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FATTY ACID COMPOSITION AND Ω3/Ω6 RATIOS OF THE MUSCLE LIPIDS OF SIX FISH SPECIES IN SUGLA LAKE, TURKEY

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Abstract- Fatty acid composition of the muscle lipids of *Carassius gibelio, Pseudophoxinus anatolicus, Sander lucioperca, Tinca tinca, Vimba vimba tenella* and *Capoeta capoeta* in Sugla Lake were determined. In all species, palmitic acid (13.25-18.54% of total fatty acids) and oleic acid (11.93-34.23% of total fatty acids) were identified as major saturated fatty acid (SFA) and monounsaturated fatty acid (MUFA), respectively. Docosahexaenoic acid (DHA) was found to be the major polyunsaturated fatty acid (PUFA) in *T. tinca, C. capoeta, C. gibelio, P. anatolicus* and *S. lucioperca* while the predominant PUFA of *V. vimba tenella* was eicosapentaenoic acid (EPA). *S. lucioperca* contained more ω3 fatty acids than the other fish species. The percentages of total ω3 fatty acids were higher than those of total ω6 fatty acids in all species. Since *P. anatolicus* is endemic and endangered, this species should be protected and produced for future marketing.

Key words: Fatty acid composition, ω3 fatty acids, fish species, Sugla Lake, Turkey

INTRODUCTION

Fish are a unique dietary source beneficial to human health. These valuable effects originate from ω3 polyunsaturated fatty acids, particularly the eicosapentaenoic acid (EPA) and DHA in the fish oil. Fish are a source of these ω3 fatty acids and are found abundantly in fish.

The quantities of EPA and DHA vary among and within a species according to environmental variables such as diet and whether fish are wild or farm raised (Kris-Etherton et al., 2002). DHA is recognized as a physiologically essential nutrient in the brain and retina for neural functioning and visual activity (Holub, 2001). Arachidonic acid and EPA are the parent compounds for the production of eicosanoids (Simopoulos, 2002). Additional health benefits from the consumption of fish or fish oil may be related to the PUFAs, especially ω3 PUFAs (Sidhu, 2003), which play a role in the prevention and treatment of heart disease, cancer, diabetes and inflammation (Atkinson et al., 1997; Connor, 2000; Hu et al., 2003). Long chain ω3 PUFAs cannot be synthesized by humans and must be obtained from the diet (Alasalvar et al., 2002). The valuable ω3 fatty acids are always present in fish flesh, even in lean fish (Ackman, 2002).

The fatty acid composition of fish lipids is influenced by diet, reproductive cycle, temperature, species, season, spawning and geographical location (Leger et al., 1977; Henderson and Tocher, 1987; Shirai et al., 2002; Çelik et al., 2005; Rasoarahona et al., 2005; Uysal and Aksoylar, 2005; Uysal et al., 2006; Guler et al., 2007; Guler et al., 2008; Bulut 2010; Bulut et al., 2010; Cengiz et al., 2010).

No reports have yet been published about the fatty acid composition of *T. tinca* (Linnaeus, 1758), *V. vimba tenella* (Nordmann, 1840), *C. capoeta* (Gueldenstaedt, 1773), *C. gibelio* (Bloch, 1782), *P. anatolicus* (Hanko, 1924) and *S. lucioperca* (Linnaeus, 1758) in Sugla Lake. As far as our literature survey could ascertain, there is no information on the fatty acid composition of *P. anatolicus*. The aim of this work is therefore to characterize and compare these species in terms of their fatty acid composition.

MATERIALS AND METHODS

Area and sample collection

Sugla Lake is a freshwater lake in Konya, Turkey. It is a large lake in Konya Province, southwestern part of Turkey. It is located at around 37°20′15″N 32°01′56″E, and has an area of 25-80 km². Zengin et al. (2008) determined the irrigation water quality and pollutions of some lake and dams including Sugla Lake in Turkey. They reported that the water samples evaluated were suitable for irrigation with respect to certain parameters. Sugla Lake is also an important wetland site for birds. *T. tinca*, *V. vimba tenella*, *C. capoeta*, *C. gibelio*, *P. anatolicus* and *S. lucioperca* are the most abundant fish species in this lake.

