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Determination of Fatty Acid Composition, Cholesterol and Fat-soluble Vitamin Levels of *Capoeta trutta*, *Luciobarbus mystaceus* and *Luciobarbus esocinus* Caught from the Keban Dam Lake, Elazığ, Türkiye

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Abstract

The fatty acid composition, cholesterol and fat-soluble vitamin levels in the muscle tissue of economically important freshwater fish *Luciobarbus esocinus, Capoeta trutta* and *Luciobarbus mystaceus* were investigated. The analysis of fatty acid methyl esters was carried out by gas chromatography, and cholesterol and fat-soluble vitamin amounts were determined by high-performance liquid chromatography (HPLC). Among polyunsaturated fatty acids (PUFA), eicosapentaenoic acid (EPA, C20:5n-3) was found to be higher in *C. trutta* (14.84%) compared to the other fish species, while the highest amount of docosahexanoic acid (DHA, C22:6n-3) was determined in *L. mystaceus* (20.43%). While the maximum amount of total n-3/n-6 PUFA ratio was determined for *C. trutta* with 4.64%, it was determined that the sum of EPA and DHA from n-3 series fatty acids was higher in *C. trutta* with 31.74%. When the fat-soluble vitamin and cholesterol levels of the species were compared, it was found that the difference between the amounts of δ-tocopherol, α-tocopherol, D3, K1, K2 and cholesterol did not differ between the species. In conclusion, *L. esocinus, C. trutta* and *L. mystaceus* living in the Keban Dam Lake are valuable food source in terms of fatty acids, vitamin and cholesterol. It is thought that the findings of this study is beneficial for researchers and fish consumers.

Introduction

Fish and other aquatic organisms are an important food source in terms of containing essential fatty acids, vitamins, low amounts of saturated fatty acids and cholesterol. They have important roles as metabolic sources. The fatty acids found in fish are rich in a longchain, highly unsaturated fatty acids (HUFA). The fatty acids of fish lipids are rich in w-3 and w-6 fatty acids. For this reason, it has physiologically important effects on the nutrition of animals and humans. Many studies have reported that w-3 polyunsaturated fatty acids have hindering influences on heart illness, antithrombotic, atherosclerosis, and antiarrhythmic diseases (Belluzzi, 2001; Lee *et al*., 2006; Tocher, 2003). Although freshwater fish species and marine fish are similar in terms of some biochemical features, it has been stated that there may be differences in some physiological functions and fatty acid composition. (Ackman, 1997). The researches in the literature indicate that freshwater fish are rich in polyunsaturated fatty acids (Özyılmaz and Palalı 2014; Uysal *et al*., 2008; Kıztanır, 2006; Gözü Dağtekin *et al*., 2018; Kaçar and Başhan 2017). The tissues of freshwater and marine fish

are generally rich in C20 and C22 fatty acids, especially 20:5n-3 and 22:6n-3. It has been reported that 18:3n-3 fatty acids are used in the synthesis of 20:5n-3 and 22:6n-3 fatty acids in rainbow trout, possibly also in other freshwater fish species (Tocher, 2003).

The fat-soluble vitamins (A, D, E, K) in fish lipids are essential components supplied only by diet. Retinol regulates gene expression and is important for maintaining resistance to infections, new cell formation in growth, and normal vision. Vitamin D is essential for calcium and phosphorus metabolism. Vitamin E, also known as tocopherol, is an antioxidant. Vitamin K is important in blood coagulation (Lovell, 1998). Cholesterol is an organic compound found in the cell membrane of the tissues of all animals and has an important effect on the metabolism of the human body. Studies have shown that cholesterol is needed for the synthesis of some hormones. Cholesterol is mostly found in animal foods, but a small amount of cholesterol in the human body is taken from the outside as food, and the rest is synthesized by the human body (Gönç *et al.*, 1996).

