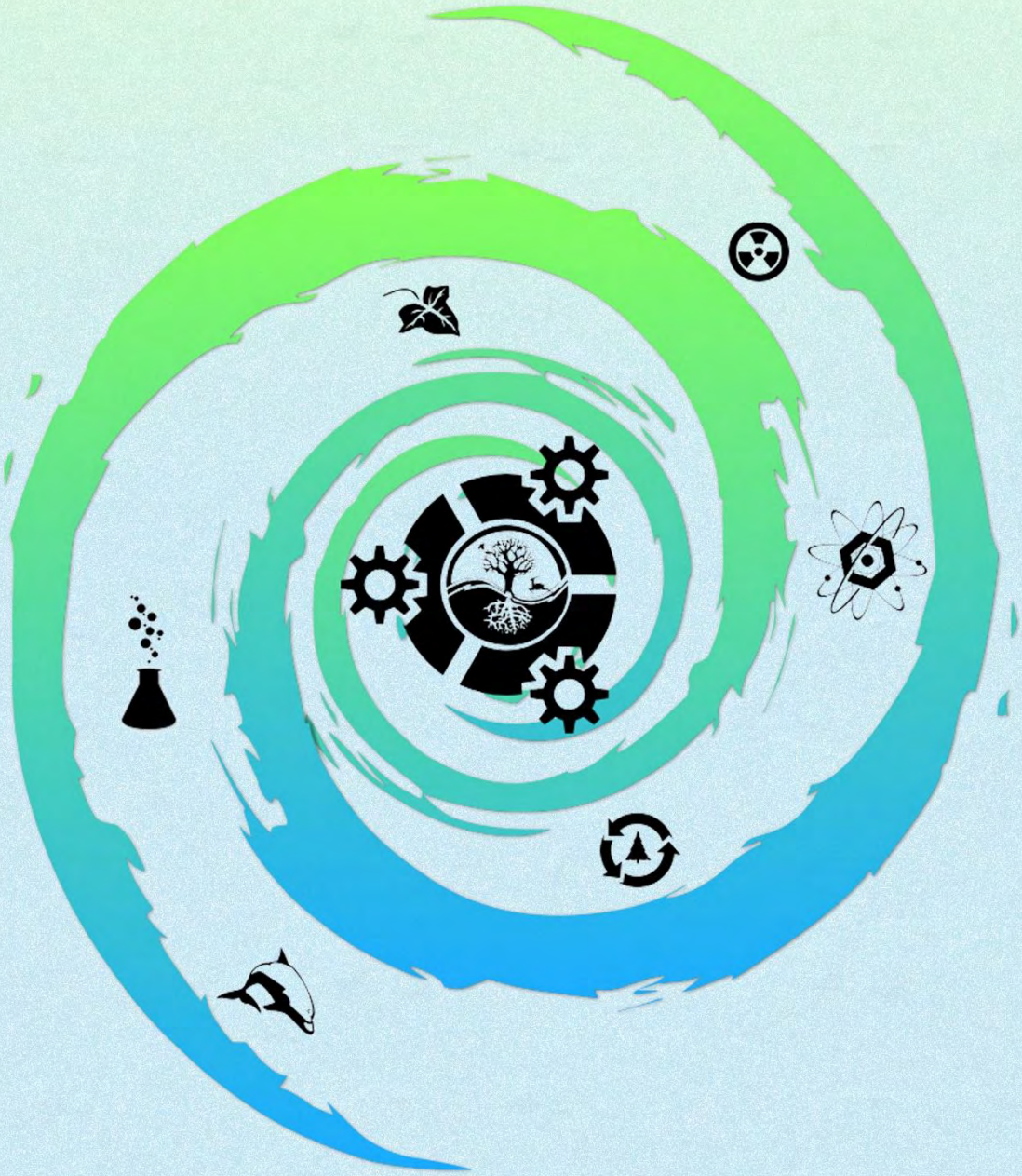
# ACTA NATURA ET SCIENTIA

VOLUME: 2 ISSUE: 1 YEAR: 2021



e-ISSN: 2718-0638

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# ACTA NATURA ET SCIENTIA

## 2021 • VOLUME 2 • ISSUE 1

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**Acta Nat. Sci. (2021) 2(1): 1-5**
DOI: 10.29329/actanatsci.2021.314.1
e-ISSN: 2718-0638

**Original Research Paper**
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ACTA NATURA ET SCIENTIA

# Blue Color Anomaly in Turkish Crayfish *Pontastacus leptodactylus* (Eschscholtz, 1823) (Crustacea, Decapoda, Astacidae) From Atikhisar Reservoir in Çanakkale, Turkey

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**Please cite this paper as follows:**
Kale, S., Berber, S., Acarlı, D., Demirkıran, T., Vural, P., Acarlı, S., & Kızılkaya, B. (2021). Blue Color Anomaly in Turkish Crayfish *Pontastacus leptodactylus* (Eschscholtz, 1823) (Crustacea, Decapoda, Astacidae) from Atikhisar Reservoir in Çanakkale, Turkey. *Acta Natura et Scientia*, *2*(1), 1-5. https://doi.org/10.29329/actanatsci.2021.314.1

**ARTICLE INFO**

*Article History*
Received: 23.09.2020
Revised: 19.12.2020
Accepted: 19.12.2020
Available online: 24.01.2021

*Keywords:*
Blue color anomaly
Crayfish
*Pontastacus leptodactylus*
Atikhisar
Çanakkale
Turkey

**ABSTRACT**

Two individuals of *Pontastacus leptodactylus* (Eschscholtz, 1823) were collected from Atikhisar Reservoir in Çanakkale, Turkey. The individuals were caught by using a fyke-net. The fyke-nets were collected after 3-days soaking time from the reservoir on 18 July 2020. The sampling was carried out during the daytime. The sediment of the sampling location had a muddy substrate. Both blue colored individuals of crayfish (*Pontastacus leptodactylus*) were female. Blue color anomaly was observed in all parts of the bodies of both individuals. Morphometric characteristics were measured and the total lengths were 104.83 mm and 76.92 mm, and weights were 36.09 g and 11.76 g, respectively. The genetics of the mutant species should be examined in future studies to better understanding of the main factors causing color anomalies.

## INTRODUCTION

Color anomalies in crayfish might be the consequence of several factors such as genetics, environmental conditions, food and diet, stage of development and molting, or a combination of any factors (Schuster, 2020). Colors in crayfishes and other crustaceans are known as the consequence of carotenoid pigments (such as astaxanthin and canthaxanthin) responsible for an extensive coloration range from colorless to dark red (Fox, 1953; Goodwing, 1960; Buchwald & Jencks, 1968; Latscha, 1989; Ando & Tanaka, 1996; Walker et al., 2000; Patoka et al., 2013; Schuster, 2020). Astaxanthin is the most common carotenoid in crustaceans (Latscha, 1989).

Some color anomalies have been reported in natural populations for some crustaceans including crayfish species by various scientists. Dowel & Winier (1969) documented a bilateral color anomaly in the crayfish (*Orconectes immunis*) captured from a stream in Iowa, USA. Kale et al. (2020) reported an albinism in crayfish (*P. leptodactylus*) collected from Atikhisar Reservoir in Çanakkale, Turkey. Although several color anomalies have been reported in the literature, the most common observed color anomaly for the crayfish is blue color anomaly (Black, 1975; Black & Huner, 1980; Walker et al., 2000). Hayes and Reimer (1975) noted a blue color anomaly in crayfish (*Orconedes deanae*) from Oklohama, USA. Aksu et al. (2012) reported blue color anomaly in crayfish (*Astacus leptodactylus*) captured from Çıldır Lake in Ardahan, Turkey.

The aim of the present paper is to contribute to the literature by providing a new knowledge on the observation of blue color anomaly in crayfish species in Atikhisar Reservoir, Çanakkale, Turkey. This paper is the first report on the observation of blue color anomaly in Atikhisar Reservoir.

## MATERIAL AND METHODS

Two individuals of *Pontastacus leptodactylus* (Eschscholtz, 1823) were collected from Atikhisar Reservoir in Çanakkale, Turkey. The individuals were caught by using a fyke-net. The fyke-nets have 17 mm mesh size and they were positioned in the bottom of the reservoir at the depth of 5 m. The fyke-nets were collected after 3 days soaking time from the reservoir on 18 July 2020. The sampling was carried out during the daytime. The sediment of the sampling location had a muddy substrate.

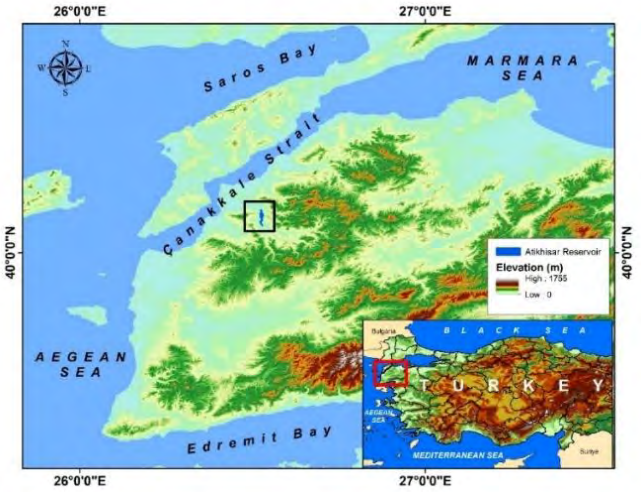


**Figure 1.** Sampling location of blue colored crayfish, Atikhisar Reservoir, Çanakkale, Turkey

Atikhisar Reservoir was built on Sarıçay Stream to supply water for drinking purposes (Kale, 2019) and the reservoir also functions as a water supplier for irrigation and drinking purposes to anthropogenic and non-anthropogenic activities in the basin (Kale & Acarlı, 2019a,b). It has a crucial importance since it is the sole source of drinking water for people living in Çanakkale (Kale & Acarlı, 2019a).

## RESULTS

Both blue colored individuals of crayfish (*Pontastacus leptodactylus*) were female. Blue color anomaly was observed in all parts of the bodies of both individuals.


**Figure 2.** The blue colored mutant crayfish individuals (both female) caught from Atikhisar Reservoir, Çanakkale, Turkey

Morphometric characteristics were measured and the total lengths were 104.83 mm and 76.92 mm, and weights were 36.09 g and 11.76 g, respectively.

The blue colored crayfish individuals were caught from 5 m water depth in the muddy sediment. The physicochemical characteristics of lake surface water were measured with a YSI probe. The salinity was 0.20 ppt, the percentage of dissolved oxygen was 148.20%, dissolved oxygen was 11.92 mg/l, pH was 8.27, the electrical conductivity was 435.00 µs/cm, and the temperature of the lake surface water was 27.2°C.

The blue colored mutant crayfish and normal crayfish were compared to well understanding the coloration between the two phenotypes (Figure 3). It can be noticeably seen that the color of the mutant crayfish is obviously different from normal crayfish.

## DISCUSSION

Scientists have ascribed that differences in the color of crayfish could be influenced by several factors such as environmental conditions (Kent, 1901; Thacker et al., 1993), food and diet (Wolfe & Cornwell, 1964; Momot & Gall, 1971; Kaldre et al., 2015), molting stage and age (Timmermans et

al., 1995), and genetics (Volpe & Penn, 1957; Wolfe and Cornwell, 1964; Dowell and Winier, 1969; Black, 1975; Black & Huner, 1980; Latscha, 1989; Thacker et al., 1993; Walker et al., 2000; Aksu et al., 2012; Kale et al., 2020). One of the first investigations on the coloration of crayfish was published by Kent (1901). The author claimed that key factors are environment and the sun in the coloration of crayfish. Dowel & Winier (1969) documented a bilateral color anomaly in the crayfish (*Orconectes immunis*) captured from a stream in Iowa, USA. The authors concluded that the specimen represented a case of mosaicism conveyed on by somatic separation of which one of a number of chromosomal or genie anomalies may be the responsible factor. The most acceptable reason was noted by the authors as a somatic mutation in very early cleavage. Thacker et al. (1993) put forward that genetic variation among crayfish populations, environmental conditions, and interaction between both environment and genetics are common reasons in the coloration of crayfish. Truong et al. (2002) compared a blue strain of *Cherax destructor albidus* with two normal-colored strains of *Cherax destructor destructor* and *Cherax destructor albidus* in terms of brood size and juvenile weight. The authors found that the reproductive performance and juvenile weight of the blue strain were significantly lesser than the two normal-colored strains. In addition, the authors indicated that the differences in phenotypes between the blue strain and normal-colored strains are most likely genetic. Aksu et al. (2012) claimed that the genetic structure of the species, food composition, and chemical characteristics of water resources have an impact on the color of crayfish.

**Figure 3.** Comparison of normal crayfish and the blue colored crayfish from Atikhisar Reservoir, Çanakkale, Turkey (both individuals are female)

Kale et al. (2020) reported the presence of albinism in crayfish (*P. leptodactylus*) collected from Atikhisar Reservoir in Çanakkale, Turkey, the same location with the present paper, and the authors noted that albinism is a syndrome that occurs in the lack of melanin. In addition, the authors clearly indicated that there were no further reason as causative agents in the sampling location. As previously noted by Kale et al. (2020), there was no fishing pressure or overexploitation probability of fisheries resources in the reservoir. Then again, any pollution was not observed in the lake surface water of the reservoir during the sampling period. Thus, blue color anomaly is probably occurred due to the genetic mechanism of the specimen and environmental factors are less likely factors that affecting the anomaly for the reported specimens in the present paper. Environmental factors were observed in normal conditions and any extreme weather condition was not recorded during the sampling period.

Schuster (2020) noted that color visualization could be a key factor in interspecific and intraspecific competition, sexual choice, communication, territoriality and camouflage. Hence, this may lead to pressure over the populations in the reservoir. Therefore, a further investigation should be carried out to better understand the main reason causing color anomaly in crayfish in the reservoir.

Colors in crayfishes and other crustaceans are known as the consequence of carotenoid pigments (such as astaxanthin and canthaxanthin) (Fox, 1953; Goodwing, 1960; Buchwald & Jencks, 1968; Latscha, 1989; Ando & Tanaka, 1996; Walker et al., 2000; Patoka et al., 2013; Schuster, 2020). The most common carotenoid is astaxanthin in crustaceans (Latscha, 1989). These pigments can also be found in the integument in addition to the exoskeleton (Schuster, 2020). Patoka et al. (2013) indicated that these pigments forms the color of carapaces and the color changes according to the concentration of each pigment. On the other hand, Buchwald and Jencks (1968) reported that the blue color anomaly in carapace of lobsters was caused by crustacyanin. Momot & Gall (1971) claimed that observed color anomalies in crayfishes could be attributed to genetics and/or diet. Black (1975) noted that the blue color anomaly of *Procambarus acutus acutus* was caused by carotenoid pigments (probably crustacyanin) deposited in the exoskeleton. The author also indicated that the blue color anomaly was still observed in the exoskeleton after molting. Latscha (1989) suggested that pigmentation in crustaceans could also be due to the complex of carotenoid-protein known as carotenoproteins. The author attributed the color anomaly in *Penaeus* shrimp to a dietary carotenoid deficiency such as astaxanthin. Latscha (1989) documented that blue colored shrimp species mutated back to their normal color when they were fed diets with astaxanthin. As noted by Schuster (2020), all these papers

highlighted that a single autosomal recessive gene was the main reason of the observed color anomalies in animals. Therefore, further investigations are required to determine the underlying reason of the color anomaly in the crayfish.

## CONCLUSION

The present paper significantly contributes to the scientific literature by providing the first information on the occurrence of blue color anomaly in crayfish (*P. leptodactylus*) in the Atikhisar Reservoir, Çanakkale, Turkey.

## ACKNOWLEDGEMENTS

This paper is a part of a research project financially supported by Çanakkale Onsekiz Mart University the Scientific Research Coordination Unit granted to Dr. Selçuk Berber (Project number: FBA-2020-3250). Lab experiments were carried out in the laboratory of Biochemistry; and laboratory of Feed and Food Analysis, Faculty of Marine Sciences and Technology, Çanakkale Onsekiz Mart University. An earlier version of the paper was presented at International Conference on Engineering Technologies (ICENTE'20) in Konya, Turkey.

### Compliance with Ethical Standards

### Authors' Contributions

SB and SK designed the study. SK, SB, DA, TD conducted sampling in the field. SK wrote the first draft of the manuscript. SA, PV, BK helped in the laboratory. All authors have read and revised the manuscript. All authors approved the final version of the paper.

### Conflict of Interest

The authors declare that there is no conflict of interest.

### Ethical Approval

For this type of study, formal consent is not required.

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**Acta Nat. Sci. (2021) 2(1): 6-16**
DOI: 10.29329/actanatsci.2021.314.2
e-ISSN: 2718-0638

**Original Research Paper**
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ACTA NATURA ET SCIENTIA

# Determining the Effectiveness of Sustainable Production Activities in Fishing Sector by Data Envelopment Analysis

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**Please cite this paper as follows:**
Sayğı, H., Kop, A., Tekoğul, H., & Taylan, B. (2021). Determining the Effectiveness of Sustainable Production Activities in Fishing Sector by Data Envelopment Analysis. *Acta Natura et Scientia*, *2*(1), 6-16. https://doi.org/10.29329/actanatsci.2021.314.2

**ARTICLE INFO**

*Article History*
Received: 28.01.2021
Revised: 22.02.2021
Accepted: 25.02.2021
Available online: 04.05.2021

*Keywords:*
Data Envelopment Analysis
Efficiency
Performance
Fisheries Sector

**ABSTRACT**

Data envelopment analysis is used when it is difficult to measure the relative effectiveness of organizational decision-making units due to a large number of similar inputs and outputs. Firstly, data envelopment analysis was discussed in this study. In this context, relative activities of 10 companies have been operating in fisheries sector for last nine years (2009-2017) which entered the Fortune 500 in Turkey and have sufficient data were measured using financial inputs and outputs. Relative effectiveness scores were obtained by examining the financial inputs and outputs of the companies that are in the Fortune 500 and operating in fisheries sector. In the second part of study, to reveal the technical efficiency and the ineffective ones resulting from the scale, DEA models including the input-oriented CCR (Charnes, Cooper, and Rhodes) and BCC (Banker, Charnes, and Cooper) model were established and the above mentioned procedures were repeated. Finally, it was investigated whether an investment system based on DEA could be established or not. DEA Frontier and DEA Solver software, one of the special software of DEA, was used for the solution of models using in data envelopment analysis. As a result of the study, the average efficacy percentage was found to be 88% for CCR and 93% for BCC. For the data obtained during 2009-2017, six companies were found to be active according to the CCR model, while seven companies were found to be effective according to the BCC model. Also, the targets were determined to activate the inactive companies.

## INTRODUCTION

In the presence of today's tough competition conditions, globalization, and developments in technology, companies, to protect their assets and continue their activities in a determined manner, have to determine the current efficiency levels of their activities and increase efficiency. Therefore, the objectives of the company are expressed by performance indicators such as high efficiency, efficiency, profit maximization, cost minimization, service satisfaction, growth, and respectability (Barutçugil, 2002). Performance measures should be calculated for understanding whether the company has achieved its objectives or not one of the methods used for this purpose is effectiveness analysis. It is important to estimate the effectiveness of decision points and take the suitable decision according to the activities if there is more than one decision point for a decision-maker.

One of the most important problems of business managers is to find the best method to measure efficiency. Efficiency is a widely used concept in the economy, and it can be described as a company using its resources in the optimum way to reach its goals and objectives (Sherman,

1984; Yeşilyurt & Alan, 2003; Özden, 2008; Kyriaki, 2017; Beridze & Anbar, 2019). In other words, efficiency is a performance indicator that shows the extent to which the company has achieved its goals and objectives. Efficiency can also be expressed as the ratio between beneficial inputs and outputs. In this manner, efficiency is related to the fact that businesses can do more by considering the ratio between inputs and outputs (Torun & Özdemir, 2015).

Parametric and nonparametric methods can be used to measure the efficiency with ratio analysis. However, reviewing the literature, it was seen that the most widely used method is the nonparametric data envelopment analysis (DEA) method (Rashedul & Israt, 2012; Akgöbek et al., 2015; Dogan & Topalli, 2016; Beridze & Anbar, 2019).

Data envelopment analysis was formed for the first time in 1957 with the recommendation of the frontier production function, which was proposed by Farrell against the average performance criterion. There are two common DEA models used in literatures. These two models are the CCR model (Charnes et al., 1978; Behdioğlu & Özcan, 2009), developed by Charnes et al. (1978), based on the scale of fixed return assumption to measure the activities of the resembling KVB (decision making unit), the BCC model based on the CCR model, based on the scale-assumed return assumption developed by Banker et al. (1984) (Behdioğlu & Özcan, 2009; Bircan, 2011; Kumar & Singh, 2014; Yin et al., 2014) and the additive method developed by Banker et al. (1984) which produces results without being directed to input and/or output. The additive model is a model subject to variable return conditions according to the scale. While the efficiency score of the first model (fixed return by scale) shows the "general" technical efficiency according to the appropriate input-output structure and the size of the transactions, the effectiveness score of the second model (variable by scale) shows the "pure" technical efficiency (Coelli, 1996; Rabar, 2017).

CCR (Charnes, Cooper and Rhodes) and BCC (Banker, Charnes, and Cooper) models used in DEA can be established in two different ways i.e., input-oriented and output-oriented. According to their orientation, these models are divided into 3 groups called "input-oriented models", "output-oriented models" and "non-oriented models" (Kecek, 2010). In input-oriented CCR and BCC models, it has been tried to use the minimum input to produce the current output aiming to produce the maximum output with the current input in output-oriented CCR and BCC models (Özden, 2008). Total efficiency score is obtained for each decision-making unit when these established models are solved for all decision-making units. When this score is equal to 1, it means that decision-making units are effective; while less than 1 means that decision-making units are not effective.

To measure the effectiveness of the systems, DEA has been used in a wide range of applications to determine the performance of companies within the sector they operate. There are many sectors where data envelopment analysis is used. As the application area increased, DEA Excel Solver, DEA-Solver Pro, EMS, Warwick DEA, DEAP, Frontier Analyst computer package programs have been used for DEA.

Although studies on effectiveness and efficiency in the fisheries sector have been carried out in many countries for several years to measure the efficiency of the work, no such studies were conducted in fisheries sector. Therefore, this study has been thought having an important contribution to literatures. Ten companies that entered to FORTUNE 500 in the fisheries sector have been evaluated in our study using the data of 2009-2017 with non-parametric method DEA, which is considered to be the solution oriented suggestion of the companies. The basic aim of our study is to measure the economic effectiveness of the companies listed in FORTUNE 500 and to calculate their comparative effectiveness on economic effectiveness and also to determine the potential improvement targets of these companies for ineffective companies. A very limited number of studies carried out using this method in fisheries industry increase the importance of the study.

## MATERIAL AND METHODS

In the study, since there are multiple inputs and outputs and the relative effectiveness of the firms are measured, the DEA method was adopted, and included the companies which entered to FORTUNE 500 in 2009-2017 in agricultural, cereal, milk, meat and fisheries sector rankings, and engaged only in fisheries sectors. The activity scores of these companies covering the years 2009-2017 have been calculated and the results were included in the study.

Although it changes every year, an average of 10 companies is included in the scope of the study. Then, the inputs and outputs that were thought to have an effect on obtaining the relative activities of the companies were determined. DEA models were used with 3 different input and 4 different output sets. These are the company's number of employees, assets, and equity. In the study, the expression of CRS (constant return to scale) model was used for CCR model, which calculates the total efficiency under the assumption of fixed return (CRS) by considering financial inputs and outputs. Moreover, the BCC model, which calculates the technical efficiency under the assumption of VRS (variable return to scale), was expressed in the form of

**Table 1.** Data set to determine the activity of the companies

| Companies | Year Founded | Inputs | | | Outputs | | | |
|---|---|---|---|---|---|---|---|---|
| | | The Number of Employees | Active Total (TRY) | Equity Capital (TRY) | Net Sales (TRY) | EBIT (TRY) | PBT/Net Sales (%) | Export Value (TRY) |
| F1 | 1942 | 2450 | 860906476.9 | 399022940.9 | 1470567166 | 156039993 | 7.24 | 104415848.2 |
| F2 | 1993 | 655 | 201938357.5 | 87347123 | 237276761 | 1587161 | 0.00 | 6556718.5 |
| F3 | 1983 | 406 | 217763373.6 | 62905812.67 | 278457198 | 25375368 | 1.18 | 41802593.44 |
| F4 | 1952 | 798 | 918405055 | 444086087.7 | 2361303623 | 151022502 | 0.48 | 0 |
| F5 | 1968 | 1028 | 159942443.2 | 63955271.33 | 338394615 | 3071922 | 0.15 | 16899869.17 |
| F6 | 1997 | 828 | 385935954.6 | 201938546.7 | 368479374 | 59282710 | 14.59 | 116993797.1 |
| F7 | 1988 | 69 | 118649388.5 | 38998485 | 283290898 | 16412469 | 1.32 | 73351552 |
| F8 | 1991 | 892 | 526800325.8 | 176058116 | 404685112 | 93232656 | 8.47 | 174086479.4 |
| F9 | 1954 | 2579 | 3351682328 | 1002734245 | 1755683795 | 304868719 | 6.67 | 100886751 |
| F10 | 1973 | 504 | 342672341 | 270385966 | 307871231 | 51955546 | 15.48 | 5343085 |

**Table 2.** CRS and VRS effectiveness score with financial inputs and outputs

| CRS Effectiveness Score Input-Oriented CRS | | | | | | | VRS Effectiveness Score Input-Oriented VRS | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DMU Name | Efficiency | Optimal Lambdas with Benchmarks | | | | Reference | DMU Name | Efficiency | Optimal Lambdas with Benchmarks | | | | Reference |
| F1 | 1.00000 | 1.000 | F1 | | | 1 | F1 | 1.00000 | **1.000** | F1 | | | 1 |
| F2 | 0.46800 | 0.069 | F4 | 0.262 | F7 | 4.7 | F2 | 0.58755 | 1.000 | F7 | | | 7 |
| F3 | 0.86276 | 0.794 | F7 | 0.132 | F8 | 7.8 | F3 | 0.87416 | 0.883 | F7 | 0.117 | F8 | 7.8 |
| F4 | 1.00000 | 1.000 | F4 | | | 4 | F4 | 1.00000 | 1.000 | F4 | | | 4 |
| F5 | 0.85589 | 0.069 | F4 | 0.623 | F7 | 4.7 | F5 | 0.87442 | 0.027 | F4 | 0.973 | F7 | 4.7 |
| F6 | 1.00000 | 1.000 | F6 | | | 6 | F6 | 1.00000 | 1.000 | F6 | | | 6 |
| F7 | 1.00000 | 1.000 | F7 | | | 7 | F7 | 1.00000 | 1.000 | F7 | | | 7 |
| F8 | 1.00000 | 1.000 | F8 | | | 8 | F8 | 1.00000 | 1.000 | F8 | | | 8 |
| F9 | 0.67923 | 13.163 | F7 | 0.953 | F8 | 7.8 | F9 | 1.00000 | 1.000 | F9 | | | 9 |
| F10 | 1.00000 | 1.000 | F10 | | | 10 | F10 | 1.00000 | 1.000 | F10 | | | 10 |

VRS model. Optimization solution of DEA was realized under both the fixed return to scale (CCR = CRS) assumption and the variable return to scale (BCC = VRS) assumption.

In the measurement of the effectiveness of decision units, output-oriented effectiveness measurements were made in both methods to provide the highest possible output from the available sources (input factors). In the selection of data, to be used to measure the effectiveness of decision-making units, a literature review was carried out on the effectiveness analysis in fisheries industry and the input and output factors frequently used in the literatures were taken into account. Elimination of input and output factors has been made since the total number of inputs and outputs to be used in the application should be less than the number of decision units, although there is a small change between the outputs and outputs in the literature. In the study, the minimum number of decision-making units (DMU) required for the analysis (n + m + 1) was met, where n: the number of inputs: 3 (the number of employees, total assets (TRY), equity capital (TRY)), m: the number of outputs: (net sales (TRY), EBIT (earnings before interest tax) (TRY), PBT (profit before tax)/net sales (%) and export value (TRY). While the data subjected to the study were analyzed by BCC and CCR models, 12 linear programming models for 12 DMUs must be created and solved separately. Evaluated companies are given in Table 1 along with their founding years. DEA

Frontier and DEA Solver (Data Envelopment Analysis Solver) software, one of the special software of data envelopment analysis, was used to solve the models.

## RESULTS

Using the data between the period of 2009 - 2017, analyzes were carried out by making them under the fixed return assumption (CCR = CRS) according to the input-oriented scale and under the variable return assumption (BCC = VRS) according to the input-oriented scale shown in Table 2.

The said table shows the effectiveness measurement results and the reference set of 10 companies operating in the fisheries sector. According to the CRS results, six of the decision units were effective while the remaining four were observed to be ineffective. Effective decision units are F1, F4, F6, F7, F8, and F10 and their efficiency value is 1. Ineffective decision units are included as F2, F3, F5, and F9 companies. Furthermore, according to the VRS results, seven of the decision units were effective whereas three were observed to be ineffective. Effective decision units are F1, F4, F6, F7, F8, F9, and F10, and their activity value was noted as 1. Ineffective decision units were mentioned as F2, F3 and F5 companies.

According to the CRS results, F2 had an effectiveness value of 0.46800, F3 had an effectiveness value of 0.86276, F5 had an effectiveness value of 0.85589 and F9 had an effectiveness value of 0.67923. The most ineffective company

**Table 3.** CCR and BCC directed input results

| | | CCR Input-Oriented Results | | | BCC Input-Oriented Results | | |
|---|---|---|---|---|---|---|---|
| **Company** | **Outputs** | **Realized** | **Target** | **Potential Improvement** | **Realized** | **Target** | **Potential Improvement** |
| F1 | The Number of Employees | 2450 | 2450 | 0.00 | 2450 | 2450 | 0.00 |
| | Active Total (TRY) | 860906477 | 860906476.89 | 0.00 | 860906477 | 860906476.89 | 0.00 |
| | Equity Capital (TRY) | 399022941 | 399022940.89 | 0.00 | 399022941 | 399022940.89 | 0.00 |
| F2 | The Number of Employees | **655** | **73** | **-88.85** | **655** | **69** | **-89.54** |
| | Active Total (TRY) | **201938358** | **94507213.95** | **-53.20** | **201938358** | **118649388.50** | **-41.24** |
| | Equity Capital (TRY) | **87347123** | **40878480.66** | **-53.20** | **87347123** | **38998485.00** | **-55.35** |
| F3 | The Number of Employees | **406** | **173** | **-57.49** | **406** | **165** | **-59.44** |
| | Active Total (TRY) | **217763374** | **163948431.10** | **-24.71** | **217763374** | **166269891.14** | **-23.65** |
| | Equity Capital (TRY) | **62905812.7** | **54272540.87** | **-13.72** | **62905812.7** | **54989746.87** | **-12.58** |
| F4 | The Number of Employees | 798 | 798 | 0.00 | 798 | 798 | 0.00 |
| | Active Total (TRY) | 918405055 | 918405055.00 | 0.00 | 918405055 | 918405055.00 | 0.00 |
| | Equity Capital (TRY) | 444086088 | 444086087.67 | 0.00 | 444086088 | 444086087.67 | 0.00 |
| F5 | The Number of Employees | **1028** | **97** | **-90.53** | **1028** | **88** | **-91.45** |
| | Active Total (TRY) | **159942443** | **136893394.10** | **-14.41** | **159942443** | **139856914.99** | **-12.56** |
| | Equity Capital (TRY) | **63955271.3** | **54738779.72** | **-14.41** | **63955271.3** | **49740398.34** | **-22.23** |
| F6 | The Number of Employees | 828 | 828 | 0.00 | 828 | 828 | 0.00 |
| | Active Total (TRY) | 385935955 | 385935954.57 | 0.00 | 385935955 | 385935954.57 | 0.00 |
| | Equity Capital (TRY) | 201938547 | 201938546.71 | 0.00 | 201938547 | 201938546.71 | 0.00 |
| F7 | The Number of Employees | 69 | 69 | 0.00 | 69 | 69 | 0.00 |
| | Active Total (TRY) | 118649389 | 118649388.50 | 0.00 | 118649389 | 118649388.50 | 0.00 |
| | Equity Capital (TRY) | 38998485 | 38998485.00 | 0.00 | 38998485 | 38998485.00 | 0.00 |
| F8 | The Number of Employees | 892 | 892 | 0.00 | 892 | 892 | 0.00 |
| | Active Total (TRY) | 526800326 | 526800325.80 | 0.00 | 526800326 | 526800325.80 | 0.00 |
| | Equity Capital (TRY) | 176058116 | 176058116.00 | 0.00 | 176058116 | 176058116.00 | 0.00 |
| F9 | The Number of Employees | **2579** | **1752** | **-32.08** | 2579 | 2579 | 0.00 |
| | Active Total (TRY) | **3351682328** | **2063709072.36** | **-38.43** | 3351682328 | 3351682328.33 | 0.00 |
| | Equity Capital (TRY) | **1002734245** | **681082607.39** | **-32.08** | 1002734245 | 1002734245.22 | 0.00 |
| F10 | The Number of Employees | 504 | 504 | 0.00 | 504 | 504 | 0.00 |
| | Active Total (TRY) | 342672341 | 342672341.00 | 0.00 | 342672341 | 342672341.00 | 0.00 |
| | Equity Capital (TRY) | 270385966 | 270385966.00 | 0.00 | 270385966 | 270385966.00 | 0.00 |

in the measurement performed on the assumption of fixed return according to the scale was F2 and its effectiveness was below 47%. Considering the reference sets, the most frequently referenced company from the effective companies was the F7 company, which was referenced to 5 decision units, followed by the F4 and F8 companies which were referenced to 2 decision units. F4 and F7 companies were taken reference for the ineffective F2 company. F7 and F8 companies were taken as references for F3 and F9 companies. F4 and F7 companies were taken as references for F5 company. According to the VRS results, F2 company has a value of 0.58755, F3 with a value of 0.87416, and F5 having a value of 0.887442. The most ineffective company in the measurement performed in variable return assumption according to the scale was F2 and its efficiency was found below 59%. Considering the reference sets, the most referenced company from among active companies was F4 company, which was the reference unit for 1 decision unit. F7 was taken reference for the ineffective company F2. Company F3 took the companies F7 and F8 as the reference. F4 and F7 companies were taken as references for F5 company (Table 2).

As a result of the input-oriented CCR effectiveness application and BCC effectiveness applications, it has been observed that there was strong effectiveness in all effective decision units. According to the input-oriented CCR input-oriented effectiveness application, for F2 company which had an ineffective decision unit to be effective, the number of employees in the input group should be reduced by 88.85%, and the potential improvement ratio in the active total and the equity should be reduced by 53.20%. F2 will be active when it reaches the target values (Table 2). According to the input-oriented BCC input-oriented effectiveness application, for F2 company which had an ineffective decision unit to be effective, the number of employees in the input group should be reduced by 89.54%, and the potential improvement ratio in the Active Total should be reduced by 41.24% and the Equity should be reduced by 55.35%. F2 will be active when it reaches the target values (Table 3).

According to the input-oriented CCR input-oriented effectiveness application, for the F3 company which had an ineffective decision unit to be effective, the number of employees in the input group should be reduced by 57.49%, the active total should be reduced by 24.71% and the equity (the potential improvement ratio) should be reduced by 13.72%. According to the input-oriented CCR input-oriented effectiveness application, for the F3 company which had an ineffective decision unit to be effective, the number of employees in the input group should be reduced by 59.44%. The active total should be reduced by 23.65% and the equity (the potential improvement ratio) should be reduced by 12.58%. F3 will be active when it reaches the target values shown in Table 3.

According to the input-oriented CCR input-oriented effectiveness application, for F9 company which had an ineffective decision unit to be effective, the number of employees in the input group should be reduced by 32.08%, the active total should be reduced by 38.43% and the equity (the potential improvement ratio) should be reduced by 32.08%. Thus, F9 will be active when it reaches the target values (Table 3).

When input-oriented CCR activity application was performed, it has been observed that there was strong activity in all effective decision-making units. For F2 company, which was one of the ineffective decision units, to be effective, EBITDA (TRY) in the output group should increase by 927.95% and the export by 293.46% potential improvement. When the BCC effectiveness application of input-oriented outputs was applied, it has been observed that there was strong activity in all effective decision units. For F2 company, which was one of the ineffective decision units, to be effective, net sales in the output group should increase the rate of net sales by 19.39%, EBIT (TRY) by 934.08% and the export value by 1018.72% potential improvement. F2 will be active when it reaches the target values (Table 4).

According to the input-oriented CCR input-oriented effectiveness application, for F3 company which had an ineffective decision unit to be effective, PBT/net sales should be increased by 184.06% while the export should be increased by 194.43% (potential improvement ratio). According to the input-oriented BCC input-oriented effectiveness application, for F3 company which had an ineffective decision unit to be effective, net sales should be increased by 6.82%, PBT/net sales should be increased by 82.58% and the export should be increased by 103.59% (potential improvement ratio). F3 will be active when it reaches the target values (Table 4).

According to the input-oriented CCR input-oriented effectiveness application, for F5 company which had an ineffective decision unit to be effective, EBIT (TRY) should be increased by 669.91%, PBT/net sales should be increased by 564.28% and the export should be increased by 270.60% (potential improvement ratio). According to the input-oriented CCR input-oriented effectiveness application, for F5 company which had an ineffective decision unit to be effective, EBIT (TRY) should be increased by 550.47%, PBT/net sales should be increased by 765.15% and the export should be increased by 322.53% (potential improvement ratio). F5 will be active when it reaches the target values shown in Table 4.

