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Proximate analysis and fatty acid profile of muscle tissues in different body parts of crimean barbel (*Barbus tauricus* Kessler, 1877)

Análisis proximal y perfil de ácidos grasos de los tejidos musculares en diferentes partes del cuerpo del barbo de Crimea (*Barbus tauricus* Kessler, 1877)

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ABSTRACT

This study aimed to determine proximate analysis and fatty acid profile of whole body muscle tissue (WM) and muscles in different parts of the body, including dorsal (D), ventral (V), and caudal (C) regions, of the crimean barbel (*Barbus tauricus*), which is an species caught from the Gelingüllü Dam. In whole body muscle the protein, lipid, moisture, and ash contents of the fish were 18.61, 1.54, 78.49, and 1.09% respectively. The lipid contents of crimean barbel varied between 1.78 and 2.68%, with the highest and lowest percentages in the C and V regions, respectively. There was a significant difference (P<0.05) in the fatty acid content present in the different parts of the fish. The highest and lowest proportions of saturated fatty acids (SFA) were found in WM (23.03) and D (21.94%) region, respectively. The highest and lowest monounsaturated fatty acid (MUFA) contents were found in the D muscle (36) and V muscles (33.73%), respectively. The proportion of polyunsaturated fatty acids (PUFA) was highest and lowest in C (25.63) and D (22.62%) regions, respectively. The highest eicosapentaenoic acid (4.11) and docosahexaenoic acid (12.98%) contents were found in V and C regions, respectively. The results showed that lipid content and composition of fatty acids may vary in the different body parts of the fish.

Key words: *Barbus tauricus*; fatty acids; nutritional composition; EPA; DHA

RESUMEN

Este estudio tuvo como objetivo determinar el análisis proximal y el perfil de ácidos grasos del tejido muscular de todo el cuerpo (WM) y los músculos en diferentes partes del cuerpo, incluidas las regiones dorsal (D), ventral (V) y caudal (C), del barbo de Crimea. (*Barbus tauricus*), que es una especie capturada en la Presa Gelingüllü. Los contenidos de proteína, lípidos, humedad y cenizas del pescado fueron 18,61; 1,54; 78,49 y 1,09 %, respectivamente. Los contenidos de lípidos de del barbo de Crimea. variaron entre 1,78 y 2,68 %, con los porcentajes más altos y más bajos en las regiones C y V, respectivamente. Hubo una diferencia significativa (P<0,05) en el contenido de ácidos grasos presentes en las diferentes partes del pez. Las proporciones más altas y más bajas de ácidos grasos saturados (AGS) se encontraron en la región WM (23.03) y D (21.94 %), respectivamente. Los contenidos más altos y más bajos de ácidos grasos monoinsaturados (MUFA) se encontraron en las regiones del músculo D (36 %) y los músculos V (33.73 %), respectivamente. La proporción de ácidos grasos poliinsaturados (PUFA) fue mayor y menor en las regiones C (25.63) y D (22.62 %), respectivamente. Los mayores contenidos de ácido eicosapentaenoico (4.11 %) y ácido docosahexaenoico (12.98 %) se encontraron en las regiones V y C, respectivamente. Los resultados mostraron que el contenido de grasa y la composición de ácidos grasos varian en las diferentes partes del cuerpo del pez.

Palabras clave: *Barbus tauricus*; ácidos grasos; composición nutricional; EPA; DHA

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INTRODUCTION

Fish is one of the natural sources of nutrients essential for tissue development and body functions of the humans [1]. As fishes have high content of polyunsaturated fatty acids, essential amino acids, mineral substances, and vitamins that have multiple health benefits and are crucial part of a balanced diet [2], several studies have been conducted to unveil the nutritional composition of fishes. Lipids are the most important energy sources for animals. Fat-soluble vitamins in animals interact with proteins to form lipoproteins and affect blood fat levels, and fatty acids form the building blocks of cell membrane [3]. Moreover, fish and aquatic organisms are the largest dietary source of ω-3 polyunsaturated fatty acids. They are also known to improve heart health and cognition; reduce risk of lung, prostate, and colorectal cancer; and decrease risk of allergies in children [4, 5, 6].

