# Seasonal variations of the fatty acid profiles in the edible portions of two freshwater fish species

(Pseudophoxinus fahrettini and Capoeta mauricii)

Emre N.<sup>1</sup>; Uysal K.<sup>2</sup>; Kavasoğlu M.<sup>2\*</sup>; Emre Y.<sup>3</sup>; Yalım B.<sup>4</sup>; Pak F.<sup>4</sup>

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### **Abstract**

In this study, seasonal and sexual variations of fatty acid profiles of *Pseudophoxinus fahrettini* and *Capoeta mauricii* which are freshwater fishes in Turkey inland waters were investigated. The monounsaturated fatty acids (MUFAs) values were higher than saturated fatty acids (SFAs) and polyunsaturated fatty acids (PUFAs) values for both species. Also the ratios of MUFAs in *P. fahrettini* were higher than those of *C. mauricii* in all seasons. The results indicated that palmitic acid was the most dominant SFA for both species in all seasons. Oleic acid in the muscle of *P. fahrettini* and palmitoleic acid in the muscle of *C. mauricii* were the highest MUFA respectively in both genders in all seasons. The highest ratios of  $\omega$ 3 PUFAs were 23.00% in the muscle of *C. mauricii* in summer and 18.44% in *P. fahrettini* in winter. The ratios of  $\omega$ 3 PUFAs in muscles of both species and genders were higher than the ratios of  $\omega$ 6 PUFAs during all the seasons. Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) were significantly higher than the other PUFAs in both sexes of the species. The ratio of  $\omega$ 3 PUFAs to  $\omega$ 6 PUFAs was higher than 1.76 in both species and genders in all seasons.

**Keywords**: Pseudophoxinus fahrettini, Capoeta mauricii, Fatty acid, Season, Sex

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<sup>1-</sup>Akdeniz University, Faculty of Education, Department of Science Education, Antalya, Turkey.

<sup>2-</sup>Dumlupınar University, Faculty of Arts and Sciences, Department of Biology, Kütahya, Turkey.

<sup>3-</sup>Akdeniz University, Faculty of Sciences, Department of Biology, Antalya, Turkey.

<sup>4-</sup>The Mediterranean Fisheries Research, Production and Training Institute, Kepez, Antalya, Turkey.

<sup>\*</sup>Corresponding author's Email: kavasoglu87@hotmail.com

### Introduction

Fish meat is a vital contributor to the survival and health of the world population (Dhanapal et al., 2012). This is due to their rich oil and essential fatty acid content. Essential fatty acids cannot be synthesized in the human body and they must be taken from dietary sources (Maylet et al., 2012; Usydus et al., 2012). Essential fatty acids are provided by  $\omega 3$  and  $\omega 6$  fatty acids which are found abundantly in seafood and vegetable oil (Mahaffey, 2004; Çelik, 2008). All fatty acids, especially essential fattv acids. constitute to a significant part of the human diet by providing a concentrated source of energy and they substantial compounds in cell membrane structure in addition to their action as prostaglandins, hormones, and other molecules (Doyle, 2004). ω3 fatty particularly eicosapentaenoic acids, acid (EPA) and docosahexaenoic acid (DHA), are mainly found in fish and fish oil. These fatty acids (EPA and DHA) are used to prevent and treat coronary heart disease, cardiovascular disease, hypertension, diabetes, obesity, prostate cancer, depression, thrombosis, lung disease, and some other diseases but also used for brain development and mental health (Augustsson et al., 2003; Holub and Holub, 2004; Vrablik et al., 2009; Dhanapal et al., 2012).

Due to its importance for human health,  $\omega 3$  PUFAs capsules obtained from sea products are sold in pharmacies. The commercial fish oil capsules may lose their quality during their processing and conservation. That is why the consumption of fresh fish

instead of fish oil capsules is more beneficial for human health. The consumption of fish twice a week is recommended. Thus, it is important to know the oil composition and the  $\omega 3$  PUFAs quantity of eatable part of fishes as a human nutrient.