According to the input-oriented CCR input-oriented effectiveness application, for F9 company which had an

**Table 4.** Potential recovery rates of fisheries companies according to CCR and BCC

| Company | Outputs | CCR | | | BCC | | |
|---|---|---|---|---|---|---|---|
| | | Realized | Target | Potential Improvement (%) | Realized | Target | Potential Improvement (%) |
| F1 | Net Sales (TRY) | 1,470,567,166.00 | 1,470,567,166.00 | 0.00 | 1,470,567,166.00 | 1,470,567,166.00 | 0.00 |
| | EBIT (TRY) | 156,039,993.22 | 156,039,993.22 | 0.00 | 156,039,993.22 | 156,039,993.22 | 0.00 |
| | PBT/Net Sales (%) | 7.24 | 7.24 | 0.00 | 7.24 | 7.24 | 0.00 |
| | Export Value (TRY) | 104,415,848.22 | 104,415,848.22 | 0.00 | 104,415,848.22 | 104,415,848.22 | 0.00 |
| F2 | Net Sales (TRY) | 237,276,761.00 | 237,276,761.00 | 0.00 | 237,276,761.00 | 283,290,897.50 | **19.39** |
| | EBIT (TRY) | 1,587,161.00 | 14,728,051.14 | **927.95** | 1,587,161.00 | 16,412,468.50 | **934.08** |
| | PBT/Net Sales (%) | 0.00 | 0.38 | 0.00 | 0 | 1.32 | 0.00 |
| | Export Value (TRY) | 6,556,718.50 | 19,241,196.62 | **293.46** | 6,556,718.50 | 73,351,552.00 | **1018.72** |
| F3 | Net Sales (TRY) | 278,457,197.78 | 278,457,197.78 | 0.00 | 278,457,197.78 | 297,454,416.42 | **6.82** |
| | EBIT (TRY) | 25,375,368.22 | 25,375,368.22 | 0.00 | 25,375,368.22 | 25,375,368.22 | 0.00 |
| | PBT/Net Sales (%) | 1.18 | 2.17 | **184.06** | 1.18 | 2.15 | **82.58** |
| | Export Value (TRY) | 41,802,593.44 | 81,278,752.83 | **194.43** | 41,802,593.44 | 85,104,674.28 | **103.59** |
| F4 | Net Sales (TRY) | 2,361,303,622.67 | 2,361,303,622.67 | 0.00 | 2,361,303,622.67 | 2,361,303,622.67 | 0.00 |
| | EBIT (TRY) | 151,022,501.67 | 151,022,501.67 | 0.00 | 151,022,501.67 | 151,022,501.67 | 0.00 |
| | PBT/Net Sales (%) | 0.48 | 0.48 | 0.00 | 0.48 | 0.48 | 0.00 |
| | Export Value (TRY) | 0.00 | 0.00 | 0.00 | 0 | 0 | 0.00 |
| F5 | Net Sales (TRY) | 338,394,614.50 | 338,394,614.50 | 0.00 | 338,394,614.50 | 338,394,614.50 | 0.00 |
| | EBIT (TRY) | 3,071,921.50 | 20,579,170.67 | **669.91** | 3,071,921.50 | 19,981,991.00 | **550.47** |
| | PBT/Net Sales (%) | 0.15 | 0.86 | **564.28** | 0.15 | 1.30 | **765.15** |
| | Export Value (TRY) | 16,899,869.17 | 45,730,586.56 | **270.60** | 16,899,869.17 | 71,406,451.71 | **322.53** |
| F6 | Net Sales (TRY) | 368,479,373.71 | 368,479,373.71 | 0.00 | 368,479,373.71 | 368,479,373.71 | 0.00 |
| | EBIT (TRY) | 59,282,709.71 | 59,282,709.71 | 0.00 | 59,282,709.71 | 59,282,709.71 | 0.00 |
| | PBT/Net Sales (%) | 14.59 | 14.59 | 0.00 | 14.59 | 14.59 | 0.03 |
| | Export Value (TRY) | 116,993,797.14 | 116,993,797.14 | 0.00 | 116,993,797.14 | 116,993,797.14 | 0.00 |
| F7 | Net Sales (TRY) | 283,290,897.50 | 283,290,897.50 | 0.00 | 283,290,897.50 | 283,290,897.50 | 0.00 |
| | EBIT (TRY) | 1.6412.468,50 | 16,412,468.50 | 0.00 | 16,412,468.50 | 16,412,468.50 | 0.00 |
| | PBT/Net Sales (%) | 1.32 | 1.32 | 0.00 | 1.32 | 1.32 | 0.00 |
| | Export Value (TRY) | 73,351,552.00 | 73,351,552.00 | 0.00 | 73,351,552.00 | 73,351,552.00 | 0.00 |
| F8 | Net Sales (TRY) | 404,685,112.20 | 404,685,112.20 | 0.00 | 404,685,112.20 | 404,685,112.20 | 0.00 |
| | EBIT (TRY) | 93,232,655.60 | 93,232,655.60 | 0.00 | 93,232,655.60 | 93,232,655.60 | 0.00 |
| | PBT/Net Sales (%) | 8.47 | 8.47 | 0.00 | 8.47 | 8.47 | 0.00 |
| | Export Value (TRY) | 174,086,479.40 | 174,086,479.40 | 0.00 | 174,086,479.40 | 174,086,479.40 | 0.00 |
| F9 | Net Sales (TRY) | 1,755,683,795.11 | 4,114,503,535.79 | **234.35** | 1,755,683,795.11 | 1,755,683,795.11 | 0.00 |
| | EBIT (TRY) | 304,868,719.11 | 304,868,719.11 | **0.00** | 304,868,719.11 | 304,868,719.11 | 0.00 |
| | PBT/Net Sales (%) | 6.67 | 25.45 | **381.52** | 6.67 | 6.67 | 0.00 |
| | Export Value (TRY) | 100,886,751.00 | 1,131,387,644.97 | **1,121.44** | 100,886,751.00 | 100,886,751.00 | 0.00 |
| F10 | Net Sales (TRY) | 307,871,231.00 | 307,871,231.00 | 0.00 | 307,871,231.00 | 307,871,231.00 | 0.00 |
| | EBIT (TRY) | 51,955,546.00 | 51,955,546.00 | 0.00 | 51,955,546.00 | 51,955,546.00 | 0.00 |
| | PBT/Net Sales (%) | 15.48 | 15.48 | 0.00 | 15.48 | 15.48 | 0.00 |
| | Export Value (TRY) | 5,343,085.00 | 5,343,085.00 | 0.00 | 5,343,085.00 | 5,343,085.00 | 0.00 |

ineffective decision unit to be effective, EBIT (TRY) should be increased by 234.35%, PBT/Net sales should be increased by 381.52% and the export should be increased by 1121.44% (potential improvement ratio). F9 will be active when it reaches the target values (Table 4).

To evaluate the effectiveness of companies in fisheries sector technical efficiency, pure technical efficiency, scale effectiveness and scale-based yield characteristics are given in Table 5.

When examining Table 5 in detail, it is seen that six companies i.e.; F1, F4, F6, F7, F8 and F10) were both ineffective production scale in terms of scale effects and use their resources effectively and efficiently according to the activity scores of 10 companies in fisheries industry. These companies have the most effective scale size. While examining the companies viz F2, F3 and F5, it has been seen that they were not effective both in pure technical efficiency and technical efficiency. When examining F9 company, the scale was not technically effective but pure technical activities were found to be. This was associated with the fact that, although, they were technically effective but not purely effective. When examining the scale effectiveness of F9, it has been seen that this company have had pure technical activities but not technically effective had lower scale effectiveness as compared to F2, F3 and F5 which were both pure as well as technically inactive. It has been observed that F2 and F5 had greater scale effectiveness due to their close technical and pure technical efficacy values. It was determined that F2, F3, F5 and F9 had decreasing return characteristics according to the scale. On the other hand, the remaining companies showed a fixed return according to the scale since they were fully effective in all activity observations.

## DISCUSSION

To measure the effectiveness of the systems, DEA has been used in a wide range of applications to determine the performance of companies within the sector where they operated.

Several studies have been conducted to determine the effectiveness by DEA in Turkey as well as in the world. These sectors include aviation, automotive (Baysal et al., 2005; Çoban, 2007; Yaylalı & Çalmaşur, 2014), health (Tetik, 2003; Yiğit & Esen, 2017), manufacturing (Deliktaş, 2002; Bakırcı, 2006; Bakırcı et al., 2014; Sevinç & Eren, 2016), stock exchange and banking (Pascoe & Herrero, 2004; Chufen, 2007; Seyrek & Ata, 2010; Uyguntürk & Korkmaz, 2016), cement and textile (Kayalıdere & Kargın, 2004; Doğan & Ersoy, 2017), information technology, education, general and tourism (Walden & Kirkley, 2000; Holland & Lee, 2002; Düzakın & Demirtaş, 2005; Özden, 2008; Yükçü & Atağan, 2009; Iribarren et al., 2010; Göktolga & Artut, 2011; Çelik, 2016) and agriculture (Aktürk & Kıral, 2002, Rodríguez-Díaz et al., 2004; Reig-Martínez & Picazo-Tadeo, 2004; Koyubenbe, 2006; Kaya & Aktan, 2011; Demir et al., 2012; Daka et al., 2012; Engindeniz, 2012; Gökdoğan & Demir, 2013; Külekçi, 2014; Mohammadi et al., 2015; Sgroi et al., 2015).

Turkey, with investments made in trade agreements and the fisheries sector, has shown great development, especially after 2000s. There are many studies found in the literature on the determination of the effective and ineffective companies in fisheries sector (Sharma et al., 1999; Kirkley et al., 2002; Tingley et al., 2003, 2005; Cinemre et al., 2006; Esmaeili, 2006; Esmaeli & Omrani, 2007; Hoff, 2007; Tsitsika et al., 2008; Maravelias & Tsitsika, 2008; Gardner et al., 2008; Bozoğlu & Ceyhan, 2009; Vázquez-Rowe et al., 2010, 2012; Griffin & Woodward, 2011; Vázquez-Rowe & Tyedmers, 2013; Avadí et al., 2015; Seki & Akbulut, 2015; Demirci & Tarhan, 2016). However, no similar study was found in the literature.

In this study, which included the activity research related to fisheries sector, DEA has been used in the measurement of efficiency. DEA, a non-parametric method, is used to measure the distances to the efficiency limit by making a relative comparison of the companies called Decision Making Units (DMU). It gives values between 0 and 1 to DMUs using various constraints. DEA provides important information to managers, as it allows us to measure the effectiveness of DMUs with multiple inputs and outputs. It does not need to make conversions in inputs and outputs to make measurements, and it offers suggestions for determining and eliminating inefficiencies.

In our study, 3 inputs viz number of employees, active total (TRY) and equity (TRY), and 4 outputs namely net sales (TRY), EBITDA (TRY), PBT/net sales (%) and export (TRY) which were obtained from the financial statements of 10 fisheries companies in fisheries sector which entered Fortune 500. (TRY), BPT/net sales (%), export amount (TRY) were examined by the DEA output-oriented CCR and BCC models.

As a result of input-oriented CCR application to companies in fisheries industry, 6 companies were effective and 4 companies were ineffective, while 7 companies were effective and 3 companies were ineffective as a result of BCC implementation. According to the results of CCR and BCC effectiveness analyses; F2, F3, and F5 were found to be ineffective while F9 was found to be effective according to BBC model.

According to CCR, the efficiency score of F2 was below 47%, but in case of BCC, the efficiency score was below 59%. According to the combined results of CCR and BCC models,

**Table 5.** Scale effectiveness and scale returns for companies in the fisheries sector

| Company | Technical Activity CCR | Pure Technical Activity BCC | Scale Effectiveness | Yield by Scale |
|---|---|---|---|---|
| F1 | 1.00000 | 1.00000 | 1 | Fixed |
| F2 | 0.46800 | 0.58755 | 0.7965 | **Reducing** |
| F3 | 0.86276 | 0.87416 | 0.9869 | **Reducing** |
| F4 | 1.00000 | 1.00000 | 1 | Fixed |
| F5 | 0.85589 | 0.87442 | 0.9788 | **Reducing** |
| F6 | 1.00000 | 1.00000 | 1 | Fixed |
| F7 | 1.00000 | 1.00000 | 1 | Fixed |
| F8 | 1.00000 | 1.00000 | 1 | Fixed |
| F9 | 0.67923 | 1.00000 | 0.67923 | **Reducing** |
| F10 | 1.00000 | 1.00000 | 1 | Fixed |

potential improvement rates should be reduced by 88.95% and 89.54 in the number of employees, by 53.20% and 41.24% in the active total, respectively, by 53.20% and 55.35% in equity (potential improvement rate).

According to CCR, the efficiency score of F2 was below 47%, but in case of BCC, the efficiency score was below 59%. According to the combined results of CCR and BCC models, potential improvement rates should be reduced by 88.95% and 89.54 in the number of employees, by 53.20% and 41.24% in the active total, respectively, by 53.20% and 55.35% in equity (potential improvement rate).

In CCR application results, potential improvement rates for F3 were 184.06% for EBTI/net sales and 194.43% for export value. Although, it is not possible to reach these values where F2 had a higher chance of obtaining effectiveness under the assumption of a variable by scale (BCC). It has been associated with the necessity that a decision unit has to be both technical and scale effective in the CCR model BCC eliminates the necessity of scale efficiency for a decision unit. While the CCR model gives the total effectiveness, the BCC model is based on the variable technical return assumption based on pure technical effectiveness.

Potential improvement rates and target values were determined around 190% of F3 company which had inactive CCR. It was seen that the company which has to increase PBT/net sales by 184.06% had the potential to reach this target considering the value it achieved in the previous year.

Again, the potential improvement rates of the company, which is ineffective as a result of F5's input-oriented CCR application, were determined as EBIT (TRY) 669.91%, 564.28% for PBT/net sales and 270.60% for exports. The potential improvement rates for F5 company which was found to be ineffective as a result of input-oriented BCC application were determined to be 550.47% for EBIT (TRY), 765.15% for PBT/net sales and 322.53% for export.

The potential improvement rates for F9 company which was found to be ineffective as a result of input-oriented CCR application were determined to be 234.35% for EBIT (TRY), 381.52% for PBT/net sales and 1121.44% for export. It was found to be effective as a result of F5's input-oriented BCC application. Therefore, it is possible for F9 to meet the targets.

The technical efficiency averages of companies in the sector in that period are below the value of one. Companies in the sector cannot use their resources effectively. In other words, the reason for the increase in productivity in fisheries sector is technological progress. In the light of this survey study, following structural problems to be resolved: One of the most remarkable results of the study was the shortcomings in terms of institutionalization and the educational level of the managers, the shortcomings in marketing, usage of loans and incentives, low technical efficiency of the companies entering the FORTUNE 500 in fisheries sector. This reveals that there are structural problems in the sector. Despite the structural problems, firms use technology well and increase their total factor productivity and, thus, their competitiveness. Finding solutions for these structural problems, it is necessary to establish management mechanisms that would increase the cooperation of university with sector. The effectiveness of fisheries industry can be increased with the help of these management mechanisms and a triangle cooperation of industry, university and government sectors. A fisheries industry with increased activity can become one of the leading sectors in the economic development of Turkey. Also, examining all the efforts, it was seen that the studies in fisheries sector in Turkey using the DEA method were limited and inadequate, and it was concluded that further studies should be carried out using the DEA method. With DEA, the implementation of extension programs that will overcome the technical insufficiency in enterprises and taking policy measures covering training at the enterprise

level may contribute to the increase in economic effectiveness in the study area.

## CONCLUSION

Since this study was the first in Turkey to measure the effectiveness level of companies in fisheries sector, findings could not be compared with the findings of other studies. This can be considered as a limitation of the study, but also presents an opportunity for future studies. Different approaches/models for effectiveness measurement, different input-output combinations, and making new studies using different data periods, will contribute to filling the gap in the literature for fisheries in Turkey.

## ACKNOWLEDGEMENTS

This work has been done with the support of the Ege University Scientific Research Project 16-SÜF-035.

### Compliance with Ethical Standards

### Authors' Contributions

*Literature review*: Hülya Sayğı, Burcu Taylan

*Survey administration*: Hülya Sayğı, Aysun Kop, Hatice Tekoğul, Burcu Taylan

*Assessment*: Hülya Sayğı, Aysun Kop

*Writing the article*: Hülya Sayğı, Hatice Tekoğul

### Conflict of Interest

The authors declare that there is no conflict of interest.

### Ethical Approval

For this type of study, formal consent is not required.

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**Acta Nat. Sci. (2021) 2(1): 17-21**
DOI: 10.29329/actanatsci.2021.314.3
e-ISSN: 2718-0638

**Original Research Paper**
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ACTA NATURA ET SCIENTIA

# A Different Approach to the Interaction of Rainbow Trout (*Oncorhynchus mykiss*) Culture and the Eurasian Otter (*Lutra lutra* L.)

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**Please cite this paper as follows:**
Gültepe, N. (2021). A Different Approach to the Interaction of Rainbow Trout (*Oncorhynchus mykiss*) Culture and the Eurasian Otter (*Lutra lutra* L.). *Acta Natura et Scientia*, *2*(1), 17-21. https://doi.org/10.29329/actanatsci.2021.314.3

**ARTICLE INFO**

*Article History*
Received: 05.02.2021
Revised: 17.03.2021
Accepted: 19.03.2021
Available online: 04.05.2021

*Keywords:*
Otter
Rainbow trout
Otter breeding
Otter habitat

**ABSTRACT**

Perceived as an indicator of the balance in wildlife and clean nature, the Eurasian otter (*Lutra lutra* L.) is near-threatened due to the fact that its fur is valuable, the increase in environmental pollution, the decrease in wetlands, the rivers in their habitats are turned into channels. There are 86 rainbow trout (*Oncorhynchus mykiss*) farms legally licensed by the Provincial Ministry of Agriculture and Forestry Muğla - Turkey. Since otter meets 70% of its nutrient need from fish, it is seen as a predatory species by aquaculture producers. For this reason, it is necessary to work on establishing otter habitats and breeding farms jointly with rainbow trout farmers in order to eliminate the negative effects of both rainbow trout farms and Eurasian otters. In this way, Eurasian otters that are near-threatened, will be saved and also a different contribution will be made to our economy.

## INTRODUCTION

Turkey's rich inland water and marine resources are consisted with 8,333 km of coastline, 320 number of natural lakes, 861 reservoirs and 25 river basins. There are 2,034 aquaculture farms legally licensed by the Ministry of Agriculture and Forestry operating in these rich water resources (TOB, 2021; Çelikkale et al., 1999; Yıldırım & Okumuş, 2004). Mostly, the production in terms of aquaculture has been obtained from Muğla province in Turkey, which is located on the 32°22′ N longitude and 28°35′ E latitude. A total of 313 fish farms are found over there included with 86 rainbow trout (*Oncorhynchus mykiss*) farms, 1 ornamental fish farm and 1 common carp (*Cyprinus carpio*) - tilapia (*Oreochromis niloticus*) farm legally licensed by the Provincial Ministry of Agriculture and Forestry Muğla-Turkey. In addition, Muğla is home to wildlife as a natural protection zone due to its living species and forested areas. The majority of inland fish farms are established on Eşen Stream which hosts natural wildlife as well as aquaculture farms.

Otters live from Bering Strait to the Atlantic Ocean in different countries. These countries are Afghanistan, Albania, Algeria, Andorra, Armenia, Austria, Azerbaijan, Bangladesh, Belarus, Belgium, Bhutan, Bosnia and Herzegovina, Bulgaria, Cambodia, China, Croatia, Czechia, Denmark, Estonia, Finland, France, Georgia, Germany, Gibraltar, Greece, Hong Kong, Hungary, India, Indonesia, Iran, Iraq, Ireland, Israel, Italy, Japan, Jordan, Kazakhstan, Korea, Kyrgyzstan, Latvia, Lebanon, Liechtenstein, Lithuania, Luxembourg, Moldova, Mongolia, Montenegro, Morocco, Myanmar, Nepal, Netherlands, North Macedonia, Norway, Pakistan, Poland, Portugal, Romania, Russia, San Marino, Serbia, Slovakia, Slovenia, Spain, Sri Lanka, Sweden, Switzerland, Syria, Taiwan, China, Tajikistan, Thailand, Tunisia, Turkey, Turkmenistan, Ukraine, United Kingdom, Uzbekistan and Vietnam. Worldwide distribution of otters is given in Figure 1 (IUCN, 2021).

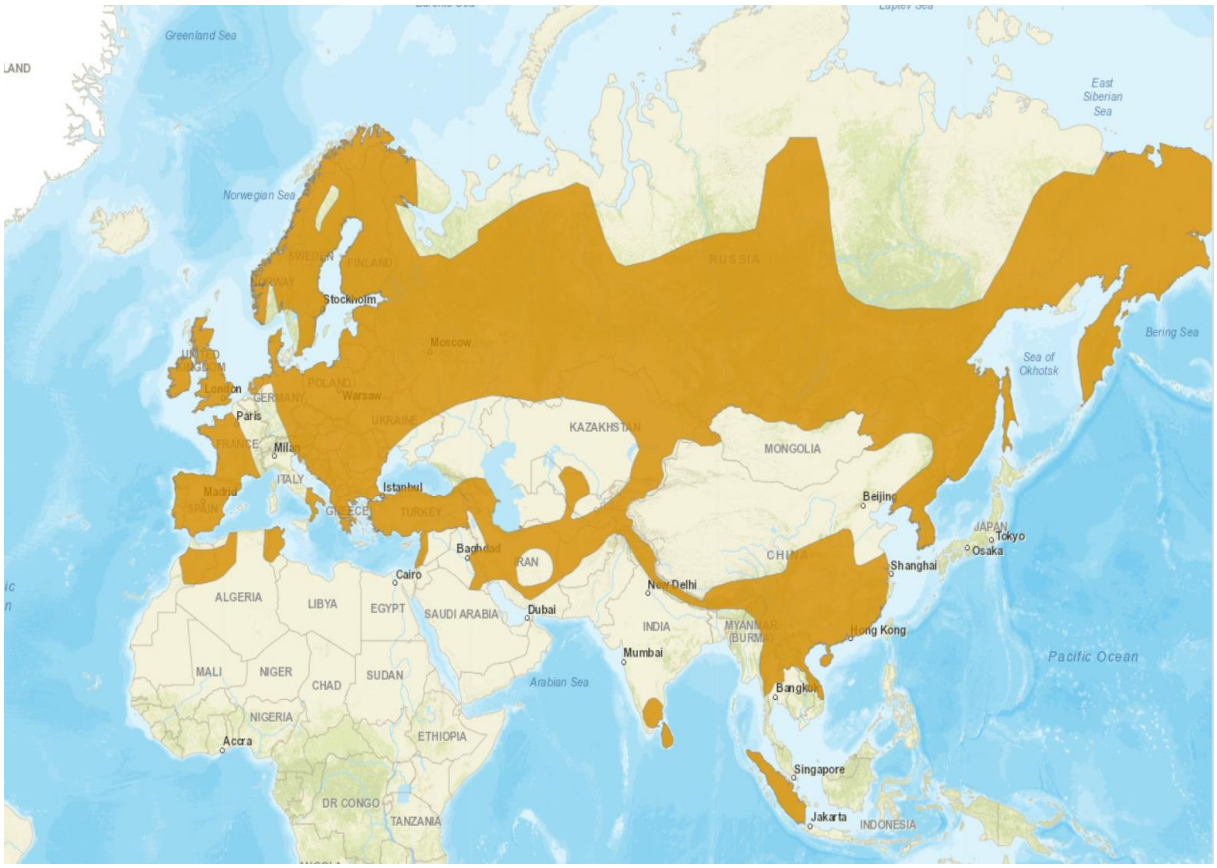


**Figure 1.** Distribution area of otters (*Lutra lutra* L.)

Since 1996, otters were assessed for the red list by IUCN (International Union for Conservation of Nature). Assessment scale and previously published red list assessments of otters are given in Table 1.

## METHODOLOGY AND DATA

The data were collected through interviews at farms exposed to otter attacks. In addition, the habitats, feeding, and behavior of otters affecting fish farms were personally observed and recorded by interviewing the farm staff in 2020.

Although they are included among the near-threatened species in the world due to their eating habits and the abundance of trout species in this region, otters live intensively in Eşen Stream, especially around the Seydikemer District of Muğla. The fact is that the otters live in this region and disturb the aquaculture producers due to their entry into fish farms and hunt them. Due to the above mentioned reasons, this study has been conducted aim to create a better living space for near-threatened otters as well as to find out the proper and suitable solution of this problem of aquaculture producers.

**Table 1.** Data set to determine the activity of the companies

| Year | Assessment |
|---|---|
| 1996 | Lower Risk/least concern (LR/LC) |
| 2000 | Vulnerable (VU) |
| 2004 | Near Threatened (NT) |
| 2008 | Near Threatened (NT) |
| 2014 |  |

## RESULTS AND DISCUSSION

It has been observed that otters came to the farms to feed just before sunrise. It has been determined that they generally come in the form of groups of 3-4 individuals and the first individual is male. It was determined that after the male individual was convinced that the environmental conditions were safe the he called other individuals by whistling with their own voices and generally used the water channels as the way to come to the farm (Figure 2).

An individual otter can eat 5 fish with an average weight of approximately 150-200 g/night. This value was calculated on the basis of the decrease in the number of fish in the pools in these farms. Because of these features, they have been seen as a predatory species by the breeders and they were shot and killed. Normally, otters that enter into the pools only for feeding, enter the pools to damage the pools by acting similar to the Mediterranean monk seals in case a family member kills them. Otters, mostly consume the bony parts of the fish such as the head and spine, eat the whole fish in the pools into they enter to feed. However, if they come to a farm to damage them, they leave the fish by tearing off the half with their teeth or simply injuring them (Figure 3). No whistling sound heard in the farms when they come to cause damage, night personal can only understand the presence of otters from the situation of the fish in the pools. In addition to eating fish, otters both increase the feed conversion rate (FCR) and cause susceptibility to diseases due to intense stress. That is why, fish farmers think that the only measure to protect their farms is to kill otters. In addition, they stated that fencing the farm, feeding dogs and the measures they took with the staff did not give any results against otters. Considering the sensitivity of the region and the species, creating a common living space is seen as a suitable solution for both of otters and fish farmers. Fish farm owners state that they can give deformed fish that they euthanized in their farms through the Muğla Trout Producers Union. In this way, both the cost of these fish to the company will be reduced and otters will be fed naturally and damage to the farms will be prevented. In previous studies, it was stated that primarily the general structure of the region was examining and common living areas should be created for otters with fish breeders and thus the continuity of the species should be ensured (Aydın et al., 2008; Gültepe et al., 2009). In this study, similar to our previous studies, it is recommended to expand the Area Protected by Special Law from Antalya to the Muğla province border to Eşen State Hunting Ground (Figure 4). In conclusion, in the habitat to be created, both the fish farms will not be damaged and the euthanized fish in the farms will ensure the survival of the otters.

**Figure 2.** Otter (*Lutra lutra* L.) footprints in the water channel

**Figure 3.** Rainbow trout bitten by an otter (*Lutra lutra* L.)

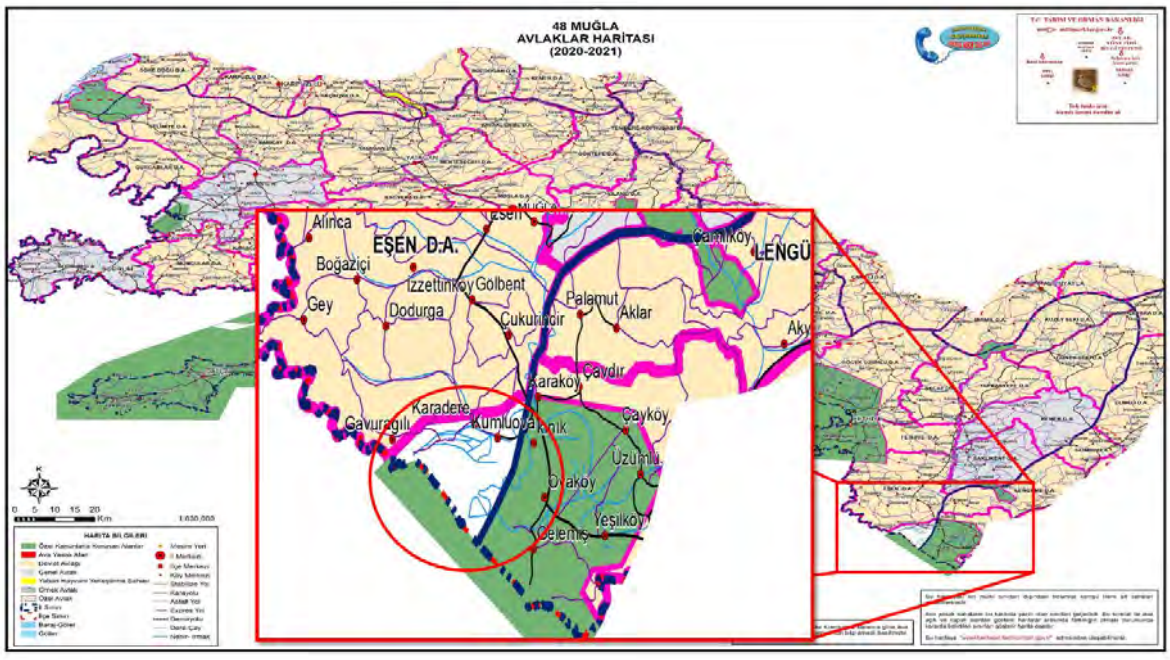


**Figure 4.** Muğla hunting ground map (TRMAF, 2021) and recommended habitat

Thus, after the creation of a habitat in terms of the continuity of the species, otter breeding can be done economically in this region to both contribute to the economy of the country and employments creation.

## Compliance with Ethical Standards

## Conflict of Interest

The author declares that there is no conflict of interest.

## Ethical Approval

For this type of study, formal consent is not required.

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**Acta Nat. Sci. (2021) 2(1): 22-28**
DOI: 10.29329/actanatsci.2021.314.4
e-ISSN: 2718-0638

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ACTA NATURA ET SCIENTIA

# First Results on Spawning and Larval Rearing of the Brown Meagre (*Sciaena umbra*)

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**Please cite this paper as follows:**
Hamzaçebi, S., & Can, E. (2021). First Results on Spawning and Larval Rearing of the Brown Meagre (*Sciaena umbra*). *Acta Natura et Scientia*, *2*(1), 22-28. https://doi.org/10.29329/actanatsci.2021.314.4

**ARTICLE INFO**

*Article History*
Received: 10.02.2021
Revised: 05.05.2021
Accepted: 06.05.2021
Available online: 06.05.2021

*Keywords:*
Aquaculture
Brown meagre
*Sciaena umbra*
Larval rearing
Spawning

**ABSTRACT**

The aim of the present study is to investigate spawning and larval rearing of brown meagre (*Sciaena umbra*). This is an important species in the Mediterranean Sea because of its beauty, calm swimming, large otoliths, souvenir potential, aggregative behaviour, excellent flesh and accessibility. Although this species is regarded as Near Threatened (in IUCN Red List Status), the demand increases the fishing. Green water technique was used for rearing the brown meagre larvae. Diameter of eggs was recorded as 1457.31±47.29 µm. Yolk was homogenous with oil globules of 371.59±18.15 µm at the centre. Hatching process began after 39 hours. Hatching rate ($H_R$) was observed as 92.17±0.24%, and larvae inflated swim bladder around 97.33±0.94%. The brown meagre juveniles reached to 40.08±1.98 mm of total length (TL) with 10.96±0.08 mm body height (BH) and 662.27±21.23 mg body weight (BW) after 55 days of post-hatching. Survival (SR) was recorded as 72.5±0.70% at the end of study. Since the brown meagre is a threatened species, with high economic interest, is a possible candidate for commercial aquaculture both food and restocking the depleted natural fisheries.

## INTRODUCTION

Brown meagre (*Sciaena umbra*) is a Mediterranean sciaenid having both of commercial and ecological values; it is aimed by commercial and recreational fishing (Colla et al., 2018) and it is included in Annex 3 of the Protocol on Specially Protected Areas and Biological Diversity of the Mediterranean to the Barcelona Convention (Basin, 1995). The fish are long from 30 to 40 cm but may reach to 60 cm in length. The flat abdomen and strongly curved back give an easily recognizable shape. Two dorsal fins and straight-ending caudal fin are yellow with a black margin. Grey body has golden and silver spots (Bay-Nouailhat, 2007). Analysis of gut content indicated that this species feeds mainly on crustaceans (Engin & Seyhan, 2009) and the most important taxon identified was decapods, which were present in 96% of stomachs, and represented 92% of total prey weight. The other dominant food species were amphipods and isopods, which occurred in 25% and 23% of stomachs, respectively (Chater et al., 2012). *S. umbra* lives in Eastern Atlantic from Mauritania to the English Channel, and in the Mediterranean Sea, the Black Sea and the Azov Sea. In Europe, this species is influenced increasingly by commercial and recreational fishing (Harmelin et al., 2015). Also, there is a loss of estuarine habitats, and reductions caused by divers and spear fishermen (Chao, 2015). The stocks have been substantially decreased because of habitat degradation, behavioural characteristics in their life cycle traits and recreational fishing in the northern Mediterranean Sea (Harmelin et al., 2015). Notwithstanding, *S. umbra* has potential for fisheries in the Aegean and Black Sea (Turkey). Two white and big bone stones behind the eyes and over the brain, are used in urolithiasis (Ergin et al., 2017). Thus, demand increases the fishing pressure although it is considered Near Threatened, globally (in IUCN Red List Status).

The early life stages of fish are critical stages where major efforts in intensification are needed to raise growth and inhibit mortality (Can, 2013). Chatzifotis et al. (2006) reported first data on the growth of cultured brown meagre *S. umbra* using different diets. However, to date, the first larval stages of *S. umbra* has not been performed. This study was aimed to investigate brown meagre larval rearing in green water technique.

## MATERIAL AND METHODS

### Broodstock Collection and Management

Acquisition of broodstock was done using professional fishing boats in which the live fish were captured and transported in a 450 l volume tank equipped with oxygenation. Fish were caught between June 2010 and May 2011, and the study has been carried out at Olivka Agricultural Products Industry and Trade Inc in Milas-Muğla. After arriving at the hatchery in the Aegean region, the fish were treated prophylactically with oxytetracycline (applied in 50 ppm baths for 2 h) and formalin (200 ppm for 1 h) for a period of 7 days. The fish were measured, weighed and stocked in a 5000 l rectangular concrete tank at 0.63 kg $m^3$. Sex of specimens was determined by using a cannula. Broodstock was recorded between 350 g and 900 g in weight, and 25-36 cm in total length. The ratio of male to female was noted as 2:3. Eggs and milt were collected from 5 selected fish. Broodstock spawned naturally (Fig. 1a). Initially, the fish were fed on frozen cuttle fish (*Sepia officialis*), shrimp (*Palaemon elegans*), anchovy (*Engraulis encrasicolus*) and sardines (*Sardina pilchardus*).

After approximately 20 days of adaptation, the diet was prepared with anchovy and sardines every other day. Adlibitum feeding was performed twice a day to 2% of the stock biomass. The egg collector of 100 l volume with a 500 µm net was installed in the tank drainage for eggs collection. Hatching rate was determined volumetrically by siphoning of unfertilized and dead eggs one day after the completion of hatching. Egg diameter was measured with a light microscope (Olympus CX22) (Fig. 1b). Buoyant eggs were incubated in equal amounts in 2 cylindroconical tanks. Incubators with a volume of 250 l of water were kept in dark at 20°C. Aeration at a rate of 40 ml per minute has been applied with minimal water renewal (<85 %). During the incubation, density of incubators was recorded as 1300 eggs $l^{-1}$. The experiment has been established using two replications.

### Rearing of Larvae

Larvae were produced in two (5000 l) fibreglass tanks using green water rearing method which is the most natural among commercially employed production technique for marine larvae. The larvae densities were initially consisted to 40-43 individuals $l^{-1}$. Water was filtered (10 µm porosity filters) and sterilised with UV. Initially, aeration was provided with 3 ceramic diffusers in tanks. However, only one diffuser was placed at the centre of tanks after first feeding. Temperature ranged between 20.5°C and 21.5°C during rearing the larval stages. Water flow rate was noted as 70 ml. $sec^{-1}$ up to day 7, measured as 145 ml. $sec^{-1}$ after 10 days of post-hatching (dph), 200 ml $sec^{-1}$ at 11-12 dph and increased to 1000 ml $sec^{-1}$ at 20 dph. The photoperiod was begun with light intensity at ~0 lux at the beginning of larval stage. When mouth opening was observed (the third day), light intensity was increased to 10–40 lux and continued to day 6 after which it was increased day by day, ranging between 20-105 lux at 7 dph, 40-250 lux at 8 dph, 75-450 lux at 9 dph, 35-450 lux at 10 dph, 120-440 lux at 11 dph, 125-635 lux at 12 dph and 280-610 lux at 13 dph. Phytoplankton (*Nannochloropsis oculata*) was added twice daily to maintain a green culturing environment at a concentration of 2-4. $10^5$ cells $ml^{-1}$ until 20 dph. (Shields et al. 1999; Papandroulakis et al. 2001).

Rotifers (*Brachionus plicatilis)* were enriched with *N. oculata* and commercial products (A1 DHA Selco and DHA Protein Selco, INVE) in 1000 l cylindroconical tanks at the

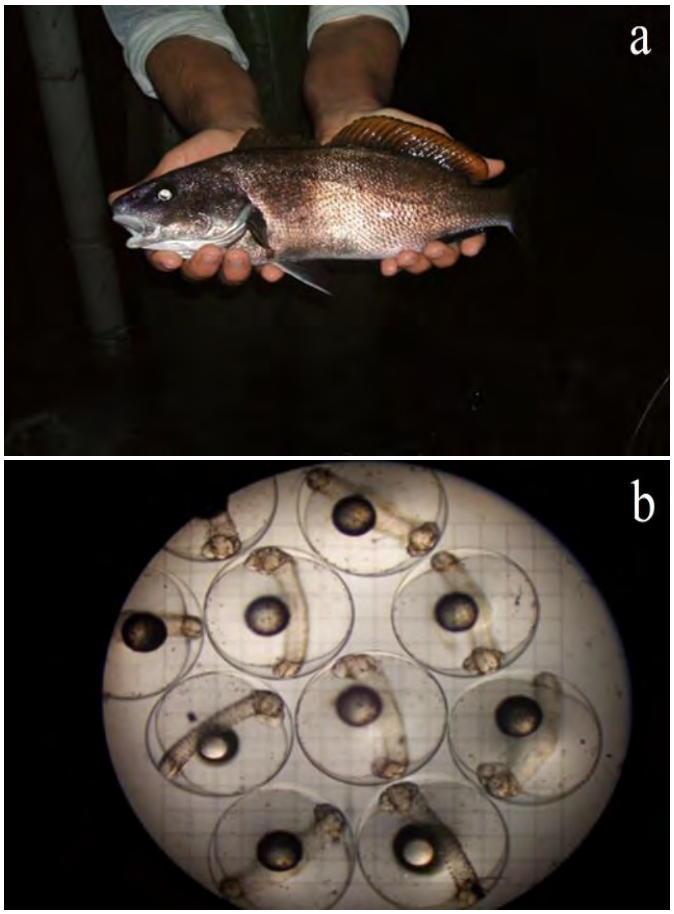


**Figure 1.** a) *Sciaena umbra* broodstock. b) Eggs of *Sciaena umbra*

density of 400 to 600 individuals $ml^{-1}$ before feeding on larvae. Larvae were initially fed on rotifers (10 prey $ml^{-1}$, from 3 dph to 20 dph), followed by AF (from 9 dph to 11 dph, (3–5 prey $ml^{-1}$), enriched EG48 *Artemia sp.* (starting in 11 dph, A1 DHA Selco, INVE) and artificial diet (INVE Aquaculture). From 9 dph, larvae were fed on a mixed diet of *Artemia* and rotifer. Larvae were fed on commercial diets (INVE Aquaculture) at 20-55 dph.

A surface skimmer was used between 4 and 15 dph for surface cleaning to maintain swim bladder inflation. Oxygen level measured between 6.0 and 7.0 mg $l^{-1}$.

### Post-Larvae Growth

About 25 dph, larvae (25-50 mg) were transferred to two rectangular tanks (10 $m^3$ each), and they were reared to 55 dph. The photoperiod was natural (light intensity ranged from 400 to 500 lux). The density of the culture was 15.300-16.425 larvae per $m^3$. The water temperature was maintained at 21.5-22.5°C whereas oxygen was at 5.9–7.8 mg $l^{-1}$. Larvae were fed manually with a commercial diet (Proton 2 150-300 μm; 54% protein, 15% lipid). Fish were sampled to measure total length (TL), body weight (BW), total height (TH), yolk sac diameter and oil globule diameter (Fig. 2a and 2b).