According to the terrestrial and inland water ecosystems biodiversity inventory and monitoring result report of Yozgat Province, it has been observed that crimean barbel (*Barbus tauricus)* is naturally found in Yozgat inland waters and its population density is very low. It is generally found in low-pollution, fast-flowing, pebbly, rocky and oxygen-rich areas [7]. Moreover, Kırankaya and Ekmekçi [8, 9] reported in their studies that crimean barbel *(Barbus tauricus)* was found in the local ichthyofauna of Gelingüllü dam lake. The spawning period usually starts in april and lasts until july [10]. Females have a higher growth rate than males detected by some researchers [11].

Gelingüllü Dam is located approximately 40 km south of Yozgat city center (39°36'30"N, 35°03'20"E) in the Central Anatolia Region. The most important water sources feeding the dam, which is located at an altitude of 1,050 m above sea level, are Kanak Stream and Eğriöz Stream [12]. However, there is no report of nutritional and fatty acid compositions of the endemic crimean barbel (*Barbus tauricus Kessler*, 1877) species caught from Gelingüllü Dam. Therefore, the nutritional and fatty acids compositions of the crimean barbel caught in this dam were described for the first time in this study. These data are important for both consumers and the processing facilities to select the most appropriate methods for processing the product. The aim of this study was to determine the nutritional composition in crimean barbel and identify and compare the fatty acid profile of the whole muscle tissue (WM) as well as the dorsal (D), ventral (V), and caudal (C) muscle tissues.

MATERIAL AND METHODS

Material

Crimean barbel (*Barbus tauricus)* samples were obtained from local fishermen who fished in Gelingüllü Dam in February 2019. Ten fish samples with an average body weight and length of 350 ± 0.20 g and 33 cm were taken from Gelingüllü Dam, brought to the laboratory in ice-filled Styrofoam boxes, and analyzed for their nutritional composition and fatty acid content. Samples were taken from the WM, D, V, and C regions (FIG. 1). The protein content of the fish was analyzed using Kjeldahl method [13]. Percentage of protein was determined using the Kjeldahl conversion factor ($N \times 6.25$). Lipid content was determined using the method described by Bligh and Dyer [14]. AOAC methods 920.153 [15] and 950.46 [16] were applied for the determination of ash and moisture content, respectively.

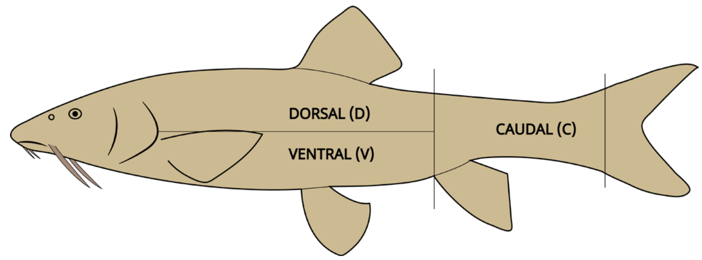

FIGURE 1. The different portions (dorsal, ventral and caudal) of crimean barbel (*Barbus tauricus*) used in the analysis

Fatty acid methyl ester analyses

Fatty acid methylester analysis of the lipid obtained according to the Bligh and Dyer method was performed using the method of Ichihara *et al.* [17]. The fatty acid composition was determined using gas chromatography Clarus 500 device (Perkin-Elmer, USA) equipped with a flame ionization detector and fused silica capillary SGE column (60 m × 0.32 mm ID BPX70 × 0.25 µm, USA or Australia). Fatty acids were identified depending on their arrival times of the FAME mixture (Supelco) consisting of 37 standard components (Supelco 37 FAME Mix C4-C24 Component, Catalog No. 18919).

RESULTS AND DISCUSSION

Analysis of the nutritional composition revealed that protein, moisture, and ash contents in fish were 18.61, 78.49, and 1.09%, respectively (TABLE I). Different lipid content was observed in muscle tissue samples taken from D, V, and C regions. The highest lipid content of 2.68% was found in C region, whereas the lowest lipid content of 1.54% was found in WM. Lipid content in the D and V regions were 2.34 and 1.71%, respectively (TABLE I).

