

Oil Content and Fatty Acid Composition of Commercially Important Turkish Fish Species

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ABSTRACT: The oil content and fatty acid composition of commercially important Turkish fish species (anchovy, *Engraulis encrasicolus*; freshwater rainbow trout, *Salmo gairdneri*; and cultured salmon, *S. salar*) were determined. Palmitic (16:0), palmitoleic (16:1), oleic (18:1), and docosahexaenoic (22:6) acids were the most abundant fatty acids in all species. Eicosapentaenoic acid (20:5) was twice as high in the anchovy oil as in the rainbow trout and salmon oils. Significant quantities of linoleic acid (18:2) and docosahexaenoic acids (22:6) were found in both rainbow trout and salmon samples. The individual fatty acid data obtained from rainbow trout and salmon were similar to each other. All three fish species contain high levels of n-3 polyunsaturated fatty acids and would be suitable for inclusion in the formulation of low-fat highly unsaturated diets.

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KEY WORDS: Anchovy, fatty acid composition, fish, n-3 fatty acids, rainbow trout, salmon.

Since the pioneering epidemiological work of Dyerberg and Bang (1) on Greenland Eskimos suggested a possible link between low incidence of heart diseases and the consumption of sea foods, many studies have been published on the role of n-3 polyunsaturated fatty acids in human health and diseases. These fatty acids, especially eicosapentaenoic acid (20:5n-3 or EPA) and docosahexaenoic acid (22:6n-3 or DHA), have been reported to have beneficial effects in cardiovascular diseases, autoimmune disorders, and other inflammations (2–5). Therefore, nutritional importance of fish consumption is associated largely with the n-3 fatty acid content (6).

The oil content and the fatty acid composition of fish vary with different species or within a species as a function of diet, temperature, or seasonal influence, age, sex, etc. (7). Consequently, the variation in oil content and fatty acid composition of fish can be enormous. Fatty acid composition data are needed by nutritionists and food scientists to aid them in dietary formulation, nutrient labelling, processing, and product development (6). The fatty acid data for different marine, freshwater, and cultured fish species, especially originating from the United States, Canada, and Japan, are available in the literature (7–17). However, information on the fatty acids of Turkish fish species is lacking. Only one report was en-

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countered in the literature, in which a packed column was used for analysis. In this study (18), it was mentioned that Black Sea anchovy oil contained 34% saturated, 61.92% unsaturated, and a minor amount of polyunsaturated fatty acids.

In Turkey, the annual catch in the late 1980s was about 630,000 tons of marine fish, largely anchovy (380,000 tons), tuna, mackerel, sardine, and bluefish, and 25,000 tons of freshwater fish species (rainbow trout, carp, and perch) (19). Due to depletion of both marine and freshwater fish populations by overfishing and pollution, there is a growing interest in culturing fish species, such as salmon, trout, and bream, in Turkey. By the year 2000, 20% of the fishery harvest may come from aquaculture systems.

The objective of this study was to collect information on fatty acid composition of commercially important Turkish fish species. Black Sea anchovy (*Engraulis encrasicolus*), freshwater rainbow trout (*Salmo gairdneri*) and cultured salmon (*S. salar*) fish species were selected, and their oil contents and fatty acid compositions were determined.

MATERIALS AND METHODS

Anchovy, rainbow trout, and salmon fish samples were obtained from Trabzon, located in the Black Sea region of Turkey. All fish samples were collected in February 1995, immediately frozen and stored at -20°C until analyzed. Prior to analysis, the head, tail, fins, viscera, and skin of the fish were removed. The fish were filleted. Fish fillets were homogenized in a food blender (Braun Type MX82; Braun, Frankfurt, Germany), and oils were extracted by the method of Bligh and Dyer (20).

The oils were analyzed for acid, saponification, and iodine values; unsaponifiable matter content; and density and refractive index according to standard AOCS methods Cd 3a-63, Cd 3-25, Cd 1-25, Ca 6b-53, Cc 10a-25, and Cc 7-25, respectively (21).

For the determination of fatty acid composition, the oil samples were converted to corresponding methyl ester derivatives and analyzed by capillary gas chromatography in a Hewlett-Packard 5890 Series 2 apparatus (Hewlett-Packard, Waldron, Germany), fitted with a flame-ionization detector and a data processor, under the following conditions: column,

Ultra 2 (25 m × 0.32 mm) with 0.52- μ m film thickness of 5% diphenyl, 95% dimethyl polysiloxane; nitrogen carrier gas at 1.72 mL/min; air flow of 450 mL/min; hydrogen flow of 69 mL/min; injection, split 50:1, 0.5 μ L; injector temperature, 225°C; flame-ionization detector temperature, 250°C; oven temperature program, 150°C (5 min), 150–225°C (5°C/min), 225°C (30 min). Peaks were identified by comparing the retention times with those of a mixture of standard methyl esters. Menhaden oil fatty acid methyl esters (Sigma Chemical Co. Ltd., Poole, England) were also utilized as secondary standard.