C. gibelio, *T. tinca*, *C. capoeta*, *P. anatolicus* and *V. vimba tenella* are members of the family Cyprinidae. *C. gibelio* is a freshwater omnivore fish. *P. anatolicus* is a species of ray-finned fish. Its natural habitat is freshwater lakes and it is endangered EN B2ab (iii, iv, v) (Crivelli and Erk'akan, 2005). It is endemic to Anatolia-Turkey and it should be included into the national threatened fish category (Özuluğ and Öztürk, 2008). *Capoeta* spp. is an important freshwater fish species, which is widely found in Turkey (Geldiay and Balık, 2007). *Tinca tinca* and *Vimba vimba* are freshwater and brackish water fish, respectively. *S. lucioperca* is one of the most valuable freshwater carnivorous percid fish in Europe, not only as food, but also for sport (Schulz et al., 2008). In Turkey, especially in Central Anatolia, *S. lucioperca* is a commercial fish species.

T. tinca, *V. vimba tenella, C. capoeta, C. gibelio*, *P. anatolicus* and *S. lucioperca* were obtained from Sugla Lake in April. Ten individuals were sampled in each species for fatty acid analyses. All fish were almost the same size and age. Fish were transported in ice to the laboratory and dorsal muscle tissues were taken as samples. The samples were frozen at -26°C until analyzed. At the beginning of analysis, the samples were allowed to equilibrate to room temperature.

Fatty acid analysis

Samples were extracted with chloroform/methanol (2:1 v/v) according to Folch et al. (1957). The fatty acids in the total lipid were esterified into methyl esters by saponification with 0.5 N methanolic NaOH and transesterified with 14% BF_3 (v/v) in methanol (Paquot, 1979).

Fatty acid methyl esters (FAMEs) were prepared from ten samples from each species. The FAMEs were analyzed on a HP (Hewlett Packard) Agilent 6890N model gas chromatograph (GC), equipped with a flame ionization detector (FID) and fitted with a HP-88 capillary column (100 m, 0.25 mm i.d. and 0.2 μm). Injector and detector temperatures were 240°C and 250°C, respectively. The oven was programmed at 160°C initial temperature and 2 min initial time. Thereafter the temperature was increased to 185°C at 4°C/min, then increased to 200°C at 1°C/min and held at 200°C for 46.75 min. Total run time was 70 min. The carrier gas used was helium (1 ml/min). GC analysis of FAMEs was performed in three replications.

Identification of fatty acids was carried out by comparing sample the FAME peak relative retention times with those obtained for Alltech (Carolean Industrial Drive, Satate Collage, PA) standards. Results were expressed as FID response area relative percentages. The results are given as mean ± SD in Table 1.

Statistical analysis

The results were submitted to analysis of variance (ANOVA), at 0.05 significance level, using SPSS 10.0.

The mean values were compared by Tukey's test.

RESULTS AND DISCUSSION

The fatty acid composition in the muscles of *T. tinca*, *V. vimba tenella*, *C. capoeta, C. gibelio*, *P. anatolicus* and *S. lucioperca* are presented in Table 1. Thirty-eight fatty acids were identified and evaluated in the fish samples.

DHA was the major fatty acid in *S. lucioperca* (22.48%) and *C. capoeta* (17.65%). Jankowska et al. (2003) stated that DHA in *S. lucioperca* meat is high and independent of the food DHA content. This fatty acid was determined as the predominant fatty acid in *S. lucioperca* (Jankowska et al., 2003; Özogul et al., 2007). Concerning *C. gibelio*, *T. tinca* and *V. vimba tenella*, oleic acid was the major fatty acid. Similarly, oleic acid was identified as the major fatty acid in *Carassius carassius*, in Porsuk Dam Lake, Turkey (Donmez, 2009) and in *Vimba vimba tenella* in Eğirdir Lake, Turkey (Kalyoncu et al., 2009). Oleic acid was also the predominant fatty acid in the cyprinid fish species, *C. carpio* (Donmez, 2009). In the present study, palmitic acid was the most abundant fatty acid in *P. anatolicus*.