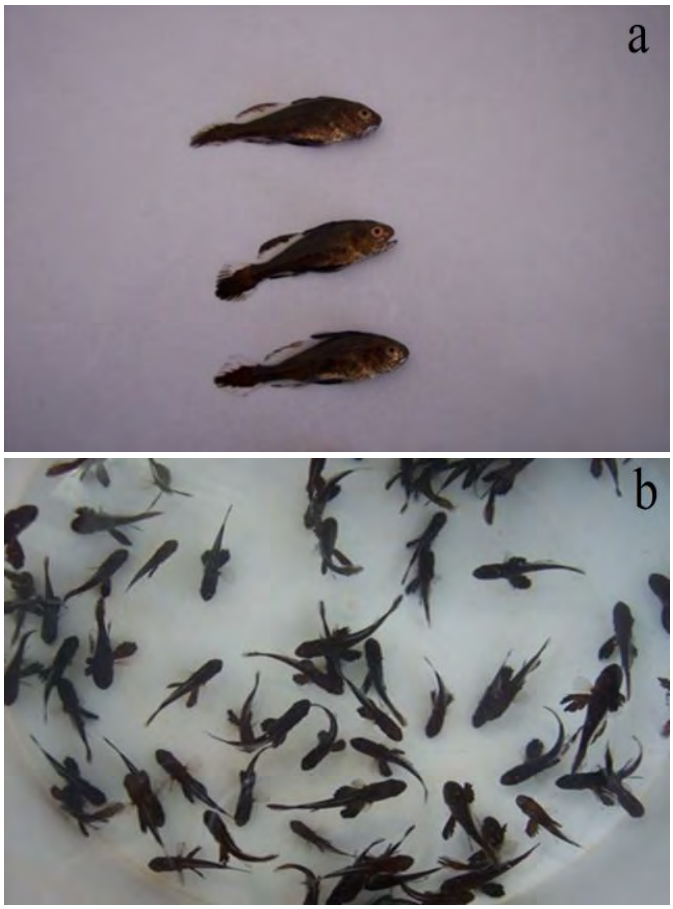


**Figure 2.** a) The post larvae of *Sciaena umbra*. b) The fries of *Sciaena umbra*

### Statistical Analysis

The descriptive statistics of the continuous variables were given as mean ± SD. To verify the homogeneity of variances data were submitted to Levene test. To check the normality assumption in this study, data were determined by Shapiro–Wilk test. Regression analyses of TL/TW, total TL/TH, and TL, TW and TH/larva age (dph) were carried out by Microsoft Excel 2010.

## RESULTS

### Broodstock and Spawning

Males used as broodstock were noted as 350 g TW 25 cm TL, 900 g TW 36 cm TL; females were 450 g TW 29 cm TL, 600 g TW 32 cm TL, 800 g TW 34 cm TL. Approximately 785 g eggs obtained from the broodstock. While buoyant eggs were 740 g, sinking eggs were 65 g. By counting the eggs it was seen that 800-900 (874±16.25) per in 1 g. The eggs were observed to be transparent, spherical and 1380–1530 μm in diameter (1457.31±47.29 μm). The yolk was homogenous with oil globules of 344–390 μm (371.59±18.15 μm) at the centre, and unsegmented. Hatching began after 39 hours, and was completed after 40 hours in 20.5±0.5°C. The hatching rate of the eggs in the incubators was 92.66±1.20%. It is critical in aquaculture in relation to egg quality since it affects the final number of fish. Thus, brown meagre is a good candidate for aquaculture.

### Larval Development

Newly hatched pre-larva was 4.86±0.26 mm in TL, 1.35±0.13 mm in body height and 1.38±0.50 mg in weight. The oil globule diameter was between 0.41±0.07 mm and 0.21±0.05 mm up to 3 dph. The yolk sac height decreased to 0.64±0.19 mm from 0.78±0.09 mm whereas the yolk sac length stayed the same (as 1.33 mm) during the first 6 days after hatching (Fig. 3a and 3b). The mouth opening of the pre-larva occurred on the 3rd day. The first peak in mortality was approximately 15%, and occurred between 8-13 dph. It was correlated with the death of the larvae, which could not become reconciled with diet, or the ability to digest rotifers, as was concluded by microscopic observation. The larvae densities were 41.50±2.12 individuals $l^{-1}$. Interestingly, before feeding started, at the 4th dph, although surface cleaning was not started the swim bladder formation was observed around 97.33±0.94%, the second cycle of raised loss of larva was (approximately 10%) observed on 23-25 dph. Cannibalism was observed between 35 dph and 40 dph. At the end of study, survival was 72.5±0.70% from pre-larva. The final number of the brown meagre juveniles was ~288000, which reached 40.08±1.98 mm total length with 10.96±0.08 mm body

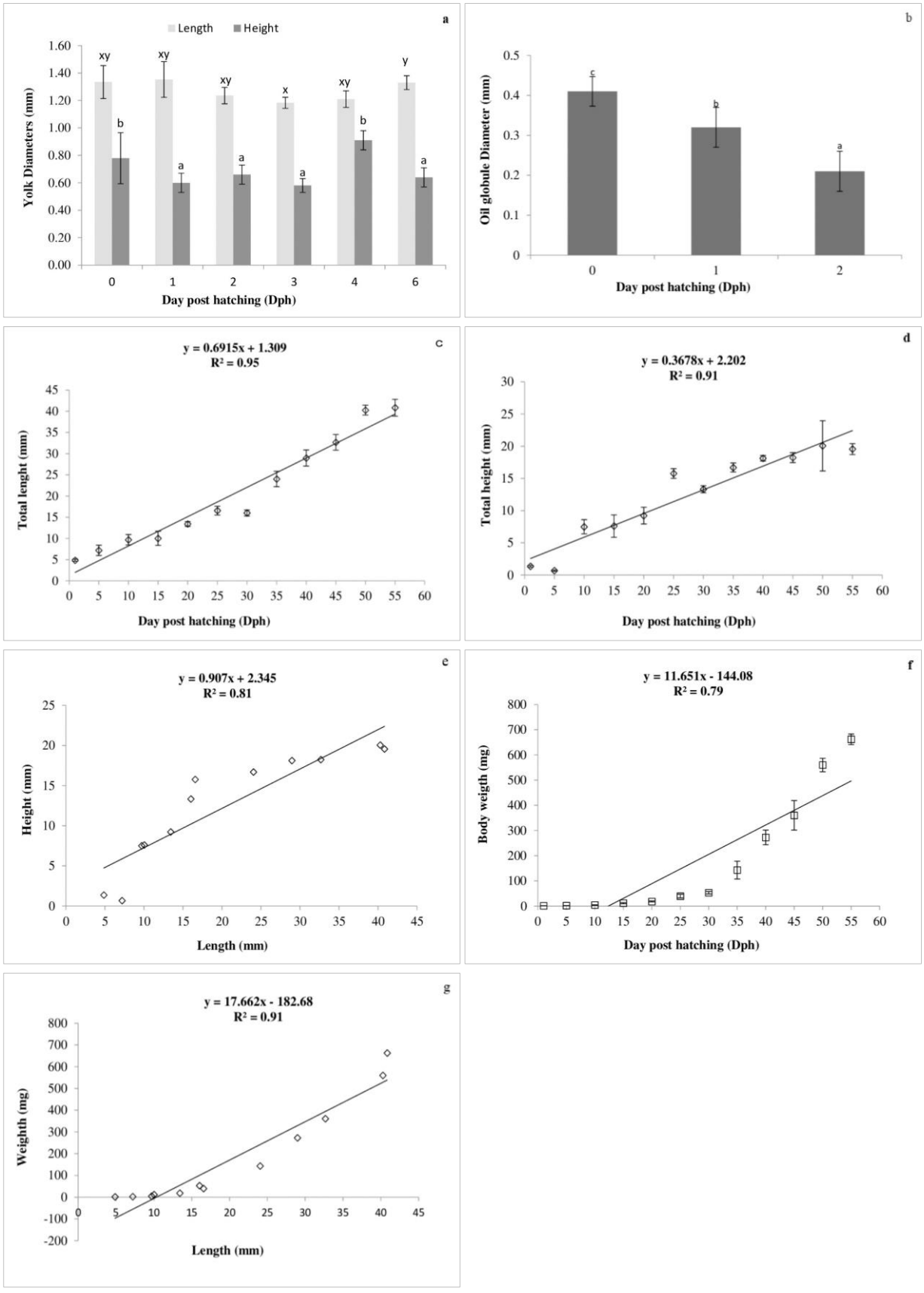


**Figure 3.** a) Yolk such diameter (length and height) changes of brown meagre during the prelarval stage. b) Oil globule diameter changes of brown meagre during the prelarval stage. c) Total length (mean ± S.D.) of brown meagre larvae during the rearing. d) Total height (mean ± S.D.) of brown meagre larvae during the rearing. e) Height and length relationships of brown meagre larvae during the rearing. f) Weight gain during the larval stage of brown meagre (mean ± S.D.). g) Length and weight relationships of brown meagre larvae during the rearing (n=30)

height and 662.27±21.23 mg body weight (Fig. 3c, 3d and 3f) after 55 dph. Positive correlations were determined in length-height and length-weight relationships of brown meagre larvae during the rearing (Fig. 3e and 3g).

## DISCUSSION

Because of its attractive features, including the presence of large otoliths, excellent flesh, and calm swimming behaviour, the brown meagre has become an important species in the Mediterranean Sea (Harmelin et al., 2015). Results obtained from the present study have highlighted the ability to rear larvae in captivity. Indeed, the egg diameter was found to be larger than with other marine fish species, for example common dentex (Can et al., 2012) and sea bass (Saka et al., 2001). Certainly, the hatching rate of 92.17 ± 0.24% was similar with those of other studies for sea bass, sea bream (Can et al., 2012), white seabream (Hamzaçebi, 2020) and red porgy (Kolios et al., 1997), but higher than that of common dentex (hatching rate ≤ 85%) (Can et al., 2012). This hatching rate is critical in aquaculture in relation to egg quality since it affects the final number of fish. Thus, brown meagre is a good candidate for aquaculture.

The swim bladder inflation was higher than 95% at 50 and 500 lux light intensity in larval rearing of sciaenid meagre (*Argyrosomus regius*) (Valles & Estevez 2013). In pre-larval stage of meagre larvae up to day 3, the swim bladder inflation was detected (Papadakis et al., 2013). On the 2nd day of shi drum (*Umbrina cirrosa*) larvae, another sciaenid, it was observed that they inflated swim bladder around 90% (Zais et al., 2006). Studies have shown similarity with the results of our study (at the 4th dph in the range of 97.33 ± 0.94%, before starting feeding, although air cleaning was not started), and this is an advantage for culturing because many of the fish, notably sparids, swim bladder inflation takes longer time with lower percentage when compared the sciaenids. The reason of that may related to feeding since feeding may increase the quantity of oil on the water surface and its cleaning is critical at this period for swim bladder formation in most of the cultured fish.

The growth can be affected by the environmental conditional and the bacterial bloom on the culture media (Can et al., 2010). The use of semi-intensive technology for larvae rearing results in higher growth performance and survival than intensive one in marine species (Roo et al., 2010) and semi-intensive larvae rearing is used in the Mediterranean area to increase the quality of juvenile fish (Divanach & Kentouri 2000; Boglione et al., 2003; Russo et al., 2010; Roo et al., 2010). In present study, green water technique, a semi-intensive production system that facilitates the rearing method of several species in larval stages, solving the issues and many of their economical, technical and human outcomes were used (Papandroulakis et al., 2005).

The raised mortality at the beginning of the larval production might have been cause of by lack of adaptation of some larvae to artificial feed (Can, 2013). Cannibalism was the critical factor inducing mortality during the juvenile phase, as well, in similar studies in other Mediterranean species, i.e., sea bass (Kayim et al., 2010) and red porgy (Roo et al,. 2010). Comparable results were observed in present study, especially between 20-30 dph. Cannibalism may be associated with problems of starvation, size dispersion, illumination and stocking density (Dou et al., 2000). Brown meagre (*Sciaena umbra*) has special characteristics and advantages making it a satisfactory candidate for aquaculture, namely the high level of swim bladder inflation before the start of feeding in the first larval stages and the speed of growth when compared to another cultured fish. Moreover, there is an established worldwide market for otoliths, which are used in folk medicine. Brown meagre is a threatened species, with high economic interest. Therefore, it is a possible candidate for commercial aquaculture for food and for restocking the depleted natural fisheries. These first results on the larval stages of *S. umbra* in captivity maintain crucial data for evaluating its culturing potential. However further researches are needed about rearing protocols related to salinity, light and temperature, also feeding strategies to obtain better results on survival and growth.

## CONCLUSION

Brown meagre (*Sciaena umbra*) has special characteristics and advantages making it a satisfactory candidate for aquaculture, namely the high level of swim bladder inflation before the start of feeding in the first larval stages and the speed of growth when compared to another cultured fish. Brown meagre is a threatened species, with high economic value. Therefore, it is a possible candidate for commercial aquaculture for food and restocking the depleted natural fisheries.

These first results on the larval stages of *S. umbra* in captivity maintain crucial data for evaluating its culturing potential. However further researches are needed about rearing protocols related to salinity, light and temperature, and also feeding strategies to obtain better results related to survival and growth.

## ACKNOWLEDGEMENTS

Authors would like to thank all the technical staff of Olivka Agricultural Products Industry and Trade Inc., especially Production Manager Mr. Bülent HAMZAÇEBİ for his technical support and knowledge during the study.

## Compliance with Ethical Standards

## Authors' Contributions

The authors contributed equally to this paper.

## Conflict of Interest

The authors declare that there is no conflict of interest.

## Ethical Approval

For this type of study, formal consent was not required while the study conducted.

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**Acta Nat. Sci. (2021) 2(1): 29-34**
DOI: 10.29329/actanatsci.2021.314.5
e-ISSN: 2718-0638

**Original Research Paper**
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ACTA NATURA ET SCIENTIA

# Seasonal Examination of Heavy Metal Levels in Muscle Tissues of European pilchard (*Sardina pilchardus*, Walbaum 1792)

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**Please cite this paper as follows:**
İrkin, L. C., & Öztürk, Ş. (2021). Seasonal Examination of Heavy Metal Levels in Muscle Tissues of Sardines (*Sardine pilchardus*, Walbaum 1792). *Acta Natura et Scientia*, *2*(1), 29-34. https://doi.org/10.29329/actanatsci.2021.314.5

**ARTICLE INFO**

*Article History*
Received: 03.04.2021
Revised: 06.05.2021
Accepted: 06.05.2021
Available online: 10.05.2021

*Keywords:*
Çanakkale Strait
Heavy metal
European pilchard
Muscle tissue

**ABSTRACT**

The sampling point of the research was determined as the shores of Çanakkale Strait, where fishing is dense. Seasonal sampling of European pilchard (*Sardina pilchardus*, Walbaum 1792) was made that caught by commercial fishing boats in Çanakkale Strait and rarely offered for consumption. Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES) allows analysis of trace, minor and major concentration levels of the chemical element, was used to determine the amount of heavy metals in the samples. Analysis of Cadmium (Cd), Copper (Cu), Iron (Fe), Manganese (Mn), Lead (Pb) and Zinc (Zn) heavy metals in samples was performed by the United States Environmental Protection Agency (US EPA). Levels of Cd, Cu, Fe, Mn, Pb and Zn were determined in muscle tissues of European pilchard. In the samples, Cd values were detected only in autumn, Cu level was found highest in winter, Fe and Zn levels were highest in spring and the level of Mn was observed higher in winter. Pb has not been detected in fish muscle dough in any season. Mn level has been obtained above the limit values and Cd level was found under the offered limits. As a result, it has been determined that the heavy metal accumulation in the muscle tissues of European pilchard caught from Çanakkale Strait increased seasonally in parallel with the increase of pollution.

## INTRODUCTION

Nowadays, aquatic ecosystem is damaged by persistent pollutants originated from agricultural and industry sectors. Heavy metal pollution has been identified as a concern in coastal areas due to discharges from industrial wastes, agricultural and urban wastewater. Heavy metal levels increase significantly in marine environment mainly because of anthropogenic activities (Sharifuzzaman et al., 2016). Fish and other aquatic organisms were not independent of environment in which they survive. This situation results in the complete extinction of species that are not tolerant to certain environmental factors, thus it causes structural and functional damage to organisms by interfering with the physiological and biochemical mechanisms. It is very important to determine the levels of heavy metals in foodstuffs, especially in sea food (Pörtner et al., 2005).

When the previous studies conducted to determine the metal accumulation in sea water in Çanakkale Strait are examined, it has been seen that these studies have relatively searched the sediment samples. Bat et al. (2019) evaluated the heavy metal pollution in water, sediment and polychaetes in Sinop coasts of Black Sea. Hg, Cd, Pb, Cu and Zn levels in water, sediment and polychaetes were determined and their anthropogenic effect on environment was evaluated. Metal concentrations in water were found as Zn> Cu> Pb> Cd> Hg, and the abundance of these metals in the sediment were

respectively: Zn> Cu> Pb> Hg> Cd. Olgunoğlu et al. (2015) investigated the concentration of Cd, Pb, Cu, Zn and Fe in the gill and muscle tissues of four benthic fish species from the Northeastern part of Mediterranean region. Heavy metal concentrations in muscle tissues were found lowest while the highest levels were obtained for each species from the gills. Salam et al. (2019) stated that advanced agricultural activities and rapid industrialization cause pollution in aquatic areas. Heavy metals can eventually be transported from aquatic animals such as fish, shrimp, and crabs to human body through food chain. In this study, four fish species viz *Euthynnus affinis, Pampus argenteus, Descapterus macrosoma,* and *Leiognathus daura*, shrimp (*Fenneropenaeus indicus*) and crab (*Organisropenus indicus*) were used aim to detect the levels of heavy metal in muscle tissues.

Aquatic organisms can accumulate heavy metals from environment by various means including respiration, adsorption and ingestion (Sönmez et al., 2016). Particularly, fish accumulate heavy metals by internal organs, gills, skin and muscle. Human health is under threat with the consumption of fish and other seafood supplied from regions with excessive heavy metal concentration. Because heavy metals accumulate in various tissues over time and can be transferred to people through their food chain (Zhang et al., 2017). Therefore, in this study, it has been investigated that how the fish species that move from the industrially developed Marmara Region through the overcurrent system to the Dardanelles Strait and then to the Aegean Sea affected by the potential metal accumulation in their tissues. Çanakkale Strait is also exposed to a lot of ship wastes by transit ship passages. Our aim has been to determine the possible metal load in water and the extent of marine pollution and to investigate the accumulation of various heavy metals in fish that are frequently caught and consumed from this habitat.

## MATERIAL AND METHODS

### ICP-OES Element Determination

Sampling was done four times (Spring-April, 2020, Summer-June, 2020, Autumn-September, 2020, Winter-January, 2021) throughout the year. Muscle tissue (meat part) required for the detection of heavy metal accumulation, was taken from the dorsal fin approximately 2 cm below. In the study, samples with an average length of 15.4 cm and a weight of 35.7 g were used.

Before heavy metal analysis, pre-treatment process, fresh samples were freeze-dried at -55˚C for 72 hours with lyophilizer. In this analysis, Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES), which allows the analysis of trace, minor and major concentration levels of the chemical element was used to determine the amount of heavy metals in samples (Fallah et al., 2011). Analysis of Cd, Cu, Fe, Mn, Pb and Zn were performed by EPA (2007) method. Pre-treatment and analysis were carried out by Çanakkale Onsekiz Mart University Science and Technology Application and Research Center.

Statistical evaluation was made according to the seasonal heavy metal accumulation comparatively. The heavy metal contents of the samples were evaluated considering the risk factors and the environment which they grown.

All data sets were subjected and analyzed for homogeneity of variances and normality test. One-way ANOVA was adopted to get a comparative outlook of heavy metals with respect to European pilchard in single tissue. Statistical analysis indicated the significant values for processed data ($p<0.05$). For the ANOVA post hoc test, Tukey was applied for pairwise mean comparisons where homogeneity of variance was established. Statistical analysis has been done with the help of SPSS 19.0 for Windows (Table 1).

## RESULTS

In our study, Cd, Cu, Fe, Mn, Pb and Zn levels in muscle tissues taken from *Sardina pilchardus* from Çanakkale Strait were determined by ICP-OES technique. Average values were determined according to the seasons. Results are given in the following table. Prior to analysis, the ICP-OES instrument was calibrated using standard solutions 0.1, 0.25, 0.5, 1, and 2 mg/L for each element. It was also used as a quality control solution in a 0.1 mg/L solution. To show the sensitivity of the method, LOD (limit of detection) study was conducted for each parameter and the values obtained because of the studies were given in Table 1.

**Table 1.** LOD and wave length values

| | Cd | Cu | Fe | Mn | Pb | Zn |
|---|---|---|---|---|---|---|
| **LOD (ppb)** | 5 | 5 | 5 | 5 | 5 | 5 |
| **Wave length (nm)** | 226.5 | 324.7 | 259.9 | 257.6 | 220.3 | 213.8 |

Cadmium values of European pilchard tissues were determined between April 2020 and January 2021. Cd could not be detected in the samples in spring, summer, and winter seasons. Cd value was only determined as 0.01 (μg/g) in autumn shown in Table 2. It has been determined that the value of Cu in spring was noted as 0.04 (μg/g), in autumn it was observed as 0.03 (μg/g) and in winter it was found as 0.05 (μg/g). During summer, Cu was not detected. In the comparison made based on seasons, the highest value for European pilchard was found in winter samples (Table 2).

Fe value in spring was recorded as 68.22 (µg/g), in autumn, it was 54.36 (µg/g), and the value in winter was 61.38 (µg/g). Fe value in summer determined as 50.74 (µg/g). In the comparison made on the basis of seasons, the highest value for European pilchard was found in spring samples (Table 2).

Mn value in spring was mentioned as 2.81 (µg/g), the value of Mn in autumn determined as 3.65 (µg/g), and the value in winter was as 5.42 (µg/g). In summer, Mn value was determined as 2.80 (µg/g). During the comparison made on the basis of seasons, the highest Mn value for European pilchard was observed in those samples which are taken in winter (Table 2).

Pb content of this species was not detected during seasonal evaluation (Table 2).

Zn value of spring samples was noted as 74.18 (µg/g), in autumn, it was recorded as 44.11 (µg/g) while the value in winter samples was determined as 59.42 (µg/g). The Zn value in summer was determined as 47.38 (µg/g). During the comparison made on the basis of seasons, the highest Zn value for European pilchard was found in spring samples (Table 2).

While the accumulation of heavy metals in the muscle tissue of the European pilchard, which tried to determine seasonally, was expected to differ, the differences between the elements such as Cd and Pb that could not be determined, and the elements that were very close to each other in some seasons and could not be statistically significant were ignored. Because the undetectable Cd and Pb are related to the minimum value to be read in the adjustment of the device, they have a very low probability of accumulation. At the same time, it shows that although there is negativity in terms of statistical significance among the elements detected at very close values in some seasons, it should be taken into account that it is above the limit value.

**Table 2.** Seasonal heavy metal values (µg/g) for *S. pilchardus*

| Heavy metals \ Season | Spring | Summer | Autumn | Winter | Limit values |
|---|---|---|---|---|---|
| **Cd** | ND | ND | 0.01 | ND | 0.01 |
| **Cu** | 0.04±0.01 | ND<br>$A^{*}$, $D^{*}$ | 0.03±0.008<br>$B^{*}$, $F^{*}$ | 0.05±0.014<br>$C^{*}$, $E^{*}$ | 0.02 |
| **Fe** | 68.22±8.21 | 50.74±7.64<br>$A^{***}$, $D^{***}$ | 54.36±7.85<br>$B^{***}$, $F^{**}$ | 61.38±8.12<br>$C^{**}$, $E^{**}$ | ND |
| **Mn** | 2.81±0.60 | 2.80±0.56<br>$A^{*}$, $D^{***}$ | 3.65±0.84<br>$B^{**}$, $F^{***}$ | 5.42±1.13<br>$C^{***}$, $E^{***}$ | 1.0 |
| **Pb** | ND | ND | ND | ND | 0.3 |
| **Zn** | 74.18±13.41 | 47.38±7.65<br>$A^{***}$, $D^{*}$ | 44.11±6.88<br>$B^{***}$, $F^{***}$ | 59.42±7.74<br>$C^{***}$, $E^{***}$ | 50 |

***Note:*** The maximum limit value for Mn (mg/kg), for the other elements the values given by WHO (2002) were considered (ND: Not defined), (Mokhtar et al., 2009). Data are given as mean ± SD. $^{*}p>0.05$, $^{**}p<0.05$, $^{***}p<0.001$, $^{***}p<0.0001$. Group comparison: A: spring and summer, B: spring and autumn, C: spring and winter, D: summer and autumn, E: summer and winter, F: autumn and winter.

## DISCUSSION

Heavy metal levels in muscle tissues of the Sardines showed variation seasonally. Cd was detected only in samples which collected in autumn. Cu has been detected in all seasons except, summer. Fe has been found in all seasons. Statistically, Fe values were determined the highest in spring and the lowest in summer season according to different seasons. Mn was determined in all seasons and the seasonal ranking was determined the highest in winter and the lowest in summer. Pb has detected in all seasons. Zn has been determined in all seasons and determined the highest in spring and the lowest in autumn. In similar studies conducted on fish samples collected from the coasts of Turkey and other countries, it was observed that there are regional differences in the accumulation of heavy metals in fish species consumed as food.

Wastewater is released because of industrial establishments, buildings, agriculture and animal husbandry practices, the operations of energy generating power plants and contains chemicals that adversely affect health, is one of the most important sources of pollution (Dündar et al., 2012). Heavy metal pollution may be higher in places where streams flow into the sea as compared to other regions (Wojciechowska et al., 2019). It is expected that there will be more heavy metal accumulation in their bodies, as the rate of fish consumption of people living in regions with coasts to the Black Sea, is higher than the rate of fish consumption of people living in regions with no coasts (Küçük, 2015). Elderwish et al. (2019) found a strong correlation in the positive direction of metals in some stations of their seasonal examined the accumulation of heavy metals in waters of the western Black Sea coast of Turkey. Engel et al. (1981) stated that metals are found in aquatic environments absorbed by

organic or inorganic compounds, free ions, and particulate matter. In this way, after some of the heavy metals enter the water, some of them are carried directly to the organisms and some to the sediment (Kaptan, 2014). Recently studies on marine pollution have increased considerably and the data obtained that the pollution is increasing day by day according to the results of the research conducted both on global basis. Pollution in the seas disrupts the aquatic ecosystem, many sea creatures, especially fish, exposed to deteriorating and accumulating elements in their tissues. Heavy metals can reach people with consuming seafood and this can cause chronic diseases (Abalaka et al., 2020). Çanakkale Strait is also highly polluted by ship crossing every year. The threat to human health of fish caught by hunting needs to be researched and clarified. Studies show that contamination is increasing and is at very high levels in some locations of Çanakkale Strait. Study results are not compatible with the results of previous studies in terms of the determined heavy metal in species (Bat et al., 2015; Culha et al., 2016).

Culha et al. (2016) investigated metal contamination in *Holothuria tubulosa* (sea cucumber) and sediments in Çanakkale Strait. This study was carried out to determine the concentrations of some trace metals (Cd, Cu, Pb, Ni, Zn, and Fe) in *H. tubulosa* (Gmelin, 1788) belonging to Echinoderm species in three different locations. The statistical difference between seasonally determined trace metals in muscle tissue of *H. tubulosa* was significant ($p<0.05$). Culha et al. (2016) obtained that there are also significant differences between seasonal trace elements accumulated by muscle tissues (Cd, Pb, Fe, Mn, Zn and Cu) of *H. tubulosa*. In this study, as far as the Zn is concerned, the highest value was determined in spring. In addition, when evaluated in terms of pollution, most of the heavy metal obtained results are below the limit values and they have changed accordingly to seasons.

Küpeli et al. (2014) evaluated trace element levels in the muscle tissues of fish species collected from three different locations in Sakarya. Trace element levels of several fish species collected from the waters of Sakarya were determined below the limit values provided by Turkey Food Codex (TFC) (Anonymous, 2002), the Food and Agriculture Organization (FAO, 2018) and the World Health Organization (WHO, 2002). Rajeshkumar & Li (2018) examined the bioaccumulation of heavy metals in fish species in Meiliang Bay-Taihu Lake, China. Bioaccumulation of heavy metal (Cr, Cu, Cd and Pb) content was determined in *Cyprinus carpio* and *Pelteobagrus fluvidraco*, which were caught from Meiliang Bay-Taihu Lake, a large, shallow, and eutrophic location. The results showed that the content of Cr, Cu, Cd, and Pb in the edible parts of the two fish species was much lower than the Chinese Food Health Criteria (Rajeshkumar & Li, 2008).

Bat et al. (2015) studied the heavy metal levels in four commercial fish from the Black Sea coast of Sinop (Turkey). The heavy metal concentrations were quite below of the limit values. Therefore, these heavy metal values in the total body load can be considered negligible. Sönmez et al. (2016) determined the heavy metal accumulation in some economical fish species caught from the coastal regions of Kastamonu. This study was carried out to determine heavy metal accumulation in whiting (*Merlangius euxmus*), bonito (*Sarda sarda*), horse mackerel (*Trachurus trachurus*), and red mullet (*Mullus barbatus*). As a result, Fe, Cu, Ni and Zn data were determined within acceptable limits within the framework of the Turkish Food Codex, European Union directives and WHO standards, while cadmium and lead were determined above these limits. According to the results obtained from this study, only Mn related results were found above the limit values for all seasons, while Zn was found to be quite high in spring. It would be beneficial to repeat the analyses in different fish species obtained from the same locations. Because the differences in results of other studies and we obtained them due to the collection of samples from different regions. Restrictions can be listed as hunting in a wide area, the variety of species highly consumed, and the variety of elements determined for analysis. In this case, it is important to investigate the issue more comprehensively conducted projects in terms of both meeting the nutritional needs for future and health.

Bawuro et al. (2018) examined the bioaccumulation of heavy metals in some fish tissues in Geriyo Lake, Adamawa State, Nigeria. Bioaccumulation of heavy metals (Zn, Pb, Cd, and Cu) was determined in the liver, gills, and muscle tissues in benthic and pelagic fish species collected over a period of two seasons. According to the obtained data, there was no threat to human consumption and for public health. These levels may be due to anthropogenic inputs, since they were interpreted as there was no industrial activity around the lake.

Ibemenuga et al. (2019) investigated the bioaccumulation of some heavy metals in three different organs of fish that have been grown in the Niger River (Nigeria). In this study, the bioaccumulation of cadmium, zinc, lead, and mercury in the gills, muscles, and intestines of *Tilapia zillii*, *Malapterurus electricus,* and *Clarias gariepinus* taken from the Niger River was investigated. The results obtained in this study revealed that the Niger River was polluted with varying levels by Zn and Cd. The proposed control measures include public disclosure of the giving up anthropogenic activities that can lead to water pollution.

## CONCLUSION

The negative effects of heavy metals, which have a high probability of mixing water, on fishery products, are a very rich food source in terms of protein and have an importance in nutrition, should not be overlooked. Wastes left to nature consciously or unconsciously can reach all organisms through the food chain. The criterion values of the authorities should be taken into consideration in the release of heavy metals, which reach from the first to the last step of the food chain and cause various health problems by investigate the correlation between metal concentrations in water and metal accumulation in fish caught from areas. For this reason, the accumulation and toxic effects of some heavy metals cause the growth and survival rates of fish larvae to decrease. In future, this problem will affect the natural fish populations, endangering sustainability and also affect the welfare of the societies with the increase of unhealthy food. Safe food and nutrition are of great importance for our health. For this reason, protecting nature is one of our most important duties that we should pay attention to both in terms of food safety as well as leaving a healthy environment for our future generations.

## ACKNOWLEDGEMENTS

This research project was supported by the Research Projects Coordination Unit of Çanakkale Onsekiz Mart University (project number: FBA-2020-3242).

### Compliance with Ethical Standards

### Authors' Contributions

Author LCİ designed the study, ŞÖ wrote the first draft of the manuscript, LCİ and ŞÖ managed the structure of manuscript. Both authors have read and approved the final shape of manuscript.

### Conflict of Interest

The authors declare that there is no conflict of interest.

### Ethical Approval

For this type of study, formal consent is not required.

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**Acta Nat. Sci. (2021) 2(1): 35-39**
DOI: 10.29329/actanatsci.2021.314.6
e-ISSN: 2718-0638

**Original Research Paper**
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ACTA NATURA ET SCIENTIA

# First Report of the Scandium Element in *Pagrus pagrus* Otoliths: A Potential Indicator of Thermal Activity From Gökçeada Island, Turkey

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**Please cite this paper as follows:**
Kızılkaya, B., Ayyıldız, H., Altın, A., & Yalçın Özdilek, Ş. (2021). First Report of the Scandium Element in *Pagrus pagrus* Otoliths: A Potential Indicator of Thermal Activity From Gökçeada Island, Turkey. *Acta Natura et Scientia*, *2*(1), 35-39. https://doi.org/10.29329/actanatsci.2021.314.6

**ARTICLE INFO**

*Article History*
Received: 07.04.2021
Revised: 09.05.2021
Accepted: 10.05.2021
Available online: 17.05.2021

*Keywords:*
Otolith chemistry
Scandium
Red porgy
Gökçeada

**ABSTRACT**

In this study, surface morphology and chemical structure of *Pagrus pagrus* (Linnaeus 1758) sagittal otolith from the shores of Gizli liman to Kefalos Cape in the north of Gökçeada Island, Turkey were investigated using scanning electron microscopy (SEM) and energy dispersion X-ray spectroscopy (EDS) analyses. According to the results of SEM analysis, the species was found to be over two years old. The age rings of *P. pagrus* were clearly identified on the otolith by SEM. According to the EDS results, it was examined that the element contents of age rings and regions between the sagittal otoliths obtained by EDS analysis. It was observed that calcium, carbon, and oxygen elements that form the calcium carbonate were the highest in EDS analysis. In addition, it has been found that the percentage of protein in ring structures, especially, in rings related to the age factor showed an increase. It can be said that this structural difference plays a major role in the clarification of age ring. Furthermore, the scandium (Sc) element was firstly discovered in the structure of the sagittal otoliths of *P. pagrus* from Gökçeada, Turkey. Scandium is one of the indicator elements in thermal regions. This study describes the presence of scandium trace element for the first time in the structure of otolith.

## INTRODUCTION

The red porgy, *Pagrus pagrus*, is a demersal marine fish associated with a variety of temperate to subtropical habitats (Vassilopoulou & Papaconstantinou, 1992; Labropoulou et al., 1999). This species distributed throughout the Atlantic Ocean and Mediterranean Sea at depths of 18 to 280 m (Manooch & Hassler, 1978). Adults of this species inhabits rocky or gravel habitats (Manooch & Hassler, 1978; Alekseev, 1982). This species is a protogynous hermaphrodite that revealed an unbalanced sex ratio in favor of females (Manooch & Hassler, 1978; Vassilopoulou & Papaconstantinou, 1992). Red porgy is a carnivorous fish species that can reach up to 15-20 kg in weight. It has great economic importance for coastal fisheries in the Turkish waters. According to TurkStat data, commercial landings of red porgy were experienced a serious decline since 2009. Based on these data, it will be possible to mention that red porgy stocks are being overexploited.

The chemical composition of otoliths has significant contribution to the fisheries science. Fish otoliths record the chemical composition of the water that fish live in and travel

through. Otoliths are metabolically inert aragonite structures that vary depending on the physical and chemical properties of environment (Campana, 1999). Therefore, they become a potential tool that keeps a chronological record of the environments in which the fish live or temporarily present (Campana & Neilson, 1985; Campana, 1999). In addition, chemical structures found in otoliths are also used to determine differences between fish stocks (Campana et al., 2000; Gillanders & Kingsford, 2000; Rooker et al., 2003). Thus, the otolith chemistry is also used in order to detect the migration paths of fish (Ashford et al., 2008; Steer et al., 2010).

The aim of the current study is to determine the chemical structure of the sagittal otoliths of red porgy from Gökçeada Island, Turkey. This study is the initial step in our attempt to find out the specific environment that fish live or pass through.

## MATERIAL AND METHODS

This study has been carried out from the shores of Gizli liman to Kefalos Cape in the north of Gökçeada Island, Turkey (Figure 1). The samples were collected using long lines, from 40–120 m depths between March and June in 2018.

The red porgy was measured for the purpose of obtaining the total length (TL) and total weight (W). Sagittal otoliths of red porgy were extracted and stored in Eppendorf tubes.

