmitic (C16:0) acid values were found to be the highest in fresh and ripened Örgü cheese samples determined by Turkoglu (2011), similar to the data obtained in our study. In addition to Örgü cheeses, it is stated that the main FFAs in Turkish white cheese are palmitic, oleic, myristic, and stearic acids (Hayaloglu et al., 2008; Ozer et al., 2011).

4. CONCLUSIONS

In this investigation, the chemical and biochemical properties were determined of Çanak cheese produced by the traditional method. The dry matter, protein and fat levels of the cheeses varied in a wide range. These differences are thought to be due to the type of raw milk and composition production techniques and storage conditions. When the nitrogen fraction values of cheese samples were examined, it was concluded that this cheese was exposed to high but low to medium depth proteolysis. Therefore, Çanak cheese take part in class of low quality and less mature cheeses. Since Çanak cheese is usually produced from raw milk, lipase in milk remains in milk and cheese, so it was causing high lipolytic activity. In addition to the factors listed above, the geographical region where the cheese is made and the production season are other factors that affect the lipolysis and proteolysis levels in cheese. In addition, it was determined that stearic and myristic fatty acids were dominant and follow by palmitic and oleic acids in cheese samples.

Author Contributions
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Conflict of Interest
The authors have no conflicts of interest to declare.

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Determination of Optimal Drilling Parameters of Massive Wooden Edge Glued Panels (EGP) and Medium Density Fiberboard using The Taguchi Method

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Abstract: In this paper, the optimization of computer numerical control (CNC) drilling parameters was conducted using the Taguchi experiment design on the drilling holes' inner surfaces roughness (*Ra*) massive wooden edge-glued panels (EGP) made of spruce (*Picea Orientalis* Link.), beech (*Fagus Orientalis* Lipsky), Iroko (*Chlorophora excelsa*) and Medium Density Fiberboard surfaced with synthetic resin sheet (MDFlam). Three drilling parameters and their effects on *Ra* were evaluated. These parameters included spindle speed, feed rate, and cutter type. Surface roughness measurements according to ISO 4287 were performed on the inner surfaces of the holes, and *Ra* values were obtained. An analysis of variance (ANOVA) was performed to identify the significant factors affecting the *Ra*. Optimum drilling parameter combinations were acquired by analyzing the signal-to-noise (S/N) ratio. It is shown that the most ideal result was obtained with a two flutes cutter (cutter number 2) at 18000 rpm and feed of 1750 mm/minute for in-hole roughness values of the MDFlam test sample. In the drilling operations performed with a double-entry cutter, the lowest roughness values were obtained in all materials.

Keywords: CNC, Drilling, MDFlam, wood, Taguchi, roughness

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1. INTRODUCTION

Wood and wood-based materials have been used as furniture and building construction materials for years (Davim, 2011). The inner surface of the holes' surface roughness of wood and wood-based materials is one of the most important properties characterizing the drilling process. The stylus method is commonly used for off-line roughness measurements of wood and wood-based materials (Sandak and Tanaka, 2003; Zhong *et al.*, 2013). Computer numerical control (CNC) has been used for the drilling of furniture materials. CNC has a lot of advantages for furniture manufacturing (Costes and Larricq,2002; Ohuchi and Murase, 2005; Karagoz *et al.*, 2011; Alves *et al.* 2015). The Taguchi Method (TM) can effectively determine the optimal combinations of machining parameters. TM uses a special design of orthogonal arrays (OA) to study entire parameter space with less experiment (Valarmathi *et al.*, 2013; Kacal ve Gülesin, 2011; Sofuoglu, 2015; Sofuoglu, 2017).

As can be observed from the literature, optimization studies on the machining of wood and wood-based materials were performed and *TM* was used in many of them. However, a lack of studies on wood and wood-based materials, especially in the applications of CNC drilling operations.

In this study, three crucial drilling parameters (spindle speed, feed rate, and cutter type) with an experimental setup made by the TM were investigated with a CNC machine. The R_a values were measured with a surface roughness measuring device on the drilled surface.

2. MATERIAL AND METHOD

In this study, the material used were 18-mm-thick; EGP made of spruce (*Picea Orientalis* Link.), and beech (*Fagus Orientalis* Lipsky), Iroko (*Chlorophora excelsa*), and MDFlam (MDF surfaced with synthetic resin sheet). The EGP are supplied by ERPAN from Simav/Kutahya, Turkey. EGP panels and MDFLam were selected randomly from the manufacturer. Experiments can be performed Skilled CNC

(Beysantaş A.Ş., Turkey) with a maximum 18000 rpm spindle speed and 2000 mm/min feed rate. The experiments were carried out with Netmak (Z2 and Z3) (Netmak group, Turkey) 8-mm-diameter CNC cutters made of solid carbide. New CNC cutters were used in drilling operation (Figure 1). The experiments evaluated three drilling parameters (spindle speed, feed rate, and cutter type) (Table 1). A total of 16x4=64 pieces were drilled on panels by a CNC router (Figure 2).

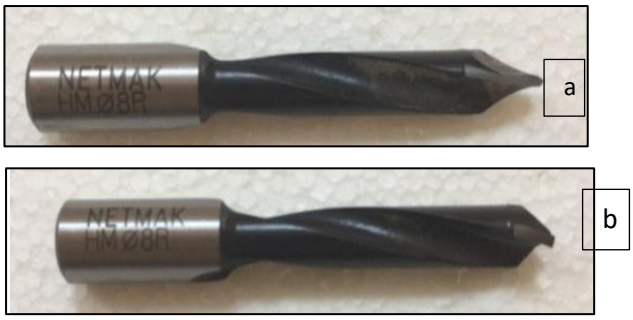

Figure 1. Solid carpide router cutters one flute (a) and two flutes (b) cutter types

Table 1. Machining parameters and levels for drilling

Machining parameter	Coded levels			
	Level 1	Level 2	Level 3	Level 4
Spindle speed (rpm)	12000	14000	16000	18000
Feed rate (mm/min)	1250	1500	1750	2000
Cutter type	1	2		

Time TR200 (China) surface roughness measurement device was used. The sampling length= 2.5 mm; the evaluation length *Lt*= 12.5 mm. measurement speed=10 mm/min, the diameter of the measurement needle= 4 µm, and the needle tip orientation= 90° were taken.

Wood drilling parameters were used as control factors, where two parameters were designed to have four levels and one parameter was designed to have two levels (Table 1). By TM, an L16 OA table with 16 rows was selected.

Figure 2. Skilled CNC 2040 CNC and drilling

Ra was measured on every drill hole three times. *Ra* is described in ISO 468 (2009), ISO 3274 (2005), and ISO 4287 (1997).

Statistical analyses (*S/N*, ANOVA) were performed by using MINITAB 19 software for a confidence level of 95%. The smaller-the-better quality characteristics for R_a *S/N* ratio.

3. RESULTS AND DISCUSSION

The experimental design of L16 and the experimental results are given in Table 2.

Table 2. Experimental Design using a TM (L16) and of Surface Roughness (R_a) (Aktaş, 2021)

Process no	Spindle speed (rpm)	Feed rate (mm/min)	Cutter type	MDFLam R_a µm	Spruce R_a µm	Beech R_a µm	Irako R_a µm
1	12000	1250	1	6.86	3.07	5.76	2.15
2	12000	1500	1	6.61	2.88	6.37	2.80
3	12000	1750	2	4.45	2.93	4.69	3.77
4	12000	2000	2	4.36	1.74	6.33	2.02
5	14000	1250	1	6.88	6.67	6.18	3.10
6	14000	1500	1	6.06	2.22	7.17	2.90
7	14000	1750	2	5.26	2.58	4.24	1.88
8	14000	2000	2	5.47	3.70	6.44	2.05
9	16000	1250	2	4.00	1.39	4.76	2.03
10	16000	1500	2	4.51	3.93	6.53	3.43
11	16000	1750	1	7.02	5.39	6.56	4.67
12	16000	2000	1	6.30	3.26	7.85	3.53
13	18000	1250	2	3.95	3.11	4.98	2.34
14	18000	1500	2	3.66	2.32	5.74	1.01
15	18000	1750	1	3.19	7.96	6.20	3.45
16	18000	2000	1	5.90	3.13	6.22	3.09

Table 3. ANOVA Results for R_a in MDFLam (Aktaş, 2021)

Source	Degrees of Freedom (DoF)	Sequential Sum of Squares (Adj SS)	Mean Sum of Squares (Adj MS)	F	P
Ra					
Spindle speed (rpm)	3	6.9711	2.3237	3.11	0.089
Feed rate (mm/min)	3	0.6720	0.2240	0.30	0.825
Cutter type	1	10.8257	10.8257	14.48	0.005
Residual error	8	5.9792	0.7474		
Total	15	24.4481			
Ra (for *S/N* ratios)					
Spindle speed (rpm)	3	23.629	7.8765	3.25	0.081
Feed rate (mm/min)	3	2.774	0.9246	0.38	0.769
Cutter type	1	26.737	26.7366	11.05	0.010
Residual error	8	19.363	2.4204		
Total	15	72.503			

Table 4. ANOVA Results for R_a in Spruce (Aktaş, 2021)

Source	DoF	Adj SS	Adj MS	F	P
Ra					
Spindle speed (rpm)	3	4.751	1.584	0.57	0.653
Feed rate (mm/min)	3	8.829	2.943	1.05	0.421
Cutter type	1	10.391	10.391	3.71	0.090
Residual error	8	22.384	2.798		
Total	15	46.355			
Ra (for *S/N* ratios)					
Spindle speed (rpm)	3	20.54	6.846	0.45	0.725
Feed rate (mm/min)	3	35.12	11.708	0.77	0.543
Cutter type	1	54.66	54.660	3.59	0.095
Residual error	8	121.83	15.229		
Total	15	232.15			

According to ANOVA results for MDFlam roughness (*Ra*) at 95% confidence level; it was seen that cutter type (0.05 > P = 0.005) was found to be a statistically significant difference, and spindle speed (0.05 < P = 0.089) and feed rate (0.05 < P = 0.825) did not make a statistically significant difference (Table 3). According to ANOVA results for spruce roughness (*Ra*) at 95% confidence level; it was seen that spindle speed (0.05 < P = 0.653), feed rate (0.05 < P = 0.421) and cutter type (0.05 < P = 0.090) did not make a statistically significant difference (Table 4).

Table 5. ANOVA Results for R_a in Beech (Aktaş, 2021)

Source	DoF	Adj SS	Adj MS	F	P
Ra					
Spindle speed (rpm)	3	1.092	0.3640	1.30	0.340
Feed rate (mm/min)	3	5.518	1.8394	6.56	0.015
Cutter type	1	4.608	4.6082	16.43	0.004
Residual error	8	2.244	0.2805		
Total	15	13.463			
Ra (for *S/N* ratios)					
Spindle speed (rpm)	3	1.827	0.6090	0.86	0.502
Feed rate (mm/min)	3	12.441	4.1469	5.82	0.021
Cutter type	1	10.593	10.5926	14.88	0.005
Residual error	8	5.696	0.7120		
Total	15	30.557			

According to ANOVA results for beech roughness (*Ra*) at 95% confidence level; it was seen that feed rate (0.05 < P = 0.015), cutter type (0.05 < P = 0.004) were found to be a statistically significant difference, and spindle speed (0.05 < P = 0.340) did not make a statistically significant difference (Table 5).

Table 6. ANOVA Results for R_a in Iroko(Aktaş, 2021)

Source	DoF	Adj SS	Adj MS	F	P
Ra					
Spindle speed (rpm)	3	2.373	0.7909	1.49	0.288
Feed rate (mm/min)	3	2.603	0.8678	1.64	0.256
Cutter type	1	3.208	3.2077	6.06	0.039
Residual error	8	4.234	0.5292		
Total	15	12.418			
Ra (for *S/N* ratios)					
Spindle speed (rpm)	3	24.16	8.055	0.99	0.446
Feed rate (mm/min)	3	22.85	7.618	0.93	0.468
Cutter type	1	42.02	42.015	5.15	0.053
Residual error	8	65.28	8.160		
Total	15	154.31			

According to ANOVA results for Iroko roughness (*Ra*) at 95% confidence level; it was seen that spindle speed (0.05 < P = 0.288), feed rate (0.05 < P = 0.256) and cutter type (0.05 < P = 0.039) did not make a statistically significant difference (Table 6).

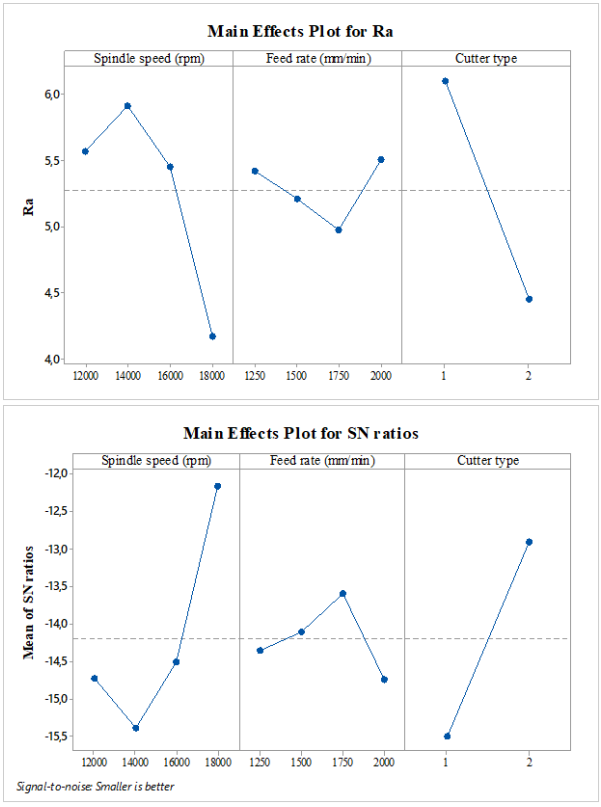

Figure 3. (a) MDFLam main effect plot for R_a; (b) mean *S/N* ratio for R_a

When the main effect and S/N ratio graphs for MDFlam *Ra* were examined (Figure 3), the lowest roughness values occurred at a speed of 18000 rpm, a feed rate of 1750 mm/min, and a cutter type 2.

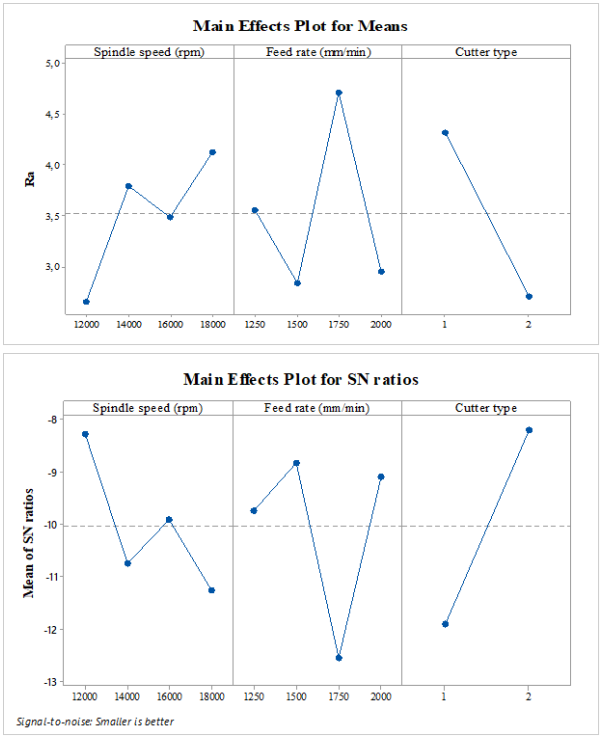

Figure 4. (a) Spruce main effect plot for R_a; (b) mean *S/N* ratio for R_a

When the main effect and S/N ratio graphs for spruce *Ra* were examined (Figure 4), the lowest roughness values occurred at a speed of 12000 rpm, a feed rate of 1500 mm/min, and a cutter type 2.

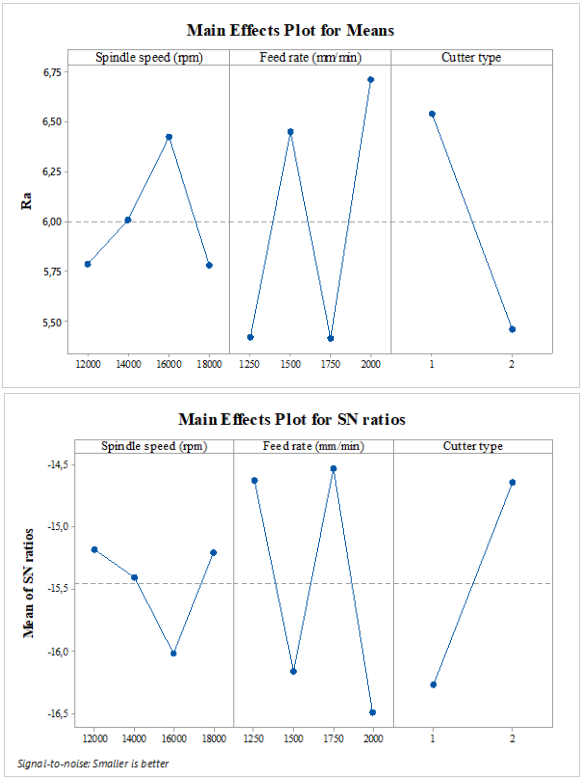

Figure 5. (a) Beech main effect plot for R_a; (b) mean *S/N* ratio for R_a

When the main effect and S/N ratio graphs for beech *Ra* were examined (Figure 5), the lowest roughness values occurred at a speed of 18000 rpm, a feed rate of 1750 mm/min, and a cutter type 2.

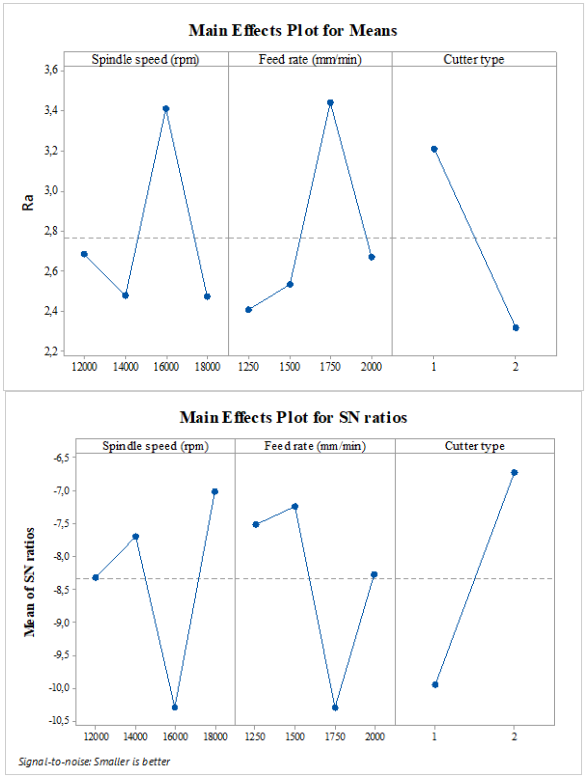

Figure 6. (a) Iroko main effect plot for R_a; (b) mean *S/N* ratio for R_a

When the main effect and S/N ratio graphs for Iroko *Ra* were examined (Figure 6), the lowest roughness values occurred at a speed of 18000 rpm, a feed rate of 1250 mm/min, and a cutter type 2.

In the literature; *Ra* decreased with the decreasing feed rates. Ra decreases with increasing spindle speed (Iskra and Tanaka 2005; Davim et al. 2009; Sutcu & Karagoz 2012; Sutcu 2013). According to some other literature; revolutions per minute were the most effective parameter for the changes in massive wooden table, which is made of Scotch pine drilling holes roughness (Kacal and Sofuoglu 2013).

Surface roughness values of drilling samples are important for determining surface quality.Average surface roughness (Ra) values were obtained as 14.58 µm, 11.18 µm, 15.17 µm, 11.94µm for ship auger bit drill and 7.06 µm, 13.02 µm, 7.91 µm, 7.55 µm for multiple spur bit drill inEuropean black pine, black poplar, sessile oak, and cedar of Lebanon respectively (Sofuoglu, *et.al*, 2015.

4. CONCLUSIONS

The following results can be drawn from the hole internal surface R_a, for the Medium Density Fiberboard with synthetic resin sheet (MDFlam), and the material used were; massive wooden edge-glued panels (EGP) made of spruce (*Picea Orientalis* Link.), beech (*Fagus Orientalis* Lipsky), Iroko (*Chlorophora excelsa*):

- The lowest roughness values occurred at a speed of 18000 rpm, a feed rate of 1750 mm/min, and a cutter type 2 for MDFlam,
- The lowest roughness values occurred at a speed of 12000 rpm, a feed rate of 1500 mm/min, and a cutter type 2 for spruce,
- The lowest roughness values occurred at a speed of 18000 rpm, a feed rate of 1750 mm/min and a cutter type 2 for beech.
- The lowest roughness values occurred at a speed of 18000 rpm, a feed rate of 1250 mm/min, and a cutter type 2 for ıroko.
- The lowest roughness values were obtained in drilling operations in all materials with the type 2 cutter.