Fatty acids in fish vary according to the sex of the fish, species, feeding conditions, geographical region and seasonal factors (Christiansen *et al*., 1989; Yılmaz *et al*., 1995). Fat-soluble vitamins, fatty acids and cholesterol are substantial in evaluating the nutritional status of different fish species. Four large species groups constitute 85% of the world's total catch in inland waters. The first of these groups is "barbels, carps and other cyprinids". The catch of these species has demontsrated a steady enhancement from around 0.6 million tonnes per year in the mid-2000s to over 1.8 million tonnes in 2018. They account for most of the increase in inland fisheries in latest years (FAO, 2020). The amount of inland fisheries caught in Turkey was 33 thousand tons in 2021 (TUIK, 2022). On the other hand, *Luciobarbus esocinus, Capoeta trutta* and *Luciobarbus mystaceus*, which belong to the Cyprinidae family living in the Tigris and Euphrates rivers, are fish species with economic importance. *Luciobarbus esocinus* and *C. trutta* are widely distributed especially in the Middle East countries Turkey, Iran, Iraq and Syria (Düşükcan & Çalta, 2012; Kuru, 1979). Therefore, these species are important for the region**.** In this study, it was aimed to define the fatty acids, cholesterol and fat-soluble vitamins (A, D, E, K) found in muscle tissue of *C. trutta, L. mystaceus* and *L. esocinus*.

Materials and Methods

Fish and Experimental Design

In this study, the samples of *L. esocinus, C. trutta* and *L. mystecaus* were obtained from the fishermen fishing, in January 2021 from Aydıncık hunting place of the Keban Dam Lake (38° 48' 23.67''N and 38° 46' 23.88''E; the surface area is 675 km^2) accommodate on the Euphrates River, which is the second-largest artificial lake in Türkiye, (Figure 1).

Six fish of each species were used. The fish were maintained in a deep freezer at -20°C until analysis. The total length and weight of the fish were determined. Total length for *L. esocinus* 36.68±0.39 cm, mean weight 583±26 g, length for *C. trutta* 34.86±0.60 cm, mean weight 449±15.20 g, length for *L. mystaceus* 41.8±0.93 cm, mean weight was determined as 632±33.4 g.

Fatty Acid, a Fat-soluble Vitamin, and Cholesterol Analysis

Analysis of Fatty Acids

The muscle lipids were extracted with hexane-isopropanol (3:2, v/v) by the methodof Hara and Radin (1978). One gram sample was homogenized with a 10 ml hexane-isopropanol mixture. The homogenate was centrifuged at 5000 rpm for 5 min at 4°C and parts of tissue remnants were precipitated. The supernatant part was used in the analysis of fat-soluble vitamins (A, D, E, and K), cholesterol, and fatty acids. Fatty acids in the lipid extracts were converted into methyl esters with

Figure 1. Map of the sampling area (URL, 1)

2% sulphuric acid (v/v) in methanol (Christie, 1992). The mixture was vortexed and then kept at 50°C for 12 h. Then, after being cooled to room temperature, 5 ml of 5% sodium chloride was added and then it was vortexed. Fatty acid methyl esters were extracted with 2x5 ml hexane. Fatty acid methyl esters were treated with 5ml 2% KHCO3 solution and then the hexane phase was evaporated by the nitrogen flow and then by dissolving in 0.5 ml fresh hexane (Christie, 1992), they were taken to autosampler vials.

Analysis of fatty acid methyl esters was performed in a Shimadzu GC-17 A Ver. 3 gas chromatograph (Kyoto, Japan). For analysis, 25 m of long Machery-Nagel (Germany) capillary column with an inner diameter of 0.25 µm and a thickness of 25 micron film was used. The colon temperature was kept at 120-220°C, injection temperature was kept at 240°C and the detector temperature was kept at 280°C. The nitrogen carrier gas flow was 1 mL/min. The nitrogen carrier gas flow was 1 ml min^{-1}. The methyl esters of fatty acids were identified by comparison with authentic external standard mixtures analyzed under the same conditions, and the Class GC 10 software version 2.01 was used to process the data.

