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Fatty acid composition of total lipids in muscle tissues of nine freshwater fish from the River Tigris (Turkey)

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Abstract: Fatty acid compositions of total lipids in the muscle of 9 freshwater fish species were examined via gas chromatography. Palmitic acid and oleic acid were the predominant saturated (SFA) and monounsaturated fatty acids (MUFA) in all the species analyzed. The highest value of total SFA was detected in *Liza abu* (48.94%). *Alburnus mossulensis* had the greatest percentage of total MUFA (55.56%). Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) were the most abundant PUFA in all the species analyzed. *Cyprinion macrostomus* had the highest percentage (72.65%) of total PUFA. The ratio of ω3/ω6 PUFAs ranged from 0.39 to 3.53. *Chondrostoma regium*, *Barbus rajonorum*, *Carasobarbus luteus*, *Leuciscus lepidus*, *Acanthobrama marmid*, *C. macrostomus*, and *Silurus triostegus* may be preferable for a healthy diet as a result of their high C20:5ω3 and C22:6ω3 content. *A. mossulensis* and *L. abu* had an ω3/ω6 PUFAs ratio of less than 1. They are not as good a source of ω3 fatty acids as freshwater fish.

Key words: Freshwater fish, fatty acid composition, Tigris, ω3/ω6 ratio

Dicle nehrinden (Türkiye) dokuz tatlı su balığının kas dokularındaki total lipitlerin yağ asit kompozisyonu

Özet: Tatlı su balıklarından 9 türün kas dokusundaki total lipitlerin yağ asidi kompozisyonu gaz kromatografisi ile incelendi. Analiz edilen bütün türlerde, palmitik asit ve oleik asit en çok bulunan doymuş ve tekli doymamış yağ asitleriydi. Total doymuş yağ asitlerinin en yüksek değeri *Liza abu*'da (% 48,94) belirlendi. *Alburnus mossulensis* toplam tekli doymamış yağ asitlerinin en büyük yüzdesine (% 55,56) sahipti. Analiz edilen bütün türlerde, eikosapentaenoik asit (EPA) ve dokosahekzaenoik asit (DHA) en bol bulunan çoklu doymamış yağ asitleriydi. *Cyprinion macrostomus* total çoklu doymamış yağ asitlerinin en yüksek yüzdesine (% 72,65) sahipti. ω3/ω6 çoklu doymamış yağ asitlerinin oranı 0,39 ile 3,53 arasında değişti. Yüksek C20:5ω3 ve C22:6ω3 içeriğinden dolayı *Chondrostoma regium, Barbus rajonorum, Carasobarbus luteus, Leuciscus lepidus, Acanthobrama marmid, C. macrostomus* ve *Silurus triostegus* beslenme için tercih edilebilir. *A. mossulensis* ve *L. abu* 1 den düşük bir ω3/ω6 çoklu doymamış yağ asitleri oranına sahipti. Bunlar tatlı su balığı olarak ω3 yağ asitlerinin iyi kaynakları değildir.

Anahtar sözcükler: Tatlı su balığı, yağ asit kompozisyonu, Dicle nehri, ω3/ω6 oranı

Introduction

Fish is a nutritious food for humans because it contains oil with high percentages of ω3 polyunsaturated fatty acids (PUFAs), such as C20:5ω3 (eicosapentaenoic acid, EPA) and C22:6ω3 (docosahexaenoic acid, DHA) (1). All fish contain EPA and DHA, but quantities vary among and within species according to environmental variables such as diet and habitat, and whether fish are wild or farmed (2). Researchers have shown that freshwater fish generally contain lower proportions of ω3 PUFAs than marine fish (3). However, there are recent reports that freshwater fish contain relatively large amounts of ω3 PUFAs (4). Moreover, ω3 PUFAs play a role in preventing cardiovascular diseases (5), and improving learning ability (6) and visual function (7). Long chain ω3 PUFAs cannot be synthesized by humans and must be obtained through diet (8). Therefore, regular ingestion of fish is important in the maintenance of human health.

Fish constitute almost 50% of the total number of recognized vertebrate species. About 39% of these fish species are found in, or almost always in, fresh water (9). Freshwater fish are also of interest because they seem to have a greater capacity than marine fish to elongate and desaturate the shorter fatty acid, synthesized by algae or plants, into the longer EPA and DHA, thereby converting food of lower nutritional value into food of higher nutritional value (10).

Freshwater fish in the Tigris river system, in southeastern Anatolia (Turkey), serve as a major source of protein for a large portion of the population who live around the river. Fish are not only the major source of protein but also contain nutritionally valuable lipids and fatty acids.