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N/A

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Author Contributions
S.A: Construction of experiments, analysis of results. SDS: Experiment design, article writing and analysis of results. All authors have read and agreed to the published version of manuscript.

Conflict of Interest
The authors have no conflicts of interest to declare.

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Determination of Adductor Pollicis Muscle Thickness in Overweight or Obese Young Women

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Abstract: The Adductor Pollicis Muscle Thickness (APMT) value is the numerical value obtained by measuring the thickness that contains components such as tissue, skin, nerve and adipose tissue by means of a caliper. A new anthropometric measurement technique, APMT, is promising for clinical use in conditions such as obesity and malnutrition. In this study, it is aimed to compare APMT measurement with other anthropometric measurements in overweight-obese and normal weight female individuals. Healthy female individuals living in Sivas, between the ages of 18-25, overweight-obese and with normal weight were included in the study. APMT measurements were taken from both the right and left hands of the participants. The measurements were repeated twice and the average of the measurements was taken. The study sample was divided into normal weight and overweight-obese groups. A total of 46 individuals were included in the study by including 23 women in the groups. While obese individuals constitute 15.2% of the sample; overweight individuals constitute 34.8%. While APMT-R was 15.37±1.90, APMT-L was 15.04±1.78 mm in individuals with normal weight; APMT-R was 17.10±2.81 and APMT-L was 16.69±22.75 mm in overweight and obese individuals. APMT and APMT index values measured on both the right and left hands were found to be higher in overweight-obese individuals than in individuals with normal weight ($p<0.05$). In the study, it was revealed that APMT and APMT index measured in the right and left hands showed a moderate positive correlation with BMI ($p<0.05$). It was observed that the correlation between APMT thickness and other anthropometric measurements was higher in overweight and obese individuals. The results obtained from the study show that the increase in weight, muscle and adipose tissue affects APMT values. Anthropometric measurements and APMT values correlate with each other. Therefore, APMT measurement is a feasible method in different age groups and in different clinical situations because it is easy and applicable.

Keywords: Adductor pollicis muscle thickness, antropometric measurements, muscle Mass, obesity.

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1. INTRODUCTION

Nutritional status is an indicator of how much of an individual's physiological nutritional needs are met (Hammond 2019). Evaluation of healthy and unhealthy individuals in the society in terms of nutrition; Identifying and diagnosing nutritional risks is essential for planning appropriate nutritional interventions. Anthropometric measurements used in the evaluation of nutritional status and determination of body composition are considered by researchers as a very important component (Uyar 2013).

Anthropometric measurements are important in terms of diagnosing malnutrition and reflecting protein and fat reserves in various parts of the body. Anthropometric measurements are frequently used in clinical practice because of their ease of application and low cost. In general, skeletal muscle mass is measured quickly and easily through anthropometric measurements such as upper middle arm muscle circumference (UMAMC) and upper middle arm muscle area (UMAMA) (Lameu et al. 2004a).

The idea of using the place called "Adductor Pollicis Muscle Thickness" (APMT) between the thumb and forefinger in determining the nutritional status of individuals by taking the measurement alone was first put forward by Lameu et al in 2004. Measurement of APMT; It is in the form of determining the thickness of the whole textural structure together with the skin, subcutaneous adipose tissue, muscle and other components. When determining the place to be measured, it was accepted that the metacarpal bones of the thumb and index fingers formed the two sides of a triangle, and the line to be drawn between the metacarpophalangeal joints at the end of these bones formed the base of the triangle. The bisectors of this imaginary triangle are drawn with a compass and their intersection points are marked. While the individual to be measured was in a sitting position, the measurement was taken with a caliper so that the wrist standing at the tip of the kneecap was 90 degrees to the homolateral lower extremity (Lameu et al. 2004b).

The method described above has been accepted as a standard in studies investigating the relationship between APMT and nutritional status (Heymsfield et al. 1982; Lameu et al. 2004a). In the studies, APMT measurement was performed only in the dominant hand (the hand used for daily work or writing). The reason for this is based on the idea that the muscles here, which are used more and more developed, will atrophy faster in the presence of malnutrition (Pereira et al. 2018). Because of these features, the measurement of this thickness has the potential to be used in clinical malnutrition screening by comparing or using other anthropometric measurements (Lew et al. 2016). Various scientific studies have shown that APMT measurement can reflect the total muscle mass in the body (Gonzalez et al. 2010; de Oliveira et al. 2012). APKT measurement emerges as an auxiliary anthropometric measurement in the clinic. When we examine the literature, there are studies in which APKT measurement is used in intensive care patients, cancer patients and postoperative patients (Ghorabi et al. 2016; Valente et al. 2016; Valente et al. 2019).

In this study, it is aimed to compare APMT measurement with other anthropometric measurements in overweight-obese and normal-weight female individuals. Normal weight and obese female individuals were included in the study and it was examined whether the APKT measurement changed in a smaller population. This study was conducted as a pilot study and was designed to form the basis of a more comprehensive study that included all age groups and all BMI groups. With the results of the study, it is thought that APMT measurement can be used in the clinic and in the evaluation of nutritional status.

2. MATERIAL AND METHODS

2.1. Study Design

The study was planned as a cross-sectional study and included between 18-25 years of age, living in Sivas, healthy female individuals with a normal weight and overweight-obese. Anthropometric measurements in the study were carried out by researchers who are specialist dietitians. In this study, APMT measurements of the dominant and non-dominant hands of the participants were taken separately and thus, the bias that could occur depending on the dominant or non-dominant hand was tried to be prevented. The measurements were repeated twice and the average of the measurements was taken.

2.2. Antropometric Measurements

The weight measurements of the participants were measured with a digital weighing instrument with an accuracy of ± 0.1 kg. The height measurement was made by means of a portable height meter that can be calibrated (with an accuracy of 20-205 cm±1 mm). The height measurement was recorded standing upright, facing straight ahead, and the upper part of the ears and the outer corner of the eyes were in a line parallel to the plane (Frankfort plane). Body mass index (BMI) was calculated by dividing weight (in kilograms) by the square of height (in meters) (WHO, 2019). Caliper was used to measure APMT and triceps skinfold thickness (TST). It has the feature of measuring the subcutaneous fat layer of the calipers used with an accuracy of ±0.2 mm. TSK measurement; The distance between the tip of the acromion protrusion of the scapula and the olecranon prominence of the ulna was measured while the elbow was flexed at 90 degrees and the midpoint was marked. The measurement was recorded 1 cm below the marked point with the individual standing upright and the arm hanging freely. Skinfold thickness (ST) values were measured while individuals were standing upright and with their shoulders and arms relaxed. A total of 2 measurements were taken at 2 min intervals to allow the tissue to recover. The ST values to be used in the study were calculated by taking the average of these 2 values (Heyward and Wagner 2004).

Upper mid-arm circumference (UMAC) measurement was performed using a non-flexible tape measure by marking the midpoint of the distance between the tip of the acromion process of the scapula and the olecranon process of the ulna. Upper middle arm muscle circumference (UMAMC) measurement, UMAC and TST values were found; calculated by means of the formula UMAMC = UMAC -- (π x TST). Upper middle arm area (UMAA); calculated with the formula UMAA = $UMAC^2/4\pi$. Upper middle arm muscle area (UMAMA); It has been determined as UMAMA = $UMAMC^2/ 4\pi$. Adductor Pollicis Muscle Thickness Index (APMTI); It was obtained by dividing the APMT value measured in millimeters (mm) by the height in meters (m) (Ghorabi et al. 2014).

Statistical analysis

The data obtained from our study were evaluated with the SPSS 23.0 program. The normality of the data was evaluated with the Mann Whitney U test. Independent sample t test was used for two independent groups in normally distributed data. Normally distributed data are shown as $\bar{x}$±SD, non-normally distributed data are shown as median. The state, direction and degree of the relationship between continuous variables were analyzed using the Pearson correlation coefficient. $p<0.05$ was considered statistically significant.

3. RESULTS AND DISCUSSION

The study sample was divided into normal weight and overweight-obese groups. A total of 46 individuals were included in the study by including 23 women in the groups. Obese individuals constitute 15.2% of the sample and overweight individuals constitute 34.8%. The mean weight of the sample was 64.13±12.72 kg, the average height was 1.6±0.48 m, and the mean BMI was 25.02±4.61 kg/m2. When the weight and BMI status of the groups are examined; in the overweight-obese group, mean weight was 72.86±11.87 kg (range: 58.6-103.8 kg), mean BMI was 28.61±3.8 kg/m2 (range: 25.12-38.59 kg/m2); in the normal weight group, the mean weight was 55.41±5.56 kg (range: 46.45-67 kg), and the mean BMI was 21.43±1.47 kg/m2 (range: 18.61-24.46 kg/m2). It was determined that the right hand of all individuals included in the study was dominant. Table 1 shows the mean and standard deviation values of the TST, UMAC, UMAMC, UMAA, UMAMA, right and left hands of the individuals' APMT and APMT index, and the lowest and highest values of anthropometric measurements according to the groups. A statistically significant difference was found between APMT, APMT index and other anthropometric measurements between overweight-obese and normal-weight individuals.

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Table 1. Adductor Pollicis Muscle Thickness and Other Anthropometric Measurements of Individuals by Group.

Anthropometric Measurements	Normal Weight Group x̄±SD	Normal Weight Group Min-Max	Overweight-Obese Group x̄±SD	Overweight-Obese Group Min-Max	Test Statistics p
APMT (mm-right hand)	15.37±1.90	11.60-18.90	17.10±2.81	12.20-22.70	0.019**
APMT (mm-left hand)	15.04±1.78	11.30-18.10	16.69±22.75	12.30-21.15	0.020**
APMİ(mm/m^2-right hand)	9.58±1.24	6.99-11.96	10.73±1.74	7.87-14.04	0.013**
APMİ (mm/m^2-left hand)	9.37±1.13	6.81-11.76	10.46±1.69	7.69-13.78	0.012**
TST (cm)	1.54±0.33	0.92-2.27	2.47±0.47	1.54-3.20	0.001*
UMAC (cm)	24.13±1.48	21.00-27.00	29.59±33.16	25.40-36.00	0.001*
UMAMC (cm)	19.27±1.15	17.67-22.18	21.81±2.47	17.93-27.68	0.001*
UMAA (cm^2)	46.52±5.69	35.11-58.04	70.48±15.42	51.37-103.18	0.001*
UMAMA (cm^2)	29.67±3.65	24.87-39.17	38.34±8.89	25.59-61.00	0.001*

* p <0.01, ** p <0.05

In the study, when the correlation relationship between BMI and APMT, APMT index was examined; It has been revealed that there is a positive correlation between BMI and right hand APMT mean r=0.608 (p=0.001), and left hand APMT mean r=0.550 (p=0.001). A positive correlation was found between the mean of the right hand APMT index, r=0.592 (p=0.001) and the mean of the left-hand APMT index, r=0.549 (p=0.001).

When the relationship between APMT and other anthropometric measurements of normal-weight individuals is examined; APMT and APMT index measured in the right and left hands were found to be positively correlated with each other (p<0.01). While APMT and APMT index measured from the right hand were not found to be associated with TST, UMAC, UMAMC, UMAA and UMAMA (p>0.05); it was found that APMT measured on the left hand showed a positive correlation with UMAC, UMAMC, UMAA and UMAMA (p<0.05). On the other hand, it was revealed that the APMT index measured on the left hand showed a positive correlation only with UMAMC (p<0.05). It was determined that TST, which is one of the other anthropometric measurements taken from individuals with normal weight, showed a positive correlation with UMAC and UMAMC (p<0.01). The correlation relationship between APMT and other anthropometric measurements of normal-weight individuals is shown in Table 2.

Table 2. Correlation Relationship Between Adductor Pollicis Muscle Thickness and Other Anthropometric Measurements of Normal Weight Individuals.

	APMT-R (mm)	**APMT-L (mm)**	**APMİ-R (mm/m²)**	**APMİ-L (mm/m²)**	**TST (cm)**	**UMAC (cm)**	**UMAMC (cm)**	**UMAA (cm²)**	**UMAMA (cm²)**
APMT-R (mm)	-	r=0.867 p=0.001*	r=0.972 p=0.001*	r=0.866 p=0.001*	r= -0.118 p=0.592	r=0.201 p=0.357	r=0.366 p=0.086	r=0.196 p=0.370	r=0.350 p=0.102
APMT-L (mm)	r=0.867 p=0.001*	-	r=0.820 p=0.001*	r=0.965 p=0.001*	r=0.106 p=0.630	r=0.451 p=0.031**	r=0.482 p=0.020**	r=0.452 p=0.030**	r=0.474 p=0.022**
APMİ-R (mm/m²)	r=0.972 p=0.001*	r=0.820 p=0.001*	-	r=0.881 p=0.001*	r= -0.204 p=0.352	r=0.095 p=0.668	r=0.307 p=0.154	r=0.087 p=0.693	r=0.288 p=0.182
APMİ-L (mm/m²)	r=0.866 p=0.001*	r=0.965 p=0.001*	r=0.881 p=0.001*	-	r=0.002 p=0.992	r=0.330 p=0.124	r=0.421 p=0.045**	r=0.328 p=0.126	r=0.410 p=0.052
TST (cm)	r= -0.118 p=0.592	r=0.106 p=0.630	r= -0.204 p=0.352	r=0.002 p=0.992	-	r=0.632 p=0.001*	r= -0.103 p=0.640	r=0.614 p=0.002*	r= -0.094 p=0.668
UMAC (cm)	r=0.201 p=0.357	r=0.451 p=0.031**	r=0.095 p=0.668	r=0.330 p=0.124	r=0.632 p=0.001*	-	r=0.706 p=0.001*	r=0.999 p=0.001*	r=0.712 p=0.001*
UMAMC (cm)	r=0.366 p=0.086	r=0.482 p=0.020**	r=0.307 p=0.154	r=0.421 p=0.045	r= -0.103 p=0.640	r=0.706 p=0.001*	-	r=0.721 p=0.001*	r=0.999 p=0.001*
UMAA (cm²)	r=0.196 p=0.370	r=0.452 p=0.030**	r=0.087 p=0.693	r=0.328 p=0.126	r=0.614 p=0.002*	r=0.999 p=0.001*	r=0.721 p=0.001*	-	r=0.728 p=0.001*
UMAMA (cm²)	r=0.350 p=0.102	r=0.474 p=0.022**	r=0.288 p=0.182	r=0.410 p=0.052	r= -0.094 p=0.668	r=0.712 p=0.001*	r=0.999 p=0.001*	r=0.728 p=0.001*	-

* p <0.01, ** p <0.05

When the relationship between APMT and other anthropometric measurements of overweight and obese individuals was examined; APMT and APMT index measured in the right and left hands were found to be positively correlated with each other (p<0.01). While APMT and APMT index measured on the right hand were found to be positively correlated with TST, UMAC, UMAMC, UMAA and UMAMA (p<0.05); it was found that the APMT and APMT index measured on the left hand showed a positive correlation with TST, UMAC, and UMAA (p<0.05). It was determined that TST, which is one of the other anthropometric measurements taken from overweight and obese individuals, showed a positive correlation with UMAC and UMAA (p<0.01). The correlation relationship between APMT and other anthropometric measurements of overweight and obese individuals is shown in Table 3.

Table 3. Correlation Relationship between Adductor Pollicis Muscle Thickness and Other Anthropometric Measurements of Overweight and Obese Individuals.

	APMT-R (mm)	**APMT-L (mm)**	**APMİ-R (mm/m²)**	**APMİ-L (mm/m²)**	**TST (cm)**	**UMAC (cm)**	**UMAMC (cm)**	**UMAA (cm²)**	**UMAMA (cm²)**
APMT-R (mm)	-	r=0.084 p=0.001*	r=0.980 p=0.001*	r=0.895 p=0.001*	r=0.520 p=0.011**	r=0.673 p=0.001*	r=0.545 p=0.007*	r=0.669 p=0.001*	r=0.547 p=0.007*
APMT-L (mm)	r=0.084 p=0.001*	-	r=0.847 p=0.001*	r=0.981 p=0.001*	r=0.497 p=0.016**	r=0.528 p=0.010**	r=0.375 p=0.078	r=0.521 p=0.011**	r=0.361 p=0.090
APMİ-R (mm/m²)	r=0.980 p=0.001*	r=0.847 p=0.001*	-	r=0.887 p=0.001*	r=0.436 p=0.038**	r=0.631 p=0.001*	r=0.542 p=0.007*	r=0.629 p=0.001*	r=0.545 p=0.007*
APMİ-L (mm/m²)	r=0.895 p=0.001	r=0.981 p=0.001*	r=0.887 p=0.001*	-	r=0.425 p=0.043**	r=0.500 p=0.015**	r=0.383 p=0.072	r=0.495 p=0.016**	r=0.370 p=0.083
TST (cm)	r=0.520 p=0.011**	r=0.497 p=0.016**	r=0.436 p=0.038**	r=0.425 p=0.043**	-	r=0.646 p=0.001*	r=0.222 p=0.309	r=0.639 p=0.001*	r=0.231 p=0.289
UMAC (cm)	r=0.673 p=0.001*	r=0.528 p=0.010**	r=0.631 p=0.001*	r=0.500 p=0.015**	r=0.646 p=0.001*	-	r=0.887 p=0.001*	r=0.999 p=0.001*	r=0.890 p=0.001*
UMAMC(cm)	r=0.545 p=0.007*	r=0.375 p=0.078	r=0.542 p=0.007*	r=0.383 p=0.072	r=0.222 p=0.309	r=0.887 p=0.001*	-	r=0.891 p=0.001*	r=0.998 p=0.001*
UMAA (cm²)	r=0.669 p=0.001*	r=0.521 p=0.011**	r=0.629 p=0.001*	r=0.495 p=0.016**	r=0.639 p=0.001*	r=0.999 p=0.001*	r=0.891 p=0.001*	-	r=0.895 p=0.001*
UMAMA (cm²)	r=0.547 p=0.007*	r=0.361 p=0.090	r=0.545 p=0.007*	r=0.370 p=0.083	r=0.231 p=0.289	r=0.890 p=0.001*	r=0.998 p=0.001*	r=0.895 p=0.001*	-

* p <0.01, ** p <0.05

Assessment of nutritional status is an important table showing the ratio of meeting the physiological nutrient needs of individuals and reflecting the health status of the individual. One of the important methods used in the

assessment of nutritional status is anthropometric measurements (Hammond 2019). The APMT value is a numerical value obtained by measuring the layer containing components such as tissue, skin, nerve and adipose tissue through the caliper. This thickness contains minimal adipose tissue. This distinctive feature makes APMT the only place in the body that can be directly measured by caliper as a muscle component. Anthropometric measurements are frequently used in the clinic due to their practical application, low cost and advantages such as being an invasive technique (Lameu et al. 2004b). A new anthropometric measurement technique, APMT, is promising for clinical use in conditions such as obesity and malnutrition. In the study, APMT measurement, which can be detected easily and quickly, the measurements can be easily repeated, and the cost is relatively lower than other anthropometric measurement methods, was used. APMT values were compared in overweight and obese and normal weight young women.

In this study, APMT-R was 15.37±1.90 mm and APMT-L was 15.04±1.78 mm in individuals with normal weight; APMT-R was 17.10±2.81 mm and APMT-L was 16.69±22.75 mm in overweight and obese individuals. In the findings obtained from the study, APMT and APMT index values measured in both the right and left hands are higher in overweight-obese individuals than in individuals with normal weight. In another recent study, it was shown that APMT value is higher in obese individuals. In the study, it was shown that APMT value was 17.6±3.1 mm in women with normal weight, 19.9±2.9 mm in overweight women and 22.9±3.8 mm in obese women (Bielemann et al. 2016). In another study in which women were the sample, the mean BMI was found to be 27.1±6.2 kg/m^2 and the mean APMT was 14.0±3.6 mm (Barreiro et al. 2018). In a study involving adolescents aged 14-19 years, APMT measurement in women was found to be 18.0 mm (de Lima Pereira et al. 2021). In another study, APKT measurement in the dominant hand of women aged 18-29 was found to be 19.4±3.10 mm (Gonzalez et al. 2010). The findings of our study are similar to the results of other studies. According to the results of the study, weight gain leads to an increase in APMT.