Analysis of A, D, E and K Vitamins and Cholesterol

Five ml supernatant was taken to 25 ml tubes with caps and 5% KOH solution was added and vortexed for 20 s. The tubes were placed in a water bath at 85°C for 15 min. The tubes were then taken and cooled to room temperature and 5 ml of distilled water was added and mixed. Lypophilic molecules that did not saponify were extracted with 2x5 ml hexane. The hexane phase was evaporated with nitrogen flow. It was dissolved in 1 mL acetonitrile/methanol mixture (50+50%, v/v) and then was taken to autosampler vials and analyzed. The analysis was done with the Shimadzu HPLC device. HPLC conditions were as follows: mobile phase 60:38:2 (v/v/v): acetonitrile/ methanol/water; The mobile phase flow rate was determined to be 1mL A UV detector was used for the analysis and as a column the Supelcosil LC 18 (15×4.6cm 5µm; Sigma USA) column was used. For vitamin E and cholesterol 202nm, retinol, 326nm and vitamin D and K 265 nm were used (Katsanidis & Addis, 1999; L'opez-Cervantes *et al*., 2006)

Statistical Analysis

The data on the fatty acid composition, fat-soluble vitamin, and cholesterol provided from *L. esocinus, C. trutta* and *L. mystaceus* muscle were analyzed statistically using one-way analysis of variance (ANOVA), followed by Duncan's new multiple range test. Significant differences were based on the P<0.05 level. The results were expressed as means ± standard error. Analyses were applied using the statistical program (SPSS 16.0).

Results

Fatty Acids

The amount of fatty acids, n-3 and n-6 series fatty acids and the n-3/n-6 ratio in the muscle of *L. esocinus, C. trutta* and *L. mystaceus* species are given in Table 1. Total saturated fatty acids (SFA), monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA), amounts in fatty acids were investigated. The total amount of PUFA was found to be higher than SFA and MUFA in all three fish species in the present study. It was found that the total amount of PUFA in *C. trutta* was 46.87%, which was statistically higher than the other fish (P<0.05). However, the amount of PUFA did not differ statistically between *L. esocinus* and *L. mystaceus* (P>0.05). While the total SFA amount was determined as 27.12% in *L. mystaceus*, it was determined that this amount was statistically higher than the other fish species in the study (P<0.05). The amount of total MUFA was found to be 24.57% in *C. trutta* and statistically lower than the amounts determined in other fish species (P<0.05).

Among the saturated fatty acids, palmitic acid (C16:0) and stearic acid (C18:0) amounts were determined to be the highest amount of saturated fatty acid in the fish species in the study. On the other hand, the amount of myristic acid (C14:0) was found to be 3.04% in *L. esocinus* and statistically higher than other species (P<0.05). It was obtained that the level of oleic acid (C18:1n-9) was 20.18% and 17.49% in *L. esocinus* and *L. mystaceus*, respectively, and it was statistically higher than the amount in *C. trutta* (12.27%) (P<0.05). The palmitoleic acid (C16:1) ratio did not diverge between the fish species studied (P>0.05). Parallelly, the amounts of arachidonic acid (C20:4n-6) polyunsaturated fatty acids did not differ statistically between the fish species (P>0.05). The levels of arachidonic acid, ARA/EPA and ARA/DHA are given in Figure 2. It was also determined that the ARA/EPA ratio was 0.51% in *C. trutta* and 1.31% and 1.62% in *L. esocinus* and *L. mystaceus*, respectively. It was determined that the amount of *C. trutta* was statistically lower than the other fish species (P<0.05). On the other hand, ARA/DHA amounts were found to be significantly higher in *L. esocinus* by 0.54% compared to the other fish (P<0.05). This amount was determined as 0.43% in *C. trutta* and 0.39% in *L. mystaceus*. The amount of EPA+DHA in *C. trutta* was higher than in the other species (P<0.05) (Table 1).