**Pseudophoxinus** fahrettini Capoeta mauricii are freshwater fishes naturally living in central Anatolia, in Turkey. They live in the benthopelagic zone of subtropical waters. Both fishes are omnivorous and feed generally on phytoplankton, benthic algae, aquatic plants, zooplankton and invertebrates (Akın et al., 2010). Currently, no studies about the fatty acid composition of P. fahrettini and C. mauricii have been published. Therefore the aim of this study is to determine the sexual and seasonal variations of muscle fatty acid composition of P. fahrettini and C. mauricii.

### Materials and methods

Fish sampling

The specimens of P. fahrettini used in this experiment were caught from Köprü River drainage and C. mauricii was caught from Sarıöz River in central Anatolia, in Turkey. Mean weights and lengths of the representative fishes were 27.56 g and 13.07 cm for P. fahrettini; 119.51 g and 21.94 cm for C. mauricii respectively. A total of 72 fishes (34 C. mauricii; 38 P. fahrettini) were used in The fishes experiments. were anaesthetized with clove oil and then dorsal muscle samples from each sex were taken and homogenized in a warring blender.

# Total lipid extraction

Total lipid extraction was performed according to the Bligh and Dyer method (1959). Methyl esters were prepared by transmethylation using 2M KOH in methanol and hexane according to the method of Ichihara *et al.* (1996). Extracted lipids (10 mg) were dissolved in 2 ml hexane and methylated by 4 ml of 2 M methanolic KOH. After centrifugation at 4000 rpm for 10 min, the hexane layer was used for GC analyses application.

# Gas chromatographic analyses

The fatty acid profiles were analyzed by GC using a flame ionization detector and a fused silica capillary column. The oven temperature was 140 °C, maintained for 5 min, then raised to 200 °C at a rate of 4 °C min<sup>-1</sup> and to 220 °C at a rate of 1 °C min<sup>-1</sup>, while the injector and the detector temperatures were set at 220 °C and 280 °C, respectively. The carrier gas was set at 16 psi. The split used was 1:40. Fatty acids were identified by comparing the retention

times of fatty acid methyl ester mixtures.

# Statistical analyses

The fatty acid results were given as % percentages±SE. Seasonal changes among the important fatty acids were statistically analyzed using One-way ANOVA test with SPSS Package Programme version 22. Variations between species and sexes were determined using the Student t-Test.

### **Results**

Seasonal variations of fatty acid ratios in muscles of females and males are shown in Table 1 and 2 for P. fahrettini and C. mauricii respectively. In this study, the levels of total SFAs in muscle of P. fahrettini changed from 24.01% to 27.04% in female and from 24.27 % to 28.45% in male (Table 1). The ratios of SFAs in the muscle of C. mauricii reached the highest levels of 28.53% in female and 28.22% in males in summer and the lowest levels of 24.03% in females and 23.82% in males were observed in spring and in winter, respectively (Table 2).

Table 1: Seasonal and sexual variations of the fatty acid ratios in muscle of *Pseudophoxinus fahrettini* (% of total fatty acids).