In this study, it was revealed that the APMT and APMT index measured in the right and left hands showed a moderate positive correlation with BMI. In a study that included both women and men, APMT was found to be moderately correlated with lean mass and lean mass index (Bielemann et al. 2016). In another study that included post-menopausal and young women, it was found that APMT showed a positive correlation with lean mass (Barreiro et al. 2018). In a study of adolescents, in women, APMT measurement showed moderate correlation with lean mass, lean mass index, and body fat mass. However, no correlation was found between BMI and APMT (de Lima Pereira et al. 2021). In a study involving healthy adults, it was found that APMT measured on both hands and weight and BMI correlated (Gonzalez et al. 2010). In a study conducted in the pediatric age group, it was determined that APMT measurement was associated with nutritional status, BMI and arm muscle circumference (Vallandro et al. 2019).In a study that included both women and men, it was revealed that APMT measurement increased with increasing BMI value (Cortez et al. 2017). In a study conducted with elderly individuals, it was revealed that there is a weak correlation between BMI and APMT. In the study, the mean BMI was found to be 26.93± 5.75 kg/m^2 (de Seabra Trevisan et al. 2021). Similar results were obtained in another study. It was determined that there was a weak correlation between APKT measurement and other anthropometric measurements (Cobero et al. 2012). In another study, right and left-handed APMT and anthropometric measurements of individuals with anorexia nervosa were performed before and after treatment. Parallel to the increase in weight and BMI in individuals after treatment, there was an increase in APMT in both the right and left hands (Soto-Célix et al. 2019). The results obtained from our study show parallelism with the results of other studies. Increases in body muscle and fat mass affect APMT.

4. CONLUSION

Anthropometric measurements and APMT measurements show correlation with each other. Therefore, APMT measurement can be applied in different age groups and in different clinical situations because it is easy and applicable. APMT measurement emerges as a new anthropometric measurement in the prediction of both obesity and malnutrition. There is a need to reveal new studies by measuring APMT in different age groups and clinical situations.

Ethics Committee Approval
N/A

Peer-review
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Author Contributions
All authors have read and agreed to the published version of manuscript.

Conflict of Interest
All authors declare that they have no conflict of interest.

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Investigation of Antioxidant Activity of Thymoquinone and Its Protective Effect on Edible Oils

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Abstract: In present study, the oxidation protection efficiency of TQ (Thymoquinone) on two different types of oils was evaluated. In addition, antioxidant capacity and hydroxyl radical scavenging (HRS) activity of the TQ were investigated according to the CUPric reducing antioxidant capacity (CUPRAC) and ferric reducing antioxidant potential (FRAP) methods. The FRAP and CUPRAC methods revealed that antioxidant and hydroxyl radical scavenging activity of TQ was remarkably effective. It was determined that TQ had a high HRS potential (80.36 ± 0.92%) even at very low concentrations (1.6 µg/mL). Research findings revealed that, compared with synthetic antioxidant (BHT), TQ was more effective in retarding the oxidation of the two types of oil. The oils with TQ incorporated exhibited much better chemical stability and lower peroxide value. As an alternative to synthetic antioxidants, TQ could be recommended as an effective natural antioxidant to improve the stabilization of edible vegetable oils.

Keywords: Antioxidant, thymoquinone, lipid oxidation, CUPRAC assay, FRAP.

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1. INTRODUCTION

Lipid oxidation is an extremely versatile process involving various reactions that cause various physical and chemical changes in lipid-rich foodstuffs (Maqsood et al. 2014). During the period from processing to storage of edible oils, compounds such as peroxides, aldehydes, ketones and other small molecules, which represent lipid oxidation, are formed. Many of these compounds formed during lipid oxidation affect food quality parameters including flavor, texture, nutritional value, odor and color. Moreover, some of these oxidizing agents have toxic effects on human health. (Karami et al. 2020). Synthetic and natural antioxidants are used to increase the storage stability of lipids. Butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) are the most commonly used synthetic antioxidants in the vegetable oil industry. However, some synthetic antioxidants used in food processing, such as (BHT) and (BHA), have proven to have side effects. These substances have been reported to have carcinogenic effects on living organisms (Ames 1983; Baardseth 1989). Therefore, government officials and consumers are concerned about the safety of foods, as well as the potential health effects of synthetic additives. At present, the research is directed towards replacing synthetic additives such as BHA and BHT with natural substances which have more antioxidant activity and stability in different edible oils and meet the increasing interest of consumers on safety. The benefits of adding natural, plant-based antioxidants to lipids in order to prevent lipid oxidation have been highlighted in recent years. Natural antioxidants retard oxidative rancidity via the following pathways: (1) capturing of free radicals; (2) decomposing/deoxidizing peroxides; and (3) scavenging oxygen (Sun et al. 2010; Lianhe et al. 2012).

Thymoquinone (TQ), a biologically active compound in black cumin (*Nigella sativa*) seeds, is responsible for its health beneficial effects (Soleimanifar et al. 2019). TQ is a natural compound which possesses potent antioxidant activity without having any phenolic hydroxyl group which is responsible for antioxidant activity (Hossen et al. 2021). The antioxidant activity of TQ is well known and is reported by many authors (Kassab et al. 2017; Mahmoud and Abdelrazek 2019).

In this study, antioxidant capacity and hydroxyl radical scavenging (HRS) potential of TQ were evaluated according to the CUPric reducing antioxidant capacity (CUPRAC) and

ferric reducing antioxidant potential (FRAP) methods. Moreover, the effects of TQ on the oxidative stability of extra virgin olive (EVOO) and safflower oils (SFO) were investigated using tests performed under accelerated thermal storage conditions.

2. MATERIAL AND METHODS

2.1. Chemicals

Copper(II) chloride dihydrate ($CuCl_2 \cdot 2H_2O$), catalase from bovine liver (2000-5000 U mg^{-1} solid), Neocuproine ($C_{14}H_{12}N_2$), and thymoquinone were purchased from Sigma Chemical Co. (St. Louis, MO, U.S.A.). Absolute ethanol (EtOH) was purchased from ISOLAB Laborgeräte GmbH (Eschau, GERMANY). Ammonium acetate (NH_4Ac), iron(II) chloride tetrahydrate ($FeCl_2 \cdot 4H_2O$),sodium salicylate ($C_7H_5NaO_3$), sodium thiosulfate pentahydrate ($Na_2S_2O_3 \cdot 5H_2O$), Potassium hexacyanoferrate(III) ($K_3[Fe(CN)_6]$), hydrogen peroxide (H_2O_2, 30 wt.%), di-Sodium hydrogen phosphate dihydrate ($Na_2HPO_4 \cdot 2H_2O$), Sodium dihydrogen phosphate dihydrate ($NaH_2PO_4 \cdot 2H_2O$), Iron(III) chloride hexahydrate ($FeCl_3 \cdot 6H_2O$), trichloroacetic acid (TCA), were purchased from Merck (Darmstadt, Germany). All other chemicals used were analytical grade and obtained from either Sigma–Aldrich or Merck.

2.2. Plant materials

Extra virgin olive oil (EVEO) were supplied by TARIS Figs, Raisins, Cotton and Oilseed Agricultural Sales Cooperatives Union (Aydın-Turkey). Safflower seeds were obtained from Isparta University of Applied Sciences. Later, SFO was obtained by cold pressed extraction method.

2.3. Preparation of solutions

$CuCl_2$ solution,10 mmol L^{-1}, was prepared by dissolving 0.4262 g $CuCl_2 \cdot 2H_2O$ in water, and diluting to 250 mL. Ammonium acetate buffer at pH= 7.0, 1.0 mol L^{-1}, was prepared by dissolving 19.27 g NH_4Ac in water and diluting to 250 mL. Neocuproine (Nc) solution, 7.5 mmol L^{-1}, was prepared daily by dissolving 0.078 g Nc in absolute ethanol, and diluting to 50 mL with ethanol. TQ solution was prepared in absolute ethanol at 1x 10^{-2} mol L^{-1} concentration. The salicylate buffer (at 10 mmol L^{-1} concentration) was prepared by dissolving 0.160 g of sodium salicylate in double-distilled water (DDH_2O). Fe(II) at 20 mmol L^{-1} concentration was prepared by dissolving 0.1988 g $FeCl_2 \cdot 4H_2O$ with 2mL of 1 mol L^{-1} HCl, and diluting to 50 mL with DDH_2O. Na_2–EDTA at 20 mmol L^{-1} concentration was prepared by dissolving 0.372 g of the salt in DDH_2O and diluting to 50 mL. Hydrogen peroxide at 10 mmol L^{-1} concentration was prepared from a 0.5 mol L^{-1} intermediary stock solution, the latter being prepared from 30% H_2O_2. The NaH_2PO_4–Na_2HPO_4 buffer solution (pH 7.4) at 200 mmol L^{-1} was prepared in DDH_2O. The original catalase solution of initial activity 2000-5000U mg^{-1} solid was diluted with 0.2 mmol L^{-1} phosphate buffer (pH 7.4) to a concentration of 400-1000 U mL^{-1}. The dilution ratio of TQ was selected so as not to give an initial CUPRAC absorbance.

The FRAP reagents were prepared as follows: To prepare 0.2 mol L^{-1} phosphate buffer at pH 6.6, 7.80 g of $NaH_2PO_4 \cdot 2H_2O$ was dissolved in water and diluted to 250 mL with H_2O such that its final concn. would be 0.2 mol L^{-1}; 8.90 g of $Na_2HPO_4 \cdot 2H_2O$ was dissolved in water and diluted to 250 mL such that its final concn. would be 0.2 mol L^{-1}. To prepare 0.2 mol L^{-1} phosphate pH 6.6 buffer, 62.5 mL of $NaH_2PO_4 \cdot 2H_2O$ solution was mixed with 37.5 mL of $Na_2HP0_4 \cdot 2H_2O$ and diluted to a total of 200 mL with H_2O (Stoll and Blanchard 2009). Potassium ferricyanide solution (1%, w/v) was prepared daily by dissolving 1 g $K_3Fe(CN)_6$ in 1 mL of 1 mol L^{-1} HCl and some water and diluting to 100 mL with water. Ferric chloride solution (0.1%, w/v) was prepared daily by dissolving 0.1 g of $FeCl_3 \cdot 6H_2O$ in 1 mL of 1 mol L^{-1} HCl and some water and diluting to 100 mL with water. Trichloroacetic acid (TCA) solution (10%, w/v) was prepared by dissolving 10 g of TCA in water and diluting it to 100 mL with H_2O (Berker et al. 2007).

2.5. Ferriccyanide (Fe^{3+}) reducing antioxidant power (FRAP) assay

Procedure. The reducing capacity (RP) of samples was assessed as described by Oyaizu (1986). 2.5 mL of 0.2 mol L^{-1} phosphate buffer (pH 6.6) and 2.5 mL of $K_3Fe(CN)_6$ solution (1%) were added to 1 mL of sample solution at different concentrations (50-100 µg/mL) in ethanol); the mixture was incubated at 50 ◦C on a water bath for 20 min. The incubated mixture was let to cool to room temperature, and 2.5 mL of TCA (10%) was added. The solution was thoroughly mixed by vortexing for 30 s. an aliquot of 2.5 mL was withdrawn from the supernatant, and 2.5 mL water was followed by 0.5 mL of $FeCl_3 \cdot 6H_2O$ solution (0.1%) added so that the final volume was 5.5 mL. The colored solution was read at 700 nm against the blank regarding standard using UV Spectrophotometer (SHIMADZU UV-1280 UV-Vis Spectrophotometer). BHA and BHT were used as standard references.

2.6. GC analysis of fatty acids

Fatty acid methyl esters (FAMEs) were prepared from the oil samples according to the method described by Seyhan et al. (2007). Briefly, 2 mL of 0.01 mol L^{-1} NaOH in methanol was added to a tube containing the oil sample (ca. 20 mg) dissolved in 0.5 mL hexane and then held in a water bath at 60 °C for 10 min. Thereafter, 0.5 mL boron trifluoride in methanol (20% of BF_3 in methanol) was added and the samples held an additional 10 min in a water bath at 60 °C. The sample was cooled under running water and 2 ml of 20% (w/v) of sodium chloride and 1 ml hexane was added. After mixing completely, the hexane layer that contained the FAMEs was separated by centrifugation and then analyzed by GC. Peak identification was performed by comparing the relative retention times with those of a commercial standard mixture of FAME (Sigma, Supelco 37 Component FAME Mix). The yields of the independent ingredients on oil content and palmitic, stearic, oleic, linoleic, and linolenic acid concentrations of the oil were examined on a percentage basis (Erdoğan and Gökçe 2021).

2.7. Incorporation of EVOO and SFO with BHT and TQ

Three EVOO and three SFO (triglyceride) experimental sets were prepared as follows.

- ✓ Extra virgin olive oil (EVOO)
- ✓ EVOO incorporated with 200 ppm of BHT
- ✓ EVOO incorporated with 200 ppm of TQ.
- ✓ Safflower oil (SFO)
- ✓ SFO incorporated with 200 ppm of BHT
- ✓ SFO incorporated with 200 ppm of TQ.
- ✓ The BHT concentration in the oil samples was 0.02% (w/w) corresponding to the level determined by Codex Alimentarius Commission (CAC), (2019).

2.8. Schaal oven test

The schaal oven test, which is aimed to determine the effect on the oxidative stability of oils under accelerated storage conditions, was performed as described by Tinello and Lante (2020). In detail, the oil samples were precisely weighed (30 g ± 0.01 g) into sealed bottles covered with aluminum foil, without headspace, and stored in an oven at a constant temperature of 60 ± 1 °C for 14 days SFO and 28 days for EVOO. Samples were taken at 7-day intervals and subjected to peroxide value (PV) and total tocopherol analysis.

2.9. Determination of PV

Determination of PV was accomplished according to the official methods AOAC Association of Official Analytical Chemists (2000b). The oil sample (1 g ± 0.01 g) was dissolved in 25 mL mixture of acetic acid-chloroform (3:2 v/v) and then 0.5 mL saturated KI solution was added. The reaction solution was shaken vigorously for 1 min and kept at room temperature for 5 min in the dark. After adding 75 mL of distilled water and 1 mL of 1% starch indicator, the reaction solution was titrated with 0.001 N for 30 s until the colorless endpoint was reached. PV was calculated according to the following equation (2).

$$PV\ (meq\ O_2/kg\ oil) = (VxNx1000)/m \quad \textbf{(2)}$$

where V is the volume of sodium thiosulfate added to the oil sample (mL); N is the normality of sodium thiosulfate; m is the mass of oil sample (g).

2.10. Statistical analysis

The presented data (mean ± standard deviation) resulted from at least three independent experiments and analyzed by SPSS (version 23 for Windows 10 pro, SPSS Inc.). The values were analyzed by one-way analysis of variance (ANOVA) and the post hoc Tukey's test, with significance set at $p < 0.05$.

3. RESULTS AND DISCUSSION

3.1. Hydroxyl radical scavenging (HRS) activity

Among the reactive oxygen species, the $OH^{\cdot}$ radical exhibits the strongest oxidative activity. Since the $OH^{\cdot}$ radical oxidizes all classes of biological macromolecules, including lipids, proteins, and nucleic acids, it can cause oxidative damage leading to many diseases, such as arthritis, atherosclerosis, cirrhosis, diabetes, cancer, Alzheimer's disease, emphysema, and aging (Özyürek et al. 2008). The HRS activity of the TQ was evaluated according to the modified CUPRAC method. Figure 1 indicates that the TQ exhibited very a potent inhibition of $OH^{\cdot}$, even at very low concentrations. The scavenging activities of the TQ on the $OH^{\cdot}$ radicals were 65 ± 0.49% and 80.36 ± 0.92% at concentrations of 0.8 µg/mL and 1.6 µg/mL, respectively. However, it was observed that the HRS activity increased with the increasing TQ concentration**.**

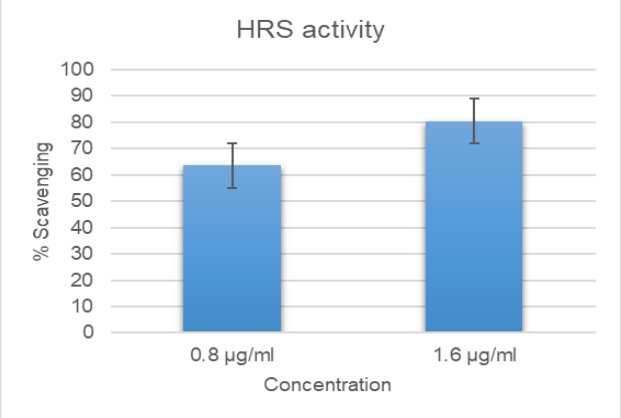

Figure 1. Hydroxyl radical scavenging activity of thymoquinone

3.2. Frap assay of total antioxidant capacity

In the FRAP method, the reducing capacity of TQ was accomplished using Fe^{3+} to Fe^{2+} reduction assay. In this analysis, the yellow color of the frap test solution changed to shades of green and Prussian blue depending on the concentration of the reducing agent. The presence of reducing agents acting as antioxidants in the samples causes the Fe^{3+}/ferricyanide complex to be reduced to the ferric form. Measuring the formation of Prussian blue of Perl at 700 nm (Gülçin et al. 2006). The absorbance values of samples and reference antioxidant substances at different concentrations at 700 nm were presented in Table 1. The higher the absorbance measured at 700 nm, the higher the reducing power. The data in Table 1 revealed that BHA had the highest FRAP value at 100 µg/mL concentration, followed by BHT, and TQ respectively. However, the absorbance value measured at 700 nm increased depending on the concentration.

Table 1. Total reducing power of different concentrations (50–100 µg/mL) of TQ, BHA and BHT determined by Ferriccyanide method of the Fe^{3+}–Fe^{2+} transformation.

Sample	FRAP value (at 700 nm)	
	50 µg/mL	100 µg/mL
BHA	0.548 ± 0.018*	0.822 ± 0.018
BHT	0.429 ± 0.015	0.653 ± 0.019
TQ	0.143 ± 0.01	0.286 ± 0.009

* Data expressed as mean ± S.D (n=3). The higher the absorbance measured at 700 nm, the higher the reducing power.

3.3. Fatty acid composition analysis

The composition of EVOO and SFO fatty acids determined according to the results of GC-FID analysis were presented in Table 2. Both EVOO and SFO consisted of varying amounts of fatty acids as well as saturated fatty acids(SFAs), monounsaturated fatty acids (MUFAs), and polyunsaturated fatty acids (PUFAs). Oleic acid (18:1) contained 66.29% of the major fatty acids of olive oil. The other fatty acids of olive oil were as follows; palmitic acid (C16:0, 13.45%), linoleic acid (C18:2, 13.16%), and stearic acid (18:0, 2.3%), respectively. On the other hand, linoleic acid (18:2) was dominant in the oil obtained from safflower seeds. Oleic acid (C18:1) contained 27.12% of the fatty acids profile of safflower seeds. Oleic acid was followed by palmitic acid (C16:0, 6.28%). While the main fatty acids of the two oils were similar, their percentage amounts were different.

