Chemistry of Natural Compounds, Vol. 46, No. 6, 2011

EVALUATION OF FATTY-ACID COMPOSITION OF FIVE MIGRATORY FISH SPECIES CAPTURED FROM THE BEYMELEK LAGOON (TURKEY) AT THE END OF THE FEEDING PERIOD

Kazim Uysal,[1] Yilmaz Emre,[2] Halil Yilmaz,[1] Muhammet Donmez,[3*] A. Kemal Seckin,[4] and Metin Bulbul[5]

UDC 547.915

It is well known that fish is beneficial and curative in human nutrition. This arises especially from long-chain n3 polyunsaturated fatty acids (n3 PUFAs), especially eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which are mostly found in fish [1, 2]. However, the fatty-acid (FA) composition of all fish species varies according to the season [3], geographical location of the catch [4], diet and feeding [5], size [6], sex, and the state of their reproductive cycle [7]. Water salinity has also an effect on FA composition, particularly on the PUFA levels of fish. The n3/n6 FA ratio is also much lower in freshwater fish than in seawater fish [8, 9]. Therefore, it has been argued that the fatty-acid compositions of freshwater and seawater fish differ greatly. Low levels of linoleic and linolenic acids and high levels of long-chain n3 PUFAs generally characterize the FA compositions of marine fish. EPA and DHA are the dominant n3 PUFAs in marine fish. Compared to marine fish, freshwater fish has low levels of n3 EPAs and DHA. High levels of n6 PUFAs, linoleic and arachidonic acids, generally characterize freshwater fish, in particular. Since freshwater fish has lower proportions of long-chain n3 PUFAs than marine fish, the ratio of total n3 to n6 PUFAs is much higher for marine fish than for freshwater fish, varying from 5 to 10 or more [10]. Therefore, the positive health effects of fish with regard to the n3 PUFAs varies with these factors.

The Beymelek Lagoon (36°15′39″-36°16′32″N, 30°02′26″-30°04′10″E) is located on the Western Mediterranean coast of Turkey and is an important fishing area. Economically important fish species migrate to the Beymelek Lagoon for feeding as well as for spawning. These fish are caught at the end of the feeding period before they migrate to the sea, usually at the end of autumn. Many studies have been conducted on the fatty-acid compositions of the Turkish freshwater and marine fish species; nevertheless, no study has so far been carried out on the fatty-acid compositions of the migrant sea fish in the Beymelek Lagoon with brackish water. Thus, the aim of the present study is to determine the fatty-acid compositions and nutritional values with respect to the proportions of n3 PUFAs of five migrant fish species in the Beymelek Lagoon.

The fatty-acid compositions of the investigated five fish species are given in Table 1. The levels of major fatty acid groups (total saturated fatty acids, SFAs; monounsaturated fatty acids, MUFAs, and polyunsaturated fatty acids, PUFAs; n3 polyunsaturated fatty acids, n3 PUFAs and n6 polyunsaturated fatty acids, n6 PUFAs) are illustrated in Figs. 1 and 2. In all species, palmitic and stearic acids were the dominant saturated fatty acids, and their proportions varied from 18.94% (in *L. aurata*) to 22.00% (in *C. labrasus)* for palmitic acid and from 6.40% (in *L. mormyrus*) to 12.20% (in *C. labrasus*) for stearic acid. The variation of palmitic acid levels among the species was not found to be significant ($p > 0.05$). It was reported that palmitic acid was a key metabolite in fish and its level was not influenced by diet [11]. The proportions of SFAs ranged from 33.20% to 38.22% among the species (Fig. 1). While *M. cephalus* has the highest SFAs level among the species, the difference in the SFAs level of *M. cephalus* was not statistically significance from those of other species. Similar proportions for palmitic, stearic, and total SFAs levels for both freshwater and seawater fish have also been reported [12, 13].