	Spring		Summer		Autumn		Winter	
Fatty Acids	male	female	male	female	male	female	male	female
C12:0	$0.48\pm0.07$	0.38±0.07	0.39±0.15	0.45±0.09	0.87±0.11	$0.45\pm0.05$	0.43±0.18	0.32±0.09
C14:0	$2.11\pm0.32$	$1.89\pm0.18$	$2.48\pm0.06$	$2.42\pm0.07$	$2.88\pm0.12$	$2.21\pm0.09$	$2.43\pm0.16$	$2.09\pm0.45$
C15:0	$0.31\pm0.01$	$0.30\pm0.05$	$0.28\pm0.02$	$0.31\pm0.01$	$0.24\pm0.01$	$0.23\pm0.02$	$0.27\pm0.02$	$0.26\pm0.02$
C16:0	$17.28\pm0.71$	16.71±0.47	$18.79\pm0.82$	17.41±0.36	$17.72\pm0.29$	16.61±0.28	15.03±0.53	$16.41\pm0.21$
C17:0	$0.36\pm0.25$	$0.48\pm0.05$	$0.33\pm0.02$	$0.41\pm0.03$	$0.26\pm0.02$	$0.29\pm0.02$	$0.42\pm0.06$	$0.39\pm0.05$
C18:0	5.01±1.27	$6.33\pm0.68$	3.53±0.17	$3.73\pm0.17$	$3.36\pm0.08$	$3.45\pm0.17$	$3.5\pm0.12$	$3.99\pm0.25$
C20:0	$0.24\pm0.00$	$0.27\pm0.05$	$0.22\pm0.02$	$0.23\pm0.02$	$0.20\pm0.00$	$0.22\pm0.01$	$0.20\pm0.00$	$0.21\pm0.01$
C21:0	$0.58\pm0.06$	$0.69\pm0.03$	$0.52\pm0.05$	$0.55\pm0.03$	$0.6\pm0.03$	$0.55\pm0.03$	$0.51\pm0.04$	$0.60\pm0.04$
C22:0	$0.06\pm0.00$	-	$0.06\pm0.00$	$0.05\pm0.01$	-	$0.03\pm0.00$	-	$0.06\pm0.00$
$\sum SFA$	26.41±1.4	27.04±0.9	26.58±0.7	25.56±0.5	26.14±0.4	24.01±0.3	$22.82 \pm 0.6$	$24.30 \pm 0.2$
C14:1	$0.12\pm0.01$	$0.16\pm0.03$	$0.12\pm0.01$	$0.11\pm0.01$	$0.13\pm0.00$	$0.12\pm0.00$	$0.15\pm0.01$	$0.11\pm0.01$
C15:1	$0.10\pm0.00$	$0.10\pm0.03$	$0.11\pm0.03$	$0.08\pm0.03$	-	-	$0.07\pm0.00$	$0.17\pm0.03$
C16:1	9.68±1.98	$8.16\pm0.82$	12.62±0.65	11.64±0.29	$13.05\pm0.22$	11.99±0.23	11.86±0.26	$10.14\pm0.63$
C17:1	$0.37\pm0.14$	$0.32\pm0.04$	$0.31\pm0.05$	$0.33\pm0.01$	$0.37\pm0.03$	$0.28\pm0.02$	$0.37\pm0.02$	$0.32\pm0.04$
C18:1ω9	22.11±2.75	20.92±1.27	22.01±0.79	21.70±0.78	19.68±0.67	20.29±1.12	18.57±0.26	18.51±1.05
C18:1ω7	5.38±0.39	$6.35\pm0.13$	$5.5\pm0.41$	$5.94\pm0.28$	$5.29\pm0.16$	$6.28\pm0.30$	5.97±0.23	$5.92\pm0.14$
C20:1	$0.93\pm0.13$	$1.03\pm0.07$	$0.75\pm0.06$	$0.76\pm0.05$	$0.72\pm0.03$	$0.59\pm0.03$	$0.61\pm0.02$	$0.86\pm0.04$
C22:1ω9	$0.04\pm0.00$	-	$0.02\pm0.00$	$0.04\pm0.01$	$0.04\pm0.01$	$0.04\pm0.01$	$0.03\pm0.00$	$0.06\pm0.02$
∑MUFA	$38.64 \pm 5.1$	36.99 ±2.1	$41.41 \pm 0.7$	$40.56 \pm 0.4$	$39.25 \pm 0.6$	39.56 ±1.1	$37.57 \pm 0.3$	$36.04 \pm 1.5$
C18:2ω6	4.99±0.61	$3.59\pm0.25$	$3.70\pm0.66$	$5.16\pm0.60$	$3.00\pm0.32$	$3.43\pm0.28$	$3.54\pm0.16$	$3.27\pm0.15$
C18:3ω3	$2.76\pm0.30$	$3.27\pm0.47$	$4.05\pm0.15$	$4.22\pm0.19$	$4.41\pm0.32$	$4.20\pm0.29$	$3.41\pm0.45$	$3.26\pm0.55$
C20:3ω6	$0.85\pm0.26$	$0.62\pm0.16$	$0.39\pm0.15$	$0.39\pm0.10$	$0.13\pm0.08$	$0.33\pm0.08$	$0.49\pm0.10$	$0.81\pm0.12$
C20:4ω6	$0.30\pm0.00$	$0.30\pm0.02$	$0.25\pm0.02$	$0.27\pm0.02$	$0.30\pm0.02$	$0.28\pm0.03$	$0.42\pm0.04$	$0.38\pm0.03$
C20:2ω6	2.33±1.13	$2.58\pm0.46$	1.27±0.18	$1.32\pm0.07$	1.58±0.99	$1.74\pm0.10$	$1.80\pm0.10$	$2.82\pm0.42$
C20:5ω3	$6.04\pm1.02$	$6.21\pm0.46$	$6.83\pm0.66$	$6.67\pm0.30$	$8.09\pm0.27$	$8.68\pm0.31$	$8.34\pm0.18$	$7.65\pm0.34$
C22:6ω3	6.13±3.50	8.31±1.60	3.21±0.49	$3.38\pm0.19$	$4.04\pm0.16$	$4.58\pm0.23$	$4.27\pm0.30$	$7.53\pm0.94$
$\sum PUFA$	23.41 ±5.0	24.87 ±1.9	19.72±0.7	21.40±0.4	$21.54 \pm 0.3$	$23.24 \pm 0.3$	$22.25 \pm 0.5$	25.72 ±1.3