Table 2. Fatty acid composition of EVOO and SFO

Fatty acids	EVOO	SFO
C16:0	13.45 ± 0.24	6.28 ± 0.11
C18:0	2.3 ± 0.04	2.42 ± 0.03
C18:1 cis-9 (n-9)	66.29 ± 0.28	27.12 ± 0.64
C18:2 cis9,12	13.16 ± 0.15	59.40 ± 0.56
Σ SFA	15.75 ± 0.28	8.70 ± 0.14
Σ MUFA	66.29 ± 0.28	27.12 ± 0.64
Σ PUFA	13.16 ± 0.15	59.40 ± 0.56
Σ UFA	79.45 ± 0.43	86.52 ± 1.20

C16:0, palmitic acid; C18:0, stearic acid; C18:1, oleic acid; C18:2, linoleic acid; EVOO, Extra virgin olive oil; SFO, Safflower oil. Data obtained by GC FID are expressed as relative values (%): mean % of total FAs ± SD; Σ SFA, sum of saturated fatty acids; Σ MUFA, sum of monounsaturated fatty acids; Σ PUFA, sum of polyunsaturated fatty acids; Σ UFA, sum of unsaturated fatty acids

3.4. Evaluation of oxidative stability

The peroxide value (PV) is used to measure the initial level of oxidation in edible oils (Iqbal and Bhanger 2007) and are the primary oxidation products. In the initial phase, molecular oxygen combines with polyunsaturated fatty acids to form peroxide and free radicals. In the presence of active methylene groups, peroxides are also unstable and turn into dihydroperoxides and secondary oxidation products. Hydroperoxides are the primary products of lipid oxidation without undesirable flavor, whereas their secondary oxidation products are mostly responsible for rancid off-flavor (Choe and Min 2007). A higher PV is attributed to a lower oxidative stability (Naghshineh et al. 2010). Changes in PV (meq O_2/kg oil) of EVOO and SFO incorporated with BHT and TQ during storage at 60 °C for different lengths of time were shown in Table 3. During the 28-day storage period, the PV values of olive oils with and without antioxidants increased significantly ($p < 0.05$), except for the TQ. On day 28, blank EVOO had higher PV (59.83 meq O_2/kg oil), while olive oil incorporated with TQ had lower PV (17.39 meq O_2/kg oil). At the end of storage, the PV value of olive oil (30.69 meq O_2/kg oil) incorporated with synthetic antioxidant (BHT) was lower than the PV value of blank olive oil, but higher than the PV value of olive oil incorporated with TQ. As a result, TQ exhibited a greater ability to delay the PV values of the oils, i.e. oils with TQ showed significantly lower PV values than oils with incorporated synthetic antioxidants. More specifically, the peroxide values of olive oil (17.39 meq O_2/kg oil) combined with TQ were consistent with the maximum Codex standard peroxide value (≤ 20.0 meq O_2/kg) for vegetable oil degradation (CAC 2019). On the other hand, peroxide values of SFO with and without antioxidants increased sharply during storage when compared to those of EVOO. This is because the degree of unsaturation of fatty acids of SFO is greater than that of fatty acids of EVOO. That is, the more double bonds the oil contains, the more it is prone to oxidation. During the storage period, PV values of SFO with and without antioxidants increased dramatically. However, the rate of increase in peroxide value of TQ-enriched SFO was lower compared to the rate of increase in peroxide value of SFO combined with Blank and BHT. However, TQ retarded the oxidation process of safflower oil after 7 days of storage (18.19 meq O_2/kg oil). On Day 14, SFO combined with TQ had significantly ($p < 0.05$) lower PV values than their corresponding oils with included blank and synthetic antioxidant (BHT).

Table 3. Changes in PV (meq O2/kg oil) of EVOO and SFO incorporated with BHT and TQ during storage at 60 °C for different lengths of time.

Oil sample	Storagetime (days)	PV meq O_2/kg-oil)		
		Blank	BHT	TQ
EVOO	0	7.59 ± 0.29^a	6.96 ± 0.06^a	7.50 ± 0.32^a
	7	20.04 ± 0.37^a	9.44 ± 0.24^b	9.24 ± 0.11^b
	14	35.91 ± 1.10^a	14.96 ± 0.12^b	10.85 ± 0.26^c
	21	45.36 ± 0.50^a	20.00 ± 0.87^b	11.92 ± 0.83^c
	28	59.83 ± 0.25^a	30.69 ± 0.46^b	17.39 ± 0.99^c
SFO	0	6.02 ± 0.05^a	4.81 ± 0.03^c	5.81 ± 0.04^b
	7	83.47 ± 1.38^a	57.36 ± 1.13^b	18.19 ± 0.31^c
	14	633.61 ± 11.53^a	114.17 ± 3.11^b	62.44 ± 2.31^c

Mean ± standard deviation. Mean values (n=3) in the same row for each oil followed by the same superscript letters are not significantly different ($p < 0.05$). Abbreviations: EVOO, extra virgin olive oil; SFO, safflower oil; PV, peroxide value; BHT, butylated hydroxytoluene; TQ, thymoquinone.

4. CONLUSION

Analysis of the TQ according to the CUPRAC and FRAP method showed that the total antioxidant and hydroxyl radical scavenging activity was quite effective. The oxidation protection efficiency of TQ on two different types of oils was evaluated. Research findings revealed that, compared with synthetic antioxidant (BHT), TQ was more effective in retarding the oxidation of the two types of oil. The oils with TQ incorporated exhibited much better chemical stability, including lower peroxide value. As an alternative to synthetic antioxidants, TQ could be recommended as an effective natural antioxidant to improve the stabilization of edible vegetable oils.

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Oleomargarine Production Using Hazelnut Oil-Carnauba Wax Mixture: Process Optimization and Characterization

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Abstract: In this study, oleomargarine production was performed by using carnauba wax for the mixture of refined hazelnut oils enriched with virgin olive oil. The response surface methodology was used for the evaluation of the studied responses depending on the production parameters and for their optimization. Hardness and stickiness value (g force), oil binding capacity (%) and crystal formation time (min.) of the oleomargarines were determined. The oleomargarine process was optimized by using the response surface methodology, where the stickiness and crystal formation time (CFT) were minimized and the oil-binding capacity (OBC) (%) was maximized. By the way the optimum production formulation was determined. Acidity, peroxide values, fatty acid composition and DSC melting profiles were analyzed besides of hardness and stickiness value (g, force), oil-binding capacity (OBC, %), crystal formation time (CFT, min). Meanwhile, in oleomargarines, the total phenolic compound and total sterol amounts were spectrophotometrically measured and tocopherol compositions were determined by HPLC. The ratio of oleogelator was found to be significant, since it causes some changes in the hardness and stickiness, CFT (min), and OBC (%) values of oleomargarines as well as physical properties including color values, melting and crystallization temperatures. Oleomargarine samples had higher values of melting and crystallization than the breakfast margarine, which were used as reference food materials. The fatty acid composition (%) of oils and oleomargarine were rich in terms of mono and polyunsaturated fatty acids, whereas saturated ones were at low. When the margarine and oleomargarine samples were compared, the saturated fatty acid content of the oleomargarine samples were found to be significantly lower than the margarine samples. Enrichment with virgin olive oil differed the fatty acid composition, total phenolic content, β- sitosterol and tocopherol composition of oleomargarines depending on its addition ratio in mixture.

Keywords: Edible oils, carnauba wax, oleomargarine, optimization, RSM.

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1. INTRODUCTION

Fats play a crucial role at the processing of various food materials due to their great nutritional properties. The amount and composition of fat have an effect on the basic properties of the food, such as rheological and sensory properties, flavor, shelf life and nutritional value. Edible oils are classified as liquid, semi-solid and solid (hard) oils according to their structural properties at room temperature. These physical states determine not only their basic properties, but also usage areas (Öğütcü and Yılmaz, 2015, Roller and Jones, 1996). For example, oils that are completely liquid at room temperature are considered as salad oil and/or edible oil. On the other hand, easy spread form solid fats are used as a breakfast spreadable margarine, and oils with higher fat content (margarine and shortening) are used in bakery and patisserie products (cookies, cakes, pastries, etc.) (Öğütcü and Yılmaz, 2015, Pehlivanoglu et al., 2018). In recent years, consumers have led their attention to healthier, natural and functional foods

to meet their nutritional needs in safeway. Bioactive components important for human health vary depending on the raw material used to produce these oils, but the common point valid for all of them is that they constitute essential fatty acids, natural antioxidants such as phenolic substances and tocopherols, and lipophilic components such as sterols (Karasu, 2015).

In addition, the rapid changes in human being-life behavior and the high rate of participation in business life increase the interest in safe and functional food consumption. One of the dietary recommendations made for the protection of human health and accepted all over the world is to reduce the total saturated fat and *trans* fatty acid intake in the diet. Mensink et al. (2003) stated that when fatty acids in the unsaturated *cis* form are consumed instead of trans fatty acids and saturated fatty acids, health risks are effectively reduced (Mensink et al., 2003). In addition, trans fatty acids cause the high level of bad cholesterol (LDL), whereas they decrease the level of good cholesterol (HDL) (Legault et al., 2004, Brandt et al., 2009). In contrast to *trans* and saturated fatty acids in fat consumption, the World Health Organization (WHO) recommends the consumption of vegetable oils being rich in unsaturated fatty acids. However, it is known that *trans* and saturated fatty acids play a major role in the texture, taste, flavor and aroma of food products, and their direct replacement with unsaturated fats may cause some technical problems in product quality. In order to provide these properties to oil-based products, some technological processes such as hydrogenation, interesterification, fractionated crystallization or a new technology, oleogelation is required to obtain a solid fat with a high melting point. Shorts and hydrogenated oils are formulated to obtain solid fats such as margarine. With the help of these techniques, oils are given functionality such as elasticity, spreadability and plasticity. The mentioned features are important in the formation of the structure that consumers like and prefer on the product (Wassell et al., 2010, Marangoni and Garti, 2011, Pehlivanoğlu et al., 2017, Pehlivanoglu et al., 2018).

In this study, it was aimed to develop a new product composition for oleomargarine that does not contain trans fat and is low in saturated fatty acid and rich in mono- or polyunsaturated fatty acids. To achieve this purpose, hazelnut oil was used as a main oil and enriched with virgin olive oil and final mixture were gellated with carnauba wax. The procedure was also optimized. It is thought that these basic results will contribute significantly to oleomargarine production and to the related food industry.

2. MATERIAL AND METHODS

2.1. Material

In the study, refined hazelnut oil used in oleomargarine production was purchased from Çotanak A.Ş. To enrich hazelnut oil, natural extra virgin olive oil was purchased from Tariş A.Ş. As an oleogelator, Kahlwax brand refined carnauba wax was obtained from Ejder Kimya A.Ş.

2.2. Experimental Design

Oleomargarines (oleogel) were prepared by mixing the hazelnut oil-olive oil mixture and gellated with carnauba wax. Table 2 presents the all trials and corresponding mixture ratios for oleomargarine production.

The textural properties, oil-binding capacity, crystal formation time and color values of oleomargarine samples were statistically evaluated using the Response Surface Method (RSM), and optimum conditions were determined for the production of oleomargarine with the desired properties. Crystal formation time, oil-binding capacity, textural properties, color values, peroxide value, acidity value and fatty acid composition of the samples were analyzed as dependent variables.

Central Composite Design was chosen as the experimental design. The independent variables are the precious oil addition ratio (X1) and wax ratio (X2) added to the base oil for enrichment. The coded and uncoded values of the independent variables are given in Table 1 and the central composite design is given in Table 2.

Table 1. The coded and uncoded values of the independent variables in the trial design used in the Production of Oleomargarine

Independent variables	Factor Levels				
	lowest (-1.41)	low (-1)	Centre (0)	High (1)	Highest (1.41)
X1:Oil Addition Ratio (g/100g)	0.00	4.39	15.00	25.61	30.00
X2:Wax Ratio (%)	5.00	5.73	7.50	9.27	10.00

Table 2. Central mixed design applied in the samples used in Oleomargarine Production

Run[a]	Encoded Variables		Independent variables	
	X1	X2	Oil Addition Ratio (g/g)	Wax Ratio (%)
1	1	-1	15.00	7.50
2	0	0	15.00	7.50
3	0	0	0.00	7.50
4	-1	1	15.00	5.00
5	0	0	25.61	9.27
6	-1.41	0	15.00	7.50
7	0	0	4.39	9.27
8	1.41	0	15.00	10.00
9	0	-1.41	15.00	7.50
10	0	-1	30.00	7.50
11	1	1	25.61	5.73
12	0	0	4.39	5.73
13	0	1.41	15.00	7.50

[a], randomized

2.3. Preparation of Oleomargarine (Oleogel)

In the study, hazelnut oil was the base oil for the production of oleomargarine (oleogel). It was enriched with natural extra virgin olive oil at different ratios (Table 2). Oleomargarine was obtained by adding carnauba wax to hazelnut oil/extra virgin olive oil mixture at the specified ratio in Table 2. In oleomargarine production, the mixing temperature was adjusted according to the wax melting temperature (90 ◦C). After the wax completely melted in the mixture, it was kept at this temperature for a certain time (5 minutes). The sample required for the oil-binding capacity and crystal formation time was taken as a liquid phase immediately after formulation was ready and the remaining part was left for the crystallization at room temperature.

2.4. Determination of oil-binding capacity

The method adapted by Da Pieve et al. (2010) was used for the analysis of oil-binding capacity (Da Pieve et al., 2010). First, the tare (a) of the empty eppendorf tube was determined. Afterwards, approximately 1 mL of oleomargarine samples from the completely melted mixture was taken into empty eppendorf and kept in the refrigerator for 1 hour for oleomargarine formation. When the oleomargarine was completely formed in the refrigerator, the tube was weighed (b). In the final step, the epondorf tube was centrifuged at 1000 rpm for 15 minutes at 20 °C, then turned down and kept that position for 3 minutes to drain excess oil and weighed again (c). Leakage oil (%) and oil-binding capacity were calculated as percent (%) for each sample according to Equations 1 and 2.

$$\%\ \mathbf{Leaked\ oil} = \frac{\{(\mathbf{b}-\mathbf{a})-(\mathbf{c}-\mathbf{a})\}}{(\mathbf{b}-\mathbf{a})} \cdot \mathbf{100} \qquad \text{Eq. 1}$$

$$\%\text{Oil Binding Capacity} = 100 - \text{Leaked oil} \qquad \text{Eq. 2}$$

2.5. Crystal formation time

Approximately 10 ml of oleomargarine sample was taken from the completely melted mixture into a glass tube and kept in a water bath at 90 °C for 2 hours. The tube was then allowed to cool down to room temperature to form a gel. Gelation time was accepted as the cooling time until the flow was not observed when the tube was turned down (Dassanayake et al., 2009).

2.6. Determination of the textural properties of oleomargarine samples

To determine the textural properties of oleomargarine samples, the produced oleomargarine samples were kept at refrigerator temperature (+4 °C) for overnight, immediately after production. At the end of the period, the hardness and stickiness values of the oleomargarine samples were determined with Texture Analyzer (model/marka) using a stainless ball probe (P/0.75S). The speed of the probe was determined as 1 mm/s during the test and 2 mm/s after the test (Moskowitz, 1987).

2.7. Determination of free acidity value

Free fatty acidity value was determined using the AOCS Ca 5a-40 standard method (AOCS, 1998) and the results were calculated as % oleic acid.

$$\text{Acidity(\% Oleic acid)} = \frac{\text{v}}{\text{m}} * 2.8 \quad \text{Eq. 3}$$

v= amount of spent KOH (ml)
m= sample amount (g)

2.8. Determination of peroxide value

The peroxide value was determined according to the AOCS Cd 8-53 standard method (AOCS, 1998) and the results were calculated as meq O2/kg oil.

$$\text{Peroxide Value}\left(\text{meq}\frac{\text{O2}}{\text{kg yağ}}\right) = \frac{(\text{a}-\text{b})\text{XNX1000}}{\text{m}} \quad \text{Eq. 4}$$

a= the amount of sodium thiosulfate consumed for the sample in the titration, ml
b= Sodium thiosulfate amount spent on the blank in the titration, mL
N= Sodium thiosulfate normality, N
m= amount of sample, g

2.9. Determination of specific absorbance values (K232, K270) in UV light

The method defined by Codex Alimentarius (2001) was used to determine the specific absorbance values (K232, K270) in UV light (Alimentarius, 2001).

2.10. Determination of total carotenoid and chlorophyll amount

Minguez-Mosquera et al. (1991), chlorophyll and carotenoid pigments of oils were calculated by measuring absorbances at 470nm, 630 nm, 670 nm and 710 nm wavelengths (Isabel Minguez Mosquera et al., 1991).

Carotenoid amount (mg carotenoid/kg oil)= ($A_{470} \times 10^6$) / (2000 × 100 × L) Eq. 5

Chlorophyll amount (mg chlorophyll/kg oil) = (A670 × 106) / (613 × 100 × L) Eq. 6

Eq, A, absorbance; L represents the beam path (cell thickness, mm).

2.11. Determination of fatty acid composition

The IUPAC 2.301 method was used for the preparation of fatty acid methyl esters (Paquot and Hautfenne, 1987). 0.1 g sample was first mixed with 2 mL of heptane and shaken, then 0.2 mL of 2N methanolic potassium hydroxide derivative solution was added. Then the mixture was kept at 70 ˚C for 30 minutes to complete derivatization. The upper phase fatty acid methyl esters with clarified heptane was injected into the Gas Chromatography system (GC) for determination. Fatty acid components of the oils were determined using the AOCS Official Method Ce 1-62 (AOCS, 1997). The characteristics and operating conditions of the GC device are presented in Table 3.

Table 3. Properties of Gas Chromatography (GC) and working conditions

Gas Chromatography	**Agilent**
Injector temperature	250 °C
Detector temperature	250 ° C
Flow Rate(psi)	15
Detector	FID
Used Gas	Helium
Used Column	Cp WAX 52 CB 50 m * 0.32 mm, 1.2 µm
Temperature Program	After 4 minutes at 60 °C, it reaches 175 °C with an increase of 4 °C per minute. It waits for 27 minutes at 175°C. Reaches 215°C with 4°C increments per minute and waits for 5 minutes. It reaches 240 °C in increments of 4 °C per minute.

In the determination of fatty acids, a mixture of methyl esters of fatty acids, including trans fatty acids, starting from butyric acid to nervonic acid, was used. The fatty acid composition of the samples was calculated as % area with the help of HP Chemistation computer program.

2.12. Determination of the total amount of phenolic substances

The total amount of phenolic compounds extracted from oils by methanol was measured using the Folin-Ciocalteu spectrophotometric method at a wavelength of 765 nm, and the result was calculated as mg gallic acid equivalent (GAE)/kg oil (Singleton and Rossi, 1965).

2.13. Tocopherol Profile Analysis by HPLC

Analysis of the tocopherol components of the oils was carried out by modifying the AOCS Official Method Ce 8-89 (De Greyt et al., 1998). 250 µL of oil samples was dissolved in the mobile phase Heptane/THF (95:5, vol/vol) solvent and the volume was completed to 1 mL and 100 µL of the sample was taken and injected into the HPLC device.

Table 4. Features of the HPLC and operating conditions

Detector	DAD Detector
Auto sampler	SIL–20AC prominence
system controller	LC- 20AT prominence
Pump	LC- 20AT prominence
Degasser	DGU-14A
Column furnace	CTO-10ACvp
Column	Luna Silika (250*4,6 mm, 5 µm)
Mobile Phase	Heptane/THF (95:5)
Flow Rate	1.2 mL/min.
Column Temperature	25˚ C
Injection Volume	20 µl

In the analysis of tocopherol components, α-(alpha) tocopherol, β-(beta) tocopherol, γ-(gamma) tocopherol and δ-(delta) tocopherol (Cabliochem, Germany) were used as standards. Analyzes were made in three parallels. The sample chromatograms showing the separations of the standards were presented in Figure 1

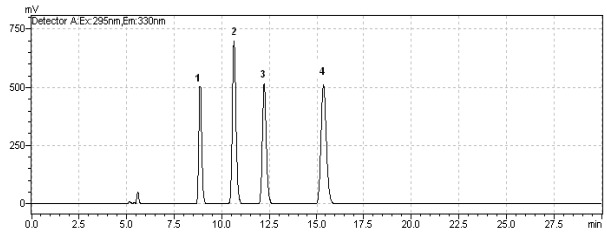

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Figure 1. Chromatogram of the standards: 1: α-(alpha) tocopherol, 2: β-(beta) tocopherol, 3: γ-(gamma) tocopherol, and 4: δ-(delta) tocopherol

In the analysis of tocopherol components, α-(alpha) tocopherol, β-(beta) tocopherol, γ-(gamma) tocopherol and δ-(delta) tocopherol (Cabliochem, Germany) were used as standards. Analyzes were made in three parallels. The sample chromatograms showing the separations of the standards were presented in Figure 1.

2.14. Spectrometric sterol determination

The cholesterol method by Rudel and Morris (1973) was modified and sterol extraction was performed from the oil samples and the total sterol (β-sitosterol) amounts were determined by the FeCl3 method. In this method, sterol substances were first extracted from the oil samples by saponification. The extracted samples were treated with FeCl3 solution to determine the amount of sterol. Then, 1 ml of H2SO4 is added on it and the pink color formed after waiting for an average of 45 minutes were read at 560 nm in the spectrophotometer. Results were calculated from the sterol calibration chart (Rudel and Morris, 1973).

2. 15. DSC analysis

DSC analyzes of oleomargarine and margarine samples were carried out at Burdur Mehmet Akif Ersoy University Scientific and Technology Application and Research Center with AOCS Official Method Cj 1-94 as a service purchase. The operating conditions used in the analysis were given below (Society, 1998).

Brand : Perkin Elmer
Model: DSC 4000
Amount of sample: 3-10 mg
Working Principle: After being heated from 25 °C to 100 °C in 10 degree increments per minute in a nitrogen environment and kept for 10 minutes, it was cooled from 100 °C to -50 °C for 30 minutes and kept from -50 °C to 100 °C. It has been heated to.