In the present study, the major SFA was palmitic acid and other predominant SFAs were stearic and myristic acid in all species. These results were similar to those reported by Çelik et al. (2005) for *S. lucioperca*, Donmez (2009) for *C. carassius* and *T. tinca,* Kalyoncu et al. (2009) for *V. vimba tenella,* Uysal et al. (2008) for *Capoeta capoeta capoeta*. In the present study, total SFAs in *P. anatolicus* (26.33%) were higher than those of *S. lucioperca* (25.71%), *C. gibelio* (24.56%), *T. tinca* (24.41%), *V. vimba tenella* (23.45%) and *C. capoeta* (21.36%). Total SFA was determined as 32.9% in *S. lucioperca* obtained from the Seyhan Dam Lake (Çelik et al., 2005), 27.84% in wild *S. lucioperca* (Jankowska et al., 2003), 32.92% in *Carassius carassius* (Donmez, 2009), 32.86% in *T.tinca* (Donmez, 2009), 24.2-29.3% in *V. vimba tenella* (Kalyoncu et al., 2009) and 30.99-31.49% in *C. capoeta capoeta* (Uysal et al., 2008).

The predominant MUFA was oleic acid and it was followed by palmitoleic acid in all the species. Similar results were observed by Özogul et al. (2007) and Guler et al. (2007) for *S. lucioperca*, Donmez (2009) for *C. carassius*, Uysal et al. (2008) for *C. capoeta capoeta* in Porsuk Dam Lake, Turkey, Özogul et al. (2007) and Donmez (2009) for *T. tinca,* Kalyoncu et al. (2009) for *V. vimba tenella*. Higher levels of palmitoleic acid have been described as a characteristic of freshwater fish (Ackman, 1967). In the present study, the oleic acid in *V. vimba tenella* (34.23%) was significantly higher than in the other species. Total MUFA in *V. vimba tenella* (55.89%) was also significantly higher than in the other species. The high level of oleic acid in comparison to *S. lucioperca*, *P. anatolicus*, *C. gibelio*, *T. tinca* and *C. capoeta* increased the total MUFA in *V. vimba tenella*. Total MUFA was reported as 32.21% in *C. carassius* (Donmez, 2009), 21.36% in wild *S. lucioperca* (Jankowska et al., 2003), 20.3% in *S. lucioperca* in Eğirdir Lake (Çelik et al., 2005), 30.77% in *T. tinca* (Donmez, 2009), 34.17-41.09% in *C. capoeta capoeta* (Uysal et al., 2008) and 40.4- 45.3% in *V. vimba tenella* (Kalyoncu et al., 2009).

In the present study, *S. lucioperca* was rich in PUFA, especially DHA, arachidonic acid, EPA, docosapentaenoic acid (DPA) and linoleic acid. These results matched with Uysal and Aksoylar (2005), who reported that EPA, DHA and arachidonic acid are the most abundant PUFA in *S. lucioperca* muscle lipids in Egirdir Lake, Turkey. In all species except for *V. vimba tenella*, DHA was identified as the major PUFA. Similarly, DHA was the major PUFA in *S. lucioperca* (Jankowska et al., 2003; Çelik et al., 2005; Guler et al., 2007; Pirestani et al., 2010), *C. carassius* (Donmez, 2009) *T. tinca* (Özogul et al., 2007; Donmez, 2009). In the present study, DHA in *S. lucioperca* (22.48%) was significantly higher than in *P. anatolicus* (13.26%), *C. gibelio* (11.03%), *T. tinca* (7.56%) and *V. vimba tenella* (3.91%). *C. capoeta* was rich in PUFA (51.86%), especially DHA (17.65%) and linoleic acid (15.04%) which is higher than that reported by Uysal et al. (2008) in *C. capoeta capoeta*. In the present study, EPA was determined as the predominant PUFA in *V. vimba tenella*. A similar result was obtained by Kalyoncu et al. (2009) for *V. vimba ten-*

Table 1. Fatty acid composition (%) of six fish species muscle lipids in Sugla Lake[t].