Despite the vast ichthyofauna diversity of the Tigris, there is no information on the fatty acid composition of fish species commonly consumed in the region. As a basis for possible nutritional and health benefits, we have determined the ω3/ω6 ratios and fatty acid composition (especially ω3 and ω6) of total lipids in the muscle tissues of 9 species commonly available for consumption.

Materials and Methods

Materials

Mature fish were collected in January 2003 from the Tigris, Turkey. The sample characteristics and fish species examined in this study are shown in Table 1. From each specimen, an edible portion of the dorsal muscle between the dorsal fin and head was excised. This section was then skinned, deboned, and the red muscle trimmed off. The remaining white muscle was homogenized in a Waring blender.

Fatty acid analysis

Total lipid extraction was performed according to the method of Bligh and Dyer (11). A chloroform and methanol mixture (2:1, vol/vol) was used as a solvent.

Table 1. The sample characteristics and fish species examined in this study.

Scientific name	English name	Turkish and local name	Mean total weight (g) mean ± SD	Mean standard length (cm) mean ± SD	Number of samples	Sex of fish
Alburnus mossulensis	Mossul bleak	Gümüş balığı	42 ± 7	14 ± 8	3	female
Chondrostoma regium	Nase	Kababurun	48 ± 6	15 ± 7	4	female
Barbus rajonorum	Barb	Sirink	230 ± 8	22 ± 5	4	female
Carasobarbus luteus	Sangal	Karagöz	129 ± 8	17 ± 4	4	female
Leuciscus lepidus	Kawar	Akbalık	162 ± 7	20 ± 6	4	female
Acanthobrama marmid	Shebhe-nazy	Kızılkanat	104 ± 4	17 ± 3	3	female
Cyprinion macrostomus	Large-mouthed barb	Beni	53 ± 5	12 ± 3	3	female
Liza abu	Abu mullet	Dicle kefali	80 ± 3	15 ± 2	3	female
Silurus triostegus	Mesopotamian catfish	Fırat yayını	453 ± 11	37 ± 20	3	female

Samples containing muscle lipid were transesterified with acidified methanol (12).

Fatty acid methyl esters (FAMEs) were extracted with hexane and analyzed via capillary gas chromatography using an Ati Unicam GC-610 equipped with a flame ionization detector (FID) and a fused silica capillary column (Quadrex 007-23, 30 m × 0.25 mm i.d.; 0.25 μm film thickness, Quadrex Corp., New Haven, CT, USA). The carrier gas was nitrogen (flow rate 1 mL/min) and the split ratio was 40:1. The temperature profiles were as follows: initial temperature, 100 °C (initial time, 3 min); heating rate, 5 °C/min; final temperature, 260 °C; injection temperature, 230 °C; and detector temperature, 300 °C.

The FAMEs were identified using retention times compared with those of standard purified fatty acids (Sigma Chemical Co., St. Louis, MO, USA). Results were expressed as FID response area relative percentages.

Results and discussion

The fatty acid composition of total lipids of fish species obtained from the Tigris showed significant differences (Table 2). The present study revealed that total SFA, total MUFA, and total PUFA levels varied between species. The main differences arose from the PUFA of total fatty acids (which ranged from 9.75% to 72.65%).

In general, the fatty acid composition of the fish analyzed is in agreement with the data available on the fatty acid composition of the fish species in the literature (13-17).

The total SFA and total MUFA percentages of the total lipid extracted from the 9 fish species ranged from 10.72% to 48.94% and from 14.84% to 55.65%, respectively. With regard to the ratio of total SFA content, the highest value was detected in *L. abu* (48.94%). Of the SFAs, C16:0 (palmitic acid) was very high in all fish and was highest in *L. abu*. C18:0 (stearic acid) was the second greatest proportionally in all species with the greatest percentage found in *L. abu*.

The total amount of SFAs in fish species obtained from the Tigris (10.72% to 48.94%) was higher than the total amount of SFA (16.8%-31%) in other freshwater fish reported by Wang et al. (18). However, Wang et al. (18) reported that, in Lake Superior fish, C16:0 accounted for 68%-79% of the total SFA. In the present study, the level of C16:0 was similar, averaging 64%-77% of total SFA. The SFA results are in agreement with the fatty acid composition of the fish species previously reported (14-17).

C18:1ω9 (oleic acid) was the main MUFA in all species analyzed. This was followed by C16:1ω7 (palmitoleic acid) and then C20:1ω9 (eicosenoic acid). *A. mossulensis* had the greatest percentage of total MUFA, whereas *C. macrostomus* had the lowest percentage (14.84%). MUFA results are in agreement with the fatty acid composition of the fish species previously reported (3,14-18).