Table 2: Seasonal and sexual variations of the fatty acid ratios in muscle of *Capoeta mauricii* (% of total fatty acids

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Fatty	Spring		Summer		Autumn		Winter			
Acids	male	female	male	female	male	female	male	female		
C12:0	0.12±0.03	0.26±0.12	0.07±0.01	0.27±0.01	0.12±0.04	0.37±0.14	0.12±0.02	0.16±0.01		
C14:0	3.21±0.18	$3.16\pm0.12$	$3.35\pm0.22$	$2.70\pm0.19$	$3.74\pm0.34$	$3.19\pm0.26$	$2.72\pm0.45$	$3.41\pm0.03$		
C15:0	$0.45\pm0.04$	$0.39\pm0.05$	$0.79\pm0.16$	$0.64\pm0.20$	1.05±0.35	$0.68\pm0.25$	$0.33\pm0.02$	$1.67 \pm 0.02$		
C16:0	16.74±0.67	16.62±0.34	$18.80\pm0.99$	18.56±0.62	$15.98\pm0.23$	15.54±0.57	$16.89\pm0.61$	$16.20\pm0.13$		
C17:0	$0.24\pm0.02$	$0.24\pm0.02$	$0.27\pm0.02$	$0.41 \pm 0.02$	$0.28\pm0.04$	$0.30\pm0.03$	$0.29\pm0.03$	$0.39\pm0.00$		
C18:0	2.71±0.13	$2.75\pm0.11$	$4.36\pm0.65$	$5.09\pm0.5$	$3.07\pm0.24$	$3.51\pm0.37$	$2.42\pm0.32$	$4.22\pm0.16$		
C20:0	$0.14\pm0.00$	$0.18\pm0.02$	$0.16\pm0.00$	$0.19\pm0.02$	$0.17\pm0.02$	$0.18\pm0.02$	$0.17\pm0.01$	$0.14\pm0.00$		
C21:0	$0.48\pm0.04$	$0.35\pm0.06$	$0.33\pm0.06$	$0.58\pm0.12$	$0.30\pm0.03$	$0.42\pm0.03$	$0.79\pm0.18$	$0.16\pm0.00$		
C22:0	$0.07\pm0.05$	$0.08\pm0.00$	$0.09\pm0.00$	$0.09\pm0.01$	$0.09\pm0.01$	$0.11\pm0.02$	$0.09\pm0.01$	-		
$\sum SFA$	24.25±1.80	24.03±1.79	$28.22 \pm 2.02$	28.53±2.00	24.8±1.71	24.3±1.66	23.82±1.81	26.35±1.93		
C14:1	$0.17\pm0.02$	$0.17 \pm 0.00$	$0.11\pm0.00$	$0.09\pm0.00$	$0.13\pm0.01$	$0.14\pm0.00$	$0.12\pm0.03$	$0.23\pm0.07$		
C15:1	$0.07\pm0.01$	$0.05\pm0.00$	$0.14\pm0.01$	$0.10\pm0.01$	$0.15\pm0.07$	$0.12\pm0.04$	$0.12\pm0.08$	$0.23\pm0.03$		
C16:1	15.63±0.73	$16.68 \pm 0.77$	13.93±1.00	11.60±1.06	$14.74\pm0.73$	13.31±0.82	$14.74\pm1.97$	$10.78\pm0.10$		
C17:1	$0.50\pm0.07$	$0.45\pm0.08$	$0.52\pm0.12$	$0.82\pm0.24$	$0.45\pm0.04$	$0.65\pm0.10$	$1.19\pm0.52$	$0.41\pm0.00$		
C18:1ω9	$11.18\pm1.00$	$10.77 \pm 0.42$	9.05±1.08	$8.18\pm0.88$	$8.38 \pm 0.86$	9.30±1.17	9.01±0.34	12.86±0.14		
C18:1ω7	$5.46\pm0.44$	$5.60\pm0.10$	4.95±0.11	$5.08\pm0.16$	5.01±0.32	5.37±0.31	$5.84\pm0.25$	$5.25 \pm 0.05$		
C20:1	$1.37\pm0.10$	$1.13\pm0.14$	$1.41\pm0.17$	$1.13\pm0.08$	$1.16\pm0.18$	$0.93\pm0.22$	$0.57\pm0.09$	$1.93\pm0.00$		
C22:1ω9	$0.14\pm0.01$	$0.09\pm0.01$	$0.14\pm0.03$	$0.15\pm0.03$	$0.23\pm0.01$	$0.18\pm0.05$	$0.11\pm0.05$	-		
∑MUFA	34.52±2.12	34.94±2.21	30.7±1.83	27.15±1.56	30.25±1.89	$30 \pm 1.80$	31.7±1.93	$31.69 \pm 2.01$		