2.16. Statistical Analyzes

In the study, the response surface methodology (Response Surface Method, RSM) was used to plan the production of oleomargarine (central mixed design), evaluate the

responses, and find the optimum points. Minitab Statistics Package Program (17) was used in the implementation of the method. Model adequacy was evaluated by considering R^2 value. Model was determined according to bivariate quadratic equality (Eq.7).

$$Z = \beta_0 + \sum_{i=1}^{2} \beta_i X_i + \sum_{i=1}^{2} \beta_{ii} X_i^2 + \sum_{i=1}^{1} \sum_{j=i+1}^{2} \beta_{ij} X_i X_j \quad \text{Eq. 7}$$

In the equation, Z dependent variable, X independent variable, β_0 constant coefficient, β_i first-order (linear) equation coefficient, β_{ii} quadratic equation coefficient and β_{ij} is the two-factor cross-interaction coefficient.

3. RESULTS

Refined hazelnut oil and natural extra virgin olive oils were used for the production of oleomargarine, and carnauba wax was used as a gelling agent. Refined hazelnut oil was enriched with extra virgin olive oil, and carnauba wax was added to the oil mixture at the specified ratio determined in the design, and oloeogel production was carried out. Before the production of oleomargarine, the main quality parameters of the oils such as free acidity, peroxide, UV specific absorbance values (K_{232} and K_{270}) and color values such as chlorophyll and carotenoid values, fatty acid composition, total phenolic substance content, tocopherol amount and sterol amount (β-sitosterol) were determined.

The free acidity value, which is defined as the percentage of oleic acid of the total unbound fatty acids in oils, and the peroxide value, which is the indicator of the primary oxidation products in oils, are determined by titration (Nas and Gökalp, 2001). K_{232} conjugated diene compounds (the indicator of the primary oxidation products) and K_{270} conjugated triene components (the indicator of the secondary oxidation products) are determined spectroscopically at a wavelength of 232 nm and 270 nm, respectively, for oil samples (Ayadi et al., 2009). Color substances, which are one of the important quality parameters, are composed of chlorophylls, which are responsible for the green color and stability of the oils and have antioxidant activity in the dark and pro-oxidant activity in the light, and carotenoids responsible for the color from yellow to brown (Ayadi et al., 2009). The values of free acidity (% oleic), peroxide (meq O2/kg oil), K_{232} and K_{270}, chlorophyll and carotenoid values of the oils used in the study were given in Table 5.

Table 5. Average values of oil quality parameters (n=3)

Sample	[a]HO	OO
Acidity (% oleic)	0.13±0.020	0.86±0.020
Peroxide Value (meq O2 /kg of oil)	4.70±0.640	6.66±0.600
K_{232}	2.43±0.010	2.06±0.010
K_{270}	0.89±0.000	0.16±0.000
Chlorophyll (ppm)	0.03±0.000	0.04±0.001
Carotenoid (ppm)	0.02±0.001	0.11±0.000

[a] HO: Hazelnut oil, OO: Olive oil

Among the quality parameters of the oil samples, acidity values were between 0.13 - 0.86, and peroxide values were between 4.70 and 6.66. These values were examined according to the Turkish Food Codex Communiqué on Oils Called by Plant Name (Communiqué No: 2012/29) and the Turkish Food Codex Olive Oil communiqué and it was determined that they were within the limits determined by the codex. Our data are compatible with the findings obtained in the literature studies. If we examine the studies on various oils, free acidity (% oleic) and peroxide values (meq O2/kg oil) were found in the range of 0.05 to 0.9 in refined hazelnut oil, respectively (Kesen et al., 2016). It has been reported that it varies between 0.52 - 1.05 and 3.20 - 9.47 in olive oils (Bozdoğan Konuşkan, 2008, Aşık and Özkan, 2011, Cevik et al., 2014). K_{232} and K_{270} values were determined as 0.89 - 2.43 in hazelnut oil and 0.16 - 2.06 in olive oil, respectively. No study has been found in the literature on the K_{232} and K_{270} values of refined hazelnut oil. The K_{232} and K_{270} values of olive oil were determined as 1.4935 and 0.0985 (Aşık and Özkan, 2011). Our data are compatible with the findings obtained in the literature studies. Chlorophyll and carotenoid values affecting the appearance of oils were determined in the range of 0.033 – 0.021 (ppm) and 0.043 – 0.111 (ppm) in refined hazelnut oil and virgin olive oil, respectively. While no study has been found in the literature on the color values of refined hazelnut oil, it has been reported that the chlorophyll and carotenoid values of the virgin olive oil were determined in the range of 0.457 - 2.276 and 0.438 - 1.383 (ppm), respectively (Aşık and Özkan, 2011, Cevik et al., 2014).

Before oleomargarine production, the fatty acid composition of refined hazelnut oil and virgin olive oil were determined and given in Table 6.

Table 6. Average values of fatty acid composition (% area) of oils (n=2)

Fatty Acid	[a]HO	OO
Myristic acid (C14)	0.04±0.00	Nd
Palmitic Acid (C16)	5.56±0.06	12.51±0.97
Stearic acid (C18)	2.73±0.02	3.18±0.08
∑SFA[b]	8.33±0.04	15.68±1.04
Palmitoleic acid (C16.1)	0.17±0.00	0.57±0.00
Oleic Acid (C18.1)	74.52±0.05	71.64±0.89
Gadoleic Acid (C20.1)	nd	0.53±0.03
∑MUFA	74.69±0.05	72.74±0.86
Linoleic acid (C18.2)	16.80±0.08	10.65±0.14
Gamma Linolenic acid (C18.3)	0.19±0.00	0.58±0.05
Alpha Linolenic acid (C:18:3n3)	nd	0.35±0.01
∑PUFA	16.99±0.09	11.58±0.18

[a] HO: Hazelnut oil, OO: Olive oil

[b] ∑SFA: Total Saturated Fatty Acid, ∑MUFA: Total Monounsaturated fatty acid, ∑PUFA: Total Polyunsaturated Fatty acid, [c]nd: below the detectable value.

The fatty acid composition of the refined hazelnut oil consisted of 8.33% saturated fatty acids, 74.69% monounsaturated fatty acids and 16.99% saturated fatty acids. The fatty acid composition of olive oil consisted of 15.68% saturated fatty acids, 72.74% monounsaturated fatty acids and 11.58% polyunsaturated fatty acids. In another study examining the fatty acid composition of crude and refined hazelnut oils, the fatty acid composition of refined hazelnut oil was found as 8.38% of saturated fatty acids, 71.20% of monounsaturated fatty acids and 20.24% of polyunsaturated fatty acids (Kesen et al., 2016). Tüfekci (2018) determined that the fatty acid composition of hazelnuts grown in the black sea region, in his doctoral thesis, the mean of SFA, MUFA, and PUFA 8.12, 83.16 and 8.56, respectively. The fatty acid composition varies depends on the harvested region and the harvest season (Tüfekci, 2018). In studies examining the fatty acid composition of Memecik and Gemlik olive oils, it was determined that the fatty acid composition were as 12.75-24.86% saturated fatty acids, 58.72-76.86% monounsaturated fatty acids and 9.44 - 13.64% polyunsaturated fatty acids (Cevik et al., 2014, Aşık and Özkan, 2011). It has been reported that the fatty acid profile of oils changed depending on maturity (Cevik et al., 2014).

Functional compounds in oils are important for human health, but they vary depending on different factors including the raw material. Thus, it is required to define them for corresponding raw materials. Essential fatty acids were given in Table 6, natural antioxidants such as phenolic substances and tocopherols lipophilic bioactive components such as colorants, sterols were given in Table 7.

Table 7. Average values of functional properties of oils (n=2)

Functional Feature	[a]HO	OO
Total Phenolic Substance (mg GAE/kg oil)	61.59±2.20	193.79±2.20
Alpha tocopherol (α)	618.64±0.53	171.13±0.19
Beta tocopherol (β)	27.61±0.20	37.43±0.50
Gamma tocopherol (γ)	85.89±0.45	[nd]
Total sterol (β-sitosterol)	866.21±4.58	1160.60±8.02

[a] HO: Hazelnut oil, OO: Olive oil
[nd]: not determined

The total amount of phenolic substances of the oils was determined as gallic acid equivalent (GAE). It was determined as 61.59 mg/kg for hazelnut oil and 193.79 mg/kg for olive oil. Yorulmaz (2009) determined the sterol, phenolic and triglyceride structures of Turkish olive oils. They reported the total phenolic content of olive oils obtained from different regions in the range of 48.72-646.30 ppm (Yorulmaz, 2009). Aşık and Özkan (2011) studied the physical, chemical and antioxidant properties of olive oil obtained from the Memecik olive variety, and found the total phenolic content of olive oils as 169.25 mg GAE/kg oil. Cevik et al. (2014) examined the effect of harvest time on the physicochemical quality parameters, oxidation stability and volatile compounds of extra virgin olive oil obtained from Gemlik olive fruits at different maturity stages. The total phenolic content of the oils varied from 86.11 and 227.80 mg GAE /kg oil according to the harvest time. Delil et al. (2022), in their study of optimizing the phenolic composition of extra virgin olive oil, determined the total phenolic content of the olive oils obtained at different kneading temperatures and times in the range of 86.11-338.94 mg/kg oil (Delil et al., 2022).

The amounts of α, β and γ tocopherols for corresponding refined hazelnut oil/olive oil was found to be as 171.13/618.64 mg/kg oil, 27.61/37.43 mg/kg oil and nd/85.89 mg/kg oil, respectively. In the study about the lipid properties and oxidative stability of Turkish Tombul hazelnut (*Corylus avellana* L.), oil sample was extracted from Tombul hazelnuts and the tocopherol composition of hazelnut oil was determined. The amount of α tocopherol was determined as 38.23 mg/100 g oil, the amount of β tocopherol was 1.15 mg/100 g oil and the amount of γ tocopherol was 3.89 mg/100 g oil (Alasalvar et al., 2003). In the study investigating the effect of refining on the bioactive composition and oxidative stability of hazelnut oil, it was stated that the refining process caused a decrease in the amount of tocopherol. At the end of the refining process, the tocopherol composition of hazelnut oil was determined and the amount of α- tocopherol was 459.69 mg/kg oil, β- tocopherol amount was 10.41 mg/kg oil, γ-tocopherol amount was 97.35 mg/kg oil, and δ- tocopherol amount was 4.82 mg/kg oil ((Durmaz and Gökmen, 2019).

In the study conducted by Aşık and Özkan (2011) the physical, chemical and antioxidant properties of olive oil obtained from the Memecik olive variety were investigated. The tocopherol composition of olive oils was determined

and the amount of α- tocopherol was 205.45 mg/kg oil, β-tocopherol amount was 1.645 mg/kg oil, γ- tocopherol amount was 6.065 mg/kg oil, δ- tocopherol amount was 0.325 mg/kg oil. Cevik et al. (2014), in their study the tocopherol composition of the oil samples extracted from Gemlik at different maturity stages. It has been determined that the amounts of α-, β-, and γ- tocopherol varied in the ranges of 128.35-154.50 mg/kg oil, 0.90-5.45 mg/kg oil, and 0.80-1.20 mg/kg oil.

The variation range of total sterol content (in terms of β-sitosterol) was determined. The result was in the range of 866.21 – 1160 mg/kg oil. No study has been found in the literature on determining the sterol content of oils by spectroscopic method. However, in literature studies, total sterol amounts of oils were determined by GC method. In one of them, Turkish Chubby Hazelnut (*Corylus avellana* L.) lipid properties and oxidative stability, the sterol composition of plump hazelnut oil were examined. The amount of β-sitosterol was determined as 105.48 mg/100 g oil (Alasalvar et al., 2003). Yorulmaz (2009) studied the sterol, phenolic and triglyceride structures of Turkish olive oils and determined the total sterol amount of olive oils obtained from different olive varieties in the range of 728.75 – 2247.07 mg/kg. In their study, Matthaus and Özcan (2011) determined the total sterol content of olive oils obtained from Turkish olive varieties and reported their range as 1200.80 - 2762 mg/kg oil ((Matthäus and Özcan, 2011). Aydin et al. (2020) studied the effect of kneading temperature and time on the total sterol content of olive oils. They found that total sterol content was in the range of 936.78 - 1574.55 mg / kg oil (Aydın et al., 2020). Our results about total sterol content of oil samples are consistent with the part of the literatures, although there are differences as well. These variations in the results were thought to be due in part to the differences in methodologies used.

3.1. Experimental Design of Oleomargarines in which Refined Hazelnut Oil is Enriched with Extra Virgin Olive Oil

After enrichment of refined hazelnut oil with extra virgin olive oil, oleomargarin was produced using carnauba wax. The textural values of hardness (g force) and stickiness (g force), crystal formation time and oil binding capacity of oleomargarine samples were measured (Table 8). The models defining the variation in these parameters (hardness (g force) and stickiness (g force), OBC (%) and CFT (min)) depending on process variables were developed and the obtained coefficients and model performance values were given in Table 9.

Table 8. Hardness (g, force), stickiness (g, force), OBC (%) and CFT (min.) values of oleomargarine samples

Run[a]	HOC[b]			
	Hardness	Stickiness	OBC	CFT
1	246.34	-58.94	85.18	9.20
2	245.03	-56.43	86.09	9.12
3	258.20	-60.46	85.67	10.00
4	43.84	-10.43	64.30	10.59
5	509.14	-109.82	96.46	9.50
6	247.68	-56.66	86.03	9.25
7	512.60	-108.47	96.52	9.36
8	673.69	-112.25	97.26	9.10
9	245.29	-57.35	87.41	9.20
10	250.52	-61.32	85.36	10.05
11	94.12	-21.23	70.42	10.38
12	89.19	-21.15	71.25	10.48
13	221.20	-54.79	86.18	9.27

[a], randomized, [b], HOC, Hazelnut oil, olive oil, carnauba wax

The hardness of oleomargarine samples was measured after the samples were kept at +4 ˚C for one night and the results were found to be varied in the range of 43.84 - 673.69 g.force. It was determined that the stickiness value changed in the range of (-)112.25 – (-)10.43 g.force. The oil binding capacities (%) of the HOC samples were 64.30-97.26, respectively, while the crystal formation times (min) varied from 9.10 to 10.59 min. In the literature, no study was found in which refined hazelnut oil was enriched with extra virgin olive oil and gelled with carnauba wax. However, there are studies on the structuring of these oils and the production of oleomargarine. In the study, where it was aimed to determine the product with the most suitable spreadability for oleomargarine samples prepared by adding carnauba wax oleogelator (at the ratio of 3%, 7% and 10%) to olive oil, the hardness values were found to be in between 6.99 and 728.75 g, the stickiness value was between 10 and 200 g, and the OBC values (%) were found to vary between 40.82 – 93.41 (Yılmaz and Öğütcü, 2014a). In the study where they aimed to determine the product with the most suitable spreadability in oleomargarine samples prepared by adding carnauba wax oleogelator (at the ratio of 3%, 7% and 10%) to olive oil, the hardness values were between 6.99 and 728.75 g, whereas the stickiness values were between 10 and 200 g (Öğütcü and Yılmaz, 2014). In that study the OBC values of oleomargarine samples were determined and the results were found to vary between 40.82 – 93.41. In the study of optimization and characterization of soybean oil carnauba wax oleogel, hardness and OBC value changed between ND – 16.63(N), 75.33 – 99.73 (%), respectively (Thakur et al., 2022).

Table 9. Models of the changes in the hardness (g force), stickiness (g force), OBC (%) and CFT (min.) values of oleomargarines produced using carnauba wax after enrichment of refined hazelnut oil with natural extra virgin olive oil, depending on the production conditions. coefficients and evaluation parameters

Model	HOC			
Coef.[a]	Hardness	Stickiness	OBC	CFT
β0	358.8***	46.5***	-11.00***	18.25***
β1	-0.69ns	0.91ns	-0.04ns	-0.13ns
β2	-152.1***	-6.69***	19.10***	-1.86***
β11	0.047ns	-0.027ns	-0.002ns	0.004***
β22	18.40***	-1.05ns	-0.82***	0.102***
β12	-0.11ns	-0.02ns	0.01ns	0.003*
Model	***	***	***	***
R^2	99.60	97.78	99.20	99.32

[a]. β_0 constant coefficient. β_i Coefficient of first order (linear) equation. β_{ii} quadratic equation coefficient and β_{ij} is the two-factor cross-interaction coefficient. [ns]. nonsignificant statically ($p \geq 0.05$); [*]. Statistically significant at the 95% level ($p \leq 0.05$); [**]. Statistically significant at the 99% level ($p \leq 0.01$); [***]. Statistically significant at the 99% level ($p \leq 0.001$).

The developed expression for each response was evaluated in terms of model performance. All obtained equations explain more than 97% of the changes in the hardness and stickiness values of oleomargarine samples (HOC) depending on the processing conditions (R^2 >0.97) (Table 9). In the models the oil addition ratio was found to be statistically insignificant in the models of hardness, stickiness and OBC (%) values of the HOC samples (p> 0.05). While the first-order term of oil addition ratio was statistically insignificant for the expression developed for the CFT (min.) value, its second-order term and interaction with wax ratios were found to be significant ($p \leq 0.05$). Another independent variable, the wax ratio, was significant for first order terms of all developed models and second order terms of the models for the hardness, OBC and CFT values of HOC samples ($p \leq 0.001$) (Table 9). The change of hardness and stickiness of oleomargarines as a function of oil addition and wax ratios were shown in Figure 2.

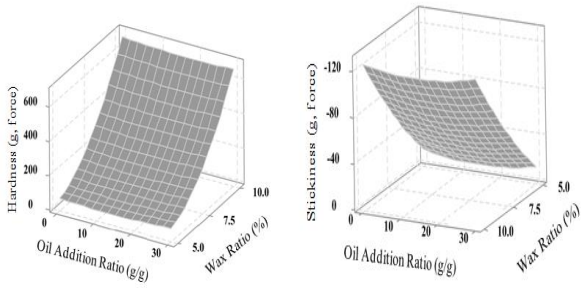

Figure 2. The effect of oil addition ratio (%) and wax ratio (%) variables of HOC oleomargarine samples on hardness (g force) and stickiness (g force) values of oleomargarines

As can be seen from Figure 2, there was no significant effect of oil addition ratio on the hardness value of the HOC sample. From the same figure, the strong effect of wax ratio can be seen, where the hardness increased with an increase in wax ratio (Figure 2). Similar effects of oil addition and wax ratios were determined on the stickiness value (Figure 2). With the increase of oil addition and wax ratios, an increase is observed in the adhesiveness value (Figure 2). Being consistent with our results, in other studies, an increase in the hardness and stickiness values of oleomargarines was detected with increasing ratio of gelling agents used (Yılmaz and Öğütcü, 2014a, Öğütcü and Yılmaz, 2014, Yılmaz and Öğütcü, 2014b).

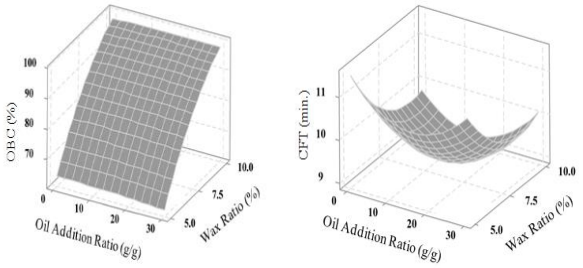

Figure 3. The effect of oil addition ratio (%) and wax ratio (%) variables on HOC oleomargarines OBC (%) and CFT (min) values

The effect of processing conditions on OBC (%) and CFT (min.) values of the HOC oleomargarine samples can be seen from Figure 3. There was no significant effect of oil addition ratio on OBC value of the HOC samples. On the other hand, an increase in the OBC value was detected with the increase in the wax concentration. The effects of oil addition and wax ratios on the CFT value were curved and had the same trends. The increases in both affected the CFT value of oleomargarine and CFT value initially decreased, but after a certain level of oil addition or wax ratio was exceeded, its trend change and an increase in CFT was observed (Figure 3).

Similarly, the oil-binding capacity of the oleomargarine s obtained by the sunflower wax, beeswax, carnauba wax or monoglyceride addition to olive oil increased as the amount of gelling agents added to the oil increased (Yılmaz and Öğütcü, 2014b;c;a). In that study, the crystallization time was also studied and it was found to decrease with

increasing wax ratio. This outcome showed an in accordance with the trend observed in our study. OBC is a measure showing the degree of liquid oil entrapment in the gel network. It has also been noted in previous studies that an increase in the gelator ratio in oil results in higher OBC and lower gelation time.

3.2. Oleomargarine Production Optimization and Model Validation

By using the response surface methodology, optimum production formulation of oleomargarine samples produced by adding carnauba wax to the blended oils in which refined hazelnut oil was enriched with natural extra virgin olive oil was determined. Stickiness value and crystal formation time were minimized, while oil binding capacity (%) value was maximized. The final formulation determined was given in Table 10.