From the *A. mossulensis* fish species analyzed, the MUFA content was higher than the SFA and PUFA content. This is similar to the studies carried out by Nair and Gopakumar (19) and Rahman et al. (20).

The PUFA percentages of the total lipid ranged from 9.75% (*L. abu*) to 72.65% (*C. macrostomus*). C20:5ω3 (0.65%-20.15%) and C22:6ω3 (0.72%-27.08%) were the dominant PUFAs in all species. Henderson and Tocher (10) reported C20:5ω3 values for freshwater fish ranging from 1.4% to 16.3% and C:22.6ω3 values ranging from 0.3% to 30% of total lipids.

Generally, in this study, 18:1ω9 and 16:0 were the most abundant fatty acids in *A. mossulensis* and *L. abu*, respectively. In the other fish, C20:4ω6 (arachidonic acid, AA), C20:5ω3, and C22:6ω3 were the major fatty acids.

The results of this study also indicated that the ω3/ω6 PUFAs ratios were higher than 1, except for *A. mossulensis* (0.39) and *L. abu* (0.67). The ratio of ω3/ω6 PUFAs ranged from 0.39 to 3.53 and showed variation in many species as reported by Hearn et al. (21). In the present study, the ratio of ω3/ω6 PUFAs was within the range found for freshwater fish.

The ratio of ω3/ω6 PUFAs in total lipids of freshwater fish changes mostly between 0.5 and 3.8, whereas it changes between 4.7 and 14.4 in marine fish (10). Wang et al. (18) reported that the ratio of ω3/ω6 PUFAs ranged from 1.7 to 2.5. Rahman et al. (20) found that the ω3/ω6 PUFAs ratio of freshwater

Table 2. Fatty acid composition of freshwater fish from the Tigris (results are expressed as a percentage of the total fatty acids present).