C18:2ω6	2.91±0.47	$3.04\pm0.18$	$1.93\pm0.33$	$2.41\pm0.42$	$2.00\pm0.23$	$2.91\pm0.54$	$3.05\pm0.44$	$3.38\pm0.02$		
C18:3ω3	$3.84\pm0.28$	$3.25\pm0.58$	$2.67\pm0.54$	4.93±1.27	$2.66\pm0.33$	$3.81\pm0.65$	$7.06\pm1.48$	$1.63\pm0.05$		
C20:3ω6	$0.20\pm0.08$	$0.17\pm0.02$	$0.15\pm0.00$	$0.18\pm0.02$	$0.12\pm0.01$	$0.19\pm0.03$	$0.18\pm0.01$	$0.14\pm0.00$		
C20:4ω6	$0.17\pm0.02$	$0.13\pm0.02$	$0.14\pm0.01$	$0.17\pm0.02$	$0.14\pm0.01$	$0.14\pm0.01$	0.21±0.03	$0.17\pm0.00$		
C20:2ω6	$1.88 \pm 0.22$	$1.38\pm0.14$	$2.08\pm0.26$	2.53±0.37	1.67±0.09	$2.11\pm0.23$	1.77±0.32	$2.47 \pm 0.04$		
C20:5ω3	$8.26 \pm 0.68$	$9.88 \pm 0.81$	$9.96\pm0.67$	$9.69\pm0.91$	12.15±0.31	11.55±0.69	$7.94 \pm 0.27$	$9.98 \pm 0.07$		
C22:6ω3	$6.25 \pm 0.68$	$4.24\pm0.21$	$8.41\pm1.00$	$8.38 \pm 0.64$	$6.20\pm0.35$	$6.54\pm0.51$	$5.28 \pm 1.46$	$8.36 \pm 0.04$		
$\sum PUFA$	23.51±1.14	22.09±1.27	25.34±1.49	28.29±1.43	24.94±1.63	27.25±1.52	25.49±1.20	26.13±1.48		

According to our results, palmitic acid was the major SFA. The highest ratios of palmitic acid in males and females in summer were found to be 18.79% and 17.41% for *P. fahrettini* and 18.80% and 18.56% for *C. mauricii*, respectively.

The levels of monounsaturated fatty acids (MUFA) in the present study were found to be in the range of 27.10% to 34.92% in C. mauricii and 36.04% to 41.41% in P. fahrettini. The ratios of MUFAs in the muscle of both species were generally higher than other fatty acid groups (Tables 1 and 2). MUFAs values in P. fahrettini were higher than those of C. mauricii in all seasons. Particularly, these differences between species were statistically significant in autumn and summer (p < 0.05). Oleic acid in P. fahrettini and palmitoleic acid in C. mauricii were the major MUFAs in all seasons (Tables 1 and 2). Oleic acid content of female P. fahrettini was at minimum in the winter (18.51%) and at maximum in summer (21.70%). However the ratio of oleic acid content of male P. fahrettini significantly decreased to minimum (22.18%)level in summer and increased to maximum in winter (18.58%) (Table 1). Palmitoleic acid of female C. mauricii reached the highest level in spring and decreased to the lowest level in winter, but there were no changes in both sexes significant (p>0.05). This situation

associated to the differences in nutrition and reproduction physiologies of the sexes.