Total n-3 series fatty acids were obtained to be 38.49% in *C. trutta*. This amount was significantly upper when compared to the total n-3 series fatty acids determined in *L. esocinus* and *L. mystaceus* (P<0.05). Total n-6 series fatty acids were found to be 11.77% in *L. esocinus* and the difference was significant when compared to the other fish species (P<0.05). In fish meat; while the n-3/n-6 ratio was determined the highest in *C. trutta* with 4.64%, it was determined as

3.02% and 2.26% in *L. mystaceus* and *L. esocinus*, respectively. It was observed that these ratios among fish species differed statistically (P<0.05).

Fat-soluble Vitamins and Cholesterol

The amount of fat-soluble vitamins and cholesterol found in *L. esocinus, C. trutta* and *L. mystaceus* muscle are given in Table 2.

Discussion and Conclusion

The amount of fatty acids in fish differs depending on the fish species and environmental factors. In the literature, the fatty acid profile of both freshwater fish and marine fish was determined and it was stated that the differences were at a significant level. For example, the fatty acids of *Carassius gibelio, Ctenopharyngodon idella* and *Capoeta trutta* fish caught from the Atatürk Dam Lake were determined by Özyılmaz and Palalı (2014). While the amount of SFA in these fish species was determined as 28.52, 29.52 and 30.24, respectively, the SFA fatty acids with the highest amount were palmitic acid (C16:0), stearic acid (C18:0), myristic acid (C14:0) has been reported. The amount of monounsaturated fatty acids *C. gibelio, C. idella* and *C. trutta* species are reported to be 21.34, 30.69 and 31.16, respectively, and the MUFA components C16:1n-7, C16:1n-9, C18:1n7 and C18:1n-9 fatty acids differ between species. Also, high amounts of palmitic acid and oleic acid were determined in fish such as *Rutilus rutilus, Barbus plebejus escherichi* and *C. capoeta* caught from the Porsuk Dam Lake (Uysal *et al*., 2008). Similarly, in this study, the most abundant SFA and MUFA fatty acids in *L. esocinus, C. trutta L. mystaceus* muscles were palmitic acid (C16:0), stearic acid (C18:0) oleic acid (C18:1n-9) and palmitoleic acid (C16:1n-7). It was observed that palmitic acid and oleic acid amounts in freshwater fish are higher than those of marine fish (Rahman *et al*., 1995).

Fatty acid levels were investigated in fish caught from the Atatürk Dam Lake by Kaçar and Başhan (2016). While the lipid content was determined as high in *C. trutta*, the amount of SFA was determined as 29.77%, MUFA 40.74% and PUFA 29.41% in this species. In another similar study, the muscle and liver tissue total lipid, phospholipid and triacylglycerol fatty acid composition of *C. trutta* caught from the Atatürk Dam Lake was investigated by Kaçar & Başhan (2017). They found that the amounts of SFA, MUFA and PUFA in muscle as 34.52, 34.63 and 30.75, respectively. However, in the present study, the highest amount of PUFA in *C. trutta* was determined as 46.87%, followed by SFA at 26.49% and MUFA at 24.57%. It is thought that the difference in fatty acids may be due to the season and the differences in the nutrients in the water. In addition, the level of n-3/n-6 PUFA in *C. trutta* was determined as 4.64. Fatty acids of C20:5n-3 and C22:5n-3 were observed to be high. In the study conducted by Kaçar and Başhan (2016), the level of n-3/n-6 PUFA in *C. trutta* caught in November was determined as 4.71, which is consistent with the finding in our study. However, in another study carried out in the same habitat by Kaçar and Başhan (2017), the n-3/n-6 PUFA ratio in *C. trutta* caught in May was determined as 5.95.