TABLE I
Proximate composition (%) of the muscle tissue of crimean barbel (*Barbus tauricus*) in Gelingüllü Dam Lake

Name of fish	Composite	Whole (WM)	Dorsal (D)	Ventral(V)	Caudal(C)
Crimean barbel (*Barbus tauricus*)	Protein	18.61 ± 0.60			
	Lipid	1.54 ± 0.07	2.34 ± 0.33	1.71 ± 0.06	2.68 ± 1.76
	Moisture	78.49 ± 0.14			
	Ash	1.09 ± 0.10			

Data are shown as mean ± standard deviation (SD)

The protein content was 18.61% in this study. In studies conducted on other *Barbus* species and freshwater fishes revealed the protein content of 19.74 in *Carasobarbus luteus* [1], 15–21.6 in *Arabibarbus grypus* [18] and 15.78–22.50% in *Chelon auratus* [19], respectively, and 13–13.71% in female and male *Pangasianodon hypophthalmus* [20], 25 in *Piaractus mesopotamicus*, 20.73 in *Colossoma macropomum* and 16.79% in *Piaractus brachypomus* [21]. The main ingredients of fish meat are protein, lipid, and water. Generally, this composition includes 14–20 protein, 0.1–22 lipid, 66–84, water, and 0.8–2.0% minerals [19], respectively. The findings of the present study agree these values.

It was found that different lipid contents in different body parts of the fish. The highest and lowest lipid contents were 2.68 in C and 1.54% in WM regions, respectively (TABLE I). In previous studies, lipid content of *Barbus* species were reported as 5.07 in *Carasobarbus luteus* [1], between 1.34–4.57 in *Luciobarbus capito capito* [22], 1.13 in *Luciobarbus xanthopterus* [23] and 2.0–5.3% in *Arabibarbus grypus* [18]. Lipid contents vary depending on the species, sex, age, season, nutritional status, and living environment of the fish [19]. The lipid and protein content may vary, as they vary with muscle movement and nutritional composition [24]. The study conducted by Thammapat *et al.* [24] supported in this investigation, and they divided the fish body into seven parts: cranial–dorsal, central–dorsal, caudal–dorsal, cranial–ventral, central–ventral, and caudal–ventral. They found that the lipid content in these parts was different due to varying muscle movements and the movement of the fish. Moreover, lipids are not homogeneously distributed in the fish. Lean fishes store most lipids in the abdominal or liver tissue, whereas fat fishes store lipids in the form of globules between muscle tissues. While most lipids are used as energy sources, some portion of lipids participates in physiological events in different parts of the body [25].

The fatty acid composition of WM and different parts of the muscle tissues of crimean barbel (*Barbus tauricus)* caught from Gelingüllü Dam is given in TABLE II and FIG 2. The fatty acid composition of crimean barbel (*Barbus tauricus)* varied in muscle tissues of different body parts (P<0.05) from 21.94 to 23.03% for saturated fatty acid (SFA). The highest and lowest SFA levels were found in the WM and D regions, respectively. Monounsaturated fatty acid (MUFA) content varied between 33.73% and 36%, with the highest and lowest MUFA contents in the D and V regions, respectively. PUFA contents were 23.10, 22.62, and 24.24% in the WM, D, and V regions, respectively, and C region had the highest PUFA content of 25.63%. The highest EPA (4.11) and DHA (12.98%) contents were found in the V and C regions, respectively.

The total MUFA content was higher than total SFA and PUFA values in different muscle tissues and WM of crimean barbel (*Barbus tauricus)* (P<0.05). The highest total MUFA content of 36.0% was found in the D region (TABLE II and FIG. 2). Oleic acid (C18:1n9), palmitoleic acid (C16:1), and cis-vaccenic acid (C18:1n7) were the most abundantly present MUFA in all groups. The highest amount of oleic acid and palmitoleic acid was found in the D region. Total MUFA detected in this investigation is similar those reported for freshwater fish, including *Arabibarbus grypus* (35.2–44.2), *Luciobarbus capito capito* (19.3–23.4), *Luciobarbus xanthopterus* (33.79), *Salmo trutta macrostigma* (between 22.17–37.48), *Scardinius erythrophthalmus* (30.33), and *Anguilla anguilla* (47.28%) [18, 22, 23, 26, 27, 28].