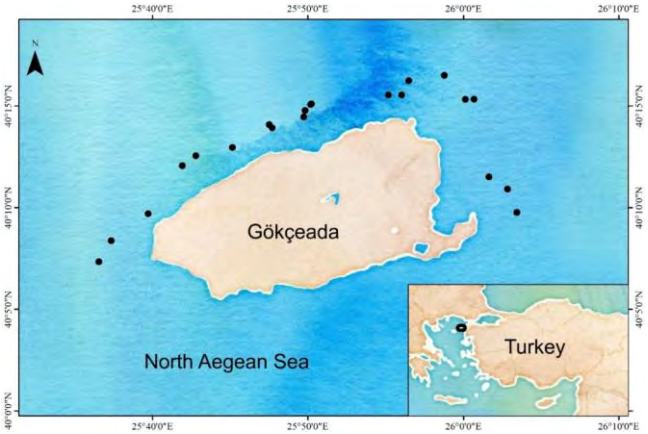


**Figure 1.** Sampling stations where red porgy, *Pagrus pagrus* were collected with long lines from the island of Gökçeada, Turkey, March–June in 2018

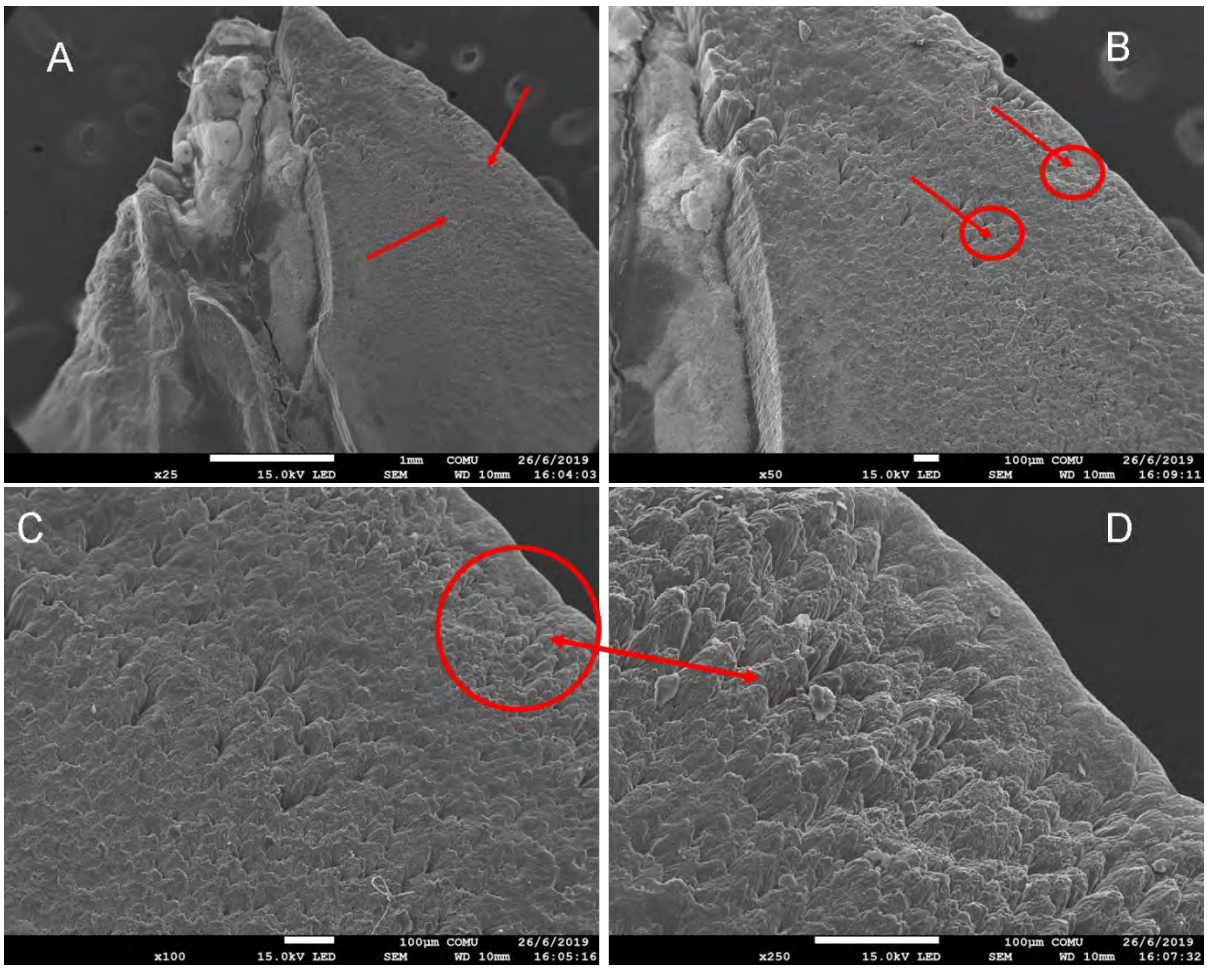


**Figure 2.** Scanning electron microscopy (SEM) images of *Pagrus pagrus*

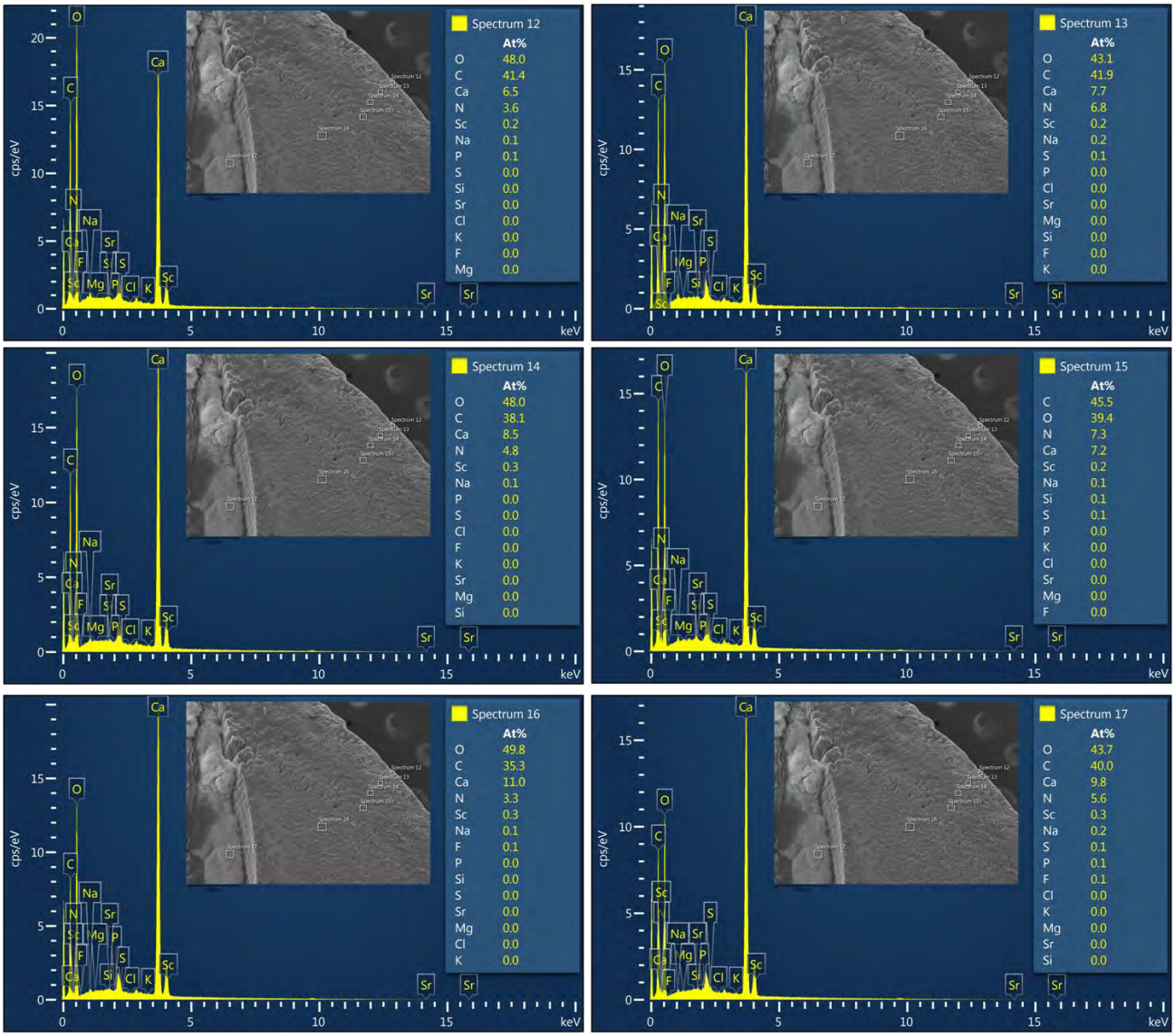


**Figure 3.** Energy dispersion X-ray spectroscopy (EDS) analyses of *Pagrus pagrus*

## Scanning Electron Microscopy (SEM) Image and Energy Dispersion X-Ray Spectroscopy (EDS) Analysis

SEM images and EDS analyses were performed in the Science and Technology Application and Research Center of Çanakkale Onsekiz Mart University using JEOL JSM-7100F scanning electron microscope. The magnification capacity of the instrument and the accelerator voltage is between × 40 and 300,000 and 0.2 and 30 kV, respectively. The sample was coated with gold-palladium (80-20%) to increase the conductivity properties in 10 mA voltage and $8\times10^{-1}$ mbar/Pa vacuum using Quorum coating device. It was used as secondary electrons for SEM images. Results related to EDX analysis are given in the form of percentages.

## RESULTS

SEM images of the sagittal otolith of *P. pagrus* are given in Figure 2. There are two sharp and distinct layers on otolith showing in SEM images (A) and (B) and these layers were separated from each other. It seems that this fish is over two years old.

According to SEM images (C) and (D), it has been clearly seen that the calcium carbonate ($CaCO_3$) layers forming the main building block of otolith. Ca ($CO_3$) layers progressed layer by layer. It can be said that Ca ($CO_3$) layers progress depending on the growth and age of the fish on daily and/or annually.

The main chemical structure of otoliths is calcium carbonate ($CaCO_3$) and it is consisted of a small amount of protein as binding. Some specific elements of environment in which a fish lives are likely to include in an otolith. In addition to SEM images of *P. pagrus* ($PP_{121}$), important information has been obtained about the element contents and distributions by EDS analysis determined on different regions of the sagittal otolith. Analysis and the spectrum EDS results from 6 different regions of the sagittal otoliths of *P. pagrus* ($PP_{121}$) are shown in Figure 3. Calcium (Ca), carbon (C)

and oxygen (O) are the most common and basic elements in otoliths which are the main structural elements in the formation of Ca ($CO_3$) as shown in Figure 3. The minor elements of red porgy sagittal otoliths are represented by nitrogen (N), scandium (Sc), sodium (Na), silicon (Si), chlorine (Cl), phosphorus (P), sulfur (S), strontium (Sr) and magnesium (Mg) captured from Gökçeada Island. Particularly, the presence of Sc element is noteworthy. In addition, it has been seen that the amount of nitrogen (N) in proteins of otolith structure varies between 3.6% and 7.3%. EDS spectrum from different regions of otoliths provided important information about the basic structure of otolith. As Figure 3 indicates, especially for the spectrum 13 and 15, these regions belonging to the transition regions between the first and second age. In addition, according to the element results of EDS analysis, the nitrogen (N) amount is higher than the other regions.

It is believed that the ring lines of the fish age consist of protein-based structure instead of pure calcium carbonate. This situation might possibly cause to make clearer the age ring. The elemental distributions of 16, 14 and 12 spectrums in the intermediate regions of age rings showed that the nitrogen amount is low.

## DISCUSSION

Scanning electron microscopy provides detailed and comprehensive information about surface morphology. Thus, the surfaces of the sagittal otoliths of red porgy can be examined in detail. In this study, surface morphology and chemical structure of *Pagrus pagrus* (Linnaeus 1758) sagittal otolith from the shores of Gizli liman to Kefalos Cape in the north of Gökçeada Island, Turkey were investigated using scanning electron microscopy (SEM) and energy dispersion X-ray spectroscopy (EDS) analyses. Otoliths are mainly composed of aragonite and elemental ratios which record the physico-chemical properties of water inhabited by a fish at any point during its life (Thorrold & Swearer, 2009). According to the results obtained from SEM analysis, it was observed that the surface morphology and properties of otoliths changed according to age factor. Age rings were observed in otolith structure and the regions inside the age rings differs in terms of surface properties.

According to the obtained element contents, it has been seen that Ca, C and O elements, the basic structure of $CaCO_3$, are formed in otolith structure. In addition, it is found that the protein structure in otolith is also determined with the presence of N element in the results of EDS analysis. Na, K and Li elements were not determined by EDS analysis. This is mainly due to the EDS analysis performs a percentage amounts to determine the detection limit of elements. This does not mean that there are no undetectable elements in the results of EDS analysis. Furthermore, that's why, Sr and similar trace elements cannot be determined by EDS analysis. In this study, surface properties, age rings, basic structure, and trace elements of *P. pagrus* otoliths were determined by SEM and EDS analyses.

## CONCLUSION

The scandium (Sc) element was firstly discovered in the structure of sagittal otoliths of *P. pagrus* from Gökçeada, Turkey. Scandium is one of the indicator elements in thermal regions. This study describes the presence of scandium trace element for first time in the structure of otolith. There is information about Sc, hydrothermal events and erosion and volcanic rocks being mobilized during metamorphosis (Finlowbates & Stumpfl, 1981). Oudin & Cocherie (1988) conducted sedimentary analysis in Red Sea and associated hydrothermal activities and the accumulation of some trace elements, including Sc in sediment. Accordingly, a hypothesis can be established that the *P. pagrus* used in this study spend a certain part of their lives in specific environment or pass through with hydrothermal resources. Consequently, it is recommended to test this hypothesis in future studies.

## ACKNOWLEDGEMENTS

This study was funded by Çanakkale Onsekiz Mart University The Scientific Research Coordination Unit, Project number: FBA-2018-1406.

### Compliance with Ethical Standards

### Authors' Contributions

All authors made contributions in necessary fields during the preparation of samples, conduction of experiments, evaluation of results, and writing of the article.

### Conflict of Interest

The authors declare that there is no conflict of interest.

### Ethical Approval

For this type of study, formal consent is not required.

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**Acta Nat. Sci. (2021) 2(1): 40-48**
DOI: 10.29329/actanatsci.2021.314.7
e-ISSN: 2718-0638

**Original Research Paper**
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ACTA NATURA ET SCIENTIA

# Growth Parameters of Blotched Picarel (*Spicara maena* Linnaeus, 1758) From Saros Bay (Northern Aegean Sea, Turkey)

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**Please cite this paper as follows:**
Cengiz, Ö., & Paruğ, Ş. (2021). Growth Parameters of Blotched Picarel (*Spicara maena* Linnaeus, 1758) From Saros Bay (Northern Aegean Sea, Turkey). *Acta Natura et Scientia*, 2(1), 40-48. https://doi.org/10.29329/actanatsci.2021.314.7

**ARTICLE INFO**

*Article History*
Received: 09.03.2021
Revised: 29.05.2021
Accepted: 29.05.2021
Available online: 30.05.2021

*Keywords:*
Blotched picarel
*Spicara maena*
Growth
Saros Bay
Turkey

**ABSTRACT**

In this study, growth parameters of 648 specimens of *Spicara maena* captured by small-scale commercial fishermen around Saros Bay between January 2016 and December 2016 were studied. Of the 648 specimens analyzed, 509 were female and 139 were male. The length-weight relationship was calculated as $W$=0.0024$TL^{3.34}$ for females and $W$=0.0032$TL^{3.29}$ for males. The von Bertalanffy growth equations were computed as $L_\infty$ =22.1 cm, $k$=0.27 year$^{-1}$, $t_0$ =-1.42 year for the females; $L_\infty$=20.6 cm, $k$=0.39 year$^{-1}$, $t_0$= –1.11 year for the males. The growth performance index (Φ′) was found as 2.12 and 2.22 for the females and males, respectively. This study includes preliminary information on the growth of the blotched picarel in Saros Bay (Northern Aegean Sea, Turkey).

## INTRODUCTION

The determination of the age and information on the growth of fish species is important for a comprehensive understanding of their population dynamics. Thus, this knowledge forms the basis of the calculations of growth, productivity estimates, and mortality rates (Campana, 2001) and help in describing the present status and history of fish populations along with the future program of the fishery management (Khan & Khan, 2014; Ayyıldız et al., 2020). However, the knowledge from LWR is essential to assess fish stocks, fisheries, and environmental monitoring programs (Froese et al., 2011; Giarrizzo et al., 2015) and studies on LWR are relevant due to the need to comprehend the fish lifecycle, principally in the regions where fisheries represent one of the most important economic activities (Frietas et al., 2014).

The Sparidae is a family of the order Perciformes and contains 164 species in 38 genera (Eschmeyer's Catalog of Fishes, 2020; Fishbase, 2020a). Recently, the family Centracanthidae (picarels) has also been merged with the Sparidae (Santini et al., 2014; Fishbase, 2020b) while they were previously listed separately (Golani et al., 2006; Nelson, 2006). Genus *Spicara* is represented in the Mediterranean by two species, *Spicara maena* and *Spicara smaris* (Karachle & Stergiou, 2014). According to Froese & Pauly (2020), *Spicara flexuosa* is considered as a synonym of *Spicara maena*. However, the genetic distances and phylogenetic tree topologies revealed that three *Spicara* species were distinctly separated from each other and *S. flexuosa* and *S. maena* are more closely related than *S. smaris* (Bektas et al., 2018). Blotched picarel (*Spicara maena* Linnaeus, 1758), belonging to the family Sparidae, is a commercial species inhabiting the Eastern Atlantic: Portugal, Morocco, and the Canary Islands including the Mediterranean and even the Black Sea. It

mostly occurs over *Posidonia* beds and sandy or muddy bottoms and distributes up to 100 m of depth. This species mainly feeds on zooplankton and is a protogynous hermaphrodite (Froese & Pauly, 2020).

Numerous studies are available on *Spicara maena*. The growth parameters of this fish from Greek waters were studied by Mytilinieou & Papaconstantinou (1991) while the same aspects were investigated in Tunisian waters by Hattour et al. (1985), in Egypt by Rizkalla (1997), and in the Adriatic Sea by Dulčić et al. (2000). However, Arculeo et al. (1996) researched the protein differences among the Mediterranean species of the genus *Spicara* while some authors gave the information on its fecundity from Eastern Adriatic Sea (Matić-Skoko et al., 2004) and from Algeria (Harchouche, 2006; Dalouch et al., 2019). In addition, the feeding habits of the blotched picarel were studied in Algeria by Harchouche et al. (2009) and in the North Aegean (Greece) by Karachle & Stergiou (2014). As for Turkish waters, the information on growth and reproduction of the species was obtained from Babadillimani Bight (Çiçek et al., 2007), İzmir Bay (Mater et al., 2001; Soykan et al., 2010), Gallipoli Peninsula (Cengiz et al., 2014a), Edremit Bay and Sea of Marmara (Saygılı et al., 2016a), and Saros Bay (Cengiz, 2019, 2020). However, Saygılı et al. (2016b) examined the otolith morphometry of blotched picarel in the same regions. Yet, there is no information concerning the growth of *Spicara maena* which was so far available on Saros Bay (Northern Aegean Sea, Turkey). For this reason, the aim of the present study was to determine the preliminary information on the growth of the blotched picarel from Saros Bay and to compare these results with the previous studies in other areas.

## MATERIAL AND METHODS

The northern Aegean coasts of Turkey are divided into sub-regions as Saros Bay, Gallipoli Peninsula, Gökçeada Island, Bozcaada Island, and Edremit Bay (Cengiz & Paruğ, 2020). The length of Saros Bay is about 61 km and the largest width of the bay is about 36 km (Eronat & Sayın, 2014). As bottom trawling is forbidden in the bay since 2000 (Cengiz et al., 2014b) and no industrial activity was prevalent in the area (Sarı & Çağatay, 2001), it can be considered as a pristine environment (Cengiz et al., 2015). Samples were monthly obtained between January 2016 and December 2016 in random stratified sampling from the catches of the small-scale commercial fisherman around Saros Bay (Figure 1).

Specimens were measured to the nearest centimeter (total length), weighed to the nearest gram (total weight). Sexes were determined by examining the gonads both macroscopically and microscopically. Chi-square ($\chi 2$) test was performed to find out the differences in the sex ratio.


**Figure 1.** Saros Bay (Northern Aegean Sea, Turkey)

Student's *t*-test was used to analyze the differences in the mean length and weight of the sexes. The length-weight relationship was estimated with fitting an exponential curve (Equation 1) (Le Cren, 1951)

$$W = aL^b \quad (1)$$

where $a$ and $b$ parameters of the exponential curve were estimated with linear regression analysis over log-transformed data (Equation 2):

$$\log W = \log a + b \log L \quad (2)$$

where $W$ is the total weight (g), $L$ is the total length (cm), $a$ is the intercept, and $b$ is the slope or with allometric coefficient using the least-squares method. If the value $b > 3$, it shows positive allometric growth while value $b < 3$ indicates negative allometric growth. It is isometric growth when value $b$ is equal to 3 (Bagenal & Tesch, 1978). The growth type was identified by Student's *t*-test.

The otoliths were evaluated for age determination. Following removal, the sagittal otoliths were put in a mixture of first 5% HCL and then 3% NaOH solutions, washed in distilled water and subsequently dried. The sagittal otoliths placed in watch glass filled with water were read with using a stereoscopic zoom microscope under reflected light against a black background. Opaque and transparent zones were counted; one opaque zone plus one transparent zone was assumed to be 1 year (Cengiz, 2019). Growth parameters were estimated with using the von Bertalanffy growth equation (Equation 3):

$$L_t = L_\infty \left[1 - e^{-k(t-t_0)}\right] \quad (3)$$

where $L_t$ is fish length (cm) at age $t$, $L_\infty$ is the asymptotic fish length (cm), $t$ is the fish age (years), $t_0$ (years) is the hypothetical time at which the fish length is zero, and $k$ is the

growth coefficient (year$^{-1}$). FAO-ICLARM Stock Assessment Tools (FISAT II) were used to estimate growth parameters which were calculated with non-linear least-squares method. The growth parameters obtained in this study were compared with the parameters obtained in other studies from various geographical areas using the growth performance index (Φ′) (Pauly & Munro, 1984). It was estimated with using the formula (Equation 4):

$$\Phi' = \log(k) + 2\log(L_\infty) \quad (4)$$

## RESULTS

### Length Distribution and Length-Weight Relationship

Of 648 specimens examined in this study, 509 (78.5%) were females and 139 (21.5%) were males. The sex ratio (F:M) was 1:0.27, which is significantly different from the equal representation of sexes ($\chi$2 test: $P$<0.05). The mean ± standard error (and range) of total length were 12.7 ± 0.07 (8.6 – 15.9) cm TL for the females and 15.1 ± 0.12 (11.6 – 18.3) cm TL for the males (Figure 2). The respective values for the total weight were 27.70 ± 0.56 (5.20 – 65.90) g for the females and 43.02 ± 1.02 (16.48 – 85.12) g for the males. The student's $t$-test showed significant differences between the mean lengths and weights of both sexes (all P<0.05). The length-weight relationship was estimated as $W$=0.0024$TL^{3.34}$ ($r^2$=0.93) for the females and $W$=0.0032$TL^{3.29}$ ($r^2$=0.94) for the males (Figure 3). The $b$-values and $t$-test results indicated positive allometric growth for both sexes. However, the length-weight relationships reveal that the males are heavier than the females (Figure 3). The individuals longer than 16.0 cm were all males (Figure 2, Table 1).

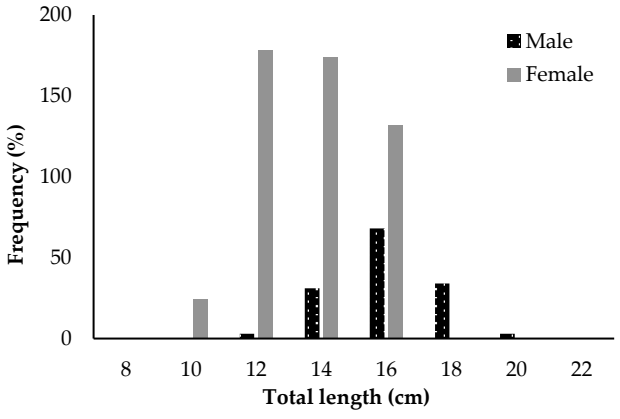


**Figure 2.** The length-frequency distribution for the females and males of *Spicara maena* from Saros Bay (Northern Aegean Sea, Turkey)

### Age Composition and Growth Parameters

Results obtained from the otolith study showed that the ages of the fishes were found to be within the range of 1 to 5 years. Most of the females were 2 years old while most of the males were 3 (Table 1). The von Bertalanffy growth equations were computed as $L_\infty$ =22.1 cm, $k$=0.27 year$^{-1}$, $t_0$ = –1.42 year for females; $L_\infty$=20.6 cm, $k$=0.39 year$^{-1}$, $t_0$= –1.11 year for the males (Figure 4). The growth performance index ($\Phi'$) was found as 2.12 and 2.22 for females and males, respectively. The $t$-test showed no significant differences from the growth performance indexes in the other localities.

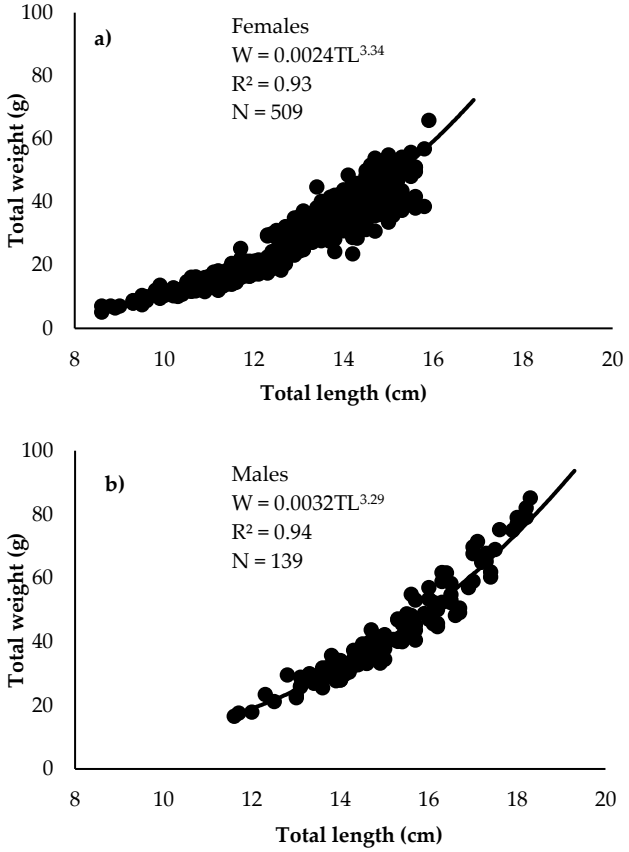


**Figure 3.** The length-weight relationships for the females (a) and males (b) of *Spicara maena* from Saros Bay (Northern Aegean Sea, Turkey)

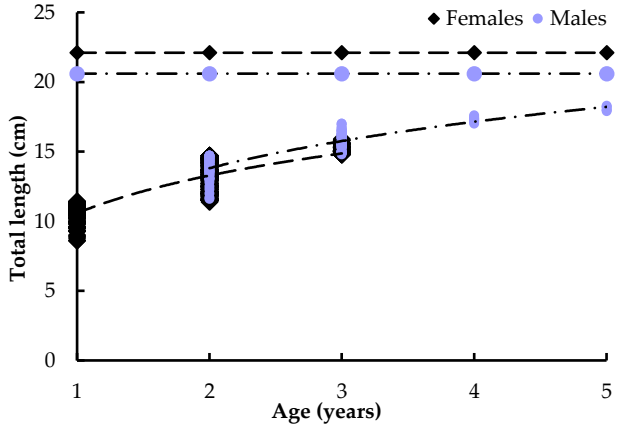


**Figure 4.** The growth curves for the females and males of *Spicara maena* from Saros Bay (Northern Aegean Sea, Turkey)

**Table 1.** The age-length key for the females and males of *Spicara maena* from Saros Bay (Northern Aegean Sea, Turkey)

| Length class (cm) | Age (years) | | | | | Females | Males |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | |
| 8.0 – 9.0 | 5 | - | - | - | - | 5 | - |
| 9.1 – 10.0 | 19 | - | - | - | - | 19 | - |
| 10.1 – 11.0 | 70 | - | - | - | - | 70 | - |
| 11.1 – 12.0 | 47 | 64 | - | - | - | 108 | 3 |
| 12.1 – 13.0 | - | 72 | - | - | - | 67 | 5 |
| 13.1 – 14.0 | - | 133 | - | - | - | 107 | 26 |
| 14.1 – 15.0 | - | 107 | 33 | - | - | 103 | 37 |
| 15.1 – 16.0 | - | - | 61 | - | - | 30 | 31 |
| 16.1 – 17.0 | - | - | 21 | 1 | - | - | 22 |
| 17.1 – 18.0 | - | - | - | 9 | 3 | - | 12 |
| 18.1 – 19.0 | - | - | - | - | 3 | - | 3 |
| **Females** | | | | | | | |
| N | 141 | 317 | 51 | - | - | 509 | - |
| Min | 8.6 | 11.4 | 14.8 | - | - | 8.6 | - |
| Max | 11.4 | 14.7 | 15.9 | - | - | 15.9 | - |
| Mean | 10.6 | 13.2 | 15.2 | - | - | 12.7 | - |
| S.E | 0.05 | 0.06 | 0.04 | - | - | 0.07 | - |
| **Males** | | | | | | | |
| N | - | 59 | 64 | 10 | 6 | - | 139 |
| Min | - | 11.6 | 14.8 | 17.0 | 17.9 | - | 11.6 |
| Max | - | 14.7 | 17.0 | 17.6 | 18.3 | - | 18.3 |
| Mean | - | 13.8 | 15.7 | 17.3 | 18.1 | - | 15.1 |
| S.E | - | 0.10 | 0.07 | 0.06 | 0.06 | - | 0.12 |

## DISCUSSION

Table 2 summarizes the studies on the length-weight relationship (LWR). Soykan et al. (2010) reported that the individuals longer than 18 cm were all males. Whereas, Dulčić et al. (2000) determined that the samples longer than 19.8 cm were all males. This case may be explained by protogynous hermaphroditism because females are predominated in smaller size classes and males larger ones (Çiçek et al., 2007; Soykan et al., 2010). The allometric coefficient *b* varied from 2.66 to 3.67 for species in different regions. Generally, the *b* value obtained from LWR estimation within the same species can change depending on the degree of gonad maturity, sex, diet, sample preservation techniques, stomach fullness (Wootton, 1990), number of specimens analyzed, area/season effects, sampling duration (Moutopoulos & Stergiou, 2002), fishing gear used (Kapiris & Klaoudaos, 2011), and size selectivity of the sampling gear (İşmen et al., 2007).

The mean lengths at different ages for the females and males of *S. maena* given by various authors are listed in Table 3. However, to compare the growth of *S. maena* population with others, all available literature data of the maximum ages and von Bertalanffy growth parameters and $\Phi'$ values including the results from the present study are presented in Table 4. In this sense, the maximum ages can vary widely among the populations within species especially those that

**Table 2.** Comparison of the length-weight relationship of *S. maena* with previous studies

| Reference | Location | N | Sex | Length range (cm) | a | b |
|---|---|---|---|---|---|---|
| Petrakis & Stergiou (1995) | South Euboikos Gulf (Greece) | 33 | Σ | 11.7 – 18.4 | 0.00083 | 2.66 |
| Dulčić & Kraljević (1996) | Eastern Adriatic Sea (Croatian) | 220 | Σ | 14.5 – 27.5 | 0.0000396 | 3.03 |
| Moutopoulos & Stergiou (2002) | Cyclades (Greece) | 808 | Σ | 14.3 – 26.0 | 0.010 | 3.09 |
| Çiçek et al. (2006) | Babadillimani Bight (northeastern Mediterranean Turkey) | 1381 | Σ | 4.2-17.8 | 0.008 | 3.11 |
| Karakulak et al. (2006) | Gökçeada Island (northern Aegean Sea, Turkey) | 133 | ♀ | 11.5 – 18.1 | 0.004 | 3.35 |
| | | 142 | ♂ | 13.5- 22.0 | 0.001 | 3.67 |
| İşmen et al. (2007) | Saros Bay (northern Aegean Sea, Turkey) | 353 | Σ | 8.8 – 17.8 | 0.00984 | 3.01 |
| Gökçe et al. (2010) | Iskenderun Bay (Eastern Mediterranean, Turkey) | 17 | Σ | 13.0 – 17.9 | 0.021 | 2.80 |
| Soykan et al. (2010) | Central Aegean Sea (Turkey) | 2547 | Σ | 7.5 – 20.0 | 0.011 | 3.02 |
| Demirel & Dalkara (2012) | Sea of Marmara (Turkey) | 175 | Σ | 10.4 – 18.0 | 0.010 | 3.25 |
| Bolognini et al. (2013) | Adriatic Sea (Italy) | 1810 | Σ | 8.5 – 25.5 | 0.007 | 3.15 |
| Cengiz et al. (2014a) | Gallipoli Peninsula (northern Aegean Sea, Turkey) | - | ♀ | - | 0.011 | 3.26 |
| | | - | ♂ | - | 0.044 | 3.16 |
| Saygılı et al. (2016a) | Sea of Marmara (Turkey) | 155 | Σ | 8.4 – 18.1 | 0.003 | 3.53 |
| | Edremit Bay (northern Aegean Sea, Turkey) | 168 | Σ | 12.8 – 18.8 | 0.010 | 3.06 |
| This study | Saros Bay (northern Aegean Sea, Turkey) | 509 | ♀ | 8.6 – 15.9 | 0.002 | 3.34 |
| | | 139 | ♂ | 11.6 – 18.3 | 0.003 | 3.29 |

***Note:*** N: Sample size; ♀ = Female, ♂ = Male, Σ = All samples; *a* and *b*: intercept and slope of length- weight relationships.

**Table 3.** The mean lengths at different ages for the females, males and all samples of *S. maena* given by various authors

| Reference | Location | Sex | Age (Years) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Mytilineous & Papaconstantinous (1991)[a,b] | Patraikos Gulf (Greece) | ♀ | 9.2 | 11.2 | 12.6 | 13.5 | 14.4 | - | - | - |
| | | ♂ | 9.3 | 11.4 | 13.0 | 14.0 | 14.4 | - | - | - |
| Dulčić et al. (2000) | Adriatic Sea (Croatia) | Σ | 9.5 | 15.9 | 19.4 | 21.5 | 23.4 | 24.6 | - | 27.5 |
| Mater et al. (2001)[a,b] | Izmir Bay (Aegean Sea, Turkey) | ♀ | 11.3 | 12.9 | 13.7 | 14.9 | - | - | - | - |
| | | ♂ | - | 12.8 | 13.9 | 14.9 | - | - | - | - |
| Çiçek et al. (2007) | Babadillimani Bight (northeastern Mediterranean, Turkey) | ♀ | 7.6 | 11.8 | 14.9 | - | - | - | - | - |
| | | ♂ | - | 12.9 | 15.2 | 17.3 | - | - | - | - |
| Saygılı et al. (2016a) | Sea of Marmara (Turkey) | Σ | 11.2 | 13.5 | 15.1 | 15.8 | - | - | - | - |
| | Edremit Bay, (northern Aegean Sea, Turkey) | Σ | - | 14.1 | 15.4 | 16.2 | 17.3 | 17.8 | - | - |
| This study | Saros Bay (northern Aegean Sea, Turkey) | ♀ | 10.6 | 13.2 | 15.2 | - | - | - | - | - |
| | | ♂ | - | 13.8 | 15.7 | 17.3 | 18.1 | - | - | - |

***Note:*** [a]FL: Fork length, [b]syn. *S. flexuosa*, ♀ = Female, ♂ = Male, Σ = All samples

**Table 4**. The results of maximum ages, growth parameters and growth performance indices obtained from previous studies for *S. maena*

| Reference | Location | Method | Sex | Age (Year) | $L_\infty$ | K | $t_0$ | Φ′ |
|---|---|---|---|---|---|---|---|---|
| Mytilineous & Papaconstantinous (1991)[a,b] | Patraikos Gulf (Greece) | Otolith | ♀ | 1 - 5 | 16.3 | 0.31 | -1.89 | 1.92 |
| | | | ♂ | 1 - 5 | 17.5 | 0.34 | -1.90 | 2.02 |
| Dulčić et al. (2000) | Adriatic Sea (Croatia) | Scale | Σ | 1 - 8 | 24.8 | 0.53 | -0.08 | 2.51 |
| Mater et al. (2001)[a,b] | Izmir Bay (Aegean Sea, Turkey) | Otolith | ♀ | 1 - 4 | 17.1 | 0.31 | -0.63 | 1.96 |
| | | | ♂ | 2 - 4 | 18.2 | 0.24 | -2.62 | 1.90 |
| Çiçek et al. (2007) | Babadillimani Bight (northeastern Mediterranean Turkey) | Otolith | ♀ | 1 - 3 | 25.3 | 0.26 | -0.35 | 2.22 |
| | | | ♂ | 2 - 4 | 37.3 | 0.09 | -3.38 | 2.10 |
| Soykan et al. (2010) | Izmir Bay (central Aegean Sea, Turkey) | Otolith | Σ | 1 - 7 | 21.9 | 0.25 | -1.16 | 2.08 |
| Cengiz et al. (2014a) | Gallipoli Peninsula (northern Aegean Sea, Turkey) | - | ♀ | - | 21.8 | 0.26 | -1.52 | 2.09 |
| | | | ♂ | - | 20.3 | 0.36 | -1.08 | 2.17 |
| Saygılı et al. (2016b) | Sea of Marmara (Turkey) | Otolith | Σ | 1 - 4 | 17.2 | 0.52 | -1.04 | 2.18 |
| | Edremit Bay (northern Aegean Sea, Turkey) | Otolith | Σ | 2 - 6 | 18.7 | 0.20 | -1.98 | 2.09 |
| This study | Saros Bay (northern Aegean Sea, Turkey) | Otolith | ♀ | 1 - 3 | 22.1 | 0.27 | -1.47 | 2.12 |
| | | | ♂ | 2 - 5 | 20.6 | 0.39 | -1.11 | 2.22 |

***Note:*** [a]FL: Fork length, [b]syn. *S. flexuosa*, ♀ = Female, ♂ = Male, Σ = All samples, $L_\infty$ = theoretical asymptotic length, K = growth rate coefficient, $t_0$ = theoretical age when fish length is zero, Φ′ =growth performance index

have wide distributions (Gibson, 2005). In this case, the reasons of differences in longevity could be attributed to the effects of temperature, intensities of competition for food, food availability, life history strategies, and fishing efforts (Nash & Geffen, 2005). Within the Mediterranean Sea, there exists a west-east gradient (Krom et al., 1991; Turley et al., 2000). The Eastern Mediterranean has been identified as one of the most oligotrophic areas of the world (Azov, 1986; Krom et al., 1993; Paruğ & Cengiz, 2020). The maximum age of the blotched picarel was reported as VIII in the Adriatic Sea (Croatia) by Dulčić et al. (2000). This value from the western Mediterranean area is the highest one compared to all other eastern Mediterranean values. This may be because the eastern Mediterranean is one of the most oligotrophic areas of the world.

Besides, the differences in mean lengths at ages and growth parameters among the study areas could probably be attributed to a combination of sample characteristics (sample sizes and range of sizes), geographical differences, ageing methodology used (Monterio et al., 2006), incorrect age interpretation (Matić-Skoko et al., 2007; Bayhan et al., 2008), size, quantity and quality of food and water temperature (Santic et al., 2002), and differences in length at first maturity (Champagnat, 1983). Besides, the selectivity of the fishing tool used can also affect the estimates of growth parameters (Ricker, 1969; Potts et al., 1998). Therefore, the possible

reasons for the differences in the results between the other studies and this study may be related to one or more factors given above.

## CONCLUSION

The present study provides preliminary information on the growth of *Spicara maena* for Saros Bay. There are no technical regulations imposed on *Spicara maena* fisheries in Turkey. If some legal regulations are not implemented (e.g., determination of minimum landing size, fishing gear selectivity, catching quota, fishing effort control, efficacious monitoring and surveillance systems, etc.), the sustainability of stock can be at risk as time goes by. This information will help fisheries scientists in future studies about *S. maena* populations worldwide.

## ACKNOWLEDGEMENTS

The authors would like to thank the commercial fishermen for their assistance in obtaining the samples.

### Compliance with Ethical Standards

### Authors' Contributions

Both authors have contributed equally to the paper.

### Conflict of Interest

The authors declare that there is no conflict of interest.

### Ethical Approval

For this type of study, formal consent is not required.

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**Acta Nat. Sci. (2021) 2(1): 49-52**
DOI: 10.29329/actanatsci.2021.314.8
e-ISSN: 2718-0638

**Original Research Paper**
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ACTA NATURA ET SCIENTIA

# Fuchsine Dye Adsorption of Surface Modified Biogenic Apatite With Tryptophan and Histidine

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**Please cite this paper as follows:**
Tan, E., & Kızılkaya, B. (2021). Fuchsine Dye Adsorption of Surface Modified Biogenic Apatite With Tryptophan and Histidine. *Acta Natura et Scientia*, *2*(1), 49-52. https://doi.org/10.29329/actanatsci.2021.314.8

**ARTICLE INFO**

*Article History*
Received: 12.04.2021
Revised: 19.05.2021
Accepted: 20.05.2021
Available online: 30.05.2021

*Keywords:*
Fuchsine
Surface Modification
Apatite

**ABSTRACT**

In this study, the adsorption change of products obtained by chemical modification of waste fish bones, which are a biogenic-induced apathetic source, has been examined. Histidine (MH) and tryptophan (MT) were used for chemical surface modification, and cationic paint was used as fuchsine adsorbent. Paint adsorption was performed in water. The adsorption of MH and MT products was determined as 0.48 and 0.69 $mg.g^{-1}$ in 6.76 $mg.L^{-1}$ dye solution. The amount that MH and MT modified materials removed from the solution was 35.46 and 50.71%, respectively. As a result, it has been determined that the apatite-induced bones have affected the adsorption capacities of dyers as a result of different chemical molecular modifications. Additionally, it has been determined that the molecules with different qualities and properties affect the balance of adsorption. It has been observed that unprofitable products were suitable for chemical modification and adsorption procedures thanks to surface modification. With the development of studies in this field, it can be said that waste-resourced products will contribute to environmental use with effective, qualified, and useful materials.