The levels of total PUFAs in muscle of *P. fahrettini* changed from 21.40% to 25.72% in females and from 19.72% to 23.41% in males. The levels of total PUFAs in muscle of *C. mauricii* also ranged from 22.09% to 28.29% in females and from 23.51% to 25.49% in males.

The ratios of ω3 PUFAs in the muscle of P. fahrettini ranged from 14.09% to 16.54% in males and from 14.26% to 18.44% in females (Fig. 1); the levels of ω3 PUFAs of C. mauricii ranged from 17.37% to 23.00% in females and from 18.35% to 21.04% in males (Fig. 2). EPA and DHA were the two major ω3 PUFAs in the muscle of the species. The ratio of EPA in the muscle of female Р. fahrettini significantly increased to a maximum level in autumn (8.68%) and decreased to a minimum in spring (6.21%), and EPA level of males was at the highest point in winter (8.34%) and at the lowest point in spring (6.04%) (Table 1). On the other hand, the EPA levels of C. mauricii reached the highest level in males (12.15%)and in females (11.55%) in autumn. The EPA ratios in the muscle of C. mauricii were significantly higher than those of P. fahrettini in both sexes for all seasons (p<0.05), except in males in winter.

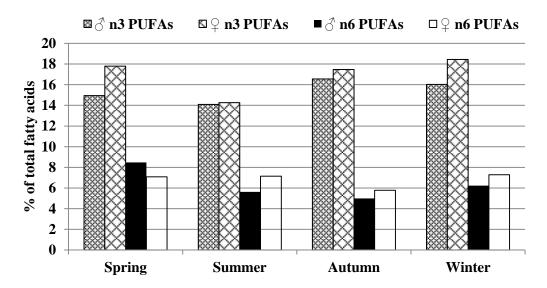


Figure 1: Seasonal and sexual variations of total ω3 PUFAs and ω6 PUFAs ratios in muscle of Pseudophoxinus fahrettini (% of total fatty acids).

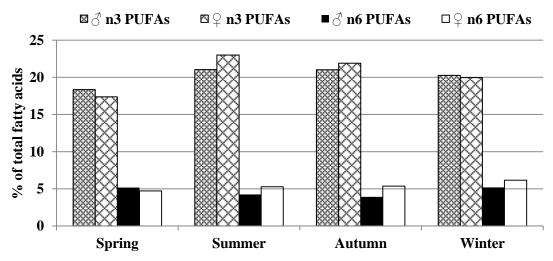


Figure 2: Seasonal and sexual variations of total n3 PUFAs and n6 PUFAs ratios in muscle of *Capoeta mauricii* (% of total fatty acids).

DHA levels of *P. fahrettini* were the highest in females (8.31%) and males (6.13%) in spring, while DHA levels of *C. mauricii* were the highest in summer with a rate of 8.41% in males and 8.38% in females. DHA values were higher in *C. mauricii* than in *P. fahrettini*, except in spring in females. The ω6 PUFAs ratios of *P. fahrettini* ranged from 5.00% to 8.47% in males and from 5.79% to 7.28% in females

(Fig. 1); the levels of  $\omega$ 6 PUFAs ratios of *C. mauricii* ranged from 4.71% to 6.15% in females and from 3.93% to 5.20% in males (Fig. 2). The ratios of total  $\omega$ 6 PUFAs in both sexes of the species were remarkably lower than the  $\omega$ 3 PUFAs ratios.