The maximum and minimum values of the main SFAs were palmitic acid (C16:0; 13.63% in C; 14.15% in V), stearic acid (C18:0; 3.74 in D; 4.87% in WM), followed by myristic acid (C14:0; 1.90 in V; 2.13% in D) in whole and different parts of the fish. The highest and lowest total SFA levels were found in the WM (23.03) and D (21.94%) regions, respectively. Total SFA values detected in this study were similar those reported for freshwater fishes, including *Arabibarbus grypus* (29.1–34.4), *Luciobarbus capito capito* (14.7–23.6), *Luciobarbus xanthopterus* (33.17), *Salmo trutta macrostigma* (29.26–35.75), *Chelon auratus* (24.74–33.95), *Chelon labrosus* (30.27–33.67%), and *Tinca tinca* (29.59–33.71%) [18, 19, 26, 27, 29].

Total PUFA contents of crimean barbel (*Barbus tauricus*) were 23.10, 22.62, 24.24, and 25.63% in the WM, D, V, and C regions, respectively. The highest and lowest total PUFA values were found in the C and D

TABLE II

Total (%) fatty acid compositions in different part body muscle tissues of the crimean barbel (*Barbus tauricus*) caught from Gelingüllü Dam Lake

Fatty acids	Whole muscle (WM)	Dorsal (D)	Ventral (V)	Caudal (C)
C12:0	0.09±0.01^{ab}	0.10±0.01^{a}	0.08±0.01^{c}	0.09±0.08^{bc}
C14:0	2.09±0.05^{a}	2.13±0.04^{a}	1.90±0.09^{b}	1.92±0.11^{b}
C15:0	0.93±0.03^{a}	0.94±0.02^{a}	0.84±0.02^{b}	0.86±0.03^{b}
C16:0	14.05±0.21^{a}	14.04±0.12^{a}	14.15±0.17^{a}	13.63±0.05^{b}
C17:0	0.52±0.02^{ab}	0.53±0.00^{a}	0.50±0.01^{b}	0.50±0.01^{b}
C18:0	4.87±0.09^{a}	3.74±0.27^{b}	4.85±0.17^{a}	4.80±0.38^{a}
C20:0	0.29±0.01^{a}	0.27±0.01^{a}	0.26±0.03^{a}	0.28±0.02^{a}
C22:0	0.10±0.01^{b}	0.11±0.01^{b}	0.12±0.01^{a}	0.10±0.01^{b}
C24:0	0.09±0.01^{a}	0.07±0.01^{a}	0.07±0.02^{a}	0.09±0.03^{a}
ΣSFA	**23.03±0.39^{a}**	**21.94±0.28^{c}**	**22.76±0.06^{ab}**	**22.25±0.25^{bc}**
C14:1	0.39±0.01^{ab}	0.40±0.01^{a}	0.35±0.03^{bc}	0.34±0.03^{c}
C15:1	0.33±0.02^{ab}	0.35±0.01^{a}	0.29±0.02^{b}	0.29±0.04^{b}
C16:1	9.86±0.14^{b}	10.57±0.30^{a}	9.50±0.50^{b}	9.51±0.45^{b}