1) Department of Biology, Faculty of Arts and Sciences, Dumlupinar University, 43100, Kutahya, Turkey; 2) The Mediterranean Fisheries Research, Production and Education Institute, Kepez, Antalya, Turkey; 3) Altintas Vocational School, Dumlupinar University, 43800 Altintas, Kutahya, Turkey, fax: +90 274 3112965, e-mail: muhammet@dumlupinar.edu.tr; 4) Food Engineering Department, Celal Bayar University, 45140 Manisa, Turkey; 5) Department of Chemistry, Faculty of Arts and Sciences, Dumlupinar University, 43100, Kutahya, Turkey. Published in Khimiya Prirodnykh Soedinenii, No. 6, pp. 807–809, November–December, 2010. Original article submitted June 10, 2009.

 0009-3130/11/4606-0946

TABLE 1. Fatty-Acid Compositions (% of total fatty acids) of the Species

Fatty acid	*L. mormyrus*	*M. cephalus*	*L. aurata*	*L. ramada*	*C. labrasus*
14:0	4.08	3.81	3.89	2.45	3.91
15:0	0.66	0.54	0.95	0.33	0.49
16:0	21.25	19.94	18.94	20.77	22.00
17:0	0.40	0.59	0.78	0.25	0.55
18:0	6.40	12.06	7.21	7.81	12.20
20:0	0.09	0.11	0.16	0.51	0.34
22:0	0.28	0.86	1.46	0.79	0.74
24:0	0.05	0.34	0.16	0.77	0.15
16:1	4.62	4.11	9.07	3.08	9.20
18:1	17.71	16.92	10.60	16.23	15.64
20:1	0.37	0.25	0.23	0.35	0.05
22:1	0.13	0.20	0.24	0.12	0.18
18:2 *cis* n6	2.98	1.93	2.28	3.95	2.23
18:3 n3	1.84	2.47	1.23	1.31	1.73
18:4 n3	0.43	0.92	1.07	0.46	0.69
20:3 n3	0.11	0.38	0.62	0.23	0.34
20:4 n3	2.23	2.55	2.21	2.06	1.74
20:5 n3	3.14	4.96	7.45	3.51	3.66
22:5 n3	2.50	3.42	4.64	1.82	2.59
22:6 n3	4.38	8.56	13.00	20.26	4.19
n3/n6	4.90	12.05	13.29	7.43	6.70
EPA + DHA	7.52	13.52	20.45	23.77	7.85

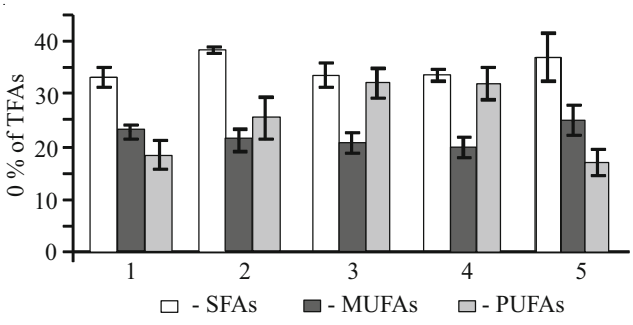

Fig. 1

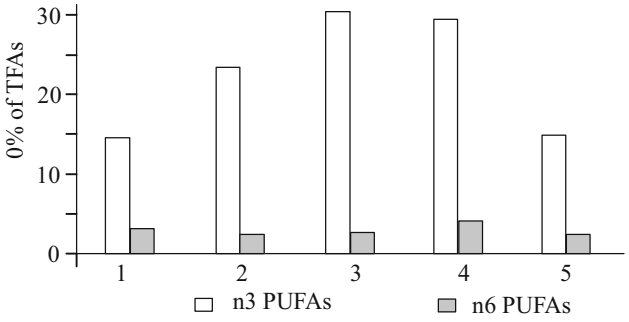

Fig. 2

Fig. 1. The ratios of fatty acid groups in muscle of investigated species: *Lithognathus mormyrus* (1), *Mugil cephalus* (2), *Liza aurata* (3), *Liza ramada* (4), *Chelon labrasus* (5).

Fig. 2. The ratios of n3 PUFAs and n6 PUFAs in muscle of the investigated species: *Lithognathus mormyrus* (1), *Mugil cephalus* (2), *Liza aurata* (3), *Liza ramada* (4), *Chelon labrasus* (5).