## INTRODUCTION

Today, many studies are carried out to use waste materials as convenient products in different areas. Decomposition and recycling of waste are important for nature and all living creatures. It is seen that the deficit of drinkable and available water resources in recent years makes pollution a dangerous threat for the environment and people. There are various methods used for the disposal of waste. However, it is seen that most of these methods are expensive and insufficient. Especially in recent years, most of the studies focus on converting wastes into qualified materials. Some studies were also carried out to utilize waste bones. As known, 30% of the bones are organic and the remaining 70% is the inorganic hydroxyapatite ($CA_{10}(PO_4)_6(OH)_2$, HA) forms (Narasaraju & Phebe, 1996; Kizilkaya et al., 2010; Dimovic et al., 2009). Qiu et al. (2005) synthesized nano-HA and made surface modification using lactic acid oligomer without using any catalyst. Since polylactic acid, with its mechanical force endurance, is a biocompatible and biodegradable material, studies on such polymers are focused on. Synthetic HA is synthesized by calcium hydroxide reaction along with phosphoric acid. Again, using one of the other organic stearic acid (SA), modifications were made on synthetic HA. In the modification process, changes on the surface of HA were examined using different rates from 1% to 11%. The reaction occurs with the esterification reaction between the OH groups on the surface of HA and COOH of the acid. In the study, it was observed that it was successfully modified to

the HA surface and the change in the particle size distribution as a result of the modification was seen. According to the FT-IR spectrum of the SA modifications in different rates, it is clear that it comes from the aliphatic $CH_3$ and $CH_2$ groups in 2954 $cm^{-1}$. The peak that appears in 1548 $cm^{-1}$ with the increase of SA aldehyde rates was determined as non-symmetrical COOC vibration bands (Li & Weng, 2008). The removal of HA cations occurs in the ion exchange of calcium ions on the surface (Banat et al., 2000; Ozawa et al., 2003; Smiciklas et al., 2006; Dimovic et al., 2009). Within the studies on natural bones, they have been especially focused on metal adsorption. In this respect, removal and adsorption of cobalt (Dimovic et al., 2009), zinc (Banat et al., 2009), chrome (Chojnacka, 2005), copper, and nickel (Alasbeb et al., 1999) were investigated. Due to the low resolution of HA in water, high stability in oxidation and reduction, high surface area, and good buffering capacity of heavy metals; it was considered as available for heavy metal sorption and reduction. In this field, synthesizing synthetic HAs; studies on the removal of cobalt (Smiciklas et al., 2006), lead (Janga et al., 2008), copper (Corami et al., 2008), and cadmium (Zhu et al., 2008) has been made. In this study, the adsorption effect of biogenic-induced fish bones in cationic dye substance removal with chemical modification was investigated.

## MATERIAL AND METHODS

### Materials and Chemicals

In the present study, magnetic stirrer-heater with contact thermometer (Wise Stir MSH-20D), centrifuge (Nüve NF400) and ultrasonic bath, ultra-pure water (SG, Ultra Clear 2001-B) were used. Histidine (Sigma) and tryptophan (Sigma) were used as modification chemicals. Fuchsine (Merck, 85%) was used for preparing dye solutions.

### Functionalization of Bone Surfaces With Tryptophan and Histidine

The functioning of bone surfaces was carried out according to Kizilkaya et al. (2015). In the short method, fishbone particles were treated in the boiling point and inert atmosphere under the condenser with tryptophan and histidine amino acids. After refluxing, the mixture was cooled under the condenser, and the mixture was rested for 12 hours till it reached room temperature. The mixture was then centrifuged at 2000 rpm with technical water, methanol, and acetonitrile, and it was dried in the solid phase, modified by 5 times washing, at 45°C on the oven.

### Cationic Dye Removal and Adsorption Methods

Fuchsine was used as the cationic dye. Measurements were made with PG Instruments Brand T80-UV / Vis spectrophotometer in the Faculty of Marine Sciences and Technology. Adsorption studies were carried out in the water with UV Spectrophotometer and measured at $\lambda_{max}$ 550 nm. The fuchsine solution was treated for 24 hours with each modified product in the 1: 200 adsorbent / solvent ratio. At the end of the experiment, the adsorption change of the solution was determined with the UV spectrophotometer by filtration from the 0.45 μm syringe filter of the liquid phase from the solution.

Adsorption amount in adsorption studies is expressed as $q_e$ and gram (G) is the amount of adsorbent adsorbed and calculated as $mg.g^{-1}$. The adsorption capacity was calculated by the following equation (1) in experimental studies (Kaushal & Tiwari, 2010; Kizilkaya et al., 2010; Rafatullah et al., 2010):

$$q_e = V \times (C_o - C_e) \times 1000 \,/\, W \quad (1)$$

$q_e$: The amount of adsorbed substance per unit adsorbent ($mg.g^{-1}$)

$C_o$: Beginning adsorbent concentration of the solution ($mg.L^{-1}$)

$C_e$: Adsorbent concentration remaining in the solution after adsorption ($mg.L^{-1}$)

$V$: Volume of solution (mL)

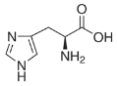
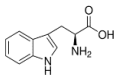
$W$: Adsorbent amount

## RESULTS AND DISCUSSION

In the scope of the study, the technical information of histidine and tryptophan amino acids, the adsorption capacity of the fuchsine paint adsorptions of the resulting materials ($q_e$) and percentages (A%) are given in Table 1. The molecular weights of histidine and tryptophan amino acids are 155 and 204 $g.mol^{-1}$, respectively. The molecular mass of the fuchsine dyer substance is 337 $g.mol^{-1}$. As a result of the experiments, cationic paint adsorption of MH and MT, bone surface-modified, was measured as 0.48 and 0.69 $mg.g^{-1}$, respectively. The bones, whose main composition is apatite, are known as the source of natural cation change. Adsorption is an event that takes place on the surface. There are many factors affecting adsorption. Foremost among them, there are factors such as surface morphology, surface properties, and surface chemistry. The adsorption process can take place with either ion exchange or surface adsorption. There are –OH groups in accordance with ion exchange in the components of apatite and bone. Positively charged hydrogen ($^{+}H$), one of these –OH groups, can cause ion exchange with the other cation groups. Thus, it can be said that the adsorption takes place with ion exchange. In this study, the -OH groups that take place on the surface of the bones –histidine and tryptophan molecules– were reacted

with –COOH acid groups. Therefore, it can be said that the adsorption process takes place with the sorption effect on the molecules and surface morphology. At the end of the study, it is observed that two different chemicals affected the adsorption capacities of the bone surfaces. This effect shows the impact of the chemical on the sorption. It is considered that the reason for tryptophan having a higher capacity than histidine derives from two different chain structures in molecules and other chemical determinants.

**Table 1.** Information of modification chemicals and fuchsine adsorption

| | | Molecule | $M_A$ | Fuchsine | |
|---|---|---|---|---|---|
| | | | (g.mol$^{-1}$) | $q_e$ (mg.g$^{-1}$) | A % |
| **MH** | Histidine |  | **155.16** | 0.48 | 35.16 |
| **MT** | Tryptophan |  | **204.23** | 0.69 | 50.71 |

It is estimated that there are colourants over 100000 in parallel with the increase in the use of textile, food, cosmetics, and many other industrial operations and many of these dyes are toxic for living creatures and the environment (Mahmoodi et al., 2011; Al-Sayed, 2011). For example, it is known that methylene blue causes burning eyes, frequent sweating, and different carcinogenic effects (Sharma et al., 2011). Therefore, it has been obligatory to remove dyer substances from water sources and industrial wastewater. Active carbon is a good adsorbent but it is not very commonly used due to its expense (Baccar et al., 2009; Mahmoodi et al., 2011). Therefore in recent years; cheap, effective, and easy to find natural resources and various industrial by-products are used and investigated instead of active carbon. Different methods are applied to remove the toxic substances present in water resources. These methods include neutralization and chemical precipitation, adsorption, ion exchange, reverse osmosis, phytoextraction, membrane and solvent extraction (Bailey et al., 1999; Donat et al., 2005). In these methods, it is known that ion exchange, chemical precipitation, membrane processes, and solvent extraction are expensive and insufficient for water with low metal content and wastewater. The adsorption process can be said as a low-cost and effective method of removal of toxic substances from water and wastewater resources.

## CONCLUSION

Production and consumption of fish products in our country are known to have a wide range of space. Most of the bones from fish production facilities are not used. As a biogenic apatite source, bones are lower-cost, alternative, natural materials compared to synthetic HAPs. Hydroxyapatites can be used as an important material because of having both ion-exchange property and hydroxyl (-OH) groups. Within the scope of the project, it was investigated that the fish bones -as industrial waste- were transformed into functional materials with chemical modification. Within the scope of the study, the surface of fish-bone particles was modified with histidine and tryptophan amino acids. The materials obtained from modifications interacted with the cationic fuchsine dyer substance in the aqueous solution. The cationic dye adsorption for both modification products, MH and MT, was determined as 0.48 and 0.69 mg.g$^{-1}$, respectively.

## ACKNOWLEDGEMENTS

This study was supported by The Scientific and Technological Research Council of Turkey (Project No: 213M200).

## Compliance with Ethical Standards

### Authors' Contributions

Both authors made contributions in each step during the preparation of the samples, conduction of the experiments, evaluation of the results, and writing the article.

### Conflict of Interest

The authors declare that there is no conflict of interest.

### Ethical Approval

For this type of study, formal consent is not required.

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**Acta Nat. Sci. (2021) 2(1): 53-57**
DOI: 10.29329/actanatsci.2021.314.9
e-ISSN: 2718-0638

**Short Communication**
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ACTA NATURA ET SCIENTIA

# Some Observations on the Depth Range and Size of Devil Firefish *Pterois miles* (Bennett, 1828) (Scorpaenidae) in Silifke, Mersin (Turkey)

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**Please cite this paper as follows:**
Taskavak, E., Gurkan, S., & Taylan, B. (2021). Some Observations on the Depth Range and Size of Devil Firefish *Pterois miles* (Bennett, 1828) (Scorpaenidae) in Silifke, Mersin (Turkey). *Acta Natura et Scientia*, *2*(1), 53-57. https://doi.org/10.29329/actanatsci.2021.314.9

**ARTICLE INFO**

*Article History*
Received: 22.04.2021
Revised: 29.05.2021
Accepted: 29.05.2021
Available online: 08.06.2021

*Keywords:*
Devil firefish
*Pterois miles*
Taşucu
Mersin
Invasive

**ABSTRACT**

In this study, we discussed the size of devil firefish *Pterois miles* (Bennett, 1828) specimen obtained from commercial fishermen who trawl off the coast of Taşucu, Silifke (36°3'32.70"N; 34°3'51.33"E). The obtained specimen was 335 mm in total length, 258 cm in standard length, and 0.696 kg in weight. The dissected specimen was a mature male. The testicles were weighed as 20.77 g and are in the third maturity stage. Additionally, during scuba diving to the underwater cave of Mersin Silifke, Beşparmak Island, a group of devil firefish was photographed at depths less than 15 meters. Contrary to many records on the hard rocky bottom at depths more than 20 meters, it has been observed by us that many anglers on the dock of Mersin Taşucu port were catching the devil firefish together with sympatric pufferfish (*Lagocephalus sceleratus*) in shallow waters of sandy bottom less than 3 meters at depth.

## INTRODUCTION

The members of the genera *Pterois* are native to coral reefs in the tropical waters of the South Pacific and Indian Oceans. Those are highly invasive species that threaten the well-being of coral reefs and other marine ecosystems, including the commercially and recreationally important fishes that depend on them. With the opening of the Suez Canal, the lessepsian fish species that have migrated from the Red Sea to the Mediterranean, consequently the coast of Turkey, gained momentum in recent years and reached 73 fish species (Turan et al., 2018). *Pterois miles*, a member of the family Scorpaenidae, is considered the most invasive fish species on the Atlantic and Mediterranean coasts (Kletou et al., 2016). Devil firefish *Pterois miles*, which have intense distribution in the Indian Ocean and the Mediterranean (Froese & Pauly, 2020), was reported for the first time by Golani & Sonin (1992) from the eastern Mediterranean, the Gulf of Haifa, in 1991. The first record of the Indo-Pacific lionfish for the Turkish coasts was given by Turan et al. (2014) from Iskenderun Bay. The Indo-Pacific immigrant *P. miles*, which are usually found in depths from 25 to 85 m on The hard rocky bottom, coral reefs and artificial substrate, may reach a maximum size of 35 cm in standard length (Sommer et al., 1996; Hare & Whitfield, 2003).

This study aims to document the size of the species and observations on the depths where the species was seen and caught, updating our knowledge on this alien fish species.

## MATERIAL AND METHODS

In March 2020, a single male *P. miles* specimen was obtained from commercial fishermen who trawl off the coast of Taşucu, Silifke at depths of 100-110 meters (36°3'32.70"N;

34°3'51.33"E) during open fishing season (Figure 1). The species determination was assigned according to Golani & Sonin (1992). The determination of the age of the lionfish by any method was not taken into consideration in this study. Total length (TL), Standard length (SL), and weight (TW, g) measurements of the male specimen were determined in the laboratory with a measuring board (0.1 cm), and a digital balance to the nearest 0.01 g. 13 morphometric measurements (caudal peduncle length, peduncle height, head length, dorsal fin length, anal fin length, prepectoral length, prepelvic length, eye diameter, preorbital distance, preanal length, snout length, interorbital distance, supraorbital tentacles) were taken with a Mitutoyo digital caliper to nearest 0.01 millimeter, and similarly six meristic characters (size of gill rakers, dorsal fin ray, anal fin ray, pectoral fin ray, pelvic fin ray, caudal fin ray) were evaluated as well (Table 1). All morphometric and meristic measures were expressed as % of the standard length (SL) and four as % head length (HL). The Sample was preserved in a 4% formalin solution. After length and weight measuring processes, the specimen was dissected and its sex was determined.


**Figure 1.** Bottom trawling area where *Pterois miles* specimen was caught as bycatch (36°3'32.70"N; 34°3'51.33"E).

In addition to the size record obtained from a single specimen, during scuba diving to the underwater cave of Mersin Silifke, Beşparmak Island to monitor the Mediterranean monk seal, *Monachus monachus*, a group of devil firefish was photographed (Figure 2). Moreover, in 2018, 2019, and 2020 we observed that many anglers on the dock of Mersin Taşucu port have also occasionally caught the devil firefish.

**Table 1.** Metric (mm) and meristic characteristics of *Pterois miles* specimen caught in March 2020 off the coast of Taşucu, Mersin Turkey

| **Metric measurements** | **This Study** | | **Oray et al. (2015)** | | **Turan et al. (2014)** | | **Golani & Sonin (1992)** | |
|---|---|---|---|---|---|---|---|---|
| | *mm* | *SL%* | *mm* | *SL%* | *mm* | *SL%* | *mm* | *SL%* |
| Total length | 335.00 | | 373.00 | | 276.00 | | | |
| Standard length | 258.00 | | 275.00 | | 211.00 | | 328.00 | |
| Body width | 92.98 | 36.04 | 110.80 | 40.30 | | 32.20 | | 41.40 |
| Caudal peduncle length | 39.93 | 15.48 | 43.80 | 15.90 | | | | |
| Peduncle height | 29.34 | 11.40 | 23.80 | 8.70 | | | | |
| Head length | 80,53 | 31.21 | 84.90 | 30.80 | | 30.80 | | 31.70 |
| Dorsal fin length | 155.10 | 60.12 | 164.60 | 59.80 | | | | |
| Anal fin length | 45.73 | 17.72 | 45.90 | 16.70 | | | | |
| Prepectoral length | 70.40 | 27.29 | 91.20 | 33.20 | | | | |
| Prepelvic length | 79.37 | 30.76 | 87.60 | 31.90 | | | | |
| Eye diameter | 7.50 | 9.31 %HL | 9.70 | 11.5 %HL | | | | 19.6 %HL |
| Preorbital distance | 35.54 | 13.78 | 23.90 | 28.20 | | | | |
| Preanal length | 185.00 | 71.70 | 188.60 | 68.60 | | | | |
| Snout length | 39.69 | 47.43 %HL | | | | 31.2 %HL | | 39.9 %HL |
| Interorbital distance | 12.78 | 15.27 %HL | 15.70 | 18.50 | | 34.21 %HL | | 23.8%HL |
| Supraorbital tentacles | 23.42 | 29.08 %HL | | | | 33.85 %HL | | |
| **Meristic characters** | | | | | | | | |
| Dorsal Fin rays | XIII + 11 | | XIII + 11 | | | XIII + 10 | XII+I+10 | |
| Anal Fin rays | III + 7 | | III + 7 | | | III + 6 | III + 6 | |
| Pectoral fin rays | 14 | | 14 | | | 13 | 14 | |
| Pelvic Fin rays | I, 5 | | I, 5 | | | I, 6 | | |
| Caudal Fin soft Rays | 13 | | | | | 14 | | |
| Gill rakers | 16 | | | | | 14 | 14 | |

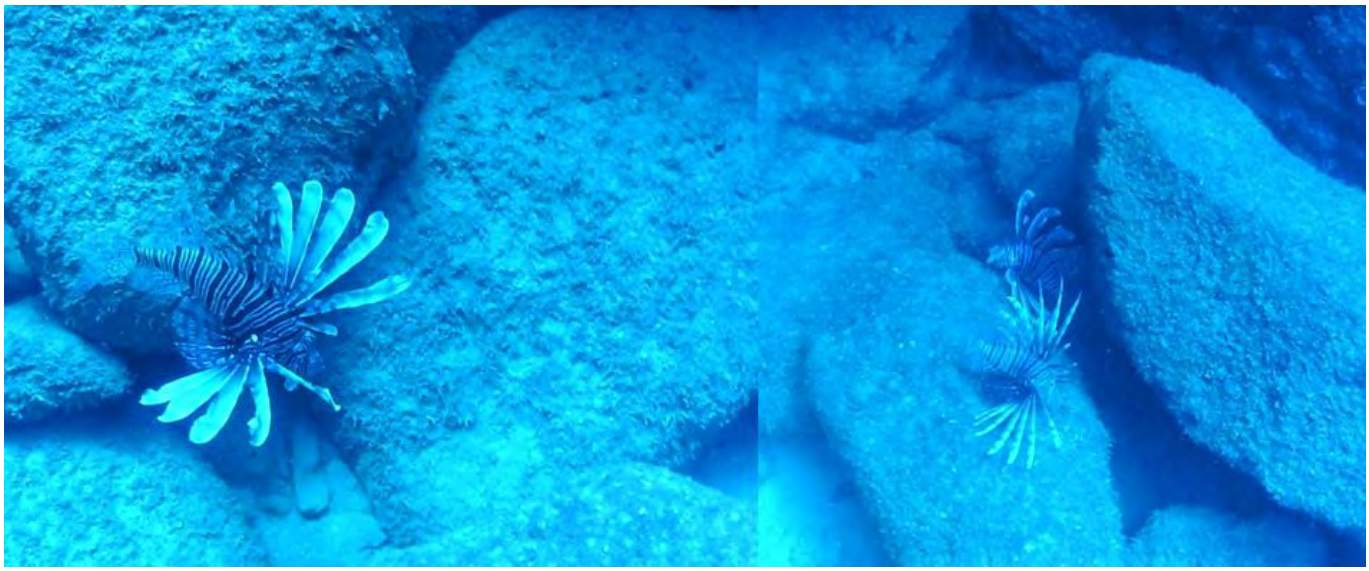

**Figure 3.** The invasive *Pterois miles* photographed by diver, Fatih Volkan Özel during scuba diving to the underwater cave of Mersin, Silifke Beşparmak Island on September 12, 2018

## RESULTS AND DISCUSSION

The obtained specimen was 335 mm in total length, 258 mm in standard length, and 0.696 kg in weight. The determined morphometric and meristic characters of the specimen were given in Table 1. It was seen that the dissected specimen was a mature male (Figure 3). The testicles were weighed as 20.77 g and are in the third maturity stage, according to Holden & Raitt (1974).


**Figure 2.** A male Indo-Pacific lionfish *Pterois miles* and its testes, caught off the coast of Taşucu, Silifke Mersin

The captured specimen of Turan et al. (2014), who gave the first record of *P. miles* for the Turkish marine waters, was 276 mm in total length and 211 mm in standard length. In our study, it was determined that the *P. miles* specimen belongs to the largest individual identified in the Turkish seas (except for the ambiguous record given by Dağhan & Demirhan (2020) for Iskenderun Bay) as well as the third one in the Mediterranean. Studying some bio-ecological characteristics of 179 *P. miles* specimens caught from Iskenderun Bay, Dağhan & Demirhan (2020) stated length and age group of their specimens only in the abstract section of their study, which ranged between 14.5-35.5 cm and 1-6 years, respectively. The 37.3-centimeter fish length (27.5 cm Standard length) given by Oray et al. (2015) is the second maximum length of *P. miles* recorded for the Mediterranean. A 328 mm *Pterois miles* specimen of Golani & Sonin (1992), which was given for the first time from the Mediterranean almost three decades ago, is the largest one recorded in the Mediterranean so far. Considering the species' further westward distribution in the Mediterranean, Zannaki et al. (2019) and Vavasis et al. (2020) recorded 31.5 and 22.5 cm of *P. miles* specimens, respectively, for the Greek marine waters.

The presence and abundance of relatively larger individuals in a fish population may give some insight into the existence of fishing pressure on the related species, as well as the prey-predator relationship. Growth is critically important since body size strongly influences predator-prey interactions (Rice et al., 1993; Lorenzen, 2006) and is a key determinant of reproductive output in fishes (Hixon et al., 2013). In the determination of growth parameters, they are freely estimated with the exception of the maximum observed size, a common convention. Constraining the maximum observed size is usually required if relatively few old fish are captured, and the length data contained little information about maximum size. However, in Von Bertalanffy growth parameters, Dağhan & Demirhan (2020) calculated $L_\infty$ value with the data obtained from age readings as 44.6271 cm for 179 *P. miles* specimens (female and male together) from Iskenderun Bay.

In addition to the size record obtained from a single specimen, another issue we want to discuss in this study is

the depths where the devil firefish were observed or caught. In the easternmost Mediterranean range of this invasive species, the depths are recorded as 35 m (trawl) by Golani & Sonin (1992) and 30 m (gill net) Bariche et al. (2013) for Israel and Lebanon, respectively. Similarly, Turan et al. (2014) and Oray et al. (2015) have given the depths, which this invasive species was caught, as 25 and 40 meters, respectively, for Turkey and Cyprus. In their study on invasive lionfish caught from the locality and depths where we made our observations and sampling presented here, Yaglioglu & Ayas (2016) mentioned specimens caught with bottom trawl at 100-110 meters depths in Yeşilovacık Bay, Mersin. On the other hand, unlike the examples given above, a total of 36 samples were captured by spear gun on rocky bottoms at depths ranging from 1 to10 meters on the coast of Rhodes Island (Zannaki et al., 2019). In contrast, Turan & Öztürk (2015) observed this nuisance invader for the first time at 11 m depth on a sandy bottom in Dalyan on the Aegean Sea coast of Turkey. In 2019, diver Fatih Volkan Özel photographed a group of devil firefish with GoPro HERO7 White by an underwater cave entrance of Beşparmak Island, Mersin. This observation on the hard rocky bottom was at depths less than 15 meters (Figure 2). Contrary to our observation on the hard rocky bottom, in 2018, 2019, and 2020 it has been observed that amateur fishers on the dock of Mersin Taşucu port were catching the devil firefish together with sympatric pufferfish (*Lagocephalus sceleratus*) in shallow waters of sandy bottom less than 3 meters at depth.

Invasion of marine alien species, both vertebrate and invertebrate, is one of the most critical threats negatively affecting marine biodiversity worldwide. *P. miles* has been reported to be among the most invasive species documented among aquatic creatures (Hixon et al., 2013). This Red Sea immigrant fish threaten native fish and the environment in coastal waters. They are capable of causing extinctions of native plants and animals, reducing biodiversity, competing with native organisms for limited resources, and altering habitats. *P. miles*, with a Basic Risk Assessment (BRA) score of 45.5, is the most invasive species known in the Mediterranean to date and the most severely threatening species to biodiversity (Bilge et al., 2019). Up to date, considering the sizes of *P. miles* found in the Mediterranean (328 mm SL by Golani & Sonin, 1992; 373 mm TL and 275.0 SL by Oray et al., 2015; and 335 mm TL 258 mm SL by the present study) and the prey fish found in their stomach contents (23 genera of 13 families given by Zannaki et al., 2019 and *Mullus surmuletus*, Gobiidae sp., given by Özgür Özbek et al., 2017) as well as the effects of lionfish predation on adult fish is also likely to represent a significant impact of this invasive species on native communities in the Mediterranean.

## CONCLUSION

Consequently, the findings we have obtained here regarding the maximum sizes of *P. miles* in the Mediterranean, the depths where we observed the species and the sandy bottom on which the fish were seen show how devil firefish settle successfully at Turkey's Mediterranean coasts. Moreover, the fact that the captured devil firefish is a mature male with 20.77 grams of testicles may also indicate that this species can reproduce successfully in the eastern Mediterranean basin. In his study aims to predict the potential geographic distribution and future expansion of *Pterois miles* with ecological niche modeling along the Mediterranean Sea, Turan (2020) claimed that almost more than 2/3 of the whole Mediterranean would be in trouble with this invader in a few decades. Thus, ministries that are directly related to the subject (Ministry of Food, Agriculture and Livestock and Minister of Environment and Urbanization), universities, nongovernmental organizations, relevant fisheries sector representatives and fisheries cooperatives have to hard to develop ways to prevent and control further spread existing populations.

## ACKNOWLEDGEMENTS

We thank Ekrem Evren IŞIK, "Paşa Balıkçılık Silifke/Mersin" for informing us and for providing mature male devil firefish. We also owe a debt of gratitude to "DOKAY Mühendislik ve Danışmanlık Ltd./Ankara" for making travel to Mersin fieldworks feasible.

## Compliance With Ethical Standards

### Authors' Contributions

Authors have contributed equally to the paper.

### Conflict of Interest

The authors declare that there is no conflict of interest.

### Ethical Approval

For this type of study, formal consent is not required.

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**Acta Nat. Sci. (2021) 2(1): 58-67**
DOI: 10.29329/actanatsci.2021.314.10
e-ISSN: 2718-0638

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ACTA NATURA ET SCIENTIA

# The Effect of Using Wheat Protein at Different Ratios Instead of Fish Meal on Growth Parameters and Fatty Acid of Juvenile Sea Bass (*Dicentrarchus labrax* L. 1758)

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**Please cite this paper as follows:**
Akın, S., & Bulut, M. (2021). The Effect of Using Wheat Protein at Different Ratios Instead of Fish Meal on Growth Parameters and Fatty Acid of Juvenile Sea Bass (*Dicentrarchus labrax* L. 1758) *Acta Natura et Scientia*, *2*(1), 58-67. https://doi.org/10.29329/actanatsci.2021.314.10

**ARTICLE INFO**

*Article History*
Received: 28.04.2021
Revised: 27.05.2021
Accepted: 28.05.2021
Available online: 16.06.2021

*Keywords:*
Seabass wheat flour protein
Growth
Fatty acid

**ABSTRACT**

In this study, a feeding experiment was conducted using different rations (25%, 50%, 75%, and 100%) of wheat flour protein instead of fishmeal in fry fish *(Dicentrarchus labrax)* feeds. In the experiment, an average weight of 2.33±0.2 g juvenile seabass was used. Seabass fries were fed with the experimental feeds for 60 days. The experiment was designed in triplicates. At the end of the experiment, the growth parameters and fatty acid composition of fish fries were examined. As a result, it was statistically determined that the use of wheat flour protein at a high rate had a negative effect on the growth parameters of the fish. Significant changes in fatty acid composition were also observed.

# Balık Unu Yerine Farklı Oranlarda Buğday Proteini Kullanımının Yavru Levrek Balıklarının (*Dicentrarchus labrax* L. 1758) Büyüme Parametreleri ve Yağ Asidi Üzerine Etkisi

**MAKALE BİLGİSİ**

*Makale Geçmişi*
Geliş: 28.04.2021
Düzeltme: 27.05.2021
Kabul: 28.05.2021
Çevrimiçi Yayımlanma: 16.06.2021

*Anahtar Kelimeler:*
Levrek buğday proteini
Büyüme
Yağ asidi

**ÖZET**

Bu araştırmada yavru levrek balığı (*Dicentrarchus labrax L. 1758*) yemlerinde balık unu yerine farklı oranlarda (%25, %50, %75, %100) buğday unu proteini kullanılmasına yönelik besleme denemesi yapılmıştır. Denemede ortalama 2,33±0,2 g yavru levrek balıkları kullanılmıştır. Levrek yavruları 60 gün süresince hazırlanan bu yemlerle her bir grup üç tekerrürlü olacak şekilde beslenmiştir. Deneme sonunda bu balıkların büyüme parametreleri ve yağ asidi kompozisyonu incelenmiştir. Araştırma sonunda yüksek oranda buğday unu proteini kullanımının balıkların büyüme parametreleri üzerine negatif bir etki ettiği istatistiksel olarak belirlenmiştir. Yağ asidi kompozisyonunda da önemli değişimler gözlenmiştir.

## GİRİŞ

Çevresel etkilerden dolayı dünya düzeni gün geçtikçe bozulmaktadır. Küresel ısınma, kirlilik ve çevresel faktörler dünya düzenini bozmaktadır. Bu olumsuzluklar çeşitli mikropların çoğalmalarına neden olmaktadır. Bu da insan sağlığını tehdit etmektedir. İnsanlar bu mikroplardan korunmak için bağışıklık sistemlerini güçlü tutmak zorundadır. Balık sağlıklı beslenme ve bağışıklık için oldukça önemli bir besindir. Bu besinin kolay ve ucuz ulaşılabilir olması gerekmektedir. Dünya nüfusu hızlı bir artış gösterdiğinden balık stokları da gün geçtikçe azalmaktadır. Dolayısıyla kültür balıkçılığının hızlı bir şekilde bu açığı kapatma zorunluluğu vardır. Ancak bu açığı kapatmada balık unu yerine alternatif ucuz ham maddelere ihtiyaç vardır. Akuakültür üretim miktarının artması ile doğru orantılı olarak yem miktarı gereksinimi de artış göstermektedir. Balık yemlerinde başlıca protein kaynağının balık unu olması nedeniyle, balık unundaki fiyat dalgalanması doğrudan balık yemi maliyetlerini, dolayısıyla da üretimde son ürün olan balık fiyatını da etkilemektedir. Balık unu üretiminin önceden belirlenememesi ve buna bağlı olarak yıldan yıla gösterdiği büyük dalgalanma (Hardy, 2006; Tacon & Metian, 2008) nedeni ile bu protein kaynağının fiyatlarının gelecekte artma eğilimi göstereceği tahmin edilmektedir (Morris vd., 2011). Bu yüzden balık ve diğer sucul canlıların sürdürülebilir yetiştiriciliklerinin devamının sağlanması, işletmelerde kullanılan karma yemlerde balık unu ve balık yağına bağımlılığın azaltılmasını sağlayacak bitkisel veya hayvansal kaynaklı ucuz alternatif protein kaynaklarına ihtiyaç vardır. Bitkisel kökenli yem ham maddelerin araştırılması ile yem maliyetinin düşürüldüğü çeşitli çalışmalarda rapor edilmiştir (Mourente & Bell, 2006; Martinez-Llorens vd., 2007). Buğday dünya üzerinde hemen hemen her bölgede yetiştirilen en ucuz tahılgillerdendir. Dolayısıyla bu çalışmada dünyada ilk defa yavru levrek balıkları yemlerinde farklı oranlarda buğday proteini kullanılmıştır. Buğday üretimi Türkiye'nin hemen her bölgesinde yapılmakta olup, tarla ürünleri içerisinde ekili alanı ve üretim miktarı bakımından ilk sırayı almaktadır. Ekili alanların % 51'inde buğday ekilmektedir. Türkiye'de buğday ekim alanlarında fazla bir değişim görülmemekte olup, ekili alanlar 9-9,4 milyon hektar dolayında değişim göstermiştir. (Kızılaslan, 2004)

Buğday, dünya nüfusuna bitkisel kaynaklı besinlerden sağlanan toplam kalorinin yaklaşık %20'sini sağlamakta, başta unlu mamuller olmak üzere birçok gıda ve sanayi sektöründe kullanılmaktadır (Özcan vd., 2021). Bu araştırmada buğday ham maddesi kullanılmış olup Bu yemler ile beslenen balıkların, yem tüketimi, verimliliği, büyüme performansı, balık vücudunun biyokimyasal kompozisyonu ve yağ asidi içeriği etkilerinin belirlenmiştir.

## MATERYAL VE YÖNTEM

### Deneme Yeri ve Sistemi

Bu araştırma, Çanakkale Onsekiz Mart Üniversitesi Deniz Bilimleri ve Teknolojisi Fakültesi Canlı Balık Yetiştirme Ünitesinde kurulan kapalı devre deniz sisteminde yapılmıştır. Bu sistemde çökeltme tankı, kaba filtrasyon, kum filtre, biyolojik filtre ve ısıtma-soğutma ünitesinden oluşmaktadır. Deneme 30 L hacmindeki fiberglas tanklarda yapılmıştır. Denemede günlük olarak %10-15 oranlarında su değişimi gerçekleştirilmiştir. Ayrıca otomatik zamanlayıcılar yardımıyla 12 saat aydınlık, 12 saat karanlık fotoperiyodu uygulanmıştır. Deneme 60 gün sürmüştür.

**Tablo 1.** Denemede kullanılan yem formülasyonu

| Yem İçeriği | Kontrol | BUP %25 | BUP %50 | BUP %75 | BUP%100 |
|---|---|---|---|---|---|
| Balık unu (g/kg) | 60 | 45 | 30 | 15 | 0 |
| Buğday proteini (g/kg) | 0 | 15 | 30 | 45 | 60 |
| Mısır nişastası (g/kg) | 11 | 10,5 | 10 | 9,5 | 9 |
| Buğday unu (g/kg) | 15 | 15 | 15 | 15 | 15 |
| Vitamin (g/kg) | 4 | 4 | 4 | 4 | 4 |
| Balık yağı (g/kg) | 10 | 10,5 | 11 | 11,5 | 12 |
| % (g/kg) | 100 | 100 | 100 | 100 | 100 |

***Not:*** BUP: Balık unu proteini; Hamsi balık unu: Koptur Balıkçılık. Trabzon. Türkiye. Hamsi balık yağı: Agromarin Yem San. ve Tic. A.Ş. İzmir. Türkiye. Vitamin karışımı: Vitamin A, 18000 IU $kg^{-1}$ yem; Vitamin $D_3$, 2500 IU $kg^{-1}$ yem; Vitamin E, 250 mg $kg^{-1}$ yem Vitamin $K_3$, 12 mg $kg^{-1}$ yem; Vitamin $B_1$, 25 mg $kg^{-1}$ yem; Vitamin $B_2$, 50 mg $kg^{-1}$ yem; Vitamin $B_3$, 250 mg $kg^{-1}$ yem; Vitamin $B_6$, 20 mg $kg^{-1}$ yem; Vitamin $B_{12}$, 0,06 mg $kg^{-1}$ yem; Vitamin C, 220 mg $kg^{-1}$ yem; Folik asit, 10 mg $kg^{-1}$ yem; Kalsiyum d–pantothenate. 50 mg $kg^{-1}$ yem; Biyotin, 1 mg $kg^{-1}$ yem; İnositol, 210 mg $kg^{-1}$ yem; Kolin Klorid, 2000 mg $kg^{-1}$ yem.

### Deneme Yemleri

Yem ham maddeleri balık yemi üreten bir ticari işletmeden temin edilmiştir. Balık unu, buğday unu, mısır nişastası, balık yağı ve vitamin-mineral karışımı, nem, protein, yağ ve kül gibi besin maddesi analizleri yapılmıştır (AOAC, 1998). Tablo 1'de yer alan ham maddeler ve katkı maddeleri homojen oluncaya kadar laboratuvar tipi yem karıştırıcısında karıştırılmıştır. Uygun kıvama gelen karışımlar kontrol yemi, %25, %50, %75 ve %100 oranlı yem içerikleri hazırlandıktan sonra makine yardımıyla pelet yem haline getirilip 4 saat boyunca fırında kurutulmuştur. Fırında kurutulan yemler, yavru levrek balıklarının yemi alabileceği boyuta getirilmek üzere öğütme makinesi ile her grup ayrı ayrı öğütülüp, gruplara ait numaralandırılmış kaplara konup güneş görmeyen ortamda muhafaza edilmiştir.

### Büyüme Performansı ve Yemden Yararlanma

Denemede büyüme performansı ve yemden yararlanmanın hesaplanmasında Denklem 1-4'teki formüller kullanılmıştır (Yılmaz & Ergün, 2013):

$$CAA\ (\%) = \frac{(\text{Son ağırlık} - \text{Başlangıç ağırlığı})}{\text{Başlangıç ağırlığı}} \times 100 \quad (1)$$

$$SBO(\%\ Gün^{-1}) = \frac{[ln(\text{Son ortalama ağırlık}) - ln(\text{Başlangıçtaki ortalama ağırlık})]}{\text{Deneme gün sayısı}} \times 100 \quad (2)$$

$$YDO = \frac{Yem\ tüketimi}{Ağırlık\ kazanımı} \times 100 \quad (3)$$

$$Ağırlık\ Kazanımı = Son\ ağırlık - Başlangıç\ ağırlığı \quad (4)$$

Bu formüllerdeki ağırlık hesaplamaları g cinsinden hesaplanmıştır. *CAA (%)* yüzde canlı ağırlık artışı, *SBO (% Gün$^{-1}$)* günlük yüzde spesifik büyüme oranı, *YDO* yem dönüşüm oranını ifade etmektedir.

### Balık Yemi ve Etlerinde Kimyasal Besin Madde Analizleri

Deneme yemleri ve balıkların kimyasal kompozisyonunu (nem, protein, yağ ve kül) analizleri Denklem 5-7'de verilen yöntemlerle yapılmıştır.

Nem yüzdeleri Denklem 5'teki formüle göre hesaplanmıştır (AOAC, 2000):

$$Nem(\%) = \frac{(\text{Kuru örnek+dara-ilk örnek ağırlığı})}{\text{Başlangıç örnek ağırlığı}} \times 100 \quad (5)$$

Protein miktarlarının belirlenmesi için Kjeldahl metodu kullanılmıştır (AOAC, 2000). Protein yüzdesi Denklem 6'daki formüle göre hesaplanmıştır:

$$Ham\ Protein\ (\%) = \frac{(\text{Titrasyonda harcanan-Kör örnek}) \times 0{,}1 \times 14{,}007 \times 6{,}25}{\text{Örnek ağırlığı}} \times 100 \quad (6)$$

Krozelerin ağırlık değişimine göre örneklerin kül içeriği Denklem 7'deki formüle göre hesaplanmıştır (AOAC, 2000).

$$Ham\ Kül\ (\%) = \frac{\text{Krozenin ağırlık değişimi}}{\text{Örnek ağırlığı}} \times 100 \quad (7)$$

Yağ analizi AOAC (2000) tarafından uygulanan yöntem esas alınarak yapılmıştır.

Yağ asidi analizlerinde elde edilen ham yağ materyal olarak kullanılmıştır. Bu şekilde elde edilen ham yağın öncelikle esterleşmesi yapılmıştır. Ardından enjektörle bu solüsyondan çekilip 1 µL gaz kromatografisine (GC) enjekte edilerek yağ asitleri kompozisyonu tespit edilmiştir (IUPAC, 1987). Yağ asitleri Shimadzu marka gaz kromatografisi ile belirlenmiştir. FAME Supelco 37 bileşimli yağ asidi standardı kullanılarak pik tanımlanması yapılmıştır.

### İstatistiksel Değerlendirmeler

Deneme sonunda elde edilen veriler SPSS istatistik programının tek yönlü varyans analizi (ANOVA) testi ile analiz edilmiş ve Tukey, Scheffe ve Duncan çoklu karşılaştırma testleri ile karşılaştırmalar yapılmıştır.

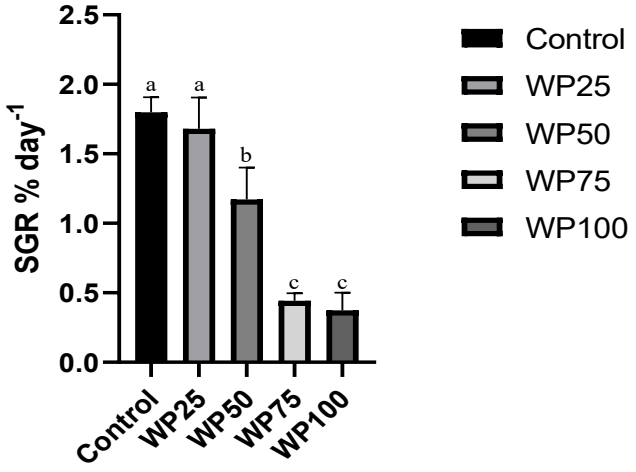
## BULGULAR

### Suyun Kimyasal ve Fiziksel Özellikleri

Deneme sırasında kullanılan suyun sıcaklığı, içindeki çözünmüş oksijen miktarı ve pH değerleri günlük ölçümlerle takip edilmiştir. Su sıcaklığı 15°C±0,94°C, sudaki çözünmüş oksijen miktarı 7,3±1,02 mg/l, suyun pH değeri 7,6±0,5 ve tuzluluk ‰24,2±0,98 aralığındadır.