# **Discussion**

Fish adaptation to cold may be the reason for high level of SFA in

temperate conditions and low level in winter (Logue et al., 2000). For instance, it was also reported that the highest concentrations of SFAs, mainly in the form of palmitic acid, were found in summer in Capoeta erhani (Emre et al., 2014). In this study, there were no statistical differences between the SFAs ratios in the muscle of the species. This situation may be due to the fact that the studied species belong to the same family and live in neighboring habitats. It was reported that palmitic acid was the primary SFA for both sea water and freshwater fish species such Dicentrarchus labrax (Alasalvar et al., 2002), Acipenser oxyrinchus desotoi, Pomoxis spp. (Chen et al., 1995; Grün et al., 1999), Cyprinus carpio, Labeo rohita and Oreochromis mossambicus (Jabeen and Chaudhry, 2011). The ratios of palmitic acid in many freshwater and seawater fish species ranged from 17.83% to 46.00% (Uysal Aksoylar 2005; Jabeen and Chaudhry, 2011; Marichamy et al., 2012: Murillo et al.. 2014). consideration of these values, it can be said that the palmitic acid is the key metabolite for fishes.

It was proposed that oleic acid was the dominant MUFA in Baltic sprat (Sprattus sprattus balticus) with a mean ratio of 25.18% (Usydus et al., 2012), in Epinephelus aeneus, Cephalopholis taeniops and Serranus scriba with the range of 11 - 16% seasonally (Louly et al., 2011). It was also known that oleic and palmitoleic acids were the most abundant MUFAs in fish tissues.

As shown in Tables 1 and 2, the PUFA rates of both species have not

been significantly affected by seasons. The PUFA quantities in fishes are quite important for adaptation to cold conditions. As the total **PUFA** quantities studied in both species are not significantly affected by season variations, it is supposed that the fatty acid compositions of the studied species are not very affected by the temperature changes between seasons. The species was studied live near to the source sections of the streams and these parts of streams are slightly affected by temperature changes. seasonal No important differences have detected between the PUFA rates of the species except from summer. But the ratio of PUFAs in the muscle of C. mauricii was higher than in P. fahrettini in summer (p<0.05).

It was reported that DHAs were the most abundant **PUFAs** in Chondrostoma regium, Barbus rajonorum, Carasobarbus luteus. Leuciscus lepidus. Acanthobrama marmid, Cyprinion macrostomus, and Silurus triostegus as freshwater fishes (Cengiz et al., 2010). Louly et al. (2011) reported that DHA ratios ranged from 5% to 9% for C. taeniops, from 13% to 17% for S. scriba, and from 10% to 16% for E. aeneus. The DHA levels of the species studied were similar to the DHA levels of many fish species mentioned in the literature.

The ratio of  $\omega$ 3 PUFAs to  $\omega$ 6 PUFAs is mostly used for the determination of nutritional value of fishes. Diet including food with appropriate ratio of  $\omega$ 3 PUFAs /  $\omega$ 6 PUFAs reduces heart diseases and risk of cancer (Kinsella *et al.*, 1990). Ackman *et al.* (1975) have

shown that the ω3 PUFAs sources like linoleic acids were lower in freshwater fish oils in comparison with marine oils. However, our results have shown that the ω3 PUFAs /ω6 PUFAs ratios reached the levels of 3.31 in P. fahrettini and 5.35 in C. mauricii in autumn and these results were quite high compared to the literature, in particular for C. mauricii. The \omega3 PUFAs /ω6 PUFAs ratios in Salmo trutta macrostigma tissues were found to be 2.59 in male and 2.26 in female muscle (Akpinar et al., 2009). Güler et al. 2007 reported that ω3 PUFAs /ω6 PUFAs ratios were 1.49, 1.45, 1.22, 0.72 in spring, autumn, winter, and summer, respectively. Rasoarahona et al. (2005) proposed that  $\omega$ 3 PUFAs  $/\omega$ 6 PUFAs ratios vary between 0.5 and 1.6 for three tilapia species (Oreochromis niloticus, O. macrochir and Tilapia rendalli). Zenebe et al. (1998) observed that the ω3 PUFAs /ω6 PUFAs ratios varied considerably (1.1-7.6)freshwater fish of commercial importance.

The results obtained in this study have shown that  $\omega 3$  PUFAs  $/\omega 6$  PUFAs ratios (an important indicator of the dietary quality in human nutrition) of the species studied were quite high. Thus, it is possible to say that these species are an important source of  $\omega 3$  PUFAs for local population. Besides, as the  $\omega 3$  PUFAs rates of the species were not affected too much by seasons.

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