Fatty Acids	C. gibelio	P. anatolicus	S. lucioperca	T. tinca	V. vimba tenella	C. capoeta
C 8:0 [y]	0.03 ± 0.01 [b]	0.01 ± 0.00 [b]	0.02 ± 0.01 [b]	0.12 ± 0.01 [a]	0.01 ± 0.00 [b]	0.02 ± 0.00 [b]
C 10:0	0.10 ± 0.03 [b]	0.08 ± 0.07 [b]	0.03 ± 0.03 [b]	0.42 ± 0.21 [a]	0.01 ± 0.00 [b]	0.04 ± 0.01 [b]
C 11:0	0.03 ± 0.02 [a]	0.02 ± 0.01 [a]	0.01 ± 0.01 [a]	0.04 ± 0.00 [a]	0.01 ± 0.00 [a]	0.02 ± 0.00 [a]
C 12:0	0.13 ± 0.02 [a]	0.12 ± 0.12 [a]	0.04 ± 0.01 [a]	0.17 ± 0.01 [a]	0.07 ± 0.00 [a]	0.02 ± 0.00 [a]
C 13:0	0.07 ± 0.01 [b]	0.01 ± 0.00 [c]	0.02 ± 0.01 [c]	0.14 ± 0.06 [a]	0.03 ± 0.01 [bc]	0.02 ± 0.01 [c]
C 14:0	1.93 ± 0.40 [a]	1.36 ± 0.47 [a]	2.36 ± 1.14 [a]	1.31 ± 0.08 [a]	1.86 ± 0.01 [a]	1.54 ± 0.01 [a]
C 15:0	0.89 ± 0.22 [a]	0.24 ± 0.05 [b]	0.44 ± 0.11 [b]	0.44 ± 0.01 [b]	0.60 ± 0.01 [ab]	0.32 ± 0.04 [b]
C 16:0	15.27 ± 0.25 [b]	18.54 ± 0.28 [a]	17.94 ± 1.01 [a]	15.96 ± 0.18 [b]	17.94 ± 0.01 [a]	13.25 ± 0.04 [c]
C 17:0	0.42 ±0.14 [a]	1.34 ± 0.82 [a]	0.36 ± 0.03 [a]	0.98 ± 0.19 [a]	0.48 ± 0.04 [a]	0.32 ± 0.00 [a]
C 18:0	4.52 ± 0.69 [a]	2.98 ± 0.85 [ab]	4.07 ± 0.77 [a]	4.24 ± 0.11 [ab]	1.86 ± 0.04 [b]	5.05 ± 0.00 [a]
C 19:0	0.18 ± 0.03 [a]	0.03 ± 0.02 [b]	0.03 ± 0.02 [b]	0.03 ± 0.01 [b]	0.02 ± 0.00 [b]	0.03 ± 0.02 [b]
C 20:0	0.32 ± 0.07 [a]	0.61 ± 0.35 [a]	0.21 ± 0.10 [a]	0.21 ± 0.00 [a]	0.13 ± 0.01 [a]	0.43 ± 0.02 [a]
C 21:0	0.62 ± 0.14 [ac]	0.95 ± 0.25 [a]	0.16 ± 0.02 [b]	0.29 ± 0.01 [bc]	0.39 ± 0.08 [bc]	0.24 ± 0.01 [bc]