It is reported by Kıztanır (2006) that the amount of C18:1n-9, oleic acid, which is one of the fatty acids determined in the meat of *Cyprinus carpio* fish in January, is 22.84% and the amount is higher than other fatty acids. On the other hand, it was determined that the amount of palmitic acid (C 16:0, 14.79% - 16.63%) and the amount of palmitoleic acid (C16:1, 11.13% - 14.6%) were high. In this study, oleic acid was determined as 20.18% in *L. esocinus* species and 17.49% in *L. mystaceus* species, while it was found in lower amounts as 12.27% in *C. trutta* and different species and diets are thought to cause this difference. The amount of palmitic acid was determined as 16.76%, 18.07% and 19.39% in this study, while the amount of palmitoleic acid was 7.94%, 6.51% and 6.91%.

It has been reported that EPA and DHA, which are polyunsaturated fatty acids, have important effects in the prevention of coronary artery diseases and stroke (Hollander *et al.*, 2019). In this study, the amount of EPA

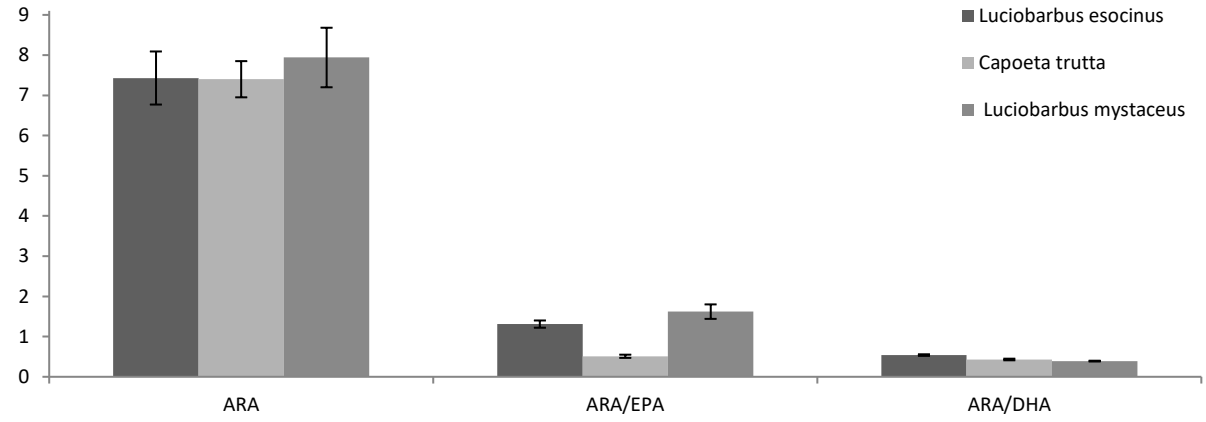

Figure 2. Ratio of arachidonic acid (ARA), arachidonic acid to eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) determined in muscle tissue of *L. esocinus, C. trutta* and *L. mystaceus*

determined especially in *C. trutta* fish was found to be 14.84%, on the other hand, the amount of DHA was found to be higher at 20.43% in *L. mystaceus*.

The rate of Σ n-3/ Σ n-6 fatty acids in fish is generally applied as an index to assess nutritional quality (Chen & Zhang, 2007). Long-chain n-3 fatty acids are important for healthy nutrition (Zmijewski *et al*., 2006). The rate of Σ n-3/ Σ n-6 fatty acids by Özparlak (2013) was 3.19, 2.36, 2.08 and 1.06 in *Sander lucioperca, Carassius gibelio*, *Leuciscus lepidus* and *C. carpio* fish caught from Apa Dam Lake, respectively. It is set to Çitil et al. (2014) the n-3/n6 ratio in *C. carpio* (Işıklı Dam Lake), *Tinca tinca, Scardinius erythrophthalmus, C. carpio* (Karacaören) and *Carassius carassius* species was 2.12, 1.19, 2.15, 2.87 and 2.82, respectively. Bayar *et al*., (2021) determined the rate of n-3/n-6 polyunsaturated fatty acids be 2.29 in *A. anguilla* and 1.48 in *S. erythrophthalmus*. Gözü Dağtekin *et al*. (2018) studied the amount of fatty acids in *Carassius gibelio* fish. They determined that the rate of Σ n-3/ Σ n-6 fatty acids was 1.99 in the fish caught in the autumn, and this ratio was 1.47 in the fish caught in the spring and summer months. In a different study, this rate was found to be slightly higher at 5.95 in *C. trutta* caught from the Atatürk Dam Lake (Kaçar & Başhan, 2017). It was determined that this ratio was 4.71 in *C. trutta* fish caught from the Atatürk Dam Lake and 1.22 in *C. gibelio*. The total n3/n6 ratio was found to be 4.55 in *Salmo trutta* obtained from the Munzur River (Kayım *et al*., 2011). In this study, the rate of Σ n-3/ Σ n-6 fatty acids was determined as 4.64 in *C. trutta*, 2.26 in *L. esocinus* and 3.02 in *L. mystaceus*. The n-3/n-6 ratio in polyunsaturated fatty acids is