Table 10. Optimum conditions used in the production of oleomargarine

Sample	X1(Addition Oil Ratio)	X2 (Wax Ratio)	d (Desirability)
[a]HOC	17.27	9.71	1.00

[a], HOC; Hazelnut oil, olive oil, carnauba wax

The oil addition and wax ratios were determined as 17.27% and 9.71%, respectively. Depending on the criteria selected for optimization, the "desirability value" was calculated as 1.0.

Table 11. Experimental data of the stickiness value of oleomargarines produced under optimum conditions and values of model estimation intervals

Run	Experimental Data	Model Prediction Intervals (95% Confidence Level)	d (Desirability)
	Stickiness Value (g force)	Stickiness Value (g force)	
aHOC	-108.06±4.50	-126.25; -98.23	0.99

[a], HOC; Hazelnut oil, olive oil, carnauba wax

In order to experimentally verify the predictive value of the model, the stickiness values of oleomargarines produced under optimum conditions (oil addition ratio and wax ratio) were determined and its mean value was -108.06±4.50 which was in the confidence interval produced by model (Table 11). The models of stickiness was experimentally confirmed.

Table 12. Experimental data and model estimation intervals of OBC (%) and CFT (min.) values of oleomargarines produced under optimum conditions

Sample	Experimental Data		Model Prediction Intervals (95% Confidence Level)			
	OBC (%)	CFT (min.)	OBC (%)	d	CFT (min.)	d
[a]HOC	92.38± 0.53	8.03± 0.04	94.87-100.00	1.0	8.97-9.23	1.0

[a], HOC; Hazelnut oil, olive oil, carnauba wax

Similar to the model for stickiness value, accuracies of the expressions corresponding to OBC (%) and CFT (min) also were experimentally checked. Confidence intervals for these responses were given in Table 12 with the mean values of experimental OBC (%) and CFT (min) results of oleomargarine produced at the optimal conditions. The mean values of OBC and CFT were found to be within the model estimation ranges given in Table 12, and the models obtained according to these results were experimentally verified.

3.3. Determination of Characteristic, Functional and Quality Parameters of Oleomargarines Produced under Optimum Conditions

Hardness and stickiness, OBC (%) and CFT (min), acidity and peroxide values, fatty acid composition and DSC melting profiles were determined as the characteristic parameters of oleomargarine produced under optimum conditions and given in Table 13 - 16. Similarly, total phenolic and sterol content of oleomargarins as their functional properties were determined spectrophotometrically and tocopherol profile was figured out chromatographically and all were also presented in Table 17. It has been stated that there is a correlation between hardness and spreadability, but this relationship is not perfect. Hardness is defined as the force required to compress the sample under a certain pressure, while stickiness is defined as the force required to remove the sample from the surface. Therefore, it has been determined that both hardness and stickiness values should be at moderate levels in order to obtain an ideal spreadability. A good quality margarine should be hard enough to maintain its fluidity at room temperature and sticky enough to adhere to the surface it is applied to.

Table 13. Oleomargarine of produced under optimum conditions and margarine average values of hardness and stickiness values

[a]Sample	HOC	M
Hardness Value (g force)	612.34±5.85	417.96±8.50
Stickiness Value (g force)	-108.06±4.5	-168.72±7.74

[a], HOC; Hazelnut oil, olive oil, carnauba wax, M; Margarine

The hardness value of HOC sample was higher than the margarine, and the stickiness value was lower (Table 13).

Table 14. Quality parameters of oleomargarines produced under optimum conditions

Quality parameters	[a]HO	OO	HOC
Acidity (% oleic acid)	0.13±0.02	0.86±0.02	0.55±0.00
Peroxide Value (meq O2 /kg of oil)	5.20±0.07	6.66±0.11	6.45±0.05
Chlorophyll (mg/kg oil)	0.033±0.000	0.043±0.001	0.037±0.003
Carotenoid (mg/kg oil)	0.021±0.001	0.111±0.000	0.036±0.000

[a], HO; Hazelnut oil, OO; Olive oil HOC; Hazelnut oil, olive oil, carnauba wax

The acidity and peroxide value of the oils used in the study were in the ranges of 0.13 – 0.86 and 5.20– 6.66, respectively. Similarly, HOC samples produced at the optimal conditions was also analyzed and the acidity was found as 0.55 and peroxide was 6.45 (Table 14). In the literature, peroxide values of oleogel samples prepared by adding 3, 7 and 10% beeswax and carnauba wax to fish, hazelnut, pomegranate seed oil and olive oil, coincidence results were seen to be with those in this study. In the other study of virgin olive oil oleogels acidity and peroxide values determined as 1.95 - 2.14 and 12.48 - 16.76, respectively (Yilmaz and Demirci, 2021). Researchers' reports that the oil and wax samples used in gelling were effective on acidity and peroxide values (Yılmaz ve Öğütcü, 2014b;a, Öğütcü vd., 2015, Öğütcü ve Yılmaz, 2015a). It is thought that reasons such as the methods of obtaining the wax samples, the melting point in the oil, the waiting time by contacting the air at the wax melting temperature are also effective on the peroxide value. In addition, since the peroxide value is maximum 5 in the margarine codex, alternatively produced oleomargarines should not exceed this limit. Total chlorophyll and carotenoids content of the oils used in the study were determined as 0.033-0.043 and 0.021- 0.111 mg/kg oil and the HOC oleomargarine sample was examined and chlorophyll and carotenoids were found to be 0.037 and 0.036 mg/k g oil, respectively (Table 14). As a result of the literature survey, this is the first time reporting total chlorophyll and carotenoid content of oleomargarine.

Table 15. Fatty acid composition (%) of the oils used in the study, oleomargarines produced under optimum conditions and margarine

Fatty Acid	HO	OO	HOC	M
Lauric Acid	0.00±0.00	0.00±0.00	0.00±0.00	3.78
Myristic acid (C14)	0.04±0.00	0.00±0.00	0.03±0.00	2.02
Palmitic Acid (C16)	5.56±0.06	12.51±0.97	7.08±0.01	25.66
Stearic acid (C18)	2.73±0.02	3.18±0.08	2.83±0.02	10.86
∑SFA[b]	8.32±0.04	15.68±1.04	9.94±0.03	42.32
Palmitoleic acid (C16.1)	0.17±0.00	0.57±0.00	0.20±0.01	0.45
Oleic Acid (C18.1)	74.52±0.05	71.64±0.89	73.59±0.03	52.5
Gadoleic Acid (C20.1)	0.00±0.00	0.53±0.03	0.00±0.00	3.19
∑MUFA	74.69±0.05	72.74±0.86	73.79±0.03	56.14
Linoleic acid (C18.2)	16.80±0.08	10.65±0.14	15.59±0.02	0.00
Gamma Linolenic acid (C18.3)	0.19±0.00	0.58±0.05	0.46±0.03	0.89
Alpha Linolenic acid (C:18:3n3)	0.00±0.00	0.35±0.01	0.22±0.00	0.65
∑PUFA	16.99±0.09	11.58±0.18	16.27±0.02	1.49

[a] M; Margarine HO; Hazelnut oil, OO; Olive oil, HOC; Hazelnut oil, olive oil, carnauba wax

[b] ∑SFA: Total Saturated Fatty Acid, ∑MUFA: Total Monounsaturated fatty acid, ∑PUFA: Total Polyunsaturated Fatty acid, [c]nd: below the detectable value.

Hazelnut oil, olive oil, oleomargarine, and margarine were individually analyzed and each corresponding fatty acid composition was presented in Table 15. The saturated fatty acid percent (%) of hazelnut oil and olive oil were determined as 8.32% and 15.68%, respectively. As expected, saturated fatty acid percent of oleomargarine (9.94%) was in between 8.32 to 15.68% which was dependent partially on the mixing ratio in formulation followed during oleomargarine production. The corresponding value for margarine was determined as 42.32%. Total monounsaturated fatty acid content (%) of the oils varied from 72.74 - 74.69 and total polyunsaturated fatty acid content (%) was in between 11.58 - 16.99. Total monounsaturated fatty acid content (%) of oleomargarine and margarine were 73.79% and 56.14%, respectively. Table 15 also showed that total polyunsaturated fatty acid content (%) for oleomargarine and margarine were as 16.27% and 1.49%, respectively. The saturated fat content of the margarine sample was found higher than the HOC oleomargarine samples. The fatty acid composition of the oleomargarines produced in the study varies depending on the type of oil used in the mixture and the addition ratios in oil. Dominant monounsaturated fatty acid and polyunsaturated fatty acid were oleic acid (>70%) and linoleic acid (> 10%) for hazelnut oil, olive oil, and

oleomargarine, whereas those corresponding values were clearly lower for margarine (Table 15).

Table 16. DSC Values of oleomargarines produced under optimum conditions and margarine

	DSC Values	HOC	M
Crystallization (Tc)	[a] Onsetc (◦C)	68.77±1.0	19.52+0.6
	Peak (Tc. ◦C)	65.84±0.1	17.37+0.1
	Hc (J/g)	-1.52±0.1	-1.5+0.1
Melting (Tm)	Onsetc (◦C)	66.64±0.1	42.72+0.3
	Peak (Tm. ◦C)	76.09±0.1	42.94+0.2
	Hm (J/g)	8.31±0.7	0.19+0.4

a, Onsetc; crystallization initiation temperature, Tc; crystallization temperature, Hc: crystallization enthalpy, Onsetm; melting start temperature, Tm; melting temperature, Hm; enthalpy of fusion. HOC; HOC; Hazelnut oil, olive oil, carnauba wax, M; Margarine

Thermal properties of oleomargarine and margarine were summarized in Table 16. Crystallization temperature and melting temperature of the oleomargarine sample were found to be as 65.84 °C and 76.09 °C, respectively. The crystallization temperature of the margarine was 17.37 °C and the melting temperature was 42.92 °C. The crystallization and melting temperature of the HOC sample was found to be higher than that of margarine. Similar to our results, it was reported that oleomargarine produced using carnauba wax had high crystallization and melting temperature values (Öğütçü, 2014). DSC melting profiles of oleomargarine samples (3, 7 and 10% carnauba wax add to olive oil) were investigated and crystallization temperature, melting temperature, crystallization enthalpy, and melting enthalpy was found to be varied in the ranges of 50.77 – 61.17 ◦C, 65.83 – 76.0 ◦C, -10.57 - -15.51 J/g, and 10.39 – 14.81 J/g, respectively. They reported that as wax concentration increased, the crystallization temperature of the oleogels decreased and the melting temperature increased (Öğütcü and Yılmaz, 2014). Carnauba wax oleogel DSC melting profiles was determined onset melting point 60 ◦C and peak point 85◦C (Tabibiazar et al., 2020). The thermal properties of the prepared thyme and cumin-flavored virgin olive oil-sunflower wax oleogels examined. Crystallization onset temperature, peak temperature and crystallization enthalpy was found to be varied in the ranges of 60.55 – 61.37 ◦C, 58.72 – 59.54 ◦C, -11.44 - -8.58 J/g, respectively. Melting onset temperature, peak temperature and melting enthalpy was found to be varied in the ranges of 48.41 – 53.51 ◦C, 62.53 – 62.83 ◦C, 12.73- 13.64 J/g, respectively (Yilmaz and Demirci, 2021).

Table 17. Functional Properties of oils used in the study and oleomargarine produced under optimum conditions

Sample	HO	OO	HOC
Total Phenolic Substance (mg GAE / kg oil)	61.59± 2.20	193.79± 2.20	83.52±1. 48
Sterol (mg β-sitosterol / kg oil)	866.21 ±4.58	1160.60 ±8.02	1052.92± 24.05
Alpha tocopherol (α) (mg/ kg oil)	618.64 ±0.53	171.13± 0.19	616.53±1 .27
Beta tocopherol (β) (mg/ kg oil)	27.61± 0.20	37.43±0. 2	27.14±0. 53
Gamma tocopherol (γ) (mg/ kg oil)	85.89± 0.45	Nd	85.72±0. 08

HO; Hazelnut oil, OO; Olive oil, HOC; Hazelnut oil, Olive oil, Carnauba wax, nd, no detectable

The functional properties of HOC oleomargarine sample and oils were examined the total phenolic substance (mg/kg oil), total sterol (mg/kg oil) and tocopherol (mg/kg oil) content of samples were determined and given in Table 17. Total phenolic content (mg GAE/kg oil) of hazelnut oil, olive oil and HOC samples were as 61.59 mg/kg oil, 193.79 mg/kg oil and 83.52 mg/kg oil, respectively. Being as tocopherols, α, β and γ tocopherol were chromatographically detected and their amounts were calculated. They were in the ranges of 171.13 - 618.64 mg/kg oil, 27.14 - 37.43 mg/kg oil, and nd- 85.89 mg/kg oil, respectively. Total sterol amount was in between 866.21 mg/kg oil to 1160.60 mg/kg oil. It varies depending on the oil type and addition ratios.

4. DISCUSSION AND CONCLUSIONS

Vegetable oils are important due to the nutritional contents like essential fatty acids, bioactive, and fat-soluble vitamins. Additionally they are good energy sources. In recent years, consumers have changed their diet behaviors to healthy, natural and functional foods instead of eating behaviors like meeting some part of nutritional and energy requirements by fats used in the diet and/or fats in the food composition. The worldwide accepted dietary recommendation for health is to reduce the total saturated fat and trans fatty acid intake in the diet.

Solid fats used in the diet; are produced as breakfast, kitchen and food industry margarine according to its usage area. The composition of margarine varies depending on the national standards of the countries and the type of margarine. The ratio of saturated fatty acids in the composition of margarine is considerably higher than vegetable oils.

In this project, it was aimed to produce, optimize and characterize oleomargarine, which does not contain *trans* fat, is low in saturated fat and rich in mono or polyunsaturated fatty acids, by enriching hazelnut oil with natural extra virgin olive oil and gellated using carnauba wax. As the ratio of gelling agent added to the oil mixtures increased, it was determined that the hardness and stickiness and OBC (%) values of oleomargarines increased, while the CFT (min.) value decreased. Color

values varied according to the type of oil used in the production of oleomargarine, and the addition ratio of oil and wax. Type and ratios of added oleogelator were effective on the melting and crystallization temperatures. The acidity and peroxide values of edible oils were within the limits specified by the codex, according to the Turkish Food Codex Communique on Olive Oil and Oils Named by Plants. Oleomargarine is an alternative product to margarine and its acidity value (% oleic acid) is maximum 1.5 and peroxide value (meq O2 /kg of oil) is 5 in the margarine codex values. The fatty acid composition (%) of edible oils and oloemargarine produced from these oil mixtures were found to be rich in mono and polyunsaturated fat content, but low in saturated fat content. When the margarine and oleomargarine samples were compared, the saturated fat content of the margarine sample was found to be considerably higher than the HOC oleomargarine samples. Fatty acid composition, total phenolic substance amounts, sterol (β-sitosterol) and tocopherol compositions of oleomargarines changed depending on the oil addition ratios used in the mixture.

In short, in this study, optimum conditions for oleomargarine production (oil addition ratio 17.27% and wax ratios 9.71%) were determined by using different vegetable oil mixtures and carnauba wax, and it is thought that these basic results will contribute significantly to oleomargarine production and food industry.

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Ethics Committee Approval
N/A

Peer-review
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All authors declare that they have no conflict of interest.

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Length-Weight and Length-Length Relationships and Condition Factor of An Endemic Fish Species (*Capoeta tinca* (Heckel, 1843)) Inhabiting Bayat Pond (Ankara, TÜRKİYE)

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Abstract: The aim of this study is to determine the length-weight relationship, length-length relationship, and Fulton's condition factor (K) of *Capoeta tinca*, which is endemic to Turkey. A total of 52 samples were obtained from Bayat Pond in 2017. The total length (TL) of the samples ranged between 20 and 34 cm. Total weights (W) of they also varied from 85 to 446g. Strong correlations were found between length and weight. In the length-weight relationship equation, a and b were found as 0.0144 and 2.9028, respectively. The b value was not statistically different from 3 (t-test, P>0.05). Therefore, this species showed isometric growth in the Bayat Pond. The value of Fulton's condition factor was 1.0485. Total length - Fork length (FL), Total Length - Standard length (SL) and Fork length - Standard length conversion equations were calculated. There was a high correlation between all length types. In this study, the length-weight relationship, length-length relationship, and Fulton's condition factor values of *Capoeta tinca* inhabiting Bayat Pond were determined for the first time.

Keywords: Anatolian khramulya, condition factor, length-weight relationships, length conversion.

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1. INTRODUCTION

Morphometric data and statistical relationships are widely used in fisheries biology studies (Yılmaz et al., 2007; Bostancı et al., 2014; Yazıcı and Yazıcıoğlu, 2020; Yazıcı et al., 2020; Olentino et al., 2021; Sidiq et al., 2021). Length-weight relationship parameters calculated using morphometric data are important for fish biology and fisheries management (Garcia et al., 1989; Haimovici and Velasco, 2000; Moutopoulos and Stergiou, 2002). Length-weight relationships provide estimation of fish length-to-weight and comparison of fish growth between different regions or localities (Koutrakis and Tsikliras, 2003; Oscoz et al., 2005). Because direct measures of weight can be time-consuming in the field, length-weight regressions have been widely used to estimate weight from length (Sinovčić et al., 2004). In addition, length-weight relationships indicate whether fish growth is isometric or allometric (Le Cren, 1951; Ricker, 1975).

Length-length relationships allow conversion between different length types (Yazıcıoğlu and Yazıcı, 2016). Many studies have used these relationships (Yılmaz et al., 2010; Borah et al., 2018; Biolé et al., 2020). These relationships are very useful for comparing the results of studies using different length types. Condition factor, also known as condition coefficient or length-weight factor, is a parameter that shows the relative fatness of a fish. Changes in condition factors primarily reflect sexual maturity and nutritional level (Le Cren, 1951; Williams, 2000).

Anatolian khramulya, *Capoeta tinca* (Heckel, 1843) belongs to the Cyprinidae family and is an endemic fish species for Turkey (Geldiay and Balık, 2007). According to Turan et al.

(2006) defined the *C. tinca* populations in Sakarya and Kızılırmak as a separate species with the name *Capoeta baliki* based on some morphological characters. However, subsequent molecular studies show that *C. baliki* is not much different from *C. tinca* and remains only a minor synonym (Çiçek et al., 2021). The Sakarya, Kızılırmak, and Çoruh river basins, as well as those streams in the Marmara area that are hydrologically related to the Black Sea, all have significant populations of *C. tinca*. However, it is absent from Thrace and the Mediterranean Basin, which make up Turkey's European region (Erk'akan, 1983). This species, which shows omnivorous feeding characteristics (Geldiay and Balık, 2007), can live in highly polluted rivers and has a wide ecological tolerance (Ekmekçi, 2002). They can easily adapt to stagnant waters, streams, natural lakes, and ponds. Spawning times are between May and June, and males reach reproductive maturity at 2 years old and females at 3 years old (Ekmekçi and Özeren, 2003).

There are many studies on *C. tinca* in different habitats (Gül and Yılmaz, 2002; Yılmaz and Polat, 2009; Birecikligil et al., 2016; Buhan et al., 2016). However, there is no research specific to the Bayat Pond. In addition, since the species is endemic to Turkey, its biological information is very valuable. Therefore, in this study, it was aimed to determine the length-weight and length-length relations and condition factor values of *C. tinca*.

2. MATERIAL AND METHOD

Bayat Pond, located within the borders of the Ayaş district of Ankara (Turkey) province, was built to meet the irrigation needs of the village of Bayat (Bayar, 2019). It is located in the north of the Asartepe Dam, which is the largest dam in the district, and its bird-fly distance is 19200 meters (Nazır, 2020).

A total of 52 *C. tinca* were obtained from local fishermen carrying out commercial activities in Bayat Pond in 2017. The total length (TL), fork length (FL) and standard length (SL) of the fish were measured with an accuracy of 0.01 cm and their weights were weighed with an accuracy of 0.1 g.

$W = a \times L^b$ equation was used to calculate the length-weight relationship (Ricker, 1975). In the equation, W is body weight (g), L is length (cm), a is the point where the curve that determines the length-weight relationship intersects the y-axis and b is the slope of the curve that determines the length-weight relationship. The a and b parameters of the length-weight relationship were estimated by transforming the equation into linear regression of the form Log W = Log a + b Log L. Whether the b parameter is different from isometric growth (b= 3) in the length-weight relationship was tested with the t-test (Zar, 1999).

The following equation was used to calculate the condition factor (Ricker, 1975).

$$K = \frac{W}{L^3} \times 100$$

Here, K = Fulton's condition factor, W = fish weight (g), and L= fish length (cm).