C 22:0	0.04 ± 0.02 [a]	0.03 ± 0.01 [ab]	0.01 ± 0.00 [b]	0.04 ± 0.02 [ab]	0.03 ± 0.01 [ab]	0.05 ± 0.01 [a]
C 24:0	0.01 ± 0.00 [a]	0.01 ± 0.00 [a]	0.01 ± 0.00 [a]	0.02 ± 0.01 [a]	0.01 ± 0.00 [a]	0.01 ± 0.00 [a]
∑ SFA[z]	24.56 ± 0.23 [ab]	26.33 ± 1.40 [a]	25.71 ± 0.43 [ab]	24.41 ± 0.07 [abc]	23.45 ± 0.05 [bc]	21.36 ± 0.00 [c]
C 14:1ω5	0.27 ± 0.02 [a]	0.10 ± 0.03 [b]	0.20 ± 0.09 [a]	0.24 ± 0.00 [a]	0.13 ± 0.01 [ab]	0.13 ± 0.02 [ab]
C 15:1ω5	0.37 ± 0.08 [bc]	0.95 ± 0.25 [a]	0.09 ± 0.05 [c]	0.43 ± 0.21 [bc]	0.17 ± 0.04 [bc]	0.66 ± 0.06 [ab]
C 16:1ω7	9.50 ± 0.23 [b]	7.10 ± 1.33 [b]	8.25 ± 2.01 [b]	9.49 ± 0.23 [b]	18.13 ± 0.01 [a]	6.89 ± 0.00 [b]
C 17:1ω8	1.89 ± 0.20 [b]	0.43 ± 0.08 [c]	0.80 ± 0.37 [c]	3.14 ± 0.23 [a]	2.02 ± 0.01 [b]	0.91 ± 0.15 [c]
C 18:1ω9	17.40 ± 2.43 [c]	11.93 ± 1.51 [d]	12.93 ± 2.13 [d]	23.04 ± 0.42 [c]	34.23 ± 0.11 [a]	16.42 ± 0.31 [cd]
C 18:1ω7	0.43 ± 0.19 [a]	0.35 ± 0.21 [a]	0.13 ± 0.07 [a]	0.73 ± 0.45 [a]	0.23 ± 0.15 [a]	0.51 ± 0.01 [a]
C 20:1ω9	0.79 ± 0.34 [a]	0.59 ± 0.18 [a]	0.70 ± 0.34 [a]	0.26 ± 0.00 [a]	0.56 ± 0.13 [a]	0.93 ± 0.03 [a]
C 22:1ω9	0.79 ± 0.18 [b]	1.25 ± 0.23 [a]	0.53 ± 0.12 [b]	0.63 ± 0.01 [b]	0.41 ± 0.00 [b]	0.32 ± 0.01 [b]
C 24:1ω9	0.01 ± 0.00 [b]	0.01 ± 0.00 [b]	0.02 ± 0.01 [b]	0.04 ± 0.01 [a]	0.01 ± 0.00 [b]	0.01 ± 0.00 [b]
∑ MUFA[z]	31.45 ± 3.13 [b]	22.71 ± 2.30 [c]	23.65 ± 4.45 [c]	38.00 ± 0.18 [b]	55.89 ± 0.12 [a]	26.78 ± 0.42 [bc]
C 18:2ω6	6.23 ± 1.04 [bc]	9.18 ± 2.80 [b]	4.04 ± 1.33 [c]	6.09 ± 0.00 [bc]	2.75 ± 0.23 [c]	15.04 ± 0.09 [a]