### Büyüme ve Yem Değerlendirme Oranları

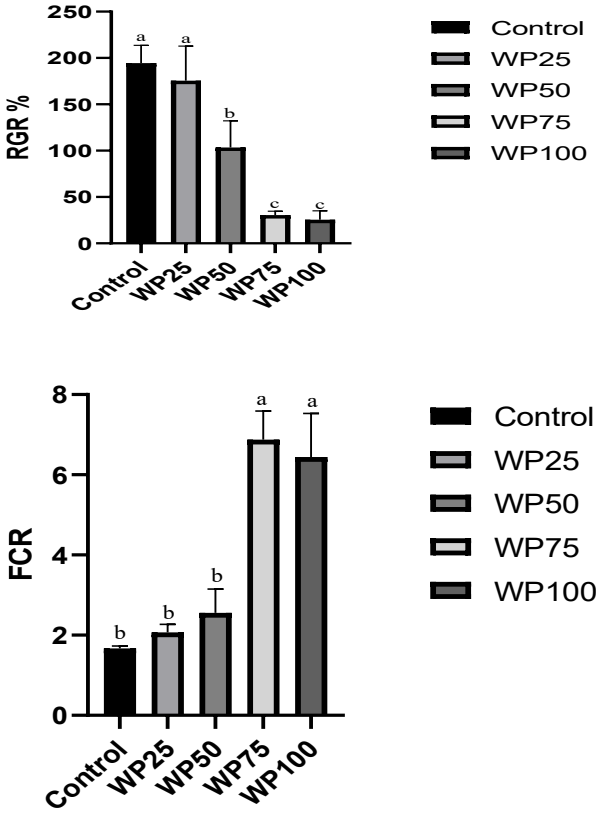
Araştırmada, balıkların ortalama canlı ağırlık artışları 15 günlük periyotlarla tartılmak üzere hesaplanmıştır. Deney tanklarından alınan 20'şer adet balığın ağırlıkları tartılmış ve elde edilen verilerin ortalama değerleri ile standart sapmaları hesaplanmıştır. Deneyin ilk aşamasında deneme gruplarındaki balıkların ortalama ağırlıkları 2,33±0,2 g olarak hesaplanmıştır. Deney sonunda kontrol grubu ve %25 buğday unu içeren gruptaki balıkların canlı ağırlık artışları diğer gruplara göre daha yüksek bulunmuştur (Şekil 1). Bunları takiben canlı ağırlık artışı sırasıyla %50, %75, %100 buğday unu içeren gruplarda gözlenmiştir. En düşük canlı ağırlık artışı %100 olan gruptadır (0,3744±0,1259). Yüksek oranda buğday kullanımının büyümeye bir etkisi olmadığı tespit edilmiştir. Spesifik büyüme oranları ve ortalama yem değerlendirme oranları Tablo 1 ve Tablo 2'de verilmiştir.




**Şekil 1.** Ortalama spesifik büyüme oranları

**Tablo 2.** Ortalama spesifik büyüme oranları (SBO)

| Deneme Grubu | N | Ortalama | Standart Sapma | %95 Güven Aralığı |
|---|---|---|---|---|
| Kontrol | 3 | 1,7982 | 0,1082 | 1,5874-2,0090 |
| %100 | 3 | 0,3744 | 0,1259 | 0,1636-0,5852 |
| %%25 | 3 | 1,679 | 0,226 | 1,468-1,890 |
| %50 | 3 | 1,173 | 0,229 | 0,962-1,384 |
| %75 | 3 | 0,4422 | 0,0556 | 0,2314-0,6530 |




**Şekil 2.** Yem değerlendirme oranları

En iyi yem değerlendirme oranı kontrol grubunda tespit edilmiştir (1,6721±0,0572). Bunu sırasıyla %25 buğday unu içeren grup (2,068±0,205), %50 buğday unu içeren grup (2,555±0,596), %100 buğday unu içeren grup (6,442±1,086) ve %75 buğday unu içeren grup takip etmiştir (6,87±0,716) (Şekil 2, Tablo 3). Bu analizlerden anlaşılacağı üzere %25 oranından fazla buğday unu içeren grupların yem değerlendirme katsayısında bariz bir yükseliş görülmektedir.

**Tablo 3.** Ortalama yem değerlendirme oranları (YDO)

| Deneme Grubu | N | Ortalama | Standart Sapma | %95 Güven Aralığı |
|---|---|---|---|---|
| Kontrol | 3 | 1,6721 | 0,0572 | (0,8398-2,5043) |
| %100 | 3 | 6,442 | 1,086 | (5,609-7,274) |
| %25 | 3 | 2,068 | 0,205 | (1,236-2,900) |
| %50 | 3 | 2,555 | 0,596 | (1,722-3,387) |
| %75 | 3 | 6,874 | 0,716 | (6,042-7,706) |

## Deneyde Kullanılan Balıkların Vücut Kompozisyonu

Tüm gruplardaki deneme balıkları, deneme sonunda homojen hale getirilip, ham yağ, ham kül, ham protein ve nem analizleri yapılmıştır. (Şekil 3).

Yapılan analizler sonucunda ham yağ miktarı %50 buğday unu içeren yemle beslenen grupta en yüksek, %100 buğday unu içeren yemle beslenen grupta en düşük olarak görülmüştür (Şekil 3) Ham kül oranı ise en yüksek %25 buğday unu içeren yem ile beslenen grupta görülmüştür. Diğer gruplar arasında önemli bir fark görülmemiştir. Nem analizlerinde buğday unu içeriği %75 ve %100 olan gruplarda önemli bir fark olmayıp en yüksek değeri almaktadır. Kontrol grubu, %25 ve %50 olan gruplarda da önemli fark görülmeyip en düşük değerler bu gruplarda tespit edilmiştir. Araştırma sonunda yapılan istatistiksel hesaplamalara göre balıkların vücudundaki ham protein oranı %25 ve %50 buğday unu içeriği olan gruplarda önemli bir fark görülmemiştir ve en yüksek değerler bu iki grupta gözlenmiştir. Protein analizi sonucunda en düşük değerler %75 buğday unu içeren yemle beslenen grupta görülmüştür.

Araştırma sonunda deneme yemleri ile beslenen yavru levrek balıklarının yağ asidi içerikleri belirlenmiştir (Tablo 4). Buna göre önce yemlerin yağ asidi içerikleri incelenmiş ve daha sonra balıkların kas dokularındaki yağ asidi değişimleri tespit edilmiştir. Tüm canlılarda olduğu gibi balıklarda da kullanılan besinin canlı dokulara etki ettiği görülmüştür. Balık etlerindeki doymuş yağ asitleri incelendiğinde gruplar arasında önemli farklar görülmemiştir (Tablo 5). Doymuş yağ asitleri içinde önemli olan 14:0, 16:0 ve 18:0 yağ asitleri incelendiğinde 14:0'da gruplar arasında bir fark görülmemiştir (2,8867±0,0723 – 3,1800±0,0100). Bununla birlikte 16:0'da da önemli bir fark görülmemiştir (15,7833±0,1050 – 16,8600±0,1670). Ayrıca, 18:0'da bütün gruplarda oranlar birbirlerine yakın olup istatistiksel olarak bir fark tespit edilmemiştir.

**Tablo 4.** Deneme başında kullanılan yemlerin yağ asidi kompozisyonu

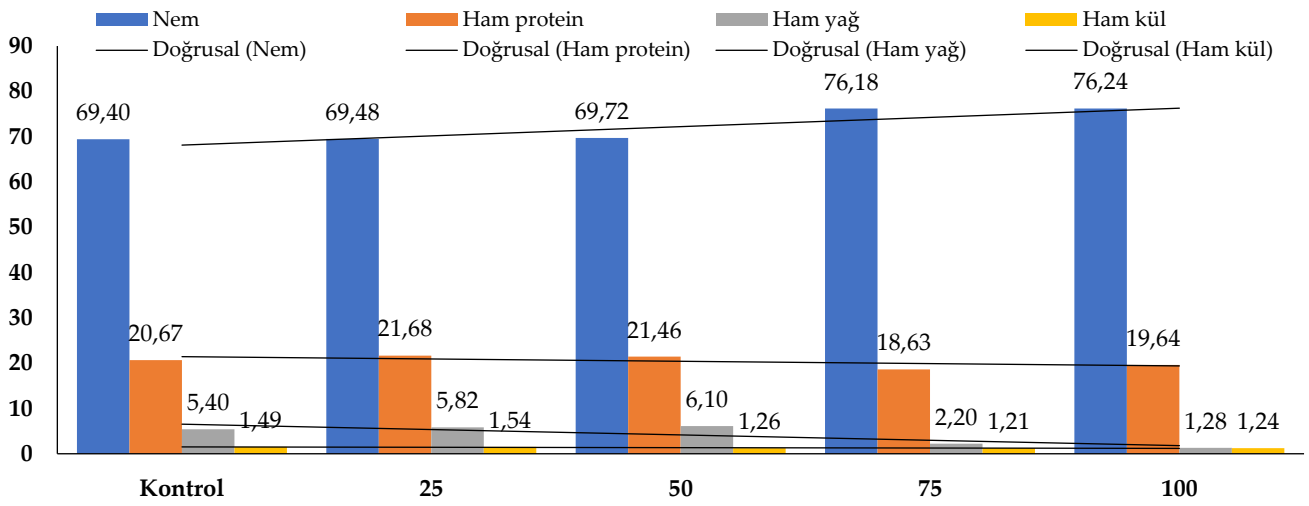
| **Yağ Asidi** | **Araştırma Yemleri** | | | |
|---|---|---|---|---|
| **ΣSFA** | **BUP%25** | **BUP%50** | **BUP%75** | **BUP%100** |
| C4:0 | 0,3±0,0 | 0,3200±0,0 | 0,4433±0,0115 | 0,5333±0,0577 |
| C6:0 | 0,0±0,0 | 0,0±0,0 | 0,0±0,0 | 0,0000±0,0000 |
| C8:0 | 0,0±0,0 | 0,0±0,0 | 0,0±0,0 | 0,0000±0,0000 |
| C10:0 | 0,0±0,0 | 0,0±0,0 | 0,0±0,0 | 0,0100±0,0000 |
| C11:0 | 0,0167±0,0058 | 0,0667±0,0577 | 0,0133±0,0058 | 0,0167±0,0058 |
| C12:0 | 0,0±0,0 | 0,3667±0,4619 | 0,0000±0,0000 | 0,0000±0,0000 |
| C13:0 | 0,0±0,0 | 0,2333±0,0577 | 0,0200±0,0000 | 0,0433±0,0058 |
| C14:0 | 3,72±0,0896 | 3,9933±0,0115 | 3,8333±0,0577 | 4,3667±0,1155 |
| C15:0 | 0,01±0,00 | 0,0097±0,0006 | 0,0000±0,0000 | 0,0100±0,0000 |
| C16:0 | 15,423±0,0306 | 15,653±0,2055 | 15,9933±0,0115 | 17,4567±0,1966 |
| C17:0 | 0,3300±0,0265 | 0,6333±0,0577 | 0,6967±0,0058 | 0,3233±0,0252 |
| C18:0 | 15,100±0,1000 | 7,5100±0,0557 | 13,0000±0,1000 | 11,7500±0,0500 |
| C20:0 | 0,5667±0,0115 | 0,3833±0,0058 | 0,4000±0,0100 | 0,3433±0,0208 |
| C21:0 | 0,0667±0,0058 | 0,0133±0,0058 | 0,0100±0,0000 | 0,0000±0,0000 |
| C22:0 | 0,2333±0,0115 | 0,2333±0,0058 | 0,2167±0,0058 | 0,0900±0,0100 |
| **ΣMUFA** | | | | |
| C14:1 | 0,0±0,00 | 0,3000±0,1000 | 0,0000±0,0000 | 0,0000±0,0000 |
| C15:1 | 0,0167±0,0058 | 0,0467±0,0058 | 0,0000±0,0000 | 0,0000±0,0000 |
| C16:1 | 4,7833±0,5659 | 5,3400±0,0200 | 5,1333±0,0577 | 5,5000±0,1000 |
| C17:1 | 0,1367±0,0321 | 0,3500±0,0000 | 0,3400±0,0100 | 0,5100±0,2516 |
| C18:1n9c | 25,0733±0,0643 | 30,0433±0,0666 | 25,0300±0,1212 | 24,4533±0,5065 |
| C20:1n9 | 2,9167±0,0577 | 2,3400±0,0100 | 2,5300±0,0300 | 2,1333±0,0577 |
| C22:1n9 | 0,3500±0,0520 | 0,3333±0,0153 | 0,3567±0,0058 | 0,2700±0,0265 |
| C24:1n9 | 0,5433±0,0208 | 1,9333±2,6558 | 0,5967±0,0058 | 0,6267±0,0058 |
| **ΣPUFA** | | | | |
| C18:2n6c | 11,8467±0,1361 | 0,2000±0,0000 | 0,1433±0,0058 | 0,1333±0,0058 |
| C18:2n6t | 0,2133±0,0231 | 13,3667±0,1528 | 12,1900±0,2330 | 11,0500±0,1323 |
| C18:3n6 | 0,00±0,00 | 0,2667±0,0577 | 0,4667±0,3786 | 0,3000±0,0000 |
| C18:3n3 | 3,7433±0,0577 | 3,6667±0,0577 | 3,1833±0,0289 | 2,9333±0,0764 |
| C20:2 | 1,1333±0,0577 | 0,9000±0,0100 | 0,8533±0,0058 | 0,7833±0,0289 |
| C20:3n6 | 0,4233±0,0058 | 0,3567±0,0058 | 0,3333±0,0153 | 0,1833±0,0289 |
| C20:3n3 | 0,6967±0,0058 | 0,5833±0,0289 | 0,6167±0,0153 | 2,5333±0,0577 |
| C20:4n6 | 0,3667±0,0153 | 0,2967±0,0058 | 0,2367±0,0115 | 0,1000±0,0000 |
| C20:5n3 | 5,5667±0,0577 | 6,5300±0,0700 | 6,2100±0,0529 | 7,3200±0,0721 |
| C22:2 | 0,1000±0,0000 | 0,1000±0,0000 | 0,1000±0,0000 | 0,1000±0,0000 |
| C23:2c4 | 0,0367±0,0058 | 0,0267±0,0058 | 0,0233±0,0058 | 0,0267±0,0058 |
| C22:6n3 | 6,8467±0,0379 | 7,5400±0,0781 | 7,9567±0,0586 | 9,1667±0,0577 |

***Not:*** ΣSFA (Toplam doymuş yağ asitleri); ΣMUFA (Toplam tekli doymamış yağ asitleri); ΣPUFA (Toplam çoklu doymamış yağ asitleri, n3/n6)

**Tablo 5.** Deneme sonunda balıkların etlerindeki yağ asidi içeriği

| **Yağ Asidi** | **Balık Etlerinin Yağ Asidi Kompozisyonu** | | | |
|---|---|---|---|---|
| **ΣSFA** | **BUP%25** | **BUP%50** | **BUP%75** | **BUP%100** |
| C4:0 | 0,0533±0,0058 | 0,0000±0,0000 | 0,0233±0,0058 | 0,0533±0,0058 |
| C6:0 | 0,0333±0,0058 | 0,0233±0,0058 | 0,0267±0,0058 | 0,0233±0,0058 |
| C8:0 | 0,0000±0,0000 | 0,0000±0,0000 | 0,0000±0,0000 | 0,0000±0,0000 |
| C10:0 | 0,0000±0,0000 | 0,0000±0,0000 | 0,0000±0,0000 | 0,0000±0,0000 |
| C11:0 | 0,0000±0,0000 | 0,0000±0,0000 | 0,0000±0,0000 | 0,0000±0,0000 |
| C12:0 | 0,0533±0,0058 | 0,0597±0,0015 | 0,0750±0,0050 | 0,0767±0,0058 |
| C13:0 | 0,0267±0,0058 | 0,0143±0,0040 | 0,0233±0,0058 | 0,0233±0,0058 |
| C14:0 | 2,9467±0,1102 | 2,8867±0,0723 | 3,1800±0,0100 | 2,9600±0,0529 |
| C15:0 | 0,0000±0,0000 | 0,0130±0,0061 | 0,0000±0,0000 | 0,0433±0,0058 |
| C16:0 | 16,0633±0,1193 | 15,9567±0,0611 | 15,7833±0,1050 | 16,8600±0,1670 |
| C17:0 | 0,6500±0,0265 | 0,6700±0,0100 | 0,4600±0,0436 | 0,5500±0,0436 |
| C18:0 | 7,0100±0,0100 | 7,0533±0,0416 | 6,7167±0,0551 | 6,7000±0,1000 |
| C20:0 | 0,3633±0,0153 | 0,3533±0,0058 | 0,3000±0,0000 | 0,2967±0,0058 |
| C21:0 | 0,0667±0,0115 | 6,5733±0,0757 | 5,0100±0,0100 | 5,9067±0,0153 |
| C22:0 | 0,3100±0,0100 | 0,0733±0,0058 | 0,1567±0,0058 | 0,1367±0,0058 |
| **ΣMUFA** | | | | |
| C14:1 | 0,0167±0,0058 | 0,0377±0,0025 | 0,0567±0,0058 | 0,0433±0,0058 |
| C15:1 | 0,0167±0,0058 | 0,0100±0,0000 | 0,0167±0,0058 | 0,0167±0,0058 |
| C16:1 | 3,9800±0,0300 | 4,7667±0,0569 | 4,5667±0,0907 | 4,5700±0,0700 |
| C17:1 | 0,3900±0,0265 | 0,4367±0,0231 | 0,2733±0,0115 | 0,3167±0,0289 |
| C18:1n9c | 29,4867±0,8893 | 20,7033±15,3213 | 31,9933±0,0115 | 29,5967±0,1680 |
| C20:1n9 | 2,2133±0,0252 | 1,9633±0,0153 | 1,9833±0,0208 | 1,7667±0,0289 |
| C22:1n9 | 0,4567±0,0208 | 0,4367±0,0115 | 0,4533±0,0058 | 0,3900±0,0100 |
| C24:1n9 | 0,6267±0,0208 | 0,5867±0,0058 | 0,6000±0,0000 | 0,5933±0,0058 |
| **ΣPUFA** | | | | |
| C18:2n6c | 0,0667±0,0058 | 0,0867±0,0058 | 0,0433±0,0058 | 0,0667±0,0058 |
| C18:2n6t | 11,5133±0,0929 | 10,4600±0,0173 | 13,4867±0,0635 | 11,2267±0,2250 |
| C18:3n6 | 0,2633±0,0379 | 0,2767±0,0252 | 0,2000±0,0000 | 0,1833±0,0058 |
| C18:3n3 | 2,2300±0,0781 | 2,2900±0,0436 | 2,4867±0,0635 | 1,9500±0,0458 |
| C20:2 | 0,9833±0,0058 | 0,9067±0,0058 | 0,9633±0,0153 | 0,8000±0,0000 |
| C20:3n6 | 0,3200±0,0100 | 0,3433±0,0058 | 0,3300±0,0173 | 0,3000±0,0000 |
| C20:3n3 | 1,5900±0,0361 | 0,0490±0,0010 | 0,0333±0,0058 | 0,0467±0,0058 |
| C20:4n6 | 0,2967±0,0058 | 1,3033±0,5747 | 1,0500±0,0100 | 1,4600±0,0361 |
| C20:5n3 | 5,7067±0,2892 | 0,2967±0,0058 | 0,2667±0,0577 | 0,2500±0,0100 |
| C22:2 | 0,1567±0,0058 | 0,1300±0,0100 | 0,1467±0,0058 | 0,1333±0,0115 |
| C23:2c4 | 0,0333±0,0058 | 0,0333±0,0058 | 0,0233±0,0058 | 0,0233±0,0058 |
| C22:6n3 | 14,0400±0,0529 | 13,5200±0,0300 | 10,4500±0,0300 | 13,8567±0,1626 |

***Not:*** ΣSFA (Toplam doymuş yağ asitleri); ΣMUFA (Toplam tekli doymamış yağ asitleri); ΣPUFA (Toplam çoklu doymamış yağ asitleri, n3/n6)




**Şekil 3.** Balıkların vücut kompozisyonu

Doymamış yağ asitlerinde ise; özellikle tekli doymamış yağ asidi olan C18:1 oranında gruplar arasında önemli değişimler gözlenmiş olup en düşük oran %50 protein ile beslenen grupta tespit edilmiştir (20,7033±15,3213). En yüksek oran ise %75'lik grupta görülmüştür (31,9933±0,0115). C20:5n3 (EPA) oranına bakıldığında %25'lik grupta istatistiksel olarak oldukça yüksek tespit edilmiştir (5,7067±0,2892). Diğer üç grup arasında istatistiksel olarak bir fark tespit edilmemiştir C22:6n3 (DHA) oranına bakıldığında %75'lik grupta en düşük (10,4500±0,0300), %25'lik grupta en yüksek (14,0400±0,0529) DHA tespit edilmiştir.

## TARTIŞMA

Son zamanlarda balık üretim maliyetlerinin artmasına paralel olarak yükselen balık fiyatları nedeniyle insanların balık tüketim miktarları düşmektedir. Balık tüketimini arttırmak için balığı ucuza üretmek gerekmektedir. Buğdayın hem kolay üretilmesi, hem de ucuz olmasından dolayı yem maliyetini düşüreceği tahmin edilmektedir. Araştırmada balık unu yerine %25,%50,%75 ve %100 oranlarda buğday proteini içeren dört farklı yem hazırlanmıştır. Bu oranların kullanılmasıyla ilgili birçok araştırıcı farklı balıklar üzerine denemeler gerçekleştirmişlerdir. Çeşitli araştırıcılar balık unu yerine yüksek oranda bitkisel kaynaklı ham maddelerin kullanılabileceğini belirtmişlerdir (El-Saidy & Gaber, 2002; Webster vd., 2016). Deneme sonunda balıklar başlangıç canlı ağırlıklarının %25 ve 50'lik grupta iki katına ulaşmış, %75 ve %100'lük grupta ise çok az bir büyüme gerçekleşmiştir. Ulaşılan son ağırlık açısından deneme grupları arasında istatistiksel açıdan farklılıklar gözlenmiştir. Kontrol grubunda büyüme oldukça fazla gerçekleşmiştir (Tablo 2). Tilapya (*Oreochromis niloticus*) kullanılarak yapılan çalışmalarda çeşitli alternatif bitkisel ve hayvansal protein kaynaklarının bireysel veya karışımlarının formülasyonlardaki balık ununun belli oranları veya tamamı yerine kullanımlarının büyüme ve gelişme parametrelerinde herhangi bir olumsuzluğa neden olmadan kullanılabileceğini belirtmişlerdir (Ng & Wang, 2011; Webster vd., 2016; Koch vd., 2016). Deneme sonunda kontrol grubu ve %25 buğday unu içeren gruptaki balıkların canlı ağırlık artışları diğer gruplara göre daha yüksek bulunmuştur. Bunları takiben sırasıyla canlı ağırlık artışında %50, %75, %100 buğday proteini içeren gruplardaki balıklar bulunmaktadır. En düşük canlı ağırlık artışı %100 oranında buğday proteini içeren grupta tespit edilmiştir. Elde edilen bu sonuçlar daha önce yapılan farklı bitkisel kökenli ham madde sonuçları ile benzerlik göstermektedir.

Balık yetiştiriciliğinde su sıcaklığı, suyun oksijen miktarı ve pH değeri gibi ortam koşulları yem tüketimini ve buna bağlı olarak büyüme performansını doğrudan etkileyen önemli parametrelerin başında yer almaktadır. Çalışma süresince ortam su parametreleri levrek balıkları için uygun olan sabit değerlerde tutularak su ortamının fiziko-kimyasal özelliklerinin balıklardaki yem alımına etkisi tüm deneme gruplarında eşitlenmiştir.

Akbulut vd. (1999) levrek yavrularında su sıcaklığının (25°C), SBO ve YDO değerlerini sırasıyla 2,76 ve 2,43 olarak belirtmiştir. Yildiz & Sener (2004) 7,5 g'lık levrek yavrularında mevcut çalışmadaki su sıcaklığına yakın su ortamında 2,2 düzeyinde SBO belirlerken, YDO ise 1,59 olarak belirtmişlerdir. Mevcut çalışmada elde edilen YDO tüm gruplar için daha yüksek bulunmuş ve bunlar arasından da en iyi YDO %25 grubunda belirlenmiştir (2,06±0,205).

Acar vd. (2013) karagöz (*Diplodus vulgaris*) balıkları ile yaptıkları araştırmada %40 soya küspesinin balıkların büyüme performansına negatif bir etki etmediğini belirtmişlerdir. Bu çalışmada da %25 oranında buğday unu içeriği yüksek ve %50 oranında buğday unu içeriği

uygulanabilir düzeyinde tespit edilmiş olup diğer çalışmayla paralellik göstermektedir.

Güroy vd. (2013) levrek yavrularında balık unu yerine %25, %50 ve %75 pirinç unu proteini kullanmışlar ve deneme sonunda düşük oranlı gruplarda büyümenin normal olduğunu belirtmişlerdir. Bu araştırmada da düşük oranlarda buğday proteininin (%25) balık ununa ikame de kullanılabileceği görülmüştür.

Balık eti içeriğinde yapılan kimyasal kompozisyona bakıldığında nem, kül ve protein oranlarında gruplar arasında fazla bir değişim görülmemektedir. Ancak, yağ oranına bakıldığında %75 ve %100'lük grupta yağ oranı oldukça düşük çıkmıştır. Yağ oranının düşük çıkması durumunda balıkların sağlık açısından riskli olabileceği düşünülmektedir. Bu iki grubun balıkları ileriki aşamalarda sağlık sorunları yaşayabilirler.

Yapılan bu araştırmada hazırlanan her grup yemin yağ asidi kompozisyonları belirlenmiş olup çalışma sonunda balığa nasıl etki ettiği tespit edilmiştir. Daha önce yetiştiriciliği yapılan diğer türlerle ilgili çalışmalarda da yemlere balık unu ve yağı yerine artan oranlarda veya tamamıyla bitkisel kaynakların kullanımının özellikle kas dokusu yağ asitleri kompozisyonlarına birebir yansıdığı belirtilmiştir (Izquierdo vd., 2005; Montero vd., 2005; Karapanagiotidis vd., 2007; Ng & Wang, 2011; Li vd., 2016). Araştırma sonucunda da deneme yemlerinin balık kas dokusuna etki ettiği görülmüştür. Genel olarak, buğday proteini ile beslenen balık etinde doymuş yağ asitlerinde bir azalmaya ve n-6 çoklu doymamış yağ asitlerinde ise artışa neden olmuştur. Bu bağlamda, buğday unu zengin bir doymamış yağ asitleri kaynağıdır. Özellikle oleik ve linoleik asitler diğer yağ asitlerine göre oldukça yüksek çıkmıştır. Yavru levrek etlerinde n3 ve n6 oranında bir azalma görülmüştür. Yemdeki buğday unu oranı arttığında yağ asitlerinde bir azalma görülmüştür. Benzer sonuçlara bitkisel kaynaklı ham madde içeriği ile beslenen diğer deniz balıkları türlerinde de rastlanmıştır (Trushenski vd., 2011; Deng vd., 2014). Ayrıca, bazı deniz balıkları türlerinde sınırlı ve belirli oranlarda bitkisel kaynaklı ham madde kullanılması balıklarda 18:3 (n-3), eikosapentaenoik (EPA), docosahexaenoic asit (DHA) yanı sıra 18:2 (n-6) ile 20:4 (n-6) (AA) olması özellikle omnivor balıklar için önemli görülmektedir (Bell vd., 1994; Montero vd., 2004; Izquierdo vd., 2005).

## SONUÇ

Genel olarak karnivor bir balık olan levrek balıklarının beslenmesinde hayvansal kökenli ham maddelerin kullanılması, sağlıklı balık yetiştirmek için oldukça önemlidir. Yemlere bitkisel kaynaklı ham maddelerin katılması yem üretim maliyetlerini aşağı çekmek için kullanılan yöntemlerdendir. Bu araştırma sonucunda levrek balıkları yemlerinde düşük oranda (%25) buğday proteini kullanılmasının sağlıklı levrek yetiştirmede kullanılabilirliği tespit edilmiştir.

## TEŞEKKÜR

Bu çalışma ilk yazarın doktora tezinin bir kısmından üretilmiştir.

### Etik Standartlar İle Uyum

### Yazarların Katkısı

Yazarlar bu makaleye eşit katkıda bulunmuştur.

### Çıkar Çatışması

Yazarlar herhangi bir çıkar çatışması olmadığını deklare etmektedir.

### Etik Onay

Yazarlar bu tür bir çalışma için resmi etik kurul onayının gerekli olmadığını bildirmektedir.

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**Acta Nat. Sci. (2021) 2(1): 68-75**
DOI: 10.29329/actanatsci.2021.314.11
e-ISSN: 2718-0638

**Original Research Paper**
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ACTA NATURA ET SCIENTIA

# Effects of Three Different Rooting Media on Some Rooting Parameters of Cuttings Belonging to *Lavandula angustifolia* and *Lavandula intermedia* Species

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**Please cite this paper as follows:**
Karakaş, İ., & İzci, B. (2021). Effects of Three Different Rooting Media on Some Rooting Parameters of Cuttings Belonging to *Lavandula angustifolia* and *Lavandula intermedia* Species. *Acta Natura et Scientia*, *2*(1), 68-75. https://doi.org/10.29329/actanatsci.2021.314.11

## ARTICLE INFO

*Article History*
Received: 29.05.2021
Revised: 14.06.2021
Accepted: 14.06.2021
Available online: 16.06.2021

*Keywords:*
Peat
Cocopeat
Rooting percentage
Root length
Shoot length

## ABSTRACT

This research was carried out to determine the rooting performances of different rooting media (Soil, Peat and Cocopeat) on the cuttings of the plants of the Lavender (*Lavandula angustifolia*) Hemus, Sevtopolis and Drujba varieties and Super A variety plants (*Lavandula intermedia*). Cuttings were planted in three different environments in the greenhouse mediums. Rooting rate, root length, shoot number and shoot length were determined in the cuttings left for rooting for approximately 60 days. As a result of the research, the highest rooting rate was obtained from *Lavandula intermedia* Super A variety in cocopeat medium with 62%, and the lowest rooting rate was obtained from *Lavandula angustifolia* Sevtopolis and Drujba cultivars in soil environment. The highest root length was obtained from *Lavandula angustifolia* Sevtopolis variety in cocopeat medium with 3.32 cm, and the lowest root length was obtained from *Lavandula angustifolia* Hemus cultivar in soil environment with 2.34 cm. The highest number of shoots was obtained from *Lavandula angustifolia* Drujba variety with 7.93 in cocopeat environment, and the lowest shoot number was obtained from *Lavandula intermedia* Super A variety with 6.93 in soil environment. The highest shoot length was 5.90 cm in *Lavandula angustifolia* Sevtopolis variety in cocopeat environment and the lowest shoot length was 4.19 cm in soil environment from *Lavandula angustifolia* Hemus variety.

# *Lavandula angustifolia* ve *Lavandula intermedia* Türlerine Ait Çeliklerde Üç Farklı Köklendirme Ortamının Bazı Köklenme Parametreleri Üzerine Etkileri

## MAKALE BİLGİSİ

*Makale Geçmişi*
Geliş: 29.05.2021
Düzeltme: 14.06.2021
Kabul: 14.06.2021
Çevrimiçi Yayımlanma: 16.06.2021

*Anahtar Kelimeler:*
Torf
Kokopeat
Köklenme oranı
Kök uzunluğu
Sürgün uzunluğu

## ÖZET

Bu araştırma lavanta (*Lavandula angustifolia)* Hemus, Sevtopolis ve Drujba çeşitleri ve (*Lavandula intermedia)* türüne ait Süper A çeşidi bitkilerine ait çeliklerde, farklı köklendirme ortamlarının (Toprak, Torf ve Kokopeat) çelikle çoğaltım üzerine köklenme performanslarını belirlemek amacıyla yapılmıştır. Çelikler, sera ortamında üç farklı ortama dikimleri yapılmıştır. Yaklaşık olarak 60 gün köklendirmeye bırakılan çeliklerde köklenme oranı, kök uzunluğu, sürgün sayısı ve sürgün uzunluğu belirlenmiştir. Araştırma sonucunda, en yüksek köklenme oranı %62 ile kokopeat ortamında *Lavandula intermedia* Süper A çeşidinde, en düşük köklenme oranı ise toprak ortamında *Lavandula angustifolia* Sevtopolis ve Drujba çeşidinden elde edilmiştir. En yüksek kök uzunluğu 3,32 cm ile kokopeat ortamında *Lavandula angustifolia* Sevtopolis çeşidinde, en düşük kök uzunluğu ise 2,34 cm ile toprak ortamında *Lavandula angustifolia* Hemus çeşidinden elde edilmiştir. En yüksek sürgün sayısı 7,93 adet ile kokopeat ortamında *Lavandula angustifolia* Drujba çeşidinde, en düşük sürgün sayısı 6,93 adet ile toprak ortamında *Lavandula intermedia* Süper A çeşidinden elde edilmiştir. En yüksek sürgün uzunluğu 5,90 cm ile kokopeat ortamında *Lavandula angustifolia* Sevtopolis çeşidinde, en düşük sürgün uzunluğu 4,19 cm ile toprak ortamında *Lavandula angustifolia* Hemus çeşidinden elde edilmiştir.

## GİRİŞ

Bitkiler, insanların doğal yaşam alanlarını oluşturan en önemli canlılar arasında olup çok eski zamanlardan beri insanlar ihtiyaçları için bitki ve hayvan kaynaklarını toplamışlardır (Iqbal, 1993; Walter, 2001). Bitkiler, bilinen beslenme kaynaklarıdır ve beslenme yoluyla iyileştirme kavramları nedeniyle; bitkiler ilaç olarak da kullanılmıştır. İnsanların ve hayvanların bitkilerle ilişkisi dünyadaki yaşamın başlangıcıyla ortaya çıkmıştır. Fazla mesai ve toplumların başlamasıyla birlikte insanlar yaşamda ihtiyaç duyulan barınak, oksijen, beslenme ve ilaçların çoğu formlarını bitkilerden elde etmeyi öğrenmiş ve devamında uygun bitki materyallerini tanımak ve sınıflandırmak yaşamın gerekliliği haline gelmiştir (Mamedov & Craker, 2012). İnsanlar ilk olarak beslenme, daha sonra ise yiyecekleri daha keyifli hale getiren tat ve aroma veren baharatları, ağrıyı hafifletebilen ve hastalıkları tedavi edebilen bitkileri kodlamak için deneme yanılma yöntemleri kullanarak bitkileri sınıflandırmayı öğrenmişlerdir. Tıbbi ve aromatik bitkiler, eski çağlardan beri yiyeceklere aroma ve tat vermek için baharat olarak, bitkilerden elde edilen tıbbı çaylar, droglar ve uçucu yağlar koruyucu ve terapötik özelliklerinden dolayı hastalıklardan korunmak ve tedavi etmek için ayrıca parfümeri ve kozmetik sanayisinde ve süper doğal tanrılarla mistik etkileşimler için zihinsel uyarıcı olarak bitkilerdeki kimyasal bileşenleri kullanmışlardır (Inoue & Craker, 2014).

Antik çağlardan beri tıbbı ve aromatik bitkilerin ham bitkisel özleri gıda, parfümeri ve ilaç gibi farklı amaçlar için kullanılmakta olup ayrıca polifenoller ve uçucu yağlar gibi ana ikincil metabolitleri sayesinde doğal antioksidanların kaynağıdır (Heath, 1981; Patel vd., 2010; Ekren vd., 2013). Günümüzde özellikle uçucu yağlar ve içerdikleri ana ikincil metabolitleri, ilaçlar, tatlar ve kokular, farmasötikler, zirai kimyasallar, boya ve pigmentler, pestisitler, kozmetikler, gıda katkı maddeleri, diğer endüstriyel biyokimyasallar ayrıca antibakteriyel, antiviral, antifungal, antiparazitik, insektisit, antikanser, nöroprotektif, psikofizyolojik ve yaşlanmayı geciktirici aktivitelerinden yararlanmak için yaygın olarak kullanılmaktadır (Kumar vd., 2018).

Tıbbi ve aromatik bitkiler çiçeklerden, yapraklardan, saplardan, meyvelerden ve köklerden ekstrakte edilen ve ayrıca reçinelerden damıtılan oldukça konsantre maddeler olduğu söylenen, temel terapötik maddeler olarak uçucu yağlar içermekte olup (Schippmann vd., 2006; Adaszyńska vd., 2011), bu bitkiler uçucu yağ bitkileri olarak adlandırılmaktadır ve antioksidan antidepresan, antiseptik, antibakteriyel, analjezik, antienflamatuar, antimantar, antispazmodik, yatıştırıcı ve sakinleştirici özelliklere sahip olması nedeniyle bu bitkilerden elde edilen uçucu yağlara olan talep her geçen gün artmaktadır (Ez zoubi vd., 2020). Uçucu yağlar ve / veya bileşenleri, gıda koruma, tamamlayıcı tıp ve doğal terapötik etkileri dâhil olmak üzere çok çeşitli amaçlar için kullanılıyor olup yüzyıllar boyunca uçucu yağlar, vücut, zihin ve ruh üzerinde iyileştirici potansiyele sahip aroma molekülleri olarak önemi insanoğlu tarafından keşfedilmiştir. Bu aroma molekülleri, çevreyi hastalık, bakteri, virüs ve mantardan arındıran çok güçlü organik bitki kimyasallarıdır (Hanamanthagouda vd., 2010; Dapkevicius vd., 1998; Schippmann vd., 2006). Özellikle lavanta bitkisine ait uçucu yağ ve içerdiği aroma molekülleri, antibakteriyel ve antifungal özelliklerinin yanı sıra bilhassa antibiyotikler işe yaramadığında birçok bakteri türüne karşı savunma göstermekte olduğu öne sürülmektedir. Aromaterapide kullanımının yanı sıra, sıyrıkların, yanıkların, stresin, baş ve migren ağrılarının tedavisi, yeni hücre büyümesinin teşvik edilmesi, cilt sorunları, ağrılı kaslar ve bağışıklık sistemini güçlendirmek ve ilaç sanayisinde ise bazı preperatlara koku ve aroma verici olarak, özellikle merkezi sinir sistemini düzenleyici ilaçların bileşiminde kullanılmaktadır (Nikolaevskii vd., 1990; Hay vd., 1998; Romine vd., 1999).