In order to compare the measured total, fork and standard length data with the length values in other studies, the total length-fork length, total length-standard length and fork length-standard length relations were revealed. Length-length relationships were calculated using linear regression analysis (Zar, 1999).

3. RESULTS

The average total, fork and standard length values of *C. tinca* samples obtained from Bayat Pond are 26.97 cm, 24.88 cm, and 22.73 cm, respectively. The average weight value is 211.3 g and ranges between 85 and 446 g (Table 1). The female: male ratio could not be determined due to the large number of specimens whose sex could not be determined, and all analyzes were made by considering female, male and undefined specimens.

Table 1. Descriptive statistics of length and weight of *C. tinca* specimens living in Bayat Pond.

Variable	N	Average	Min	Max	Se	Sd
Weight (g)	52	211.3	85.00	446.00	9.40	67.81
Total Length-TL (cm)		26.97	20.00	34.00	0.37	2.67
Fork Length-FL (cm)		24.88	18.50	32.00	0.34	2.51
Standard Length-SL (cm)		22.73	17.00	29.50	0.31	2.24

N: Sample count, **Min:** Minimum, **Mak:** Maximum, **Se:** Standard error, **Sd:** Standard deviation

The length-weight relationship equation was determined as $W = 0.0144*TL^{2.9028}$ and the r^2 value was determined as 0.91. It was determined that the b value was not different from the 3 representing isometric growth (t test: P>0.05, 95% confidence interval of b value was 2.627-3.179). According to this result, the species grows isometrically in Bayat Pond (Figure 1).

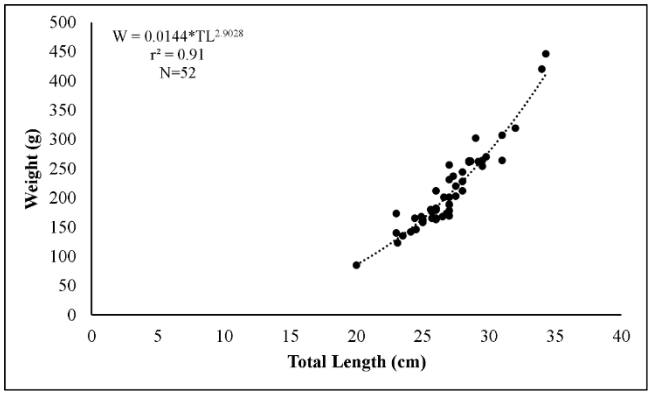

Figure 1. The length-weight relationship of *C. tinca* living in Bayat Pond.

The average condition factor of *C. tinca* was 1.0485. While the minimum condition value in the sample is 0.0859, the maximum condition value is 1.4219. According to the descriptive statistical data of the condition factor, the standard error was calculated as 0.0145 and the standard deviation as 0.1044.

Length-length relationships of the species were subjected to linear regression and the equations and values obtained are presented in Table 2.

Table 2. Length transformations of *C. tinca* population in Bayat Pond.

Equation	a	b	r^2
TL= a + bFL	1.276	1.033	0.944
TL= a + bSL	0.779	1.152	0.935
FL= a + bSL	-0.053	1.097	0.958

While the strongest relationship was found between fork length and standard length (Figure 2), the lowest relationship was determined between total length and standard length (Figure 3). Strong relationships were also detected between total length and fork length (Figure 4), and there was high agreement between the length types in general.

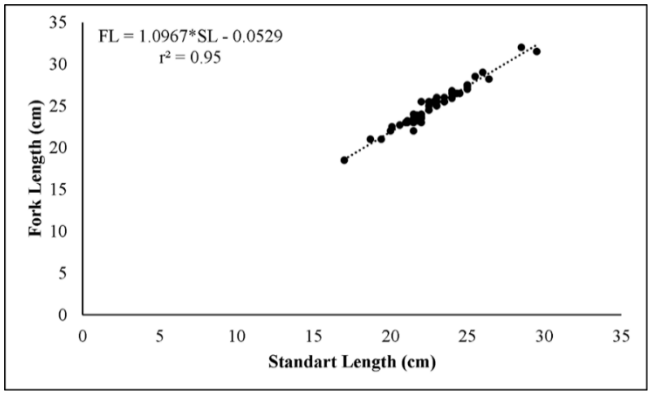

Figure 2. The fork length-standard length relationship of *C. tinca*

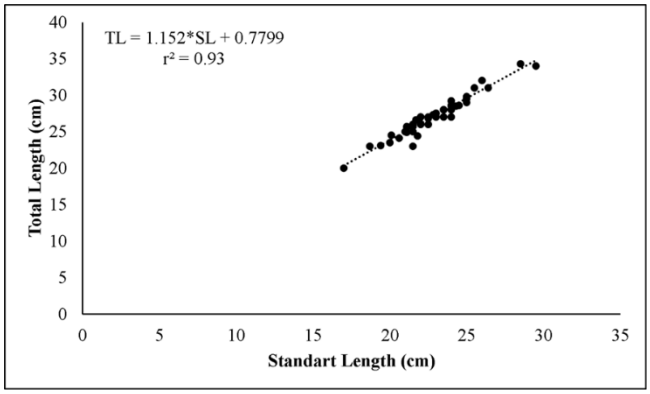

Figure 3. The total length-standard length relationship of *C. tinca*

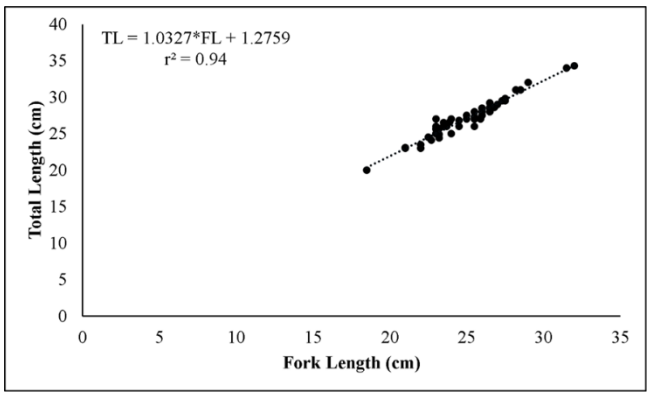

Figure 4. The total length-fork length relationship of *C. tinca*

DISCUSSION AND CONCLUSIONS

This study provides length-weight and length-length relations and condition factor values for *C. tinca* living in Bayat Pond.

In fish, weight is related to neck strength. In other words, weight gain in fish is expressed as a neck force. The "a" value in the length-weight relationship equation in fish shows the average condition of the individuals, while the "b" value shows the shape of the fish according to the conditions it is in. This value varies between 2.5 and 3.5 in different species (Erkoyuncu, 1995). On the other hand, it is known that the b value in fish varies between 2 and 4 (Bagenal and Tesch, 1978). In a fish population, if b=3, isometric growth, if b value is greater than 3, positive allometric growth is mentioned, and if it is small, negative allometric growth is mentioned (Ricker, 1975; Avşar, 2005). The b value obtained in this study was not statistically different from 3. This result shows that the species has isometric growth in Bayat Pond. The findings obtained from the studies on *C. tinca* are presented in Table 3.

Table 3. Length-weight relationship parameters obtained in different studies on *C. tinca*.

References	Location	Sex	a	b	r^2
Gül and Yılmaz, (2002)	Delice River	C	0.000039	2.811	-
Yılmaz and Polat, (2009)	Çakmak Dam Lake	C	0.0091	3.119	0.98
	Derbent Dam Lake	C	0.0043	3.352	0.97
	Divanbaşı Pond	C	0.0106	3.089	0.99
	Gamlık Stream	C	0.0213	2.828	0.99
	İstavloz Stream	C	0.0212	2.849	0.99
	Kızılırmak River (Samsun)	C	0.0075	3.207	0.99
	Küplüağzı Stream	C	0.0173	2.860	0.98
	Mertırmagı Stream	C	0.0212	2.819	0.97
	Tersakan Stream	C	0.0092	3.136	0.99
	Yakakent Stream	C	0.0434	2.544	0.97
Gaygusuz et al., (2013) *	Porsuk Stream	C	0.009	3.017	0.98
Kahraman et al., (2014) *	Sakarya River	C	0.0408	2.634	0.81
Birecikligil et al., (2016)	Kızılırmak River (Nevşehir)	C	0.017	2.839	0.95
Buhan et al., (2016)	Almus Dam Lake	C	0.0057	3.174	0.98
Zencir and Korkmaz, (2016) *	Sakarya River	C	0.019	2.855	0.95
Emiroğlu et al., (2020)	Seydisuyu and Porsuk Stream	C	-	2.943	0.98
This study	Bayat Pond	C	0.0144	2.903	0.91
C: Combined sex, *: *Capoeta baliki*					

Although the obtained length-weight relationship parameters overlap with many studies in other habitats, there are some differences (Table 3). It is thought that these differences are caused by the number of samples, length-weight distributions, sampling time, size type used and ecological conditions of the environments. As a matter of fact, length-weight relationship parameters in fish are not constant and may vary depending on factors such as nutritional adequacy, feeding rate, gonad development and breeding period (Bagenal and Tesch, 1978). In addition, considering the parameters a, it can be said that the species grows better in Bayat Pond compared to many other habitats.

In this study was found that the average condition factor of *C. tinca* was 1.0485 in Bayat Pond. The average condition factors of this species in other studies were reported as 1.4179 by Gül and Yılmaz (2002) in Delice River, 1.3126 by Dirican and Çilek (2012) in Çamlıgöze Dam Lake, 1.1375 by Dirican et al. (2012) in Kılıçkaya Reservoir and 0.96 by Birecikligil et al. (2016) in the Nevşehir region of the Kızılırmak River. Although the condition values of *Capoeta tinca* living in Bayat Pond are lower than the populations of Delice River, Çamlıgöze Dam Lake and Kılıçkaya Reservoir, they are higher than their congeners in the Nevşehir region of Kızılırmak River. These differences are natural because the condition factor reflects changes in gonad development and nutritional level in fish (Wootton, 1990) and differs depending on habitat, year, season, age group, sex, sexual maturity, and breeding period (Erkoyuncu, 1995).

In this study, the relations between the different length types of the species were determined, and the conversion between the length types was ensured. When we look at the literature, some studies on the species have presented length conversion equations and high correlation coefficients have been obtained (Birecikligil et al., 2016; Zencir and Korkmaz, 2016; Emiroğlu et al., 2020). The preference of various length measurements in different studies makes comparisons and interpretation of results difficult. For these reasons, it is very important to present the length conversion equations in the research.

In conclusion, it can be said that *C. tinca* grows isometrically in Bayat Pond and its condition is generally low compared to other habitats. In addition, information about the biology of endemic fish species is very valuable. Because determining effective fishing policies and obtaining information about the future of the species is only possible by correctly determining their biology.

Ethics Committee Approval

Ethics committee approval is not required as fish samples are purchased from commercial fishermen. In addition, animal rights and ethical rules were followed in laboratory processes and no experimental application was made.

Author Contributions

Laboratory processes and data acquisition: Ö. S.; Calculating from data and designing the article: R. Y; Other: All authors have read and agreed to the published version of manuscript.

Conflict of Interest

The authors have no conflicts of interest to declare.

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The Invasive Zebra Mussel (*Dreissena polymorpha*) Literature Review and Density Reduction Synthesis

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Abstract: In this study, the impacts of zebra mussels on aquatic communities biology, ecology, natural enemies of the zebra mussel, effects on the ecosystems, etc. were evaluated based on the international scientific literature. In the last 30 years, zebra mussel studies have been focused on their distribution, environmental interactions, and harms in different aquatic ecosystems. With this review study, a synthesis was made from studies on zebra mussels that cause damage to many aquatic ecosystems around the world, and the hypothesis for their reduction in the ecosystem was put forward. As a result of this hypothesis, suggestions such as joining the pieces of a puzzle are presented in the last part of the review. With the implementation of the suggestions given as a result of the study, it will be possible to make a great contribution to the economies of the countries by reducing the zebra mussel, which causes a billion dollars of economic damage in aquatic ecosystems. In this context, freshwater lake, which is the most intense in America, and freshwater lake in a similar ecosystem which is rarely seen in Anatolia in Eurasia, should be studied simultaneously. As a result, by preventing the reproduction of the species causing problems in many aquatic ecosystems in the world, a great distance will be covered in terms of protecting water resources for the coming years.

Keywords: Freshwater mussel, invasive, aquatic ecosystem, Asia, Europe, America.

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1. INTRODUCTION

A biological invasion consists of a species acquiring a competitive advantage following the disappearance of natural obstacles to its proliferation, allowing it to spread rapidly and conquer novel areas within recipient ecosystems in which it becomes a dominant population (Elton 1958). Invasions have stages and there are physical or biological barriers to move from one stage to the next. Biological invasion usually consists of four stages: transportation, promotion, establishment, and expansion. These stages are separated by biological (based on the occupant's physiological or ecological characteristics) or physical boundaries (Blackburn et al. 2011). Another important concept related to biological invasions is based on how they reached a specific place. Biological invasion can be natural or artificial. Natural invasions are mostly caused by the changing geological conditions of the world. Barriers that prevent the movement of large-scale species such as oceans, mountains, rivers can be changed over time by natural processes. However, artificial effects are more unpredictable. Entries can be intentional or accidental (Blackburn et al. 2011). Also, most of economic and industrial actions have completely impact on nature. Water and aquatic ecosystems, which are important life supporters, are exposed to different environmental effects caused by human activities in the water (Selamoğlu 2021a,b). This review study synthesizes the studies on the zebra mussel, which causes destruction in many aquatic ecosystems in the world, and presents a hypothesis for its reduction in the ecosystem.

1.1. Literature review

Zebra mussels (*Dreissena polymorpha*) are probably one of the most famous and known invasive species on the planet. Economic and environmental issues related to zebra mussels became more recognizable in the scientific and

public areas after reaching the Great Lakes. Their enormous economic costs and the serious environmental changes they cause have made them a serious problem. *Dreissena polymorpha* are bivalve freshwater molluscs native to the lakes of South Russia (Kanmaz 2015). They are typical members of the Dreissenidae family that have been on earth for 230 million years just before Trias. They were described by German zoologist Peter Simon Pallas in 1771, but samples were collected from the bottom floor of the Ural River in 1769. Southern Russia is their natural habitat.

The name "Zebra mussel" comes from non-universal striped shell patterns that are common for all members of the species (Kanmaz 2015). Zebra mussels follow external fertilization and embryology. A female individual can produce 30000 – 40000 eggs in a reproductive cycle (Ackerman et al. 1994). The planktonic developmental stage of this species depends on the water temperature and the amount of food. At the end of this period, which takes 3-5 weeks, their sizes reach up to 220 µm (Neumann and Jenner 1992). The most important reason for the rapid spread of the zebra mussel is that its females can produce 1 million eggs in one breeding season. It is adhering to a wide variety of hard surfaces with grabbing strands and its biomass can exceed 10 kg per m^2 (Astanei et al. 2005).

In many inland water ecosystems in Turkey (Terkos, Sapanca, Acarlar, Poyrazlar, Akgöl, Taşkısığı, Bafa, Eğirdir, Kovada, Beyşehir, Burdur and Yarışlı lakes; Hirfanlı, Kesikli, Kapulukaya, Derbent, Keban, Karakaya, Atatürk, Birecik, Karkamış, Seyhan, Aslantaş, Gazibey, İkizcetepeler, Atıkhisar, Bolu Gölköy dam lakes) zebra mussels were distributed (Özen 2017). Also, in Turkey, the reproductive biology of *D. polymorpha* was studied between March 1995 and November 1995 by taking monthly samples in the fishing area of Eğirdir Lake Bridge. Reproduction was reported to occur most intensely in July and August. The number of individuals belonging to the *D. polymorpha* population was calculated as 83.33-2541.66 per square meter. The average height of them varied between 1.51 ± 0.80 mm and 9.00 ± 2.98 mm (Bayhan 1996). The average adult individual density in Eğirdir Lake is calculated as 1985 individual / m^2. The average adult individual biome according to dry weight is 321.179 g / m^2. These values are lower than the results of many studies conducted in Europe. The average density of veliger larvae for all the lake is 97.707 individuals / m^3 (Koç 2009). Aksoylar and Ertan (2002) found the average density of *D. polymorpha* veliger larvae in Lake Eğirdir as 3.103 individuals / m^3. In the study conducted in the same lake in 2016, the average densities of mature *Dreissena* were calculated as 12.782 individuals / m^2 in Hoyran region, 1.683 individuals / m^2 in Kayaağzı region, 5.247 individuals / m^2 in Barla region, 6.171 individuals / m^2 in Köprü region, 6.039 individuals / m^2 in Gelendost region. The average of all stations is reported to be 7.511 individuals / m^2 (Erbatur et al. 2017). The fact that Kayaağzı is the narrowest part of the lake in the north-south direction of Lake Eğirdir and where continuous wind and wave movements are most intense, it is likely to affect the distribution of this species in this region (Figure 1) (Apaydın Yağcı et al. 2020).

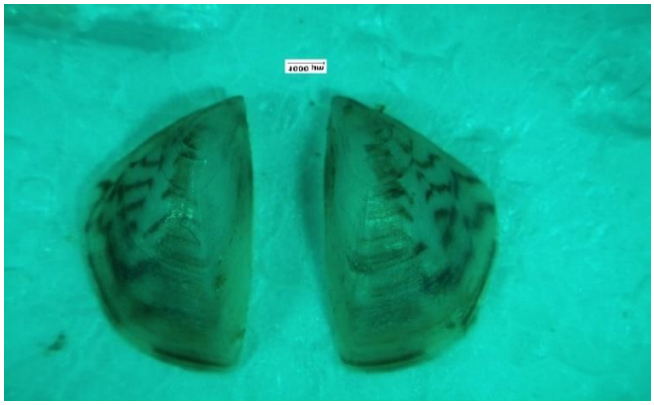

Figure 1. *Dreissena polymorpha* from Lake Eğirdir-Turkey (Apaydın Yağcı et al. 2020)

Grigorovich and Shevtsova (1995) calculated the adult *Dreissena* density as 20300 individuals / m^2 and their biomass as 4000 g / m^2 in their study in Kakhovka Canal in Canada. A negative relationship has been found between the Dreissenid biomass and the zooplankton biomass in the same study. Furthermore, in the bridge station of Eğirdir Lake, Turkey, it was investigated on seasonal variation of the chemical compositions of *Dreissena polymorpha* from bivalve molluscs. Samples were collected seasonally between November 1990 and August 1991. In *D. polymorpha* meat, moisture is 85.3%, dry matter is 14.7%, crude protein is 63.0%, crude oil is 9.2%, crude ash is 15.8%, carbon hydrate is 12.0%, calcium from mineral substances is 14, 80 mg / gr, magnesium 0,14 mg / gr. The energy level was found to be 4.9 kcal/gr in *D. polymorpha* meat (Arık 1992).

Zebra mussels show nutrition by filtering. They consume algae by filtering the water with their siphons. Due to their sessile structure, they need water flow for this process. This is the reason why they prefer to foul pipes with a steady flow of water (Kanmaz 2015). They are monotypic colonists and are extremely successful in attaching to almost every possible surface using their byssus, which is a rare feature for a freshwater bivalve. These surfaces can be natural or artificial. Another organism and even the shells of each other are possible options for them. After the zebra mussel hangs on, it begins to erode the surface and deteriorate its integrity. It stays where it hangs on during its 3-9 years of life. If there is no hard surface to hang on, they form a cluster and hang on top of each other. They also get attached to macro invertebrates during periods of excessive alluviation and fluctuations (Kanmaz 2015). Temperature; According to Zmis (2001), feeding rates decrease after 20 ºC, the best development starts between 18-20 ºC and the ovulation period starts between 8–12 ºC. PH: The pH threshold required for the survival of adults is given as 6.5, and it is recorded that the pH varies between 7.7 and 8.5 in lakes where zebra mussel lives in Europe (Claudi and Mackie 1994; Zmis 2001). The feeding rate increases as the algae rate in seston increases. The development of zebra mussel is related to nutritional quality, not seston concentration (Schneider et al. 1998). Oxygen; In studies conducted in Europe, it has been noted that zebra mussel

adults can live in waters with oxygen levels of 0.1–13.3 mg / l, but the potential for mussels to be low in oxygen at less than 4.5 mg /l. Salinity; It is noted that zebra mussel is a freshwater creature but can live in waters with salinity 5‰. Chlorophyll-a; Feeding effect of zebra mussel on phytoplankton causes a decrease in chlorophyll-a amount (Altınyar et al. 2001). The flow rate of water; Young mussels (juveniles) hang on and settle in pipes or underwater areas where the flow velocity is less than 1.5 m / s (Zmis 2001).