C17:1	0.32±0.01^{a}	0.32±0.00^{a}	0.29±0.03^{a}	0.29±0.04^{a}
C18:1n9	15.50±0.32^{ab}	16.15±0.38^{a}	15.17±0.33^{b}	14.81±0.41^{b}
C18:1n7	6.17±0.06^{a}	5.95±0.23^{a}	5.87±0.31^{a}	6.28±0.14^{a}
C20:1n9	1.74±0.04^{a}	1.73±0.04^{a}	1.72±0.02^{a}	1.77±0.05^{a}
C22:1n9	0.48±0.01^{a}	0.47±0.01^{a}	0.48±0.02^{a}	0.49±0.03^{a}
C24:1n9	0.05±0.01^{a}	0.06±0.01^{a}	0.05±0.01^{a}	0.09±0.06^{a}
ΣMUFA	**34.84±0.47^{ab}**	**36.00±0.92^{a}**	**33.73±0.87^{b}**	**33.86±1.01^{b}**
C18:2n6	3.50±0.09^{a}	3.62±0.06^{a}	3.36±0.11^{a}	4.39±1.63^{a}
C18:3n6	0.43±0.01^{a}	0.43±0.02^{a}	0.39±0.01^{b}	0.40±0.02^{b}
C18:3n3	2.15±0.10^{ab}	2.26±0.04^{a}	1.99±0.08^{c}	2.05±0.09^{bc}
C20:2 cis	0.08±0.08^{ab}	0.04±0.02^{b}	0.13±0.07^{ab}	0.17±0.02^{a}
C20:3 n6	0.87±0.02^{ab}	0.89±0.02^{a}	0.83±0.03^{b}	0.86±0.03^{ab}
C20:4 n6	0.67±0.02^{a}	0.66±0.03^{a}	0.63±0.03^{a}	0.67±0.01^{a}
C20:5n3	3.86±0.02^{b}	3.95±0.07^{ab}	4.11±0.09^{a}	4.00±0.19^{ab}
C22:2 cis	0.19±0.05^{a}	0.12±0.01^{a}	0.11±0.01^{a}	0.11±0.01^{a}
C22:6 n3	11.46±0.66^{bc}	10.65±0.60^{c}	12.69±0.34^{ab}	12.98±1.13^{a}
ΣPUFA	**23.10±0.53^{a}**	**22.62±0.53^{a}**	**24.24±0.16^{a}**	**25.63±2.98^{a}**
PUFA/SFA	1.00±0.04^{b}	1.03±0.01^{ab}	1.07±0.01^{ab}	1.15±0.13^{a}
Σn-3	17.47±0.58^{ab}	16.86±0.61^{b}	18.79±0.21^{a}	19.03±1.41^{a}
Σn-6	5.47±0.13^{a}	5.60±0.10^{a}	5.21±0.15^{a}	6.32±1.63^{a}
n6/n3	0.31±0.02^{a}	0.33±0.02^{a}	0.28±0.01^{a}	0.33±0.06^{a}
DHA	11.46±0.66^{bc}	10.65±0.60^{c}	12.69±0.34^{ab}	12.98±1.13^{a}
EPA	3.86±0.02^{b}	3.95±0.07^{ab}	4.11±0.09^{a}	4.00±0.19^{ab}
DHA/EPA	2.97±0.18^{ab}	2.70±0.13^{b}	3.09±0.14^{a}	3.24±0.15^{a}

Data are shown as mean±standard deviation (SD). SFA: saturated fatty acid; MUFA: monounsaturated fatty acid; PUFA: polyunsaturated fatty acid; DHA: docosahexaenoic acid; EPA:eicoesapentaenoic acid; Σn-6 PUFA: total n-6 polyunsaturated fatty acid; Σn-3 PUFA: total n-3 polyunsaturated fatty acid. Different letters ($^{a-c}$) in the same row for each fish indicate significant differences in TABLE II (P<0.05)