Türkiye, Lamiaceae familyası için önemli gen merkezlerinden birini oluşturmaktadır. Ayrıca, Türkiye'de bu familya ait 45 cins, 565 tür ve 735 takson bulunmaktadır (Mokhtarzadeh, 2011). Bu familyanın tıbbi ve aromatik özelliği olan en seçkin cinsleri: Nane (*Mentha*), kekik (*Thymus*), mercanköşk (*Origanum*), adaçayı (*Salvia*), dağçayı (*Sideritis*), oğulotu (*Melissa*) biberiye (*Rosmarinus*) ve lavanta (*Lavandula*) ile oluşmaktadır (İpek, 2007). Lavanta, Akdeniz'in dağlık bölgelerine özgüdür, ancak bugün Güney Avrupa, Avustralya ve Amerika Birleşik Devletleri'nde, Bulgaristan'da yaygın olarak tarımı yapılmaktadır (Guenther, 1952; Kara, 2011). Çoğu Akdeniz orijinli olan 39 kadar lavanta türü (*Lavandula* sp.) bulunmakta olup Dünyada ticari değeri yüksek üç ana lavanta türü vardır. İngiliz lavantası Lavander (*Lavandula angustifolia* Mill. = *L. officinalis* L. = *L. vera* DC) ve Spike lavander (*Lavandula spica* = *L. latifolia* Medik.) olarak adlandırılan lavanta türleri daha yüksek uçucu yağ kalitesine sahipken, melez olarak adlandırılan Lavandin (*Lavandula intermedia* Emeric ex Loisel. = *L. hybrida* L.) daha yüksek uçucu yağ verimine sahiptir (Tucker, 1985). Bu üç önemli tür dışında daha çok süs bitkisi veya dekoratif amaçlar içinde kullanılan *L. dentata* (Fransız lavantası), *L. stoechas* L. (İspanya lavantası), *L. latifolia* Medik (Geniş yapraklı lavanta), *L. multifida* (Eğreltiotu yapraklı lavanta), *L. canariensis* (Kanarya adaları lavantası), *L. lanata* (Yünlü lavanta), *L. heterophylla* ve *L.x allardii* (*L. dentata* x *L. latifolia* Medik.) (Kara & Baydar, 2013).

Lavanta en iyi bilinen uçucu yağ taşıyan bitkilerden biri olup uçucu yağı, taze çiçekleri, kurutulmuş ürünler, gıda ve diğer amaçlar için yetiştirilir (Reid, 2000; Petkova vd., 2018).

Antik çağlardan beri çiçeklerinin çekici rengi, kokusu, tedavi edici ve kozmetik özellikleri ile beğeni toplamış ve son zamanlarda çeşitli yiyeceklere lezzet veren özel bileşenler arasında yer almıştır. (Giray, 2018). Çiçeklerinden elde edilen uçucu yağ, parfüm, kozmetik, aroma, ilaç ve deterjan sanayilerinde yaygın olarak kullanılmaktadır. Lavanta, insan vücudu için bir dizi faydalı özelliğe sahip bir bitkidir. Lavanta bir çok hastalıkta antidepresan, antiseptik, antibakteriyel, analjezik, antienflamatuar, antimantar, antispazmodik, yatıştırıcı ve sakinleştirici etkilere sahip olması nedeniyle ruh, beden ve zihin için önemli etkileri bulunması nedeniyle geleneksel ve tamamlayıcı tıpta umut vaat eden çok önemli tıbbi ve aromatik bitkilerden birisidir (Shellie vd., 2002; Prusinowska & Śmigielski, 2014; Śmigielski vd., 2018).

Bitkisel tedavide uygulanmasının yanı sıra içeriğinde 150 biyoaktif bileşene sahip yarı çalımsı formda çok yıllık değerli bir uçucu yağ bitkisi olan lavanta, kozmetik, parfüm, gıda, aromaterapötik endüstrilerde ve süs ve peyzaj bitkisi olarak da yaygın olarak kullanılan lavanta 40-60 cm yüksekliğe kadar büyür ve kompakt ve düzenli kümeler oluşturur. Lavantada sapın alt kısmı odunsu, üst kısmı yeşil olup l kıvrımlı kenarları olan doğrusal veya mızrak şeklinde yapraklara ve oldukça dallanmış lifli bir kök sistemine sahiptir. Gümüş yeşili lavanta yaprakları, onları güçlü güneş ışığından, rüzgârdan ve aşırı su kaybından koruyan tomentumla kaplıdır. Lavanta çiçekleri, gövdenin üst kısmında daireler halinde daire başına 3-5 çiçek bulunmakta olup sivri uçludur ve soluk menekşe rengindedirler ancak beyaz ve pembe renkli olan çeşitleri de bulunmaktadır (Góra & Lis, 2005; Prusinowska & Śmigielski, 2014). Lavanta sadece uçucu yağlar içermez, aynı zamanda antosiyaninler, fitosteroller, şekerler, mineraller, kumarik asit, glikolik asit, valerik asit ve esterleri, ursolik asit, herniarin, kumarin ve tanenler içerir. Ancak, *L. angustifolia*'dan elde edilen en değerli madde uçucu yağdır (Smigielski vd., 2018; Giray, 2018). Lavanta uçucu yağları 100'den fazla bileşik içerir ve iki ana bileşeni linalool ve linalil asetattır. Diğer bileşenler arasında $\alpha$-thujene, $\alpha$-pinene, camphene, sabinene, β-pinene, myrcene, pcymene, limonene, 1,8-cineole bulunur. , (Z) - ve (E) -β-okimen, 7-terpinen, kafur, terpinen-4-ol, lavandulol, lavandulil asetat, β-karyofilen vb. bileşenlerden oluşmaktadır (Giray, 2018).

Lavanta vejetatif (çelikle) ve generatif (tohum ile) olarak çoğalmakta olup yüksek verim ve kaliteye sahip çoğaltma materyalini temin edebilmek en önemli sorunu oluşturmaktadır. *Lavandula* türleri tohumlar tarafından çoğaltılabilir, ancak tercih edilen bir çoğaltma yöntemi olmamalıdır, zira eşeysiz olarak çoğaltılmış lavanta mahsulleri daha homojen mahsuller sağlarken, büyük bir tekdüzelik eksikliğine neden olur ve yüksek kalitede klonlar daha yüksek kalitede uçucu yağ elde etme olasılığını artırır (Tyub vd., 2007). Bu yüzden özellikle son yıllarda lavanta tarımına olan ilginin çok artması, bu bitkinin ileri yetiştirme teknikleri üzerinde yapılan bilimsel araştırmaların önemini artırmış ve önemli gelişmeler kaydedilmiştir. Ancak uçucu yağ bitkisi olan lavanta da çelikle çoğaltmada bazı sorunlar yaşanmaktadır. Bu sorunlar en önemlisi köklendirme olup bu sorunun giderilmesi için, bazı çalışmalar yapılmış ve alınan çelik tipine göre, kullanılan farklı köklendirme ortamlarının köklenme oranında farklılıklar gösterdiği belirlenmiştir (Bona vd., 2012).

Farklı köklendirme ortamlarının kullanımı köklenme, kök uzunlukları, kök sayıları yüzdelerinin artırdığı tespit edilen birçok çalışma olup lavantada bu çalışmalar oldukça kısıtlıdır. Bu yüzden ilaç sanayinden kozmetiğe kadar birçok kullanımı olan ve ekonomik değer taşıyan lavantanın *Lavandula angustifolia* türüne ait Hemus, Sevtopolis ve Drujba çeşitleri ile *Lavandula intermedia* türüne ait Süper A çeşidinin çeliklerinin farklı ortamlarda köklenme performanslarının belirlenmesi araştırmanın amacını oluşturmaktadır. Lavanta çeliklerinin, toprak, torf ve kokopeat ortamlarında köklenme performanslarının belirlenmesi hedeflenmiştir.

## MATERYAL VE YÖNTEM

### Materyal

Araştırmada kullanılan lavanta çelikleri Çanakkale'nin Ezine ilçesi Yaylacık köyünde organik tarım yapılan bir tarımsal işletmeden ve özel sektöre ait fidanlıklardan temin edilmiştir. Deneme için *Lavandula angustifolia* türüne ait Hemus, Sevtopolis ve Drujba çeşitleri ile *Lavandula intermedia* türüne ait Süper A çeşidinden alınan çelikler kullanılmıştır. Lavantada çelikle üretimde köklendirme ortamları olarak; torf, kokopeat ve toprak kullanılmıştır. Torf; kısmen çürümüş bitki örtüsünden oluşmaktadır; diğer birçok bitkiyi bünyesinde bulundursa da, bilinen en yaygın bileşeni sfagnum yosunudur ve ağırlığının 20 katına kadar su tutabilmektedir ve pH derecesi 6-7 arasında değişmekte, %80 oranında organik madde, ortalama olarak %1 organik azot ve %46 organik karbon içermekte olup bitki çeliklerinde toprak yerine yaygın olarak tercih edilmektedir. Çelik ile çoğaltma uygulamalarında ve topraksız tarımda çok iyi sonuçlar veren kokopeat ise Hindistan cevizi özü, Hindistan cevizi lifi, Hindistan cevizi tozu veya basitçe Hindistan cevizi olarak da bilinmektedir. Kokopeat Hindistan cevizi kabuklarından yapılır ve hindistancevizi kullanan diğer endüstrilerin bir yan ürünüdür ve toprak katkı maddesi olarak kullanılır. Besin içeriği olarak fakir olduğu için genellikle bitki yetiştiriciliği için kullanılan ortamdaki tek bileşen değildir. Genellikle asidik (pH= 5,5-6,5) yapıda olup en mühim özelliği, hacminin 8-9 katı su tutmasıdır (Hartmann & Kester,

1983). Denemede kullanılan toprak özellikleri ise pH 7,6, kireç %5, elektrik iletkenliği (mmhos) 193, kum %17, kil %43, silt %44, bünye siltli-kil, organik madde miktarı %2,88'dir. Denemede çeliklerin torf, kokopeat ve toprak ortamına dikilmesi için 6 litrelik köklendirme kasaları kullanılmıştır.

## Yöntem

Çalışma 2020 yılı Mart ayında Çanakkale Onsekiz Mart Üniversitesi'nde yürütülmüştür. Deneme 3 faktörlü tesadüf blokları deneme desenine göre 3 tekerrürlü olarak kurulmuştur. Denemede kullanılan çoğaltım materyalleri Çanakkale Ezine Yaylacık Köyü'nde organik tarım yapılan bir tarım işletmesinden ve özel sektöre ait fidanlıklardan temin edilmiştir. Araştırmada kullanılan fidanlar (1+0) çıplak köklü fidanlardan seçilmiştir. Çeliklerin fizyolojik yön dikkate alınarak alt yarısının yaprakları sıyrılmıştır. 150 adet çelik 30'arlı 5 gruba ayrılarak ve her bir gruptaki çelikler, sera ortamında toprak, torf ve kokopeat ile doldurulmuş köklendirme kasalarına dikilmiştir ve sisleme şeklinde düzenli olarak sulanmıştır. Denemede kullanılan köklendirme kasaları 6 litrelik olup, her birine 6 litre torf, 6 litre kokopeat ve 6 litre toprak doldurularak hazırlanmıştır. Köklendirme ortamından 60 gün sonra Mayıs ayında sökülen çeliklerin köklenme oranları (%), kök uzunluğu (cm), sürgün sayısı (adet) ve sürgün uzunluğu (cm) verileri elde edilmiştir. Köklenme oranı; köklenen çelik sayısının toplam çelik sayısına oranı ile bulunmuştur. Kök uzunluğu; metre yardımıyla cm olarak ölçülmüştür. Sürgün uzunlukları; metre yardımıyla cm olarak ölçülmüştür. Sürgün sayısı; her köklenen çelikteki sürgünler sayılarak bulunmuştur. Veriler Tesadüf blokları deneme desenine göre varyans analizleri yapılmış ve bu analize göre istatistikî olarak önemli çıkan uygulamaya ait ortalama değerler DUNCAN Çoklu Karşılaştırma Testi ile elde edilmiştir. İstatistiki değerlendirmeler TOTEMSTAT paket programından yararlanılarak yapılmıştır.

## BULGULAR VE TARTIŞMA

## Bulgular

### *Köklenme Oranı*

Farklı köklendirme ortam uygulamalarının takip eden 60 gün sonunda elde edilen verilerde, *Lavandula angustifolia* türüne ait Hemus, Sevtopolis ve Drujba çeşitleri ile *Lavandula intermedia* türüne ait Süper A çeşidinin çeliklerinin köklenme oranı üzerine etkilerinin değişkenlik gösterdiği gözlenmiştir.

En yüksek köklenme oranı %62 ile *Lavandula intermedia* Süper A çeşidinde kokopeat ortamında elde edilirken, en düşük köklenme oranı ise %48 *Lavandula angustifolia* Sevtopolis ve Drujba çeşidinde toprak ortamından elde edilmiştir. Genel olarak köklenme ortamlarına bakıldığında ise en yüksek köklenme oranları tüm çeşitlerde kokopeat ortamındaki çeliklerden elde edilirken, torf ortamındaki çeliklerde köklenme oranı açısından elde edilen değerler kokopeat'i takip etmektedir. Toprak ortamında ise diğerlerine kıyasla köklenme oranı açısından azda olsa düşük kaldığı gözlemlenmiştir. Genel olarak çeşitlerdeki köklenme oranı ortalama değerlerine bakıldığında ise Süper A çeşidi tüm ortamlarda en yüksek köklenme oranına sahipken, Hemus ikinci sırada, Drujba üçüncü sıradan takip etmekte olup, en düşük köklenme oranı Sevtopolis çeşidinden elde edilmiştir.

**Tablo 1.** Farklı lavanta çeşitlerine ait çeliklerin farklı köklendirme ortam uygulamalarının köklenme oranına etkisi

| Köklenme Oranı (%) | | | | |
|---|---|---|---|---|
| | Köklenme Ortamı | | | |
| Çeşit | Toprak | Torf | Kokopeat | Ortalama |
| Hemus | 50,33 | 53,67 | 57,00 | 53,667 |
| Sevtopolis | 48,67 | 49,67 | 53,33 | 50,556 |
| Drujba | 48,67 | 49,67 | 58,67 | 52,333 |
| Süper A | 52,67 | 53,67 | 62,00 | 56,111 |
| Çeşit Ortalama | | | | 53,167 |

### *Kök Uzunluğu*

Farklı köklendirme ortam uygulamalarının takip eden 60 gün sonunda elde edilen verilerde, *Lavandula angustifolia* türüne ait Hemus, Sevtopolis ve Drujba çeşitleri ile *Lavandula intermedia* türüne ait Süper A çeşidinin çeliklerinin kök uzunluğu üzerine etkilerinin değişkenlik gösterdiği gözlenmiştir.

**Tablo 2.** Farklı lavanta çeşitlerine ait çeliklerin farklı köklendirme ortam uygulamalarının kök uzunluğuna etkisi

| Kök Uzunluğu (cm) | | | | |
|---|---|---|---|---|
| | Köklenme Ortamı | | | |
| Çeşit | Toprak | Torf | Kokopeat | Ortalama |
| Hemus | 2,34 | 2,46 | 2,66 | 2,489 |
| Sevtopolis | 2,86 | 3,10 | 3.32 | 3,090 |
| Drujba | 2,54 | 2,73 | 2,85 | 2,706 |
| Süper A | 2,46 | 2,62 | 2,82 | 2,633 |
| Çeşit Ortalama | | | | 2,729 |

En yüksek kök uzunluğu 3.32 cm ile *Lavandula angustifolia* Sevtopolis kokopeat ortamından elde edilirken, en düşük kök uzunluğu ise 2,34 cm ile *Lavandula angustifolia* Hemus çeşidi toprak ortamından elde edilmiştir. Genel olarak köklenme ortamlarına bakıldığında ise en uzun kök uzunluğu tüm çeşitlerde kokopeat ortamındaki çeliklerden elde edilirken, torf ortamındaki çeliklerde kök uzunluğu açısından elde edilen değerler kokopeat'i takip etmektedir. Toprak ortamında ise diğerlerine kıyasla kök uzunluğu

açısından azda olsa düşük kaldığı gözlemlenmiştir. Genel olarak çeşitlerdeki kök uzunluğu ortalama değerleri incelendiğinde ise Sevtopolis çeşidi tüm ortamlarda en yüksek kök uzunluğuna sahipken, Drujba çeşidi ikinci sırada, Süper A çeşidi üçüncü, en düşük kök uzunluğu ortalama değeri ise Hemus çeşidinden elde edilmiştir.

### *Sürgün Sayısı*

Farklı köklendirme ortam uygulamalarının takip eden 60 gün sonunda elde edilen verilerde, *Lavandula angustifolia* türüne ait Hemus, Sevtopolis ve Drujba çeşitleri ile *Lavandula intermedia* türüne ait Süper A çeşidinin çeliklerinin sürgün sayısı üzerine etkilerinin değişkenlik gösterdiği gözlenmiştir.

**Tablo 3.** Farklı lavanta çeşitlerine ait çeliklerin farklı köklendirme ortam uygulamalarının sürgün sayısına etkisi

| Sürgün Sayısı (adet) | | | | |
|---|---|---|---|---|
| | Köklenme Ortamı | | | |
| **Çeşit** | **Toprak** | **Torf** | **Kokopeat** | **Ortalama** |
| Hemus | 7,00 | 7,00 | 7,60 | 7,400 |
| Sevtopolis | 7,00 | 7,60 | 7,80 | 7,467 |
| Drujba | 7,40 | 7,73 | 7,93 | 7,689 |
| Süper A | 6,93 | 7,87 | 7,67 | 7,489 |
| Çeşit Ortalama | | | | 7,511 |

En yüksek sürgün sayısı 7,93 adet ile *Lavandula angustifolia* Drujba çeşidi kokopeat ortamından elde edilirken, en düşük sürgün sayısı 6,93 adet ile *Lavandula intermedia* Süper A çeşidi toprak ortamından elde edilmiştir. Genel olarak köklenme ortamlarına bakıldığında ise en yüksek sürgün sayısı kokopeat ortamında Hemus, Sevtopolis ve Drujba çeşidinde ve torf ortamında Süper A çeşidinden elde edilirken, toprak ortamında ise diğerlerine kıyasla sürgün sayısı değerlerine bakıldığında azda olsa düşük kaldığı gözlemlenmiştir. Genel olarak çeşitlerdeki sürgün sayısı ortalama değerleri incelendiğinde ise Sevtopolis çeşidinden en yüksek sürgün sayısı ortalaması elde edilirken, en düşük sürgün sayısı ortalaması ise Hemus çeşidinden elde edilmiştir.

### *Sürgün Uzunluğu*

Farklı köklendirme ortam uygulamalarının takip eden 60 gün sonunda elde edilen verilerde, *Lavandula angustifolia* türüne ait Hemus, Sevtopolis ve Drujba çeşitleri ile *Lavandula intermedia* türüne ait Süper A çeşidinin çeliklerinin sürgün uzunluğu üzerine etkilerinin değişkenlik gösterdiği gözlenmiştir.

En yüksek sürgün uzunluğu 5,90 cm ile *Lavandula angustifolia* Sevtopolis çeşidi kokopeat ortamından elde edilirken, en düşük sürgün uzunluğu 4,19 cm ile *Lavandula angustifolia* Hemus çeşidi toprak ortamından elde edilmiştir. Genel olarak köklenme ortamlarına bakıldığında ise en yüksek sürgün uzunluğu kokopeat ortamında, torf ortamındaki çeliklerde sürgün uzunluğu açısından elde edilen değerler kokopeat'i takip etmekte olup, toprak ortamında diğerlerine kıyasla kök uzunluğu açısından azda olsa düşük kaldığı gözlemlenmiştir. Genel olarak çeşitlerdeki sürgün uzunluğu ortalama değerleri incelendiğinde ise en yüksek sürgün uzunluğu Sevtopolis çeşidinden elde edilirken, en düşük sürgün uzunluğu Hemus çeşidinden elde edildiği gözlemlenmiştir.

**Tablo 4.** Farklı lavanta çeşitlerine ait çeliklerin farklı köklendirme ortam uygulamalarının sürgün uzunluğuna etkisi

| Sürgün Uzunluğu (cm) | | | | |
|---|---|---|---|---|
| | Köklenme Ortamı | | | |
| **Çeşit** | **Toprak** | **Torf** | **Kokopeat** | **Ortalama** |
| Hemus | 4,19 | 4,42 | 4,75 | 4,453 |
| Sevtopolis | 5,09 | 5,60 | 5,90 | 5,529 |
| Drujba | 4,57 | 4,78 | 5,07 | 4,809 |
| Süper A | 4,47 | 4,66 | 4,98 | 4,704 |
| Çeşit Ortalama | | | | 4,874 |

## Tartışma

Araştırma sonucunda genel olarak tarla toprağına kıyasla kullanılan diğer ortamlardan elde edilen değerler, köklenme oranı %62-%48, kök uzunluğu 2,34-3,32 cm, sürgün sayısı 6,93-7,93 adet, sürgün uzunluğu 4,19-5,90 cm arasında değişen artış oranları gözlemlenmiş olup kullanılan farklı ortamlar arasında özellikle kokopeat ortamının köklenme parametreleri üzerine olumlu etkilerinin olduğu gözlemlenmiştir. Kullanılan farklı ortamların çeşitler üzerindeki etkisi incelendiğinde ise kokopeat ortamının *Lavandula angustifolia* türüne ait, Sevtopolis ve Drujba çeşitleri ile *Lavandula intermedia* türüne ait Süper A çeşitlerine ait çeliklerde köklenmeyi arttırdığı belirlenmiştir.

Yapılan farklı çalışmalarda, Sarı & Kaçar (2019) biberiye (*Rosmarinus officinalis L.*) bitkisine ait çeliklerde beş farklı köklendirme ortamı ve farklı IBA dozlarının köklenme parametreleri üzerine etkilerini incelemiştir. Çalışmada çelikler IBA Kontrol-0, 1500, 2500, 3500 ve 4500 ppm dozu ile muamele edilerek tarla toprağı, torf, perlit, kokopeat ve vermikülit bulunan ortamlara dikilmiştir. Sonuç olarak en yüksek değerlerin torf ve perlit köklendirme ortamlarından alındığı ve çeliklerin 4500 ppm IBA dozu ile muamelesinin ve torf ile perlit ortamlarının köklendirme parametreleri üzerinde olumlu sonuçlar

verdiği bildirilmiştir. İzgi (2020) tarafından dört farklı bitkiye (yağ gülü (*Rosa damascena* Mill.), kadıntuzluğu (*Berberis thunbergii* DC.), biberiye (*Rosmarinus officinalis* L.) ve lavanta (*Lavandula angustifolia* Mill.)) ait çeliklerde farklı ortamların ve farklı IBA dozlarının bazı köklenme parametreleri üzerine etkilerinin incelendiği çalışmada, çeliklere IBA Kontrol-0, 1000, 2000, 3000, 4000 ve 5000 ppm dozu ile muamele edildikten sonra torf, perlit, torf ve perlit karışımı (1:1) ve kokopeat ortamına dikilmiştir. Sonuç olarak köklenme oranları yağ gülü %95,00, kadıntuzluğu %81,67, biberiye %88,33 ve lavanta %82,50; kök sayıları sırasıyla yağ gülü 19,28 adet, kadıntuzluğu 13,44 adet, biberiye 26,12 adet ve lavanta 17,38 adet ve kök uzunlukları sırasıyla yağ gülü 18,89 cm, kadıntuzluğu 14,32 cm, biberiye 25,58 cm ve lavanta 17,26 cm ile perlit köklendirme ortamında ve 4000 ve 5000 ppm IBA dozu uygularmalarında en yüksek sonuçlar alındığı ve köklendirme ortamı olarak en iyi sonuçların perlit ortamından alındığı bildirilmiştir. Özcan vd. (2013) lavantaya (*Lavandula hybrida*) ait çeliklerin farklı ortam ve farklı IBA dozlarının köklenme parametreleri üzerine etkilerini incelediği çalışmada, çeliklere kontrol-0, 500, 1000, 2000 ve 4000 ppm dozu ile muamele edilerek, perlit: torf, tarla toprağı ortamlarına dikmiştir. Sonuç olarak en yüksek değerler 2000 ve 4000 ppm IBA dozlarında elde edilmiş olup, köklenme ortamları olarak ise perlit: torf ortamının tarla toprağına göre köklenme parametreleri üzerinde olumlu sonuçlar verdiği bildirilmiştir.

Araştırmada incelenen parametrelerde köklenme oranı, kök uzunluğu, sürgün sayısı ve sürgün uzunluğu açısından en yüksek değerlerin elde edildiği kokopeat ortamının, farklı ortamların kullanıldığı çalışmalar sonucunda elde edilen bulgular ile farklılıklar göstermekte olduğu görülmektedir. Sonuçlar üzerindeki farklıkların çalışmalarda incelenen bitkilerin ve bitki çeşitlerinin farklı olması, köklendirme ortamlarının farklılığı, farklı köklendirme hormonlarının ve farklı dozlarının kullanılması ve kullanılan tekniklerin farklı olmasından kaynaklandığı düşünülmektedir.

## SONUÇ

Araştırmanın sonucunda incelenen tüm özellikler yönünden elde edilen değerler kullanılan köklendirme ortamlarına göre aralarındaki farklılıklar değişkenlik göstermiştir. Ancak tarla toprağına göre kullanılan tüm ortamlarda daha yüksek değerler saptanmıştır. Çeşitler arasında ise incelenen tüm parametrelerin kullanılan farklı ortamlara göre değişkenlik gösterdiği gözlemlenmiştir. İncelenen parametreler yönünden en yüksek değerler *Lavandula angustifolia* türüne ait, Sevtopolis ve Drujba çeşitleri ile *Lavandula intermedia* türüne ait Süper A çeşidinin çeliklerine ait olduğu, *Lavandula angustifolia* türüne ait Hemus çeşidine ait çelikler ise kullanılan farklı ortamlarda elde edilen parametreler yönünden ortalama değerlerin altında kaldığı gözlemlenmiştir. Genel olarak tarla toprağına göre kullanılan diğer ortamlardan elde edilen değerler, köklenme oranı %62-%48, kök uzunluğu 2,34-3,32 cm, sürgün sayısı 6,93-7,93 adet, sürgün uzunluğu 4,19-5,90 cm arasında değişen artış oranları gözlemlenmiştir. Sonuçlar genel olarak incelendiğinde tarla toprağına kıyasla torf ve kokopeat'in öne çıktığı gözlemlenmiştir. *Lavandula angustifolia* türüne ait Hemus, Sevtopolis ve Drujba çeşitleri ile *Lavandula intermedia* türüne ait Süper A çeşidinin çeliklerinin farklı köklenme ortamlarındaki köklenme performanslarına bakıldığında ise tarla toprağına nazaran kullanılan diğer iki ortamın köklenme için uygun olduğu, kokopeat'in öne çıktığı belirlenmiştir.

Geçmişten beri aile işletmeciliği şeklinde sadece küçük alanlarda yetiştirilmeye çalışılan lavanta son yıllarda ekonomik öneminin artmasıyla ülkemizde lavanta tarımına olan ilgi artmaya başlanmıştır. Bu yüzden ülkemiz çiftçisine katkı sağlayabilmek amacıyla böyle bir çalışmanın gerçekleştirilmesi büyük önem arz etmektedir. Türkiye'de sulanmayan, kıraç ve eğimli alanlarına son derece iyi uyum sağlamış kuru tarım bitkisi olan lavantanın, eğer dünyada pazarlanabilir kalitede uçucu yağ üreten çeşitleri belirlenir ve sonra da belirlenen bu çeşitlerin fidanları hızla çoğaltılarak üreticilere dağıtılabilirse, lavanta ülkemiz ekonomisi için büyük kazanç olacaktır.

## TEŞEKKÜR

Bu çalışma ilk yazarın yüksek lisans tezinin bir kısmından üretilmiştir.

## Etik Standartlar İle Uyum

### Yazarların Katkısı

İK çalışmayı tasarladı, makalenin ilk taslağını yazdı, Bİ istatistiksel analizleri gerçekleştirdi ve çalışmayı yönetti. Her iki yazar da makalenin son halini okudu ve onayladı.

### Çıkar Çatışması

Yazarlar herhangi bir çıkar çatışması olmadığını deklare etmektedir.

## Etik Onay

Yazarlar bu tür bir çalışma için etik onay gerekmediğini bildirmektedir.

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**Acta Nat. Sci. (2021) 2(1): 76-85**
DOI: 10.29329/actanatsci.2021.314.12
e-ISSN: 2718-0638

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ACTA NATURA ET SCIENTIA

# Effect of Regional Differences on Fatty Acid Profiles of *Ulva linza* (Linnaeus 1753), *Enteromorpha flexuosa* (Agardh, 1883) and *Taonia atomaria* (Agardh, 1848)

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**Please cite this paper as follows:**
Bakan, M., Peksezer, B., Börekçi, N. S., Alp, M. T., & Ayas, D. (2021). Effect of Regional Differences on Fatty Acid Profiles of *Ulva linza* (Linnaeus 1753), *Enteromorpha flexuosa* (Agardh, 1883) and *Taonia atomaria* (Agardh, 1848). *Acta Natura et Scientia*, *2*(1), 76-85. https://doi.org/10.29329/actanatsci.2021.314.12

**ARTICLE INFO**

*Article History*
Received: 22.12.2020
Revised: 27.05.2021
Accepted: 05.06.2021
Available online: 19.06.2021

*Keywords:*
*U. linza*
*E. flexuosa*
*T. atomaria*
Lipids
Fatty acids

**ABSTRACT**

Total fat and fatty acid levels of *Ulva linza* (Linnaeus 1753), *Enteromorpha flexuosa* (Agardh, 1883), and *Taonia atomaria* (Agardh, 1848) collected from Viranşehir, Taşkıran, and Karaduvar coasts were determined. The total oil level of the samples was found to be 1.31-1.91%, 1.23%, 7.78% for *U. linza, E. flexuosa* and *T. atomaria*, respectively. The dominant saturated fatty acids are palmitic acid and stearic acid. The highest level of palmitic acid (32.27%) was found in *E. flexuosa* in Viranşehir beach. The highest level of stearic acid was found on the coast of Viranşehir (7.20%), *U. linza*. The highest level of ΣSFA was found in the *U. linza* species on Taşkıran coast (37.89%), and the lowest level was determined in the *T. atomaria* species on the Taşkıran coast (18.13%). It is oleic acid that has a high level of monounsaturated fatty acids. The highest level of this fatty acid (10.35%) was found in *E. flexuosa* species in Viranşehir beach. The highest level of ΣMUFA was found in the Viranşehir coast (16.67%) and the lowest level (11.39%) in the *U. linza* on the Viranşehir beach. The highest level of linolelaidic acid in polyunsaturated fatty acids was found in *E. flexuosa* in Viranşehir beach (3.34%). The highest level of linoleic acid (4.85%) was found in *U. linza* on the coast of Viranşehir. The highest level of ΣPUFA was found in *T. atomaria* on the Taşkıran coast (16.56%), and the lowest level (7.03%) was found in *U. linza*.

# *Ulva linza* (Linnaeus 1753), *Enteromorpha flexuosa* (Agardh, 1883) ve *Taonia atomaria* (Agardh, 1848) Türlerinin Yağ Asidi Profilleri Üzerine Bölgesel Farklılıkların Etkisi

**MAKALE BİLGİSİ**

*Makale Geçmişi*
Geliş: 22.12.2020
Düzeltme: 27.05.2021
Kabul: 05.06.2021
Çevrimiçi Yayımlanma: 19.06.2021

*Anahtar Kelimeler:*
*U. linza*
*E. flexuosa*
*T. atomaria*
Lipit
Yağ asidi

**ÖZET**

Viranşehir, Taşkıran ve Karaduvar sahillerinden toplanan *Ulva linza* (Linnaeus 1753), *Enteromorpha flexuosa* (Agardh, 1883) ve *Taonia atomaria* (Agardh, 1848) türlerinin toplam yağ düzeyleri ve yağ asidi profilleri belirlenmiştir. Örneklerin toplam yağ düzeyi *U. linza, E. flexuosa ve T. atomaria* türleri için sırasıyla %1,31-1,91, %1,23, %7,78 olarak bulunmuştur. Doymuş yağ asitlerinden dominant olanlar palmitik asit ve stearik asittir. Palmitik asidin en yüksek düzeyi (%32,27) Viranşehir sahilinde *E. flexuosa* türünde, stearik asidin en yüksek düzeyi ise Viranşehir sahilinde (%7,20) *U. linza* türünde belirlenmiştir. ΣSFA'nın en yüksek düzeyi Taşkıran sahilinde (%37,89) *U. linza* türünde, en düşük düzeyi Taşkıran sahilinde (%18.13) *T. atomaria* türünde saptanmıştır. Tekli doymamış yağ asitlerinden dominant olan oleik asittir. Bu yağ asidinin en yüksek düzeyi (%10,35) Viranşehir sahilinde *E. flexuosa* türünde tespit edilmiştir. ΣMUFA'nın en yüksek düzeyi Viranşehir sahilinde (%16,67), en düşük düzeyi de (%11,39) Viranşehir sahilinde *U. linza* türünde belirlenmiştir. Çoklu doymamış yağ asitlerinden linolelaidik asidin en yüksek düzeyi Viranşehir sahilinde (%3,34) *E. flexuosa* türünde, linoleik asidin en yüksek düzeyi (%4,85) ise Viranşehir sahilinde *U. linza* türünde tespit edilmiştir. ΣPUFA'nın en yüksek düzeyi Taşkıran sahilinde (%16,56) *T. atomaria* türünde, en düşük düzeyi (%7,03) *U. linza* türünde belirlenmiştir.

## GİRİŞ

Algler denizlerde, tatlı ve atık sularda kolayca yetişebilen fotosentetik organizmalardır. İçeriğinin protein, aminoasit, vitamin ve çeşitli mineral maddeler yönünden zengin olduğu ayrıca polisakkarit, sterol ve yağ asitleri içerdiği, bu nedenle de kullanım alanının geniş olduğu bilinmektedir (El-Sheekh vd., 2006). Alglerden birçok alanda yararlanılmaktadır. Tıp ve eczacılık alanında yaralanmalarda, bağışıklık sisteminin dengelenmesinde, yüksek ateşi düşürmede, kan dolaşımının düzenlenmesinde, deri rejenerasyonunda, damar tıkanıklıklarının giderilmesinde ve kolesterolü düşürmede kullanıldığı bilinmektedir. Ayrıca bazı toplumlarda zengin lif, mineral, protein, düşük yağ ve sindirilebilir karbonhidrat içeriği sebebiyle *Ulva* türleri, düşük kalorili bir diyet olarak kilo verme amacıyla kullanılmaktadır (Aktar & Cebe, 2010).

Alglerden elde edilen aljinatlar ilaç sanayinde ham madde veya yardımcı madde olarak kullanılır. Bu amaçla; bazı etken maddelerin (insülin, antibiyotik, hormon, vitamin gibi) enjekte veya oral ilaç formlarında, yağ ve mumların sulu çözeltilerinde, tabletlerde dolgu maddesi olarak, yağlı kremlerin homojenizasyon ve stabilitesinin sağlanmasında, emülsiyon, süspansiyon, losyon, pomat, sabun, şampuan, tampon, diş macunu ve pastil yapımında, bağırsakta çözünen ilaç formlarının kaplanmasında kullanımları mevcuttur (Guner & Aysel, 1989; Gümüş, 2006).

Batı ülkelerin mutfaklarında daha çok alglerden elde edilen, "jelatan" olarak da isimlendirilen agar-agar, karagenan, aljinat gibi maddeler daha çok kullanım alanı bulmuştur. Bu maddeler jelleştirici, yoğunlaştırıcı, süspanse edici özellikleri ile pasta, reçel, marmelat ve dondurma yapımında kullanılmaktadır. Endüstride sucuk ve sosis kılıflarının hazırlanmasında, balıkçılığın geliştiği Avrupa ülkelerinde ise uskumru gibi yağlı balıkların saklanmasında faydalanılmaktadır (Mchugh, 2003; Zeybek, 2003).

Algler; toprağı havalandırıcı ve nem tutucu olmaları, azot yönünden çiftlik gübresi kadar zenginlik göstermeleri ve iz elementleri bünyelerinde bulundurmaları nedeniyle birçok ülkede gübre olarak da değerlendirilmektedir (Gümüş, 2006). Aynı zamanda artan insan popülasyonu ile birlikte artan enerji gereksinimi için mikro ve makro alglerden üretilen biyodizeller, doğada yenilenebilir olmaları, büyük ölçekte üretilebilmeleri ve çevre dostu olmaları nedeniyle biyodizel üretiminde kullanım için en çok teşvik edilen lipit kaynaklarından biridir (Carvalho ve ark., 2011).

Yapılan çalışmalar alglerin yüksek bir besin değerine sahip olduğunu göstermektedir. Kaliteli protein, yağ ve suda çözünür lif içeriğinin yanı sıra insan beslenmesinde önem taşıyan demir, magnezyum, potasyum ve çinko gibi mineraller açısından zengindirler. Aynı şekilde dikkate değer oranda Vitamin K, Vitamin E, riboflavin, tiamin, niasin gibi vitaminleri içerirler. Alglerin uygun şartlarda bir günde ağırlıklarını 2-3 katına çıkarabilmeleri, üretimlerinin kolay ve ekonomik olması, yan etkilerinin bulunmaması gibi nedenlerle gelecekte besin ihtiyacının karşılanmasında önemli bir kaynak olmaları mümkündür (Alçay, 2017).

Bu çalışmada kullanılan *E. flexuosa* uzun (genellikle 150 mm), ipliksi açık yeşil alglerdir. *Enteromorpha* türleri genellikle tatlı su girişlerinin meydana geldiği alanlarda büyük miktarlarda bulunurlar. Kentsel veya endüstriyel atıklardan kaynaklanan kirlilikten etkilenen kıyı bölgelerinde bol miktarda geliştikleri için genellikle kirlilik indikatörü olarak adlandırılırlar (Tabudravu et al., 2002). Ayrıca, çoğu kirlenmiş ve ötrofikasyona uğramış deniz ortamlarında yeşil alg birikimleri şeklinde ortaya çıkabilirler (Tabudravu et al., 2002).

Abiyotik çevresel stresler (sıcaklık, tuzluluk, pH ve besin bulunabilirliğindeki değişiklikler gibi) alglerin dağılımını ve bolluğunu sınırlar. Trofik seviyeleri ve hızlı büyümeleri nedeniyle algler, bir ekosistem içindeki çevresel streslere hızlı tepki verirler. Bir ekosistemin sağlığını izlemek için alglerin çeşitli fizyolojik ve morfolojik özellikleri parametre olarak kullanılmaktadır (Lewis & Wang, 1997). *Enteromorpha* türleri, çoğu temel amino asitleri içerdiği bilindiği için insan beslenmesinde önemlidir (Aguilera-Morales vd., 2005). *Enteromorpha* türleri, antioksidan bileşikler ve protein konsantreleri için potansiyel kaynaklar olarak belirlenmiş olup, gıda endüstrisi tarafından kullanılabilecek özellikleri gösterilmiştir (Ganesan vd., 2011; Kandasamy vd., 2012).

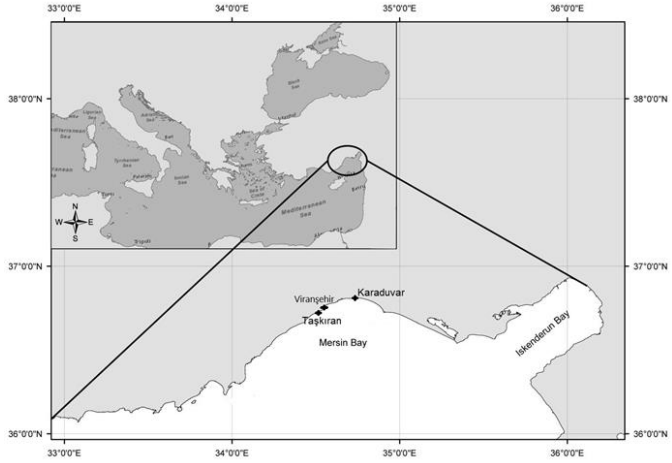
*Ulva* (Chlorophyta), biyolojik olarak eikosapentaenoik asit (C20:5n-3, EPA) ve uzun zincirli çoklu doymamış yağ asitlerinin (LC-PUFA) potansiyel bir kaynağıdır. Ayrıca *Ulva* türlerinde eser miktarda dokosaheksaenoik asit (C22:6n-3, DHA) varlığı da gösterilmiş olmakla birlikte, daha yüksek düzeyde DHA öncüsü olan stearidonik asit (C18:4n-3), heksadekatetraenoik asit (C16:4n-3), dokosapentaenoik asit (C22:5 n-3, DPA)'leri de içermektedir (Holdt & Kraan, 2011).