Table 1. Fatty acid composition (mean ± SE) in the muscle in *L. esocinus, C. trutta* and *L. mystaceus*

Fatyy acids (% total fatty acids)	*L. esocinus*	*C. trutta*	*L. mystaceus*
C14:0	3.04±0.29^{b}	0.63±0.04^{a}	1.15±0.25^{a}
C15:0	0.37±0.01^{a}	0.41±0.02^{a}	0.46±0.02^{b}
C15:1	0.86±0.11^{a}	2.44±0.23^{c}	1.75±0.22^{b}
C16:0	16.76±0.53^{a}	18.07±0.57^{ab}	19.39±0.38^{b}
C16:1n-7	7.94±0.61^{a}	6.51±0.49^{a}	6.91±0.48^{a}
C17:0	0.59±0.02	0.66±0.11	nd[1]
C17:1	0.71±0.09	0.51±0.02	nd
C18:0	4.31±0.45^{a}	6.93±0.40^{b}	6.19±0.47^{b}
C18:1n-9	20.18±1.03^{b}	12.27±1.63^{a}	17.49±1.09^{b}
C18:1n-7	1.04±0.05	nd	0.94±0.12
C18:2n-6	4.34±0.23^{c}	0.98±0.07^{a}	1.98±0.24^{b}
C18:3n-3	3.81±0.29^{c}	0.66±0.04^{a}	1.54±0.34^{b}
C20:1	1.04±0.07^{ab}	0.50±0.02^{a}	1.43±0.34^{b}
C20:3n-3	0.32±0.01^{a}	0.42±0.03^{ab}	0.50±0.10^{b}
C20:4n-6	7.43±0.66^{a}	7.40±0.45^{a}	7.94±0.74^{a}
C20:5n-3	5.62±0.19^{a}	14.84±1.32^{b}	4.95±0.30^{a}
C24:1	2.31±0.30^{a}	2.68±0.34^{a}	3.84±0.33^{b}
C22:5n-3	3.28±0.09^{a}	5.91±0.36^{b}	2.76±0.10^{a}
C22:6n-3	13.71±1.22^{a}	16.90±0.89^{ab}	20.43±1.71^{b}
C22:0	0.89±0.04	nd	nd
Σ SFA[2]	25.21±0.56^{a}	26.49±0.38^{ab}	27.12±0.62^{c}
Σ MUFA[3]	33.93±1.36^{b}	24.57±1.50^{a}	31.75±1.71^{b}
Σ PUFA[4]	38.36±1.58^{a}	46.87±2.45^{b}	39.53±2.03^{a}
Σ n-3	29.59±1.12^{a}	38.49±2.25^{b}	29.51±1.80^{a}
Σ n-6	11.77±0.51^{b}	8.38±0.48^{a}	9.93±0.62^{a}
Σ n-3/n-6	2.26±0.05^{a}	4.64±0.33^{c}	3.02±0.22^{b}
Σ n-6/n-3	0.44±0.01^{c}	0.22±0.03^{a}	0.34±0.06^{b}
PUFA/SFA	1.52±0.07^{ab}	1.77±0.10^{b}	1.46±0.09^{a}
EPA+DHA[5]	19.33±3.17^{a}	31.74±1.92^{c}	25.38±1.94^{b}