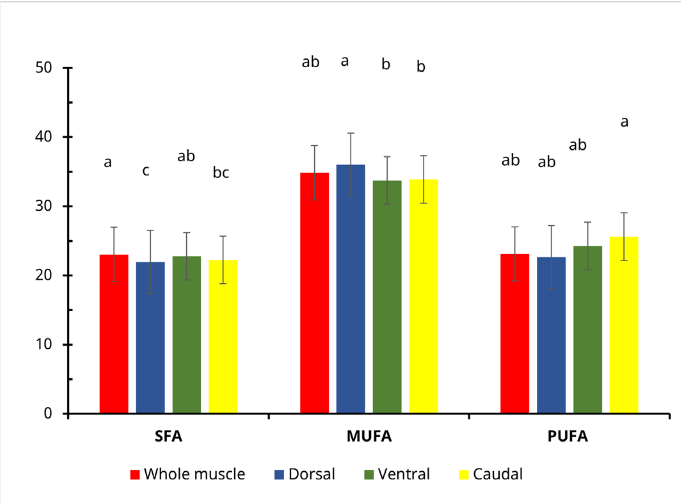

FIGURE 2. Total SFA, MUFA and PUFA values of muscle tissues in WM, D, V and C regions of *Barbus tauricus*

regions, respectively. Total PUFA values detected in this study were similar to the studies in the literature. Total PUFA values of *Arabibarbus grypus* (19.2–26.1), *Luciobarbus capito capito* (25.9–32.2), *Luciobarbus xanthopterus* (32.97), *Scardinius erythrophthalmus* (20.47), and *Anguilla anguilla* (22.15%) were in line within this research [18, 22, 23, 26].

C22:6n-3 (DHA) and C20:5n3 (EPA) were the most abundant PUFA in all groups. In this study, the highest and lowest DHA values were found in the C (12.98%) and D (10.65%) regions, respectively. In other freshwater fishes, including *Arabibarbus grypus* (5.2–10.8), *Salmo trutta macrostigma* (7.27–22.55), *Scardinius erythrophthalmus* (3.72), and *Anguilla anguilla* (9.24%), the reported DHA contents were similar to this investigation [18, 26, 27]. The highest EPA content was 4.11% in the V region in this study. EPA values found in freshwater species such as *Arabibarbus grypus* (2.7–3.7), *Scardinius erythrophthalmus* (5.68), and *Anguilla anguilla* (3.87%) in previous studies are in accord with this study [18, 26].

N-3 fatty acids such as EPA and DHA are first synthesized in water by the algae, *Chlorella pyrenoidosa* and *Dunaliella salina*, and the cyanobacteria *Arthrospira platensis*, and then accumulated in fish by the food chain. This accumulation makes fishes rich in EPA and DHA [2]. Content of fatty acids can vary depending on environmental, ecological, and morphological factors, as well as on natural diet and dietary habits [30, 31]. The different content of fatty acids among fish species may be due to these factors. The n-6/n-3 ratio is recommended as 4 by nutritionists [32]. Consuming these fatty acids more than the maximum level is dangerous to human health and can cause cardiovascular diseases [33]. In this study, ω6/ω3 ratio was 0.28–0.33, which did not exceed the maximum recommended level, in all body regions including D, A, and V regions in this fish species. Based on the nutrient content and fatty acid composition, it can be concluded that this species is nutritious and beneficial for human health.

CONCLUSIONS

In this study was found that lipid and fatty acid contents varied in different body regions of the fish. The caudal muscle part (C) (2.68%) of crimean barbel (*Barbus tauricus*) the highest lipid content, followed by D (2.34), V (1.71), and WM regions (1.54%). *Barbus tauricus* had 18.61% protein, 78.49% moisture, and 1.09% ash. The results of the study revealed that total monounsaturated fatty acid (MUFA) various between 33.73 and 36%, values were higher than those of total saturated fatty acids (SFA) of 21.94–23.03%) and polyunsaturated fatty acid (PUFA) of 22.62–25.63% in all whole muscle (WM) and different regions (D, V, and C) of the crimean barbel. The highest SFA, MUFA, and PUFA amounts were in WM, D, and C regions, respectively. The highest EPA (4.11%) value was detected in the D region while the highest DHA (12.98%) value was in the C region. The results of this study showed that this fish species can be a beneficial food source for human health, even if all or only a part is consumed, considering its nutritional composition, PUFA, EPA and DHA values and PUFA ω6/ω3 ratio. However, further studies are needed to study the seasonal fatty acid composition to help consumers in making informed fish-consumption choices and to elucidate the extent of variation in fatty acid composition of fish caused by ecological and physiological factors.

Conflict of interest

The authors have no declaration of competing interests.

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