Bu çalışmada, Mersin sahillerinden toplanan ve birçok kullanım alanına sahip olan *U. linza, E. flexuosa ve T. atomaria* türlerinin toplam yağ düzeyleri ve yağ asidi profilleri üzerine bölgesel farklılıkların etkisinin belirlenmesi amaçlanmıştır.

## MATERYAL VE YÖNTEM

Yapılan çalışma 2016 yılının ilkbahar mevsiminde Mersin sahilindeki Viranşehir, Taşkıran ve Karaduvar sahilinden toplanan *U. linza,* Viranşehir sahilinden toplanan *E. flexuosa* ve Taşkıran sahilinden toplanan *T. atomaria* örnekleri ile yürütülmüştür. Toplanan örnekler laboratuvar ortamına getirildikten sonra saf su ile yıkanmış ve daha sonra etüvde

50°C'de kurutulmuştur. Kuru örnekler laboratuvar tipi blender yardımı ile parçalanarak homojen hale getirilmiştir. Örnekler yağ analizlerinde kullanılmak üzere falkon tüplerine aktarılarak derin dondurucuda -18°C'de depolanmıştır.




**Şekil 1.** Örnekleme bölgeleri

## Toplam Yağ Tayini

Örneklerin toplam yağ tayini, Bligh & Dyer (1959) ekstraksiyon metoduna göre yapılmıştır. Her örnekten 10 g tartılarak cam tüplere aktarılmış ve üzerine 120 mL metanol/kloroform karışımı (1/2) eklenerek homojenize edilmiştir. Homojenize edilen örnekler filtre edilerek balon jojelere aktarılmıştır. Süzme işlemi sırasında örneklere ‰4'lük $CaCl_2$ çözeltisinden 20 mL eklenmiştir. Süzme işlemini takiben ağzı parafilm ile iyice kapatılan balon jojeler bir gece karanlıkta tutulmuştur. Bekletme sonucu iki faza ayrılan örneklerin alt fazının ayırma hunisi yardımıyla darası alınmış balon jojelere aktarılmıştır. Balon jojelerde bulunan çözücülerin uzaklaştırılması için Buchi marka rotary evaporatör kullanılmıştır. Örnekteki toplam yağ miktarı yüzdesi hesaplanmıştır.

## Yağ Asitleri Tayini

Yağ asitlerinin metil esterleri; Ichibara vd. (1996) tarafından modifiye edilerek geliştirilen metoda göre yapılmıştır. İçerisinde lipit bulunan 25 mg ekstrakte edilmiş yağ örneği balon jojelere 2 mL n-heptan ve 4 mL 2 M metanolik KOH eklenerek tüm lipit çözücüye geçene kadar oda sıcaklığında 2 dk vortekste karıştırılmıştır. Daha sonra, lipit çözeltisi balon jojelerden santrifüj işlemi için ağzı kapaklı santrifüj tüplerine aktarılmıştır. Soğutmalı santrifüjde 4000 rpm devirde 10 dk santrifüj edilen örneklerin, üst fazı pastör pipetleri ile çekilerek seyreltme tüplerine konulmuştur. Örnekler 20-25 µg/mL lipit olacak şekilde heptan ile seyreltilerek enjeksiyona hazır hale getirilmiştir. En son, viallere aktarılan örnekler gaz kromatografi (GC) cihazına yerleştirilerek enjeksiyonları gerçekleştirilmiştir.

### *Gaz Kromatografi (GC) Cihazının Özellikleri ve Analiz Şartları*

Yağ asitleri tayini, alev iyonizasyon dedektörü (FID) ve bir silika kapiler SGE kolonu (30 m × 0,32 mm ID × 0,25 µm BP20 0,25 UM, USA) içeren otomatik örnekleyicili Clarus 500 (Perkin Elmer, USA) gaz kromatografisi yardımıyla analiz edilmiştir. Enjektör ve FID dedektörünün sıcaklıkları sırasıyla 220°C ve 280°C'ye ayarlanmıştır. Fırın sıcaklığı ilk 5 dk boyunca 140°C'de tutulmuştur. Sonrasında 200°C'ye kadar dakikada 4°C, 200°C'den 220°C'ye ise dakikada 1°C arttırılarak getirilmiştir. Örnek miktarı 1 µL olup, taşıyıcı gazın kontrolünün 16 ps düzeyinde olması sağlanmıştır. Enjeksiyon uygulaması 1:50 oranında gerçekleştirilmiştir. Yağ asitleri tayini standart 37 bileşenden oluşan FAME karışımının (Supelco) gelme zamanları ile karşılaştırılarak tanımlanmıştır.

## Yağ Asitleri İndeksleri

Yağ asitleri tayini sonuçlarından bazı indeksler hesaplanmıştır. Aterojenite indeksi (Aİ) ve trombojenite indeksi (Tİ) yağ asitlerinin insan sağlığına etkilerini belirlemek için kullanılan indekslerdir (Ulbricht & Southgate, 1991). İnsan besini olan bir gıdanın içerdiği yağ asitlerinin kardiyovasküler hastalıkları ile ilişkisi matematiksel olarak bu formüller ile hesaplanmaktadır. Hesaplamada kullanılan formüller Denklem 1 ve 2'de verilmiştir.

$$Aİ = \frac{(a \times 12{:}0) + (b \times 14{:}0) + (c \times 16{:}0)}{(d \times (\text{PUFA n-6+n-3})) + \left(e \times (\text{MUFA}) + (f \times (\text{MUFA-18:1}))\right)} \quad (1)$$

$$Tİ = \frac{(g \times (14{:}0 + 16{:}0 + 18{:}0))}{(h \times (\text{MUFA})) + \left(i \times (\text{MUFA-18:1}) + (m \times (n\text{-}6)) + (n \times (n\text{-}3)) + \frac{n\text{-}3}{n\text{-}6}\right)} \quad (2)$$

Bu denklemlerde; a, c, d, e, f=1; b=4; g=1; h, i, m=0,5; n=3 olarak hesaplanmaktadır.

## Verilerin Değerlendirilmesi

Araştırmanın analizlerinden elde edilen veriler IBM SPSS (v 22) istatistik programı kullanılarak değerlendirilmiştir. Yağ ve yağ asitleri verilerinin değerlendirilmesi için istatistik analizi öncesinde bütün verilerin ayrılıklar yönünden kontrolü (Z değerine göre) ve varyansın homojenliği testi (Duncan çoklu karşılaştırma testi) yapılmıştır. Gruplar arasındaki farklılık tek yönlü varyans analizi (ANOVA) yardımı ile belirlenmiştir.

## BULGULAR

Viranşehir, Taşkıran ve Karaduvar sahillerinden toplanan *U. linza, E. flexuosa ve T. atomaria* türlerinin toplam yağ düzeyleri belirlenmiştir. *U. linza* için toplam yağ düzeyi %1,31-1,91 aralığında, *E. flexuosa* için %1,23, *T. atomaria* için %7,78 olarak bulunmuştur (Tablo 1).

**Tablo 1.** Alglerdeki toplam yağ düzeyi (%)

| Tür | Viranşehir | Taşkıran | Karaduvar |
|---|---|---|---|
| *U. linza* | 1,31 (1,25-1,36) | 1,45 (1,39-1,50) | 1,91 (1,86-1,95) |
| *E. flexuosa* | 1,23 (1,20-1,25) | | |
| *T. atomaria* | | 7,78 (7,55-7,98) | |

***Not:*** Parantez içerisinde verilen değerler minimum-maksimum değerleridir.

*U. linza, E. flexuosa* ve *T. atomaria* türleri için palmitik asit düzeyi sırasıyla %22,27-%29,52, %32,27, %10,19 olarak belirlenmiştir. *U. linza*'nın palmitik asit düzeyi en yüksek Karaduvar sahilinden toplanan örneklerde belirlenmiştir. Stearik asit düzeyi *U. linza* için %5,13-%7,20, *E. flexuosa* için %3,87, *T. atomaria* için %0,73'tür. *U. linza*'nın stearik asit düzeyi en yüksek Viranşehir sahilinden toplanan örneklerde belirlenmiştir. Laurik asit düzeyi *U. linza* için %0,19-%0,33 aralığında iken Taşkıran sahilinden toplanan *T. atomaria* için %0,06'dır. Laurik asit *E. flexuosa* için ise belirlenebilir limitinin altındadır. Miristik asit düzeyi *U. linza, E. flexuosa* ve *T. atomaria* türleri için sırasıyla %0,73-%1,06, %1,02, %1,80'dir. Pentadekanoik asit düzeyi *U. linza* için %0.28-%0.51, *E. flexuosa* için %0,36, *T. atomaria* için %0,45 olarak saptanmıştır. Araşidik asit düzeyi *U. linza* için %0,00-%0,15 aralığında, *E. flexuosa* için %0,14 *ve T. atomaria* için ise %4,24 olarak belirlenmiştir.

**Tablo 2**. *U. linza, E. flexuosa* ve *T. atomaria* türlerinin doymuş yağ asidi düzeyleri (%)

| Yağ asidi (%) | Viranşehir $\bar{X} \pm S_x$ | Taşkıran $\bar{X} \pm S_x$ | Karaduvar $\bar{X} \pm S_x$ | Tür |
|---|---|---|---|---|
| Laurik asit (C12:0) | 0,28±0,04$^{a,y}$ | 0,33±0,12$^{a,y}$ | 0,19±0,10$^{a,x}$ | *U. linza* |
| | 0,00±0,00$^{a,x}$ | - | - | *E. flexuosa* |
| | - | 0,06±0,01$^{a,x}$ | - | *T. atomaria* |
| Miristik asit (C14:0) | 0,73±0,03$^{a,x}$ | 0,93±0,09$^{a,x}$ | 1,06±0,21$^{a,x}$ | *U. linza* |
| | 1,02±0,14$^{a,y}$ | - | - | *E. flexuosa* |
| | - | 1,80±0,49$^{a,y}$ | - | *T. atomaria* |
| Pentadekanoik asit (C15:0) | 0,51±0,00$^{b,y}$ | 0,43±0,07$^{ab,x}$ | 0,28±0,09$^{a,x}$ | *U. linza* |
| | 0,36±0,00$^{a,x}$ | - | - | *E. flexuosa* |
| | - | 0,45±0,02$^{a,x}$ | - | *T. atomaria* |
| Palmitik asit (C16:0) | 22,27±6,01$^{a,x}$ | 29,44±3,75$^{a,y}$ | 29,52±2,45$^{a,x}$ | *U. linza* |
| | 32,27±9,19$^{a,y}$ | - | - | *E. flexuosa* |
| | - | 10,19±3,51$^{a,x}$ | - | *T. atomaria* |
| Stearik asit (C18:0) | 7,20±0,47$^{b,y}$ | 5,85±0,82$^{ab,y}$ | 5,13±1,13$^{a,x}$ | *U. linza* |
| | 3,87±0,37$^{a,x}$ | - | - | *E. flexuosa* |
| | - | 0,73±0,14$^{a,x}$ | - | *T. atomaria* |
| Araşidik asit (C20:0) | 0,00±0,00$^{a,x}$ | 0,15±0,08$^{b,x}$ | 0,09±0,03$^{b,x}$ | *U. linza* |
| | 0,14±0,01$^{a,y}$ | - | - | *E. flexuosa* |
| | - | 4,24±0,12$^{a,y}$ | - | *T. atomaria* |
| Henikosanoik asit (C21:0) | 0,40±0,01$^{a,y}$ | 0,71±0,07$^{b,y}$ | 1,36±0,23$^{c,x}$ | *U. linza* |
| | 0,00±0,00$^{a,x}$ | - | - | *E. flexuosa* |
| | - | 0,00±0,00$^{a,x}$ | - | *T. atomaria* |
| Behenik asit (C22:0) | 0,00±0,00$^{a,x}$ | 0,05±0,02$^{b,x}$ | 0,11±0,03$^{b,x}$ | *U. linza* |
| | 0,11±0,00$^{a,y}$ | - | - | *E. flexuosa* |
| | - | 0,66±0,20$^{a,y}$ | - | *T. atomaria* |
| ΣSFA | **31,39** | **37,89** | **37,74** | *U. linza* |
| | **37,77** | **-** | **-** | *E. flexuosa* |
| | **-** | **18,13** | **-** | *T. atomaria* |

***Not:*** * Her yağ asidi için aynı satır (a, b, c) ve sütunda (x, y) farklı harfler ile gösterilen değerler arasında istatistiksel bir ayrım bulunmaktadır ($p<0,05$).

Viranşehir, Taşkıran ve Karaduvar sahillerinden toplanan *U. linza, E. flexuosa ve T. atomaria* türlerinin tekli doymamış yağ asidi düzeyleri Tablo 3'te verilmiştir.

Tekli doymamış yağ asitlerinden pentadesenoik asit düzeyi *U. linza* için %1,05-%1,45, *E. flexuosa* için %0,97, *T. atomaria* için %0,37 olarak saptanmıştır. *U. linza*'nın en yüksek pentadesenoik asit düzeyi Karaduvar sahilinden toplanan örneklerde belirlenmiştir. Palmitoleik asit düzeyi *U. linza* için %0,84-%1,79 aralığında olup en yüksek değeri Karaduvar örneklerinde belirlenmiştir. *E. flexuosa* için palmitoleik asit düzeyi %1,36, *T. atomaria* için %1,48 olarak saptanmıştır. Trans oleik asit düzeyi *U. linza* için %0,81-%2,68 aralığında olup, en yüksek düzeyi ise Karaduvar örneklerinde saptanmıştır. Trans oleik asit düzeyi *E. flexuosa* için %1,40, *T. atomaria* için %6,88'dir. Oleik asit düzeyi *U. linza* türünde %6,64-%9,37 aralığında, *E. flexuosa* türünde %10,35, *T. atomaria* türünde ise %6,88 olarak tespit edilmiştir. ΣMUFA düzeyi *U. linza* için %11,39-%14,69, *E. flexuosa* için %16,67, *T. atomaria* için %16,17'dir.

Çoklu doymamış yağ asidi düzeylerinde linolelaidik asit düzeyi *U. linza'*da %1,41-%2,15 aralığında olup en yüksek düzeyi Karaduvar örneklerindedir. Linolelaidik asit düzeyi *E. flexuosa* için %3,34, *T. atomaria* için %0,30 olarak bulunmuştur. Linoleik asit düzeyi *U. linza* için %0,10-%4,85 aralığında olup, en yüksek değeri Viranşehir örneklerinde bulunmuştur. Linoleik asit düzeyi *E. flexuosa* için %1,23, *T. atomaria* için %2,98'dir. *U. linza*'nın $\alpha$-Linolenik asit düzeyi en yüksek Viranşehir örneklerinde bulunmuştur. Bu yağ asidinin düzeyi %0,07-%0,73 aralığındadır. *E. flexuosa*'nın $\alpha$-Linolenik asit düzeyi %0,24'tür. Gamma linolenik asit düzeyi *U. linza* için %4,22-%5,54 aralığında olup en yüksek değeri Karaduvar örneklerinde bulunmuştur. *E. flexuosa*'nın Gamma linolenik asit düzeyi %3,61, *T. atomaria*'nın %4,65'tir. Eikosatrienoik asit düzeyi *U. linza* için %0,04-%0,07 aralığında olup, en yüksek düzeyi Karaduvar örneklerinde bulunmuştur. *E. flexuosa* için eikosatrienoik asit düzeyi %0,05, *T. atomaria* için %4,12 olarak bulunmuştur. Dokosaheksaenoik asit düzeyi *U. linza* için %0,06-%0,27 aralığında olup, en yüksek düzeyi Viranşehir örneklerinde bulunmuştur. *E. flexuosa* için dokosaheksaenoik asit düzeyi %0,37, *T. atomaria* için %0,06'dır. ΣPUFA düzeyi *U. linza* için %7,03-%11,61, *E. flexuosa* için %8,84, *T. atomaria* için %16,56 olarak belirlenmiştir.

**Tablo 3.** *U. linza, E. flexuosa* ve *T. atomaria* türlerinin tekli doymamış yağ asidi düzeyleri (%)

| **Yağ asidi (%)** | **Viranşehir** $\bar{X} \pm S_x$ | **Taşkıran** $\bar{X} \pm S_x$ | **Karaduvar** $\bar{X} \pm S_x$ | **Tür** |
|---|---|---|---|---|
| Pentadesenoik asit (C15:1) | 1,36±0,15$^{ab,x}$ | 1,05±0,04$^{a,y}$ | 1,45±0,48$^{b,x}$ | *U. linza* |
| | 0,97±0,16$^{a,x}$ | - | - | *E. flexuosa* |
| | - | 0,37±0,02$^{a,x}$ | - | *T. atomaria* |
| Palmitoleik asit (C16:1) | 0,84±0,23$^{a,x}$ | 1,47±0,46$^{ab,x}$ | 1,79±0,13$^{b,x}$ | *U. linza* |
| | 1,36±0,31$^{a,x}$ | - | - | *E. flexuosa* |
| | - | 1,48±0,35$^{a,x}$ | - | *T. atomaria* |
| Heptadekenoik asit (C17:1) | 0,00±0,00$^{a,x}$ | 0,04±0,02$^{b,x}$ | 0,14±0,05$^{c,x}$ | *U. linza* |
| | 0,00±0,00$^{a,x}$ | - | - | *E. flexuosa* |
| | - | 0,13±0,02$^{a,y}$ | - | *T. atomaria* |
| Trans oleik asit (C18:1*n*9t) | 0,96±0,22$^{a,x}$ | 0,81±0,06$^{a,x}$ | 2,68±0,14$^{b,x}$ | *U. linza* |
| | 1,40±0,71$^{a,x}$ | - | - | *E. flexuosa* |
| | - | 6,88±2,22$^{a,y}$ | - | *T. atomaria* |
| Oleik asit (C18:1*n*9c) | 6,64±3,20$^{a,x}$ | 9,37±2,87$^{a,x}$ | 7,97±0,79$^{a,x}$ | *U. linza* |
| | 10,35±5,41$^{a,x}$ | - | - | *E. flexuosa* |
| | - | 6,88±2,22$^{a,x}$ | - | *T. atomaria* |
| Vaksenik asit (C18:1*n*7) | 0,00±0,00$^{a,x}$ | 0,05±0,02$^{b,x}$ | 0,07±0,02$^{b,x}$ | *U. linza* |
| | 0,00±0,00$^{a,x}$ | - | - | *E. flexuosa* |
| | - | 0,23±0,09$^{a,y}$ | - | *T. atomaria* |
| Gadoleik asit (C20:1*n*9) | 1,59±1,31$^{b,x}$ | 1,18±0,33$^{b,y}$ | 0,59±0,16$^{a,x}$ | *U. linza* |
| | 2,59±1,62$^{a,x}$ | - | - | *E. flexuosa* |
| | - | 0,20±0,03$^{a,x}$ | - | *T. atomaria* |
| ΣMUFA | **11,39** | **13,97** | **14,69** | *U. linza* |
| | **16,67** | - | - | *E. flexuosa* |
| | - | **16,17** | - | *T. atomaria* |

***Not:*** * Her yağ asidi için aynı satır (a, b, c) ve sütunda (x, y) farklı harfler ile gösterilen değerler arasında istatistiksel bir ayrım bulunmaktadır ($p<0.05$).

**Tablo 4.** *U. linza, E. flexuosa* ve *T. atomaria* türlerinin çoklu doymamış yağ asidi düzeyleri (%)

| Yağ asidi (%) | Viranşehir $\bar{X} \pm S_x$ | Taşkıran $\bar{X} \pm S_x$ | Karaduvar $\bar{X} \pm S_x$ | Tür |
|---|---|---|---|---|
| Linolelaidik asit (C18:2*n*6t) | 1,41±0,01$^{a,x}$ | 1,46±0,84$^{a,y}$ | 2,15±0,70$^{a,x}$ | *U. linza* |
| | 3,34±0,04$^{a,y}$ | - | - | *E. flexuosa* |
| | - | 0,30±0,08$^{a,x}$ | - | *T. atomaria* |
| Linoleik asit (C18:2*n*6c) | 4,85±0,05$^{c,y}$ | 1,06±0,58$^{b,x}$ | 0,10±0,03$^{a,x}$ | *U. linza* |
| | 1,23±0,03$^{a,x}$ | - | - | *E. flexuosa* |
| | - | 2,98±1,15$^{a,y}$ | - | *T. atomaria* |
| $\alpha$-Linolenik asit (C18:3*n*3) | 0,73±0,03$^{c,y}$ | 0,07±0,04$^{a,y}$ | 0,38±0,16$^{b,x}$ | *U. linza* |
| | 0,24±0,04$^{a,x}$ | - | - | *E. flexuosa* |
| | - | 0,00±0,00$^{a,x}$ | - | *T. atomaria* |
| Gama linolenik asit (C18:3*n*6) | 4,22±0,75$^{a,x}$ | 4,22±0,98$^{a,x}$ | 5,54±1,17$^{a,x}$ | *U. linza* |
| | 3,61±0,28$^{a,x}$ | - | - | *E. flexuosa* |
| | - | 4,65±0,99$^{a,x}$ | - | *T. atomaria* |
| Eikosatrienoik asit (C20:3*n*3) | 0,04±0,04$^{a,x}$ | 0,06±0,03$^{a,x}$ | 0,07±0,02$^{a,x}$ | *U. linza* |
| | 0,05±0,05$^{a,x}$ | - | - | *E. flexuosa* |
| | - | 4,12±1,72$^{a,y}$ | - | *T. atomaria* |
| Dihomo-γ-linolenik asit (C20:3*n*6) | 0,00±0,00$^{a,x}$ | 0,00±0,00$^{a,x}$ | 0,00±0,00$^{a,x}$ | *U. linza* |
| | 0,00±0,00$^{a,x}$ | - | - | *E. flexuosa* |
| | - | 3,55±0,92$^{a,y}$ | - | *T. atomaria* |
| Araşidonik asit (C20:4*n*6) | 0,09±0,00$^{a,y}$ | 0,06±0,03$^{a,x}$ | 0,06±0,03$^{a,x}$ | *U. linza* |
| | 0,00±0,00$^{a,x}$ | - | - | *E. flexuosa* |
| | - | 0,48±0,02$^{a,y}$ | - | *T. atomaria* |
| Eikosapentaenoik asit (C20:5*n*3) | 0,00±0,00$^{a,x}$ | 0,00±0,00$^{a,x}$ | 0,00±0,00$^{a,x}$ | *U. linza* |
| | 0,00±0,00$^{a,x}$ | - | - | *E. flexuosa* |
| | - | 0,45±0,05$^{a,y}$ | - | *T. atomaria* |
| Dokosaheksaenoik asit (C22:6*n*3) | 0,27±0,14$^{a,x}$ | 0,10±0,06$^{a,x}$ | 0,06±0,02$^{a,x}$ | *U. linza* |
| | 0,37±0,23$^{a,x}$ | - | - | *E. flexuosa* |
| | - | 0,06±0,01$^{a,x}$ | - | *T. atomaria* |
| ΣPUFA | **11,61** | **7,03** | **8,36** | *U. linza* |
| | **8,84** | **-** | **-** | *E. flexuosa* |
| | - | **16,56** | **-** | *T. atomaria* |

***Not:*** * Her yağ asidi için aynı satır (a, b, c) ve sütunda (x, y) farklı harfler ile gösterilen değerler arasında istatistiksel bir ayrım bulunmaktadır ($p<0.05$).

*U. linza, E. flexuosa ve T. atomaria* türlerinin yağ asidi indeksleri belirlenmiştir (Tablo 5).

PUFA/SFA düzeyleri *U. linza* için %0,18-%0,36 aralığında, *E. flexuosa* için %0,23 *T. atomaria* için %0,91 olarak bulunmuştur. Σn3 ve Σ*n*6'nın en yüksek düzeyi üç tür içerisinde *T. atomaria* türünde bulunmuştur.

## TARTIŞMA

Bu çalışmada birçok kullanım alanına sahip olan alglerin, toplam yağ içeriği ve yağ asidi profilleri incelenerek hammadde olarak kullanım potansiyeli araştırılmıştır. Yapılan bir çalışmada, mikroalglerin çoklu doymamış yağ asitlerinin (γ-linolenik asit, araşidonik asit, eikosapentaenoik asit, dokosaheksaenoik asit) bebek mamaları ve besin takviyelerindeki kullanımları verilmiştir (Spolaore vd., 2006). Son zamanlarda *n*3-PUFA'ların sağlık için önemli olduğu ve kronik inflamasyonda önemli bir rol oynadığı hastalık riskini azalttığı bilinmesi nedeniyle DHA'ya olan ilgi artmıştır. Buna kardiyovasküler hastalık, çeşitli kanserler, artrit ve demans dahildir. *n*-3 PUFA bitkilerden kolaylıkla temin edilebilmesine rağmen, insanlarda EPA'ya ve özellikle DHA'ya zayıf bir şekilde dönüştürülmektedir. Bu nedenle, LC-PUFA'lar içeren balık yağları insanlar için gerekli bir besin takviyesi olarak adlandırılabilir. Birçok alg türü, yağ asitleri bakımından uzun zincirli PUFA'lara (LC-PUFAs)

(>18C) sahiptir. Bu özellikle deniz türleri için geçerlidir. Alglerde %20 veya daha fazla araşidonik asit (AA), eikosapentaenoik asit (EPA) ve dokosaheksaenoik asit (DHA) gibi asitlerin varlığı, besin zincirlerinin başlangıcındaki alglerin rolü ve sağlıklı diyetlerde LC-PUFA'ların önemini göstermektedir (Harwood & Guschina, 2009). Bizim yaptığımız çalışmada ise üç makroalg türünde bu yağ asitlerinin görece düşük düzeyde olduğu saptanmıştır. Bununla birlikte tekli doyamamış yağ asitleri ve bazı LC-PUFA'ların yüksek düzeyde olduğu görülmektedir. Yapılan önceki çalışmalarda LC-PUFA'ların meme kanseri önlenmesinde en önemli yönünün, her ikisinin de mutlak konsantrasyonundan ziyade (ω-3)/((ω-6) PUFA) oranı olduğunu göstermektedir. Araştırmalar, ~1:1–1:2 oranının meme kanserlerinin gelişmesine ve büyümesine karşı en koruyucu etkiye sahip olduğunu göstermektedir (Cowing & Saker, 2001). Yaptığımız çalışmadaki (ω-3)/(ω-6) oranı üç tür içinde çok düşük düzeyde bulunmuştur. PUFA biyosentezini etkileyen başka bir noktada desatürasyonun düşük sıcaklıklarda artmasıdır (Guschina & Harwood 2006). Soğuk sularda büyüyen alg türleri daha yüksek bir (ω-3)/(ω-6) PUFA oranına sahiptir (Colombo vd., 2006). Ayrıca alglerdeki 18:3*n*-3 (gama linolenik asit) varlığı su ürünleri açısından önemlidir. Çünkü balıklar PUFA'yı sentezleyemez, ancak diyetteki 18:2 ve 18:3 yağ asitlerini desatüre edebilir/uzatabilir (Wahbeh, 1997).

Canlı bünyesine katılan yağ asitlerinin ihtiyaca göre dönüşümünde, EPA oluşturmak için $\alpha$-Linolenik asit ve Linoleik asidin varlığına ihtiyaç duyulmaktadır (Guschina & Harwood, 2006). Yaptığımız çalışmada bu dönüşüm için kullanılacak olan tekli doymamış yağ asitlerinden $\alpha$-Linolenik asit düzeyi düşük seviyededir. Linoleik asit düzeyi $\alpha$-Linolenik asidine göre daha yüksek bulunmuştur. EPA değerine katkıda bulanan yağ asit düzeyleri de düşük seviyededir.

**Tablo 5**. *U. linza, E. flexuosa* ve *T. atomaria* türlerinin yağ asidi indeksleri (%)

| Yağ asidi (%) | Viranşehir | Taşkıran | Karaduvar | Tür |
|---|---|---|---|---|
| PUFA/ SFA | 0,36 | 0,18 | 0,22 | *U. linza* |
| | 0,23 | - | - | *E. flexuosa* |
| | - | 0,91 | - | *T. atomaria* |
| Σ*n*7 | 0 | 0,05 | 0,07 | *U. linza* |
| | 0 | - | - | *E. flexuosa* |
| | - | 0 | - | *T. atomaria* |
| Σ*n*6 | 10,57 | 6,80 | 7,85 | *U. linza* |
| | 8,18 | - | - | *E. flexuosa* |
| | - | 11,96 | - | *T. atomaria* |
| Σ*n*3 | 1,04 | 0,23 | 0,51 | *U. linza* |
| | 0,66 | - | - | *E. flexuosa* |
| | - | 4,63 | - | *T. atomaria* |
| Σ*n*9 | 9,19 | 11,36 | 11,24 | *U. linza* |
| | 14,34 | - | - | *E. flexuosa* |
| | - | 13,96 | - | *T. atomaria* |
| *n*6/*n*3 | 10,16 | 29,56 | 15,39 | *U. linza* |
| | 12,39 | - | - | *E. flexuosa* |
| | - | 2,58 | - | *T. atomaria* |
| *n*3/*n*6 | 0,09 | 0,03 | 0,06 | *U. linza* |
| | 0,08 | - | - | *E. flexuosa* |
| | - | 0,38 | - | *T. atomaria* |
| AI | 0,93 | 1,07 | 1,25 | *U. linza* |
| | 1,19 | - | - | *E. flexuosa* |
| | - | 0,49 | - | *T. atomaria* |
| TI | 1,87 | 2,79 | 2,40 | *U. linza* |
| | 2,19 | - | - | *E. flexuosa* |
| | - | 0,43 | - | *T. atomaria* |

İnsanlar için önerilen minimum PUFA/SFA değeri 0,45'tir (HMSO, 1994). Bu çalışmada üç tür için de PUFA/SFA değerleri %0,18-%0,91 aralığında olup, minimum değeri karşılayan tür *T. atomaria*'dır.

Çevresel faktörlerin evsel kanalizasyon deşarjları, endüstriyel ve tarımsal atıklar, pH değişimleri, kanalizasyon deşarjı ve organik maddenin ayrışması gibi faktörler alglerin toplam lipit içeriği ve yağ asidi profillerini etkileyebilmektedir (Maghraby & Fakhury, 2015). Farklı bölgelerden örneklenen *U. linza* örnekleri için yağ asidi düzeylerinin farklılık gösterdiği saptanmıştır. Yağ asidi profillerindeki farklılıklara denizdeki inorganik madde miktarındaki değişimlerin neden olduğu düşünülmektedir.

Biyodizel üretimi için yapılan bir çalışmada Ebu Qir Körfezi'nden toplanan *U. linza*'nın toplam yağ düzeyi %3,20-%4,14 olarak bulunmuştur. *U. linza*'nın palmitik asit ve stearik asit düzeyleri sırasıyla %38,10-%48,44, %1,27-%4,99 olarak bulunmuştur (Maghraby & Fakhury, 2015). Yaptığımız çalışmada *U. linza*'nın toplam yağ düzeyi %1,31-%1,91 aralığında, palmitik asit ve stearik asit düzeyleri sırasıyla %22,27-%29,52, %5,13-%7,20 aralığında bulunmuştur. Aynı çalışmada tekli doymamış yağ asitlerinden oleik asit, palmitoleik asit ve gadoleik asit sırasıyla %0,31-%10,43, %1,25-%2,03 %0,10-%0,33 olarak bulunmuştur. Çoklu doymamış yağ asitlerinde linoleik asit ve linolenik asit sırasıyla %0,17-%1,15, %0,12-%2,56 olarak bulunmuştur (Maghraby & Fakhury, 2015). Bizim çalışmamızda ise *U. linza*'nın trans-oleik asit, palmitoleik asit, gadoleik asit ve linoleik asit sırasıyla %0,81-%2,68, %0,84-%1,79, %0,59-%1,59, %0,10-%4,85 aralığında bulunmuştur.

Antalya sahilinde yapılan bir çalışmada, *T. atomaria*'nın palmitik asit, stearik asit, oleik asit, linoleik asit, EPA, gadoleik asit, araşidonik asit düzeyleri sırasıyla %10,19, %1,20, %15,85, %6,13, %4,78, %0,20, %8,53 düzeyleri belirlenmiştir (Caf vd., 2015). Bizim çalışmamızda ise, palmitik asit, stearik asit, oleik asit, linoleik asit, EPA, gadoleik asit, araşidonik asit düzeyleri sırasıyla %10,19, %0,73, %6,88, %2,98, %0,45, %0,20, %0,48 düzeyinde bulunmuştur. Caf vd. (2015) tarafından bildirilen yağ asitleri düzeylerinin çalışmamızdakilerden düşük olduğu görülmektedir. Değerler arasındaki fark bölgesel farklılık, su sıcaklığı değişimi, kullanılan ekstraksiyon metodundaki farklılık gibi etmenlerden kaynaklanabilir.

Üç *Enteromorpha* türünün kimyasal bileşimi üzerine yapılan bir çalışmada Hindistan'ın kuzeybatı kıyısından toplanan *E. compressa*, *E. Linza* ve *E. tubulosa*'nın yağ asidi profilleri araştırılmıştır. *E. compressa*'nın palmitik asit, oleik asit, linoleik asit, EPA düzeyleri sırasıyla %44,64, %1,31, %5,79, %0,54 olarak belirlenmiştir. *E. linza*'nın palmitik asit, oleik asit, linoleik asit, EPA düzeyleri sırasıyla %35,48, %1,12, %6,43 %0,76'dır. *E. tubulosa*'nın palmitik asit, oleik asit, linoleik asit, EPA düzeyleri sırasıyla %34,80, %1,26, %9,61, %0,52'dir (Ganesan vd., 2014). Yaptığımız çalışmadaki *E. flexuosa*'nın palmitik asit, trans-oleik asit, linoleik asit düzeyleri sırasıyla %32,27, %1,40, %1,23 ve EPA düzeyi ise belirlenebilir limitinin altındadır. Her iki çalışmada palmitik asit ve oleik asidin sonuçlarının yakın düzeyde olduğu görülmektedir.

Düşük aterojenik, trombojenik ve hiperkolesterolemik indekslere sahip gıda ürünlerinin aterosklerozu geciktirmek ve dolayısıyla kardiyovasküler hastalık riski için iyi olduğu düşünülmektedir (EL-Wakf vd., 2010). Yaptığımız çalışmadaki türler içerisinde Taşkıran sahilinden örneklenmiş olan *T. atomaria* türünün Aİ seviyesi %0,49, Tİ seviyesi %0,43 ile düşük seviyede olduğu bulunmuştur.

## SONUÇ

Çalışmamızda incelemiş olduğumuz *U. linza*, *E. flexuosa* ve *T. atomaria* türlerinin LC-PUFA düzeylerinin düşük olduğu, bunun yanında önemli bir MUFA kaynağı olduğu tespit edilmiştir. Ayrıca insan sağlığı açısından önemli olan linoleik ve gama linolenik asit gibi bazı çoklu doymamış yağ asitlerini de yüksek düzeyde içerdiği belirlenmiştir. Yaptığımız çalışmada ekonomik değere sahip olan makroalg türlerinin yağ asitleri profili üzerine bölgesel farklılıkların etkisi belirlenerek, insan beslenmesinde kullanım potansiyeli belirlenmiştir.

### Etik Standartlar İle Uyum

### Yazarların Katkısı

Tüm yazarlar makaleye eşit katkıda bulunmuştur

### Çıkar Çatışması

Yazarlar herhangi bir çıkar çatışması olmadığını deklare etmektedir.

### Etik Onay

Yazarlar bu tür bir çalışma için resmi etik kurul onayının gerekli olmadığını bildirmektedir.

## KAYNAKLAR

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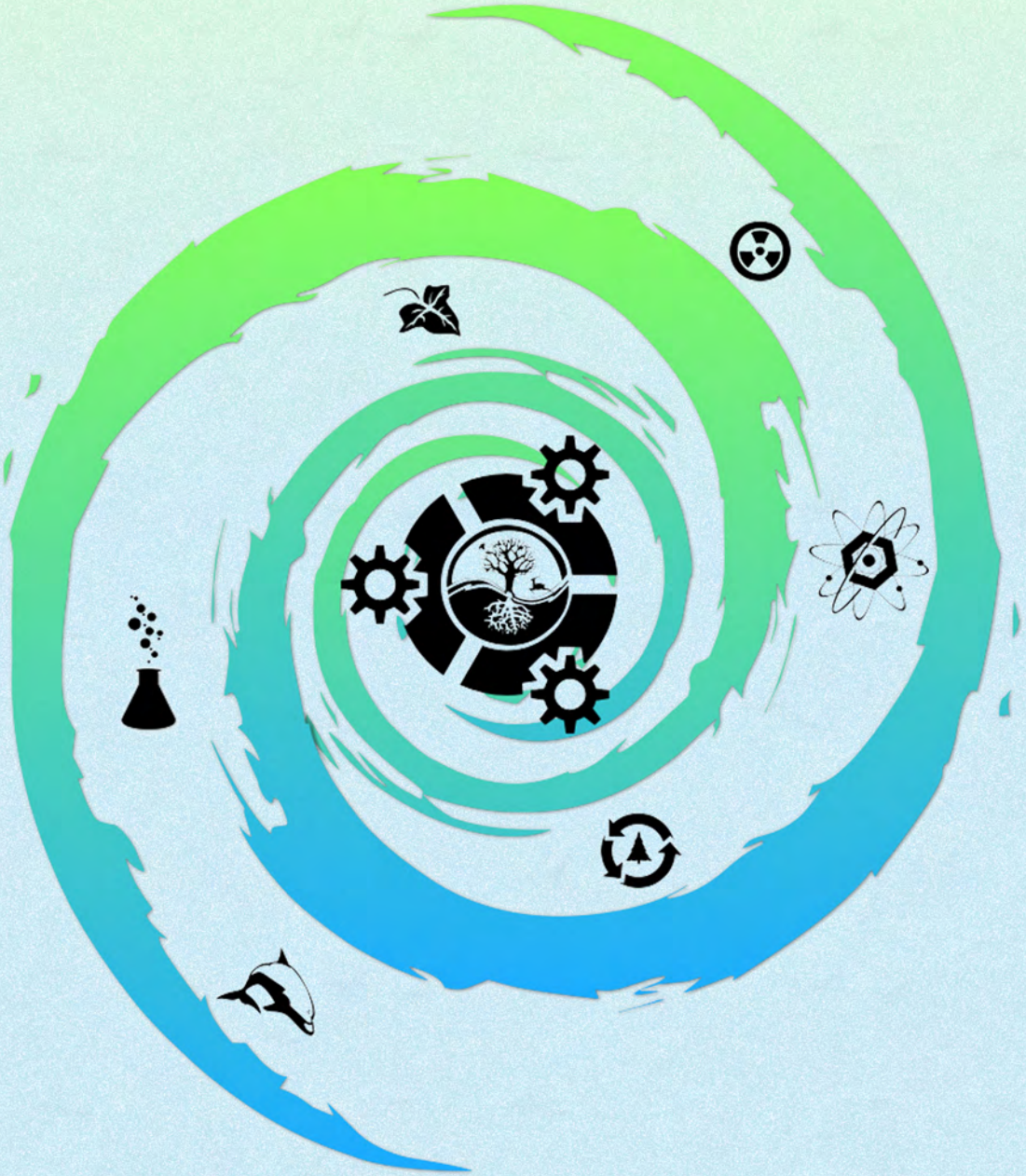

e-ISSN: 2718-0638

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