Fatty acids	*Alburnus mossulensis*	*Chondrostoma regium*	*Barbus rajonorum*	*Carasobarbus luteus*	*Leuciscus lepidus*	*Acanthobrama marmid*	*Cyprinion macrostomus*	*Liza abu*	*Silurus triostegus*
Saturated									
12:0	0.14 ± 0.01	0.15 ± 0.03	0.13 ± 0.05	0.19 ± 0.02	0.14 ± 0.05	0.11 ± 0.03	0.13 ± 0.01	0.20 ± 0.01	0.07 ± 0.02
14:0	0.83 ± 0.05	0.59 ± 0.06	0.87 ± 0.02	0.89 ± 0.06	0.71 ± 0.04	1.13 ± 0.09	0.51 ± 0.02	3.13 ± 0.13	0.60 ± 0.04
15:0	0.45 ± 0.03	0.26 ± 0.02	0.45 ± 0.01	0.25 ± 0.04	0.28 ± 0.02	0.30 ± 0.01	0.26 ± 0.05	0.94 ± 0.07	0.17 ± 0.01
16:0	8.09 ± 0.92	14.83 ± 0.23	7.65 ± 0.21	12.28 ± 0.35	18.50 ± 0.28	9.54 ± 0.92	9.57 ± 0.31	35.53 ± 0.12	14.87 ± 1.01
18:0	3.08 ± 0.62	4.11 ± 0.12	1.62 ± 0.18	3.53 ± 0.10	5.57 ± 0.51	2.63 ± 0.52	2.04 ± 0.09	9.14 ± 0.93	6.15 ± 0.96
Total saturated	12.59	19.94	10.72	17.14	25.20	13.71	12.51	48.94	21.86
Monoenoic									
16:1ω7	5.05 ± 0.37	8.60 ± 0.42	5.44 ± 0.38	5.24 ± 0.25	1.35 ± 0.12	6.59 ± 0.32	6.51 ± 0.69	13.23 ± 0.53	5.14 ± 0.26
18:1ω9	49.01 ± 1.16	14.27 ± 0.96	9.93 ± 0.85	19.64 ± 0.85	12.75 ± 0.93	30.35 ± 1.13	7.95 ± 0.73	26.96 ± 0.90	15.26 ±.0.10
20:1ω9	1.59 ± 0.03	1.60 ± 0.02	4.85 ± 0.12	1.59 ± 0.03	0.92 ± 0.06	0.48 ± 0.01	0.38 ± 0.01	1.12 ± 0.09	0.55 ± 0.01
Totalmonoenoic	55.65	24.47	20.22	26.47	15.02	37.42	14.84	41.31	20.95
Polyenoic (ω3)									
18:3ω3	2.07 ± 0.08	2.00 ± 0.13	1.87 ± 0.25	5.90 ± 0.39	2.70 ± 0.86	2.64 ± 0.56	1.40 ± 0.09	2.13 ± 0.08	1.43 ± 0.21
20:5ω3	1.54 ± 0.36	17.30 ± 0.98	13.39 ± 1.12	6.87 ± 0.78	6.52 ± 0.69	7.97 ± 1.01	20.15 ± 1.52	0.65 ± 0.07	10.87 ± 0.86
22:5ω3	1.35 ± 0.25	7.21 ± 0.45	8.06 ± 0.89	4.90 ± 0.56	5.39 ± 0.39	3.55 ± 0.85	10.71 ± 1.02	0.40 ± 0.01	7.94 ± 0.95
22:6ω3	3.97 ± 0.35	16.82 ± 1.01	26.89 ± 1.31	11.97 ± 0.81	27.08 ± 1.26	10.75 ± 0.78	22.19 ± 1.00	0.72 ± 0.01	20.61 ± 1.11
Totalω3	8.93	43.33	50.21	29.64	41.69	24.91	54.45	3.90	40.85
Polyenoic (ω6)									
18:2ω6	12.99 ± 0.79	6.42 ± 0.45	4.99 ± 0.36	8.70 ± 0.58	5.99 ± 0.69	9.85 ± 0.39	1.28 ± 0.21	3.76 ± 0.23	4.52 ± 0.85
18:3ω6	0.81 ± 0.01	0.64 ± 0.01	0.48 ± 0.01	1.65 ± 0.05	0.43 ± 0.01	0.76 ± 0.02	0.38 ± 0.01	0.35 ± 0.02	0.44 ± 0.01
20:2ω6	1.98 ± 0.05	0.84 ± 0.02	2.32 ± 0.09	1.07 ± 0.01	0.71 ± 0.02	1.12 ± 0.01	3.23 ± 0.13	0.65 ± 0.03	0.66 ± 0.02
20:3ω6	2.26 ± 0.12	1.23 ± 0.30	1.36 ± 0.05	3.06 ± 0.11	1.82 ± 0.15	1.56 ± 0.10	1.98 ± 0.09	0.34 ± 0.05	0.86 ± 0.02
20:4ω6	4.79 ± 0.65	3.13 ± 0.26	10.12 ± 0.75	12.27 ± 0.95	9.14 ± 0.85	10.67 ± 0.68	11.33 ± 0.96	0.75 ± 0.01	9.86 ± 0.36
Total ω6	22.83	12.26	19.27	26.75	18.09	23.96	18.20	5.85	16.34
Total PUFA	31.76	55.59	69.48	56.39	59.78	48.87	72.65	9.75	57.19
ω3/ω6	0.39	3.53	2.61	1.11	2.31	1.04	2.99	0.67	2.50
16:0%/SFA	64	74	71	72	73	70	77	73	68

fish was lower than that of marine fish. Altair et al. (22) reported that the best ω3/ω6 PUFAs ratio of wild freshwater species was 1.79. High ω3/ω6 PUFAs ratios (>6) were found in the freshwater whitefish (*Coregonus* spp.) by Ahlgren et al. (23).

The ω3/ω6 ratio has been suggested to be a useful indicator for comparing relative nutritional values of fish oils (24). An increase in the human dietary ω3/ω6 fatty acid ratio is essential to help prevent coronary heart disease by reducing plasma lipids and to reduce the risk of cancer (25). The amounts and balance of these fats in a person's diet will affect the body's eicosanoid-controlled functions. Eicosanoids have great significance; eicosanoids mediate several pathophysiological events in mammals, insects, and other invertebrates, including influencing ion transport and mediating cellular defense mechanisms (26,27).

Although it is generally recognized that the PUFA composition may vary among species of fish, little attention has been paid to the PUFA composition of different species when selecting fish for diets. All fish are considered to be of similar nutritional value, and selection is chiefly based on availability, freshness, flavor, and similar factors (21). EPA and DHA, found only in seafood, possess extremely beneficial properties for the prevention of human coronary artery disease (28). Therefore, fish have been suggested as a key component for a healthy human diet (20).

The present study suggests that *C. regium*, *B. rajonorum*, *C. luteus*, *L. lepidus*, *A. marmid*, *C. macrostomus*, and *S. triostegus* may be preferable as a result of their high C20:5ω3 and C22:6ω3 content. However, *A. mossulensis* and *L. abu* are not good sources of ω3 fatty acids.

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