C 18:3ω6	0.39 ± 0.25 [a]	0.02 ± 0.01 [b]	0.05 ± 0.01 [b]	0.12 ± 0.01 [ab]	0.27 ± 0.13 [ab]	0.07 ± 0.01 [b]
C 18:3ω3	6.03 ± 1.99 [b]	10.11 ± 2.67 [a]	2.52 ± 1.05 [b]	5.24 ± 0.19 [b]	1.75 ± 0.03 [b]	1.88 ± 0.01 [b]
C 20:2ω6	0.22 ± 0.04 [bc]	0.01 ± 0.01 [d]	0.21 ± 0.03 [bc]	0.27 ± 0.09 [ab]	0.33 ± 0.04 [a]	0.14 ± 0.01 [c]
C 20:3ω6	0.02 ± 0.01 [ab]	0.01 ± 0.00 [b]	0.01 ± 0.00 [b]	0.03 ± 0.01 [a]	0.01 ± 0.00 [b]	0.01 ± 0.00 [b]
C 20:3ω3	0.57 ± 0.10 [b]	1.37 ± 0.37 [a]	0.21 ± 0.03 [b]	0.68 ± 0.10 [b]	0.35 ± 0.01 [b]	0.41 ± 0.01 [b]
C 20:4ω6	6.35 ± 2.02 [bc]	8.94 ± 0.43 [a]	7.73 ± 0.95 [ab]	7.04 ± 0.31 [ab]	3.57 ± 0.13 [c]	5.87 ± 0.18 [bc]
C 20:5ω3	7.63 ± 0.82 [a]	4.94 ± 1.04 [b]	6.13 ± 0.23 [b]	6.09 ± 0.09 [ab]	4.44 ± 0.01 [bc]	2.97 ± 0.00 [c]
C 22:2ω6	0.05 ± 0.03 [a]	0.02 ± 0.02 [ab]	0.01 ± 0.00 [b]	0.02 ± 0.01 [ab]	0.03 ± 0.01 [ab]	0.04 ± 0.01 [ab]
C 22:3ω3	0.86 ± 0.30 [a]	0.30 ± 0.16 [b]	0.73 ± 0.09 [a]	0.78 ± 0.06 [a]	0.54 ± 0.02 [ab]	0.74 ± 0.01 [a]
C 22:4ω6	0.01 ± 0.00 [a]	0.08 ± 0.10 [a]	0.02 ± 0.01 [a]	0.05 ± 0.02 [a]	0.09 ± 0.11 [a]	0.02 ± 0.01 [a]
C 22:5ω6	1.30 ± 0.17 [c]	0.85 ± 0.26 [cd]	2.38 ± 0.26 [b]	0.64 ± 0.09 [d]	0.86 ± 0.02 [cd]	4.36 ± 0.14 [a]
C 22:5ω3	3.30 ± 0.60 [b]	1.87 ± 0.15 [d]	4.12 ± 0.14 [a]	2.98 ± 0.30 [b]	1.76 ± 0.06 [dc]	2.66 ± 0.09 [bc]
C 22:6ω3	11.03 ± 0.53 [bcd]	13.26 ± 2.07 [bc]	22.48 ± 5.04 [a]	7.56 ± 0.33 [cd]	3.91 ± 0.04 [d]	17.65 ± 0.12 [ab]
∑ PUFA[z]	43.99 ± 3.32 [bc]	50.96 ± 2.55 [a]	50.64 ± 4.05 [a]	37.59 ± 0.11 [c]	20.66 ± 0.16 [d]	51.86 ± 0.42 [ab]