As a result of the salinity of Bafa Lake, which was 4 ‰ in previous years, increased to 14 ‰ in recent years, it was noted that there is no zebra mussel in the lake (Altınyar et al. 2001). The history of zebra mussel infestations dates back to the eighteenth century. The underlying reason for their rapid invasion is the construction of artificial watercourses connecting the European rivers. The ships carried them to ballast tanks and hulls. In 1794, zebra mussel was observed in Hungary by the German Zoologist Grossinger. Their presence in the UK and Ireland was documented in the 1820s. *D. polymorpha* was first recorded in The Netherlands in 1827 (Van Benthem Jutting 1954). They reached Sweden in the 1920s (Benson et al. 2020; Kanmaz 2015). In 1988, they were discovered at Lake Claire at first, but further reviews showed that the estimated first entry date was 1986. It was the beginning of the zebra mussel infestation in North America. They are thought to be transported by ships. It was discovered in the eastern basin of Lake Erie in 1988, and only a year later they occupied the entire lake. In the following years, the Great Lakes were completely occupied. Zebra mussel was spotted from Lake Michigan in 1992. Today, zebra mussel infestation still continues despite all measures (Holland 1993). In Ireland, it is believed that the first introduction of the zebra mussel took place in the lower Shannon system in 1994 (Lucy 2010). The *D.poymorpha* species spread from the natural distribution in the Pontacaspian region and entered Eurasia and North America (Stepien et al. 2013; Yoo et al. 2014). Zebra mussel is an important part of this loss of biodiversity in the Great Lakes. (Ricciardi et al. 1998). In Turkey in 2015, North America's invasion of zebra mussels in the Great Lakes, was modeled using individual-based modeling methods (Kanmaz 2015). The nutritional activity of *Dreissena*; turbidity is limited by algae rate, feces, and pseudofeces production. As the concentration of the spherical single cell *Chlamydomonas reinhardtii* with a diameter of 7.4 µs increases, the turbidity decreases, while the Pandorina increases the purples, the turbidity increases. As the concentration of *C. reinhardtii* increases, larger mussels are seen rather than small mussels. It immediately extracts microcystis and other blue-green algae as pseudofeces. *Microcystis* becomes more prevalent in zones with low nutrients due to zebra mussel infestations.

1.2. Natural enemies of zebra mussels

The natural enemies of *D. polymorpha* are predators, parasites, birds, and benthic organisms such as crayfish and crab, (Molloy et al. 1997; Altınyar et al. 2001). *Abramis bjoerkna, Alburnus alburnus, Atherina boyeri, Barbus capito pectoralis, Carasobarbus luteus, Cyprinus carpio, Esox lucius, Oncorhynchus mykiss, Scardinus erythohthalmus, Stizostedion lucioperca,* and *Tinca tinca* are predators fish fed on juvenile or adult *D. polymorpha* (Molloy et al. 1997 and references therein; Altınyar et al. 2001). It was stated that rockfish is an important consumer of zebra mussels and the fishing pressure of these fish might have a significant impact on populations of this species in ecosystems with a lot of zebra mussels (Gaygusuz et al. 2007). Tufted Duck and Pochard feed almost exclusively on zebra mussels, whereas Coot and Goldeneye consume them as main and supplementary food (Suter 1982 a,b). Fishing rates of Tufted Duck have been determined to decrease depending on the water depth in Belgium (Draulans 1982). The size of the zebra mussels also should take into account for feeding preferences of birds. For example, Greater and Lesser Scaup in Lake Erie preferred zebra mussels 11 to 13 mm in length (Hamilton et al. 1994), while scaup (primarily Lesser Scaup) in Lake Michigan preferred zebra mussels 4 mm in length.

Crustaceans feed on a different stage of zebra mussels. The predatory copepod *Mesocyclops* may feed on planktonic larvae of *D. polymorpha* (Karabin 1978). In addition to this, *Dreissena* larvae are especially vulnerable to predation by calanoid copepods until the development of their first D-stage Shell (Liebig and Vanderploeg 1995). For example, it was reported that the abundance of *D.polymorpha* was low in Lake Eğirdir due to the abundance of, *Mesocylops leuckarti* during the year (Apaydın Yağcı et al. 2014a). Benthic organisms are also important predators of zebra mussels. Cage experiments in the Hudson River commit that blue crabs could be more effective in reducing zebra mussel abundance than either local fish or invertebrate predators (Molloy et al. 1997).

Malinowskaya, (1976) surveyed that in the Kyshunskoe Reservoir (Kazakhstan) zebra mussels were a predominant food item for *Astacus leptodactylus* females, whereas males ate mainly vegetation. It was determined that coelenterates, turtles, rodents, and annelids species feed on zebra mussel in various water systems (Conn and Conn 1993; Serrouya et al. 1995; Bedulli and Franchini 1978; Smit et al. 1993). Moreover, the recent increase of the crayfish population in Lake Eğirdir may derive from feeding regime of crayfish based on zebra mussel. However, some researchers claimed that zebra mussels present crayfish a with very good camouflage ability to protect them from predators in addition to a potential food relationship (Cilbiz et al. 2019). However, so many different organisms were reported in the mantle cavity of mussels. It is known that some of the host-specific ciliates *(Conchopbthirus acuminatus, C. klimentinus, Hypocomagalma dreissenae, Sphenophrya dreissenae,* and *S. naumiand)* are in the mantle cavity of *D. polymorpha* Also, it has been reported that Ciliates in the families Ophryoglenidae, Ancistridae, Scuticociliatida, and Rhynchodida live in the mantle cavity of zebra mussels (Molloy et al. 1997). Zebra mussels can be to serve as the first intermediate host (e.g., *Bucephaluspolymorphus* and *Phyllodistomum* spp.), second intermediate host (e.g., *Echinoparyphium recurvatuni),* or the only host *(Aspidogaster* spp.). Besides, it was reported that Ascetosporans, Bacteria, Nematodes, Oligochaetes,

Leeches, Chironomids, and Mites species are in the mantle cavity of *D. polymorpha* (Molloy et al. 1997).

The trophic state of the lakes also impact the increase of zebra mussels. They mostly reported from mesotrophic lakes and, eutrophication causes a reduction in zebra mussels population. (Stánczykowska and Lewandowski 1992). It also has been noted that turbidity negatively affects the feeding of mussels and the ability to filter decreases as turbidity increases (Claudi and Mackie 1994). In addition, It has been reported that the Zebra mussel changes as to some water quality parameters (secchi disc, chlorophyll, and phosphorus) in the ecosystem, and also bioenergetic application has been reported with the ingestion of algae in the environment by zebra mussel. (Madenjian 1995). In Karacaören I Dam Lake, Turkey, it has been reported that a small number of *D. polymorpha* veliger larvae were encountered, and also it has been reported to adversely affect the larval population because the water level is falling rapidly and the very narrow littoral zone (Gülle 2005).

1.3. Environmental and economical impacts of zebra mussels

Feeding filter zebra mussels increase the clarity of the water by filtering and removing the both organic and inorganic particles in the water. In Lake Oneida, after the zebra mussel infestation in 1991, an average increase in water clarity occurred. After the zebra mussel infestation in the lake, there was a 23% increase in light transmittance. The maximum spreading depth of the macrophytes was measured by the divers by hydroacoustic methods and was found as 3.0 m before the zebra mussel infestation, and then 5.1 m (Zhu et al. 2006).

The clarity in large lakes allows the light to flow deeper, thereby providing more benthic photosynthesis. These changes in light positively affect the composition and distribution of the aquatic macrophyte and algae communities. On the other hand, dreissenid mussels facilitate the transportation of plants to nutrients. The development of aquatic macrophytes mostly depends on the phosphorus and other nutrients in the sediment. The mussels carry nitrogen and phosphorus along with the particles from the water column to the sediment through defecation (Zhu et al. 2006). It is reported that benthic production increases in lakes after the invasion of *D. polymorpha*, which affects the food chain (Jaeger 2006). Zebra mussel infestation also affects the zooplankton community. Zebra mussels can absorb microzooplankton, such as veliger and rotifer, but cannot absorb mesozooplankton (0.2-20mm). After the invasion of Lake Erie, the abundance of zooplankton decreased by 55%. Microzooplankton was particularly affected by this. Both large-bodied zooplankton and microzooplankton were affected by 70% reduction in the Hudson River (Benson et al., 2020). Since *Cryptomonas erosa* and *Nannochloropsis limnetica* algae are high quality foods rich in PUFA, they have positive effects on the reproductive success of zebra mussel (Wacker and Elert 2003).

The change in the food chain will also affect the fish. Increasing competition will cause a reduction in the zooplankton biomass, and thus decrease of planktivorous fish biomass will occur. Fish larvae, which fed with microzooplankton, will be more exposed to the negative effects of zebra mussel infestation. Fish that fed on benthic can benefit from this in contrast with planktivorous fish. Changes in the diet of pelagic fish can be seen. Also, the reproduction of macrophytes can change the habitat of the fish. Experiments have shown that zebra mussels negatively affect the development of fish larvae due to their food chain interactions (Benson et al. 2020). It was determined that the primary negative effect of dreissenides on zooplankton was consuming small-bodied zooplankton as feed, the secondary negative effect was consuming food sources of zooplankton, and the third negative effect was decreasing benthic oxygen (Grigorovich and Shevtsova 1995). In open waters, Zebra mussels hang on clams, preventing the functioning of the valve, pressing on the siphon, partnering with the food, limiting its movement and metabolic residues. It eliminates the host with negative effects in the form of evacuation (Benson et al. 2020). The Zebra mussel is a notorious organism due to its biofouling effect (Yıldırım et al. 1996). It causes problems such as blocking the water flow by filling the pipes with the cluster formed on the surface it hangs on, preventing the corrosion of the boats, blocking the water filters, preventing the healthy operation of the boats by entering the engine parts, raising the balance of the boats by clinging to the spine of the boats, increasing the friction coefficient, restricting the life of other creatures naturally found in the aquatic ecosystem. opening it causes both economic and ecological problems (Bobat et al. 2004; Aksu and Yıldız 2017). It settles in pipes in hydroelectric and nuclear power plants. In these systems, they can stop the flow of water by blocking the inside of the pipes. (Benson 2020). It was found that mussels belonging to *Dreissena* were excessively reproduced in lakes and trout breeding farms in lattice nets and ropes attached to them, and they caused problems in cleaning the nets for fishermen (Öktener 2004). It settles in the cooling systems of boat engines, causing overheating and damage to the engine. Intense contamination occurs in transportation buoys and many of them become unusable (Altınyar et al. 2001). Mussel problem in Turkey was reported to occur in the Kovada I Hydroelectric power plant for the first time in 1964. Then, it was recorded that the tunnel and penstock pipes of the Kovada II Hydroelectric Power Plant were covered with mussels and thus the flow rate decreased (Anonymous 1969). It was reported that the damages caused by mussel; the in water transmission facilities are hundreds millions of dollars, in power plants in the period 1993-1999 are $ 3.2 billion in the USA and Canada, in industrial plants and workplaces are 5 billion dollars, and in power stations is 375,000 dollars for each station(Altınyar et al. 2001).

Also, bird botulism is another consequence of zebra mussel infestation. Because of the toxic substances, they accumulated through filtering, they caused thousands of bird deaths fed on them. They can reach any place containing water in the larval stage. For example, pipes create substrates that are quite suitable for them. They continue to colonize until a pipe is partially or completely

blocked. For this reason, one of the most typical damages they cause is to supply pipes and power generation stations that supply drinking and processing water to cities and industrial facilities. Zebra mussels also have an impact on ships and docks. They increase the drag by being attached to the hulls of the ships. It increases fuel consumption. In the United States, zebra mussels cost $ 500 million annually to industrial establishments that consume water (Kanmaz 2015). It is noted that zebra mussel communities in the western part of Lake Erie filter the entire body of water once a week. As a result, suspended solids accumulate at the bottom by filtration and their water qualities improve. Therefore, mussels are used in Russia and the Netherlands to clean contaminated water bodies (Neumann and Jenner 1992). It is reported that zebra mussel has a bioindicator feature and it can be understood by looking at the shell composition whether there are any toxic substances in water (Bartram and Balance 1996).

1.4. Ecological competitors of zebra mussels

Different organisms were reported as ecological competitors of zebra mussels in the literature such as sponges, amphipods, and bivalves. Sponges; Zhadin (1946) also stated the ability of sponges to compete successfully against zebra mussels in Lake Balaton. Amphipods; The presence of *Dreissena* in rocks increases the amphipod density (Quin 2007). Zebra mussels have been reported to be rare in areas where the *Corophium curvispinum* population (Lake Balaton and Lower Rhine) is located. Also, *C. curvispinum* became the most dominant macroinvertebrate species, and densities of zebra mussels were dramatically reduced in Dutch Rhine (Molloy et al. 1997). Sebestyen (1937) indicated that the establishment of this amphipod in Lake Balaton is facilitated by the appropriate substrate offered by countless crevices in mussel colonies, and the population is dense, zebra mussels are rare. It is stated that *C. curvispinum* species from Malacostraca group is very abundant in the Black Sea and the Caspian Sea, and it is likely that it has arrived at Anatolia through large rivers such as Sakarya, Kızılırmak, and Yeşilırmak. It was stated that the *C. curvispinum* species, which was first registered from Egirdir Lake in 2003, could be a Tethys Searemnant (Özbek 2003). Significant reductions in *D. polymorpha* species populations have been reported in areas where the pollution-tolerant *C. curvispinum* species are found. In the studies carried out in the lake before the 2000s, *C. curvispinum* species was not reported and *D. polymorpha* species was observed abundantly in Eğirdir Lake during these periods. Although the *C. curvispinum* species was found in all stations in Barla station especially in Eğirdir Lake in 2010, the rare occurrence of *D. polymorpha* species is supported by the literature. *C. curvispinum* species Eğirdir Lake played an active role for zoobenthic fauna (Apaydın Yağcı et al. 2013; Apaydın Yağcı et al. 2014b). Bivalves; Some bivalve species (for example, when *Mytilaster lineatus* was found in the Caspian Sea, Mediterranean, Black, and Azov Sea in the 20th Century, the density of the *Dreissena andrusovi* species in the Caspian Sea decreased (Starobogatov and Andreeva 1994). In the Great Lakes (in the Great Lakes *Dreissena bugensis* is expanding in areas where *D. polymorpha* is dominant (Molloy et al. 1997).

Macrophytes; It is stated that zebra mussels colonies decrease in the areas where *Cladophora* is located (Sebestyen 1937). At the same time, it was stated that there are no *zebra mussels* colonies in the stone fragments covered with macroalgae in the Rhine and Meuse Rivers (Smit et al. 1993). In the St. Lawrance River (New York) adult zebra mussels have been reported to be killed by the Bryozoan *Pectinatella magnifica* species (Conn and Conn 1993).

Parasite; Only one parasite, trematode *Bucephalus polymorphus*, is well documented to be seriously debilitating to zebra mussels in Europe. However, the freshwater trematodes in the Bucephalidae (e.g., *Bucephalus*) and Gorgoderidae (e.g., *Phyllodistomum*) have been demonstrated as parasites in the North American fauna. Efficiency in reducing *Dreissena* density consistently over the long term has not yet been demonstrated. As in Europe, there will be the cumulative effect of a group of enemies that have a continuous but limited role in suppressing zebra mussel populations in the future (Molloy et al. 1997).

2. Conclusion and future prospectus

In Europe and the former Soviet Union, there is a long tradition of *D.polymorpha* work, where it has been around for 150 years. The ecosystem and community level effects of *D.polymorpha* are reported in the literature in Lake Erie, Saginaw Bay, Hudson River, and Oneida Lake (Benson et al. 2020). Considering the last 25 years in Eğirdir Lake (Turkey), it has been observed that the *D.polymorpha* has increased 3 times in the period from the past to 2016. According to the international records, the density is 10 times lower compared to Eğirdir Lake. Strayer et al. (2019) analyzed 67 long-term data sets from 50 different studies in Europe and North America with joint researchers. The results of the study expressed the importance of understanding Dreissenid mussels long-term population dynamics and mechanism. In addition, understanding the dynamics in the Freshwater ecosystem has been stated as the most important indicator in controlling zebra mussels (Strayer et al. 2019). Considering the studies conducted with *Dreissena* from past to present, the following 13 items conclusions can be made.

a) With the invasion of *Dreissena*, light transmittance, macrophyte, and benthic production increase.
b) Algae bursts may occur because the zebra mussel does not use some algae in phytoplankton.
c) Zebra mussel invasion is effective in reducing zooplankton.
d) Some fish, crayfish, crab, birds feed on zebra mussels.
e) *Mesocyclops leuckarti*, which is Zooplankton, consumes the zebra mussel.
f) Zebra mussel has water cleaning feature.
g) When birds consume zebra mussels, mussels may be toxic in dense areas.
h) The development of fish larvae is negatively affected when the zebra mussel limits the life of the fish larvae.

i) The *C.curvispinum* species was not found intensely in environments where *D.polymorpha* is present.
j) *C.curvispinum* plays an active role in fauna in the ecosystem.
k) In areas with *Cladophora*, Bryozoan, and some Bivalve species, *D.polymorpha* is scarce.
l) In the ecosystem with Trematode *Bucephalus polymorphus* parasite, *D.polymorpha* invasion is less.
m) In the ecosystem where *D.polymorpha* is located, other dominant *Daphnia* species replace the existing *Daphni*a species.

According to the above-mentioned statements, it has been observed that more than one living group is effective in the absence of *Dreissena*, which creates a big problem in the waters (See the above section d, e, i, k, l).

We can piece together the puzzle by using the findings of the related literature. How can we achieve this. In order to end the *Dreissena* invasion in the ecosystem, we have to work compulsory for 3 year on a monthly basis, in the simultaneous periods of *Dreissena*'s low water body and the intense aquatic ecosystem. In the ecosystem, we can see which species *Dreissena* interacts within approximately 30 years of studies. It will guide us to find the most important factor in the increase of this creature as a result of 3 year monitoring of all parameters of the two lakes in the ecosystem (water quality, plankton, benthic organisms, fish fauna, birds, other invertebrates, fish stomach content studies, etc.). At different times, plankton, water quality, parasite, etc. studies have been done so far. The simultaneous study of two different lakes, which is the last study not done with a holistic approach, maybe the most important key in achieving the result. It is an undeniable fact to carry out this study to protect the water and aquatic ecosystems that may be the most important problem of the future, to manage them properly, and to meet the needs of people from these areas in the future.

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Yazar rehberi

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Dipnotlar: Metin içerisinde dipnotlardan olabildiğince kaçınılmalıdır. Çizelge ve şekillerde ise gerekli olması halinde ilgili objenin altında yer almalıdır.

Semboller ve kısaltmalar: Birim sembolleri Uluslararası Birimler Sistemine (The International System of Units; SI) göre olmalıdır.

Kaynaklar: Metin içinde geçen kaynaklar yazarların soyadları ve yayın yılı ile birlikte verilmelidir (Örnek: Özkan vd., 2008; Özdemir, 2015). Metin sonundaki kaynaklar önce alfabetik sonra kronolojik sıraya göre sıralanmalıdır. Bir yazarın aynı yılda birden fazla yayınına atıf yapılmışsa, bu kaynaklar yayın yılından sonra gelecek a, b, c… harfleriyle ayrılmalıdır (Örnek: Kandemir, 1999a; 2000b; 2001).

Çizelgeler ve şekiller: Bütün çizelge ve şekiller metin içerisinde atıf sıralarına göre ardışık olarak numaralandırılmalı ve ilgili yere eklenmelidir. Çizelgelerin üzerinde ve şekillerin altında başlıkları yer almalıdır. Çizelge ve şekiller hem elektronik ortamda hem de kağıt baskıda net olarak görünür ve anlaşılabilir olmalıdır. Şekiller en az 300 dpi çözünürlüğünde hazırlanmalıdır. Şekillerde kullanılan karakterler Times New Roman yazı tipinde olmalıdır.

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Kaynaklar

Kaynak kullanımları aşağıda örneklerde belirtilen şekillerde olmalıdır.

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Manuscript should be written in A4 page size, with Times New Roman font and 10 pt font size, as plain text. Page and line numbers should be included into the manuscript.

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Symbols and abbreviations: Unit symbols should comply with The International System of Units.

References: In the text, literature should be given with the last name of the author and year of the publication (For example: Özkan et al., 2008; Özdemir, 2015). At the end of the paper, references should be ordered first alphabetically and then chronologically. If there is more than one paper from the same author for a given year, these references should be identified by the letters a, b, c…, after the year of publication (For example: Kandemir, 1999a; 2000b; 2001).

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