[1]nd: not determined [2] Total saturated fatty acids [3] Total monosaturated fatty acids [4] Total polyunsaturated fatty acids [5] C20:5n-3+ C22:6n-3
Note: There is no statistical difference between the same letters on the same line (P>0.05)

Table 2. Fat-soluble vitamin and cholesterol values determined in the muscle tissues of *L. esocinus, C. trutta* and *L. mystaceus* (mean±SE)

Vitamins (µg g $^{-1}$) Cholesterol (mg/100 g)	*L. esocinus*	*C. trutta*	*L. mystaceus*
Retinol	3.46±0.01 ^{a}	3.48±0.01 ^{a}	3.66±0.16 ^{b}
D3	2.83±0.28 ^{a}	2.63±0.29 ^{a}	1.87±0.42 ^{a}
δ-Tocophereol	5.37±0.67 ^{a}	6.14±0.63 ^{a}	6.70±0.16 ^{a}
α-Tocopherol	1.66±0.23 ^{a}	1.43±0.53 ^{a}	1.38±1.17 ^{a}
K1	4.10±0.81 ^{a}	4.95±0.44 ^{a}	5.74±0.92 ^{a}
K2	2.19±0.27 ^{a}	2.41±0.26 ^{a}	2.32±0.10 ^{a}
Cholesterol	26.36±20.99 ^{a}	28.99±19.94 ^{a}	25.15±36.7 ^{a}

Note: There is no statistical difference between the same letters on the same line (P>0.05)

important in healthy growth, development, prevention of heart diseases, and protection from diseases such as diabetes and cancer (Kaçar & Başhan, 2016). The n-3/n-6 ratio in freshwater fish can generally vary between 0.5 and 3.8. It varies depending on the fish species and diet (Wang *et al*., 1990). In addition, this rate is higher in fish living in the sea than in fish living in freshwater (Steffens & Wirth, 2005). It was reported that the rate of Σn-6/Σn-3 fatty acids in polysaturated fatty acids is a maximum of 4, which is important for heart health (HMSO, 1994). It is reported that values higher than the maximum amount may be detrimental to health and cause cardiovascular diseases. In this study, the rate of Σ n-6 / Σ n-3 fatty acids in *L. esocinus, C. trutta* and *L. mystaceus* fish was determined as 0.44, 0.22 and 0.34, respectively, and it was determined that they were suitable for healthy nutrition.

When evaluated in terms of polyunsaturated fatty acids and saturated fatty acids, a PUFA／SFA rate of 0.45 or more is recommended by the UK Ministry of Health for stable fatty acid intake in a healthy diet (Wood *et al.,* 2004). In the fish species analyzed in this study, this ratio varies between 1.46-1.77 and is above the recommended rate. PUFA／SFA ratio was determined as 1.35 in *Mastacembelus simack* and 1.11 in *Barbus grypus* (Harlıoğlu & Yılmaz, 2011; Harlıoğlu, 2014). The amount of fatty acids in *Carassius gibelio* fish was investigated by Gozu Dagtekin et al. (2018). The PUFA/SFA ratio was determined as 0.82, 0.84 and 0.71 in the samples taken in summer, autumn and spring, respectively.