Oleic acid was the major MUFA, contributing approximately 10–20% of the total fatty-acid content among the investigated fish species. In all fish, palmitoleic acid had the second highest concentration, which was followed by oleic acid. It has been reported that high levels of oleic and palmitoleic acids are a characteristic property of freshwater fish oils [14]. However, it was determined that the proportions of these two MUFAs among all the investigated species from the Beymelek Lagoon with brackish water were similar to those reported in sea fish, *Dicentrarchus labrax*, *Dentex dentex*, *Pagellus erythrinus*, *Diplodus sargus*, *Mullus surmuletus*, *Solea solea*, *Scomber scombrus*, *Pomatomus saltatrix*, *Sardina pilchardus* [15]. The levels of total MUFAs ranged from 19.79% to 24.97% of the fish (Fig. 1). While no significant differences were found among the species ($p > 0.05$), the levels of total MUFAs were found to be higher in *C. labrasus* and lower in *L. ramada*. We assume that this similarity in the levels of both total SFAs and MUFAs among the investigated species might have resulted from the fact that the fish were caught from the same habitat.

The levels of total PUFAs accounted for 16.94–32.30% of the total FAs in the muscle of the investigated fish in the Beymelek Lagoon (Fig. 1). The total PUFA amounts were highest in *L. ramada* and *L. aurata*. The differences in total PUFA contents of these two species were only statistically significant compared to those of *C. labrasus* ($p < 0.05$). In all species, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) were the more abundant PUFAs, and their amounts in total FAs ranged between 3.14–7.45% and 4.19–20.26%, respectively (Table 1). It was reported that the main characteristic property of freshwater fish with respect to fatty-acid composition is higher levels of fatty acids with 16–20 carbon and lower levels of fatty acids with 20–22 carbon when compared to marine fish, and these differences are mainly due to dietary fat. It has been reported that EPA and DHA were the main n3 PUFAs in both freshwater fish and marine fish. However, it was also reported that EPA and DHA levels of sea fish were higher than those of freshwater fish [16]. In the present study, we observed that the levels of total PUFAs, EPA and DHA, were similar to the reported values both in some freshwater fish, *Sander lucioperca* [3], *Cyprinus carpio* [17], *Clarias gariepinus*, *Siluris glanis*, and *Rutilus frisii* [10] and in marine fish, Sardinella spp. and *Micropogonias furnier* [18], *Penaeus semisulcatus* [19], *Epinephelus aeneus*, *Trigla lucerna*, *Merlangius merlangus*, *Siganus rivulatus*, *Dicentrarchus labrax* and *Sparus auratus*, *Boops boops*, *Mugil cephalus*, *Sardinella aurita*, *Pagellus erythrinus*, and *Solea solea* [10].

n3 PUFAs have a vital role in human nutrition and disease prevention. Yet, it has been reported that the ratio of n3 PUFAs to n6 PUFAs is a better index for comparing the nutritional and pharmaceutical value of fish oils. For instance, it was reported that a high ratio of n3 PUFAs to n6 PUFAs in human diet is protective or curative for cardiovascular diseases, diabetes, depression, some forms of cancer, inflammatory and autoimmune diseases, Alzheimer's disease, and asthma [20, 21]. Studies have also shown that salinity and many other factors such as habitat, diet, and temperature affect the ratios of fatty acids in muscle of fish. Therefore, it has been reported that the ratio of n3 PUFAs to n6 PUFAs in freshwater fish mostly varies between 0.5 and 3.8, whereas for marine fish, the ratio is 4.7–14.4 [17]. In the present study, the ratios of n3 PUFAs to n6 PUFAs varied from 4.90 to 13.29. This ratio was lowest in *L. mormyrus* and highest in *L. aurata*. These results indicate that the fish species in the Beymelek Lagoon with brackish water display remarkably high ratios of n3 PUFAs/n6PUFAs and that they can be a crucial source of n3 PUFAs for human nutrition.