Table 1. continued

Fatty Acids	C. gibelio	P. anatolicus	S. lucioperca	T. tinca	V. vimba tenella	C. capoeta
∑ ω3	29.42 ± 0.38 [ab]	31.85 ± 4.68 [ab]	36.19 ± 4.17 [a]	23.33 ± 0.19 [bc]	12.75 ± 0.03 [c]	26.31 ± 0.20 [b]
∑ ω6	14.57 ± 2.97 [c]	19.11 ± 3.09 [b]	14.45 ± 0.21 [c]	14.26 ± 0.30 [bcd]	7.91 ± 0.13 [d]	25.55 ± 0.23 [a]
ω3/ω6	2.02 ±0 .40 [ab]	1.67 ± 0.50 [abc]	2.50 ± 0.31 [a]	1.64 ± 0.05 [abc]	1.61 ± 0.02 [abc]	1.03 ± 0.00 [c]

[t] The data are presented as average values from three analyzed lots (means ± SD).
[y] [abc] values for each sample with different letters in the same fraction are significantly different at $p < 0.05$.
[z] SFA: Saturated fatty acid, MUFA: Monounsaturated fatty acid, PUFA: Polyunsaturated fatty acid.

ella in summer. Total PUFA in *P. anatolicus* (50.96%), *S. lucioperca* (50.64%) and *C. capoeta* (51.86%) was significantly higher than in *T. tinca* (37.59%) and *V. vimba tenella* (20.66%). Total PUFA was 50.80% in wild *S. lucioperca* (Jankowska et al., 2003), 34.87% in *C. carasius* (Donmez, 2009), 36.37% (Donmez, 2009) and 43.8% (Özogul et al., 2007) in *T. tinca*, and 25.6-32.7% in *V. vimba tenella*, seasonally (Kalyoncu et al., 2009). In the present study, total PUFA was higher than total SFA and total MUFA in all the species except for *T. tinca* and *V. vimba tenella*. These results matched with Jankowska et al. (2003), Guler et al. (2007) and Özogul et al. (2007) who reported that PUFA is higher than total SFA and total MUFA in *S. lucioperca*. Donmez (2009) also reported that *C. carassius* from the Porsuk Dam Lake, Turkey, had high contents of PUFA (34.87%) compared to SFA (32.92%) and MUFA (32.21%).

EPA and DHA have beneficial properties for the prevention of human coronary artery disease (Leaf and Weber, 1988). In our study, among the ω3 series, *S. lucioperca* was a good source of EPA and DHA. EPA + DHA were 28.61, 20.62, 18.66, 18.20, 13.65 and 8.35% in *S. lucioperca*, *C. capoeta*, *C. gibelio*, *P. anatolicus*, *T. tinca* and *V. vimba tenella*, respectively. EPA + DHA were higher than that reported by Uysal et al. (2008) in *C. capoeta capoeta*, Donmez (2009) in *C. carassius* and Çelik et al. (2005) in *S. lucioperca*. This value was close to that reported for *S. lucioperca* (28.39%) in the Seyhan Dam Lake (Özogul et al., 2007) and in Beysehir Lake in autumn and spring (28.27-29.23%) (Guler et al., 2007), in Turkey. Similarly, Memon et al. (2010) determined that Indus river fish are a good source of ω3 fatty acids, particularly EPA and DHA, and should be recommended for dietary inclusion to reduce the risks of cardiovascular disease.

S. lucioperca had a higher level of DHA and therefore a high level of total ω3 fatty acids. Total ω3 fatty acids were 36.19%, 31.85%, 29.42%, 26.31%, 23.33% and 12.75% in *S. lucioperca*, *P. anatolicus*, *C. gibelio*, *C. capoeta*, *T. tinca* and *V. vimba tenella*, respectively. The ω3/ω6 ratio has been suggested to be a useful indicator for comparing the relative nutritional values of fish oils (Piggot and Tucker, 1990), and an increase in the human dietary ω3/ω6 fatty acid ratio is essential to help prevent coronary heart disease by reducing plasma lipids (Kinsella et al., 1990). In our study, a high level of ω3/ω6 ratio was observed in *S. lucioperca*. This ratio was 2.50 in *S. lucioperca*, which is higher than that reported by some authors (Guler et al., 2007; Özogul et al., 2007), while lower than that reported by Jankowska et al., (2003). This ratio was relatively low in *C. gibelio* (2.02), *P. anatolicus* (1.67), *T. tinca* (1.64), *V. vimba tenella* (1.61) and *C. capoeta* (1.03) in comparison to *S. lucioperca*. This ratio was 2.80 (Donmez, 2009) and 1.59 (Özogul et al., 2007) in *T. tinca,* 1.2-1.5 (Kalyoncu et al., 2009) in *V. vimba tenella* and 1.67 (Donmez, 2009) in *C. carassius*. In the present study, total ω6 fatty acids were lower than ω3 fatty acids in all species.

CONCLUSION

The fatty acid composition of six important fish species in Sugla Lake was determined and compared. *S. lucioperca* contained more ω3 fatty acids, which is important for human health, than the other fish

species. The percentages of total ω3 fatty acids were higher than those of the total ω6 fatty acids in all species. *S. lucioperca* and *C. gibelio* may be a good dietary source of ω3 PUFA and ω3/ω6. Since *P. anatolicus* is endemic and endangered, this species should also be protected and produced for future marketing.

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