Retinol, D 2, D 3, δ-tocopherol, α-tocopherol, K 1 and K 2 vitamin amounts 0.46 µg g $^{-1}$, 0.65 µg g $^{-1}$, 0.98 µg g^{-1} 0,52 µg g^{-1}, 26 µg g $^{-1}$, 0,41 µg g $^{-1}$ ve 5,01±1,67 µg g $^{-1}$, in *B. grypus* fish, respectively. The amount of cholesterol was determined as 46.4 mg/ 100 g (Harlıoğlu, 2014). In a different study investigating fat-soluble vitamins and cholesterol, the amounts of retinol, D2, D3, δ-tocopherol, α-tocopherol and K vitamins in *M. simack* were 0.53 µg g $^{-1}$, 0.79 µg g $^{-1}$, 1.36 µg, g $^{-1}$, 0.51 µg g $^{-1}$, 1.89 µg g $^{-1}$, 1.58 µg g $^{-1}$ respectively, while the amount of cholesterol was found to be 52.60 mg/100 g (Harlıoğlu &Yılmaz, 2011). Vitamins A, D and E have been determined in sea bass, salmon and rainbow trout. Vitamins A, D and E determined in sea bass are 36 µg/100 g, 5 µg/100 g and 0.17 mg/100 g, respectively, while in salmon 33 µg/100 g, 11 µg/100 g and 4.0 mg/100 g, in rainbow trout, these vitamins were determined as 8.8 µg/100 g, 19 µg/100 g and 0.13 mg/100 g, respectively (Dias *et al*., 2003).

The amounts of K1, K2, D2, D3 and α-tocopherol in *Esox lucius* species by Kandemir (2010) were 9,04 µg g $^{-1}$, 3,86 µg g $^{-1}$, 2,56 µg g $^{-1}$, 7,32 µg g $^{-1}$ ve 24,11 µg g $^{-1}$, respectively. Kandemir (2010) stated that high levels of α-tocopherol are a precursor of vitamin E and there was a potent relationship between PUFA and α-tocopherol. The amount of cholesterol in *Esox lucius* fish was determined as 146.4 mg/100 g by Kandemir (2010). Parlak *et al.* (2015) determined the amount of cholesterol (mg/100g) in chabut fish (*Arabibarbus grypus*) between 10.50 and 15.13 in different seasons. Cholesterol content by İmre and Sağlık (1998) (mg/100g) 43.4 sardines (*Sardina pilchardus*), 40.3 pandora (*Pagellus erytrinus*), 75.3 in sargo (*Diplodus sargus*), 63.4 mackerel (*Scomber scombrus*) determined for. In this study, the amount of cholesterol (mg/100g) was determined as 26.6, 28.9 and 25.1 in *L. esocinus*, *C. trutta* and *L. mystaceus*, respectively. The amount of cholesterol in the muscles of fish is affected by PUFAs, and the amount of cholesterol decreases with an increase in the amount of PUFA (Kinsella, 1986). In this study, it was observed that the amount of PUFA was high and the amount of cholesterol was low.

Fish meat is an important food for human health in terms of unsaturated fatty acids. Fatty acids such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), linolenic, stearidonic, docosapentaenoic fatty acids from n-3 series fatty acids, and linoleic acid, arachidonic acid from n-6 series fatty acids are effective in healthy nutrition. On the other hand, it has been stated that the n-3/n-6 ratio is of great importance along with the importance of n-3 series fatty acids in a healthy diet. Especially arachidonic acid from the n-6 series is known to be the precursor of prostaglandins from eicosanoids. For this reason, as a result of the present study it can be concluded that *C. trutta*, *L. mystaceus* and *L. esocinus* are valuable food sources in terms of n-3 and n-6 series fatty acids, vitamin and cholesterol.

In addition, it is thought that investigating the fatty acid compositions in the phospholipid fraction, triacylglycerol and phosphatidylinositol, phosphatidylcholine in *C. trutta, L. mystaceus* and *L. esocinus* will be useful in future studies.

Ethical Statement

This study was performed with the permission of Fırat University Animal Experiments Local Ethics Committee, dated 16.03.2020 and numbered 384967.

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Author Contribution

This study was conducted as a E V's masters' thesis, A G H provided supervision. EV and AGH conceived the idea. E V, Ö Y and G K organized the analyzes in the laboratory. EV, AGH and M M H performed the literature search and wrote the manuscript. M M H translated the manuscript from Turkish to English. All authors contributed to the article and approved the submitted version.

Note: This study was carried out as a part of master thesis of Enes VANLI

Conflict of Interest

The authors have no conflicts of interest to report.

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