Lipid Extraction. Muscle tissue (10 g) of each fish was homogenized and lipid was extracted with 60 mL methanol and 30 mL chloroform (2:1). The solvent was removed by evaporation under vacuum. The residual chloroform was then removed by nitrogen [22].

Gas Chromatographic Analyses. Fatty acid methyl esters were prepared according to AOCS methods [23]. The GC instrumentation used for the analyses was as follows: a Hewlett-Packard GC (model 6890) equipped with Supelco SP-2380 fused silica capillary column (60 m × 0.25 mm i.d.) and a flame ionization detector. The injection volume was 2 mL. The temperature of the GC oven was programmed from 100 to 220°C at the rate of 4°C/min. The injector and flame ionization detector temperatures were 300°C. Nitrogen was used as the carrier gas, and the flow rate was 1 mL/min. The injection volume was 2 μL with a split ratio of 1:100. The fatty acids were identified by comparing the retention times of the fatty acid methyl esters with the standard, which consists of a mixture of 37 fatty acid methyl esters.

REFERENCES

1. A. Leaf, Y.-F. Xiao, J. X. Kang, and G. E. Billman, *Pharmacol. Ther.*, **98**, 355 (2003).
2. W. S. Harris, *Pharmacol. Res. Nutr. Pharmacol*., **55**, 217 (2007).
3. K. Uysal and M. Y. Aksoylar, *Ecol. Food Nutr.,* **44**, 23 (2005).
4. M. Celik, A. Diler, and A. Kucukgulmez, *Food Chem.,* **92**, 637 (2005).
5. Z. Cai and L. R. Curtis, *Aquaculture,* **88**, 313 (1990).
6. G. Palmeri, G. M. Turchini, and S. S. De Silva, *Food Chem.,* **102**, 796 (2007).
7. K. Uysal, A. Yerlikaya, M. Y. Aksoylar, M. Yontem, and M. Ulupinar, *Ecol. Freshwater Fish,* **15**, 441 (2006).
8. H. I. Haliloglu, B. Abdulkadir, A. N. Sirkecioglu, N. M. Aras, and A. Muhammed, *Food Chem.,* **86**, 55 (2004).
9. B. S. Roesch, Y. K. Ip, and J. S. Ballantyne, *Mol. Integr. Physiol.,* **149**, 209 (2008).
10. Y. Ozogul, F. Ozogul, and S. Alagoz, *Food Chem.,* **103**, 217 (2007).
11. R. G. Acman, C. A. Eaton, and B. A. Linne, *Fishery Bull.,* **73**, 838 (1975).
12. M. Celik, A. Diler, and A. Kucukgulmez, *Food Chem.,* **92**, 637 (2005).

13. G. O. Guler, A. Aktumsek, O. B. Citil, A. Arslan, and E. Torlak, *Food Chem.,* **103**, 1241 (2007).
14. H. Osman, A. R. Suriah, and E. C. Law, *Food Chem*., **73**, 55 (2001).
15. S. Imre and S. Saglik, *Turk. J. Chem.,* **22**, 321 (1998).
16. S. Czesny, S. Kolkovski, K. Dabrowski, and D. Culver, *Aquaculture,* **178**, 103 (1999).
17. G. O. Guler, B. Kiztanir, A. Aktumsek, O. B. Citil, and H. Ozparlak, *Food Chem.,* **108**, 689 (2008).
18. L. A. Luzia, G. R. Sampaio, C. M. N. Castellucci, and E. A. F. S. Torres, *Food Chem*., **83**, 93 (2003).
19. Y. Yanar and M. Celik, *Food Sci. Technol. Int.,* **11**, 391 (2005).
20. S. Jude, S. Roger, E. Martel, P. Besson, S. Richard, P. Bougnoux, P. Champeroux, and J.-Y. Le Guennec, *Prog. Biophys. Mol. Biol.,* **90**, 299 (2006).
21. A. P. Simopoulos, *Biomed. Pharmacother.,* **56**, 365 (2002).
22. J. Folch, M. Lees, and S. G. H. Sloane, *J. Biol. Chem.,* **226**, 497 (1956).
23. *Association of Official Analytical Chemists,* Washington, 1997.