RESULTS AND DISCUSSION

The oil content and oil characteristics of Turkish anchovy, rainbow trout, and salmon fish species are given in Table 1. The oil contents of anchovy, rainbow trout, and salmon fish samples are 2.8, 2.4, and 3.8%, respectively. The species ana-

TABLE 1
Oil Content and Characteristics of Turkish Anchovy, Rainbow Trout, and Salmon Fish Species

	Anchovy	Rainbow trout	Salmon
Oil content (%)	2.8	2.4	3.8
Acid value	2.4	6.6	8.7
Saponification value	206.2	204.7	198.7
Iodine value	152.1	154.0	157.7
Unsaponifiable matter (%)	1.4	3.1	3.7
Density (g/mL, 20°C)	0.9140	0.9091	0.9075
Refractive index (20°C)	1.4785	1.4781	1.4769

lyzed in this study are low-fat type fish, according to the oil content classification (6).

The fatty acid compositions of anchovy, rainbow trout, and salmon fish species are summarized in Table 2. For comparison, the fatty acid compositions of anchovy (10,22), rainbow

TABLE 2
Fatty Acid Composition for the Anchovy, Rainbow Trout, and Salmon Fish Oils^a

Fatty acid	Anchovy oil originating from			Rainbow trout originating from			Salmon originating from		
	Turkey	South Africa (10)	Peru (22)	Turkey	Italy (8)	United States (11)	Turkey (cultured)	Canada (14) (cultured)	United States (11) (freshwater)
14:0	6.3	10.6	12.4	4.0	2.02	3.5	4.0	5.8	2.9
15:0	0.3	0.5	0.46	0.2	0.28	—	0.2	0.3	—
16:0	18.8	16.1	20.5	18.3	17.83	13.3	19.0	13.6	10.7
16:1n-7	8.5	11.4	11.1	5.7	6.12	4.8	5.7	7.1	5.0
16:1n-5	0.2	—	—	0.1	—	—	<0.1	0.2	—
16:2n-4	0.7	1.1	—	0.2	—	—	—	0.6	—
16:3n-6	0.2	1.1	—	0.3	—	—	—	0.4	—
16:4n-1	0.9	2.5	—	0.6	—	—	0.6	0.4	—
17:0	0.8	—	1.88	0.1	0.64	—	0.2	0.1	—
18:0	4.1	2.8	4.08	4.2	4.83	3.8	4.5	1.7	3.6
18:1n-9	18.7	—	—	20.7	—	18.7	22.3	10.7	24.5
18:1n-7	2.4	10.2	14.35	2.8	32.45	—	3.1	2.3	—
18:1n-5	0.2	—	—	<0.1	—	—	<0.1	0.4	—
18:2n-4	0.3	—	—	0.9	—	—	0.3	—	—
18:2n-6	2.4	1.0	3.56	10.6	14.33	5.5	11.3	3.3	5.2
18:3n-3	1.6	0.4	—	0.5	0.31	4.4	1.0	0.8	3.5
18:3n-6	0.2	—	—	0.4	—	—	0.2	0.1	—
18:4n-3	0.7	1.5	—	0.3	0.35	2.1	0.6	1.3	1.5
18:4n-1	0.6	—	—	0.4	—	—	0.4	0.3	—
20:0	0.2	0.4	0.27	0.2	—	—	0.2	0.1	—
20:1n-9	0.9	0.5	2.10	2.8	2.63	1.5	2.9	13.9	1.8
20:1n-7	<0.1	—	—	0.4	—	—	0.2	0.5	—
20:2n-6	2.0	—	2.48	<0.1	0.67	—	—	0.2	—
20:4n-3	0.8	1.7	0.50	0.8	1.29	2.8	0.6	0.6	2.3
20:4n-6	0.6	—	—	0.4	0.51	3.4	0.2	0.3	4.3
20:5n-3	7.4	24.6	10.70	3.9	1.97	5.1	3.1	4.7	4.5
22:1n-11	1.8	1.0	1.73	0.4	—	1.0	0.9	14.4	1.0
22:1n-9	0.2	—	—	0.5	—	—	0.3	1.1	—
22:4n-3	0.7	—	—	—	—	—	—	—	—
22:4n-6	0.9	—	2.18	0.3	0.27	—	—	—	2.2
22:5n-3	1.4	1.9	1.39	2.0	0.80	3.7	1.7	1.4	5.0
22:6n-3	12.3	9.8	4.37	15.0	10.28	21.0	16.7	11.1	17.0

^awt% of total fatty acids.

trout (8,11), and salmon (11,14) oils reported in the literature are included in Table 2.

Of the 33 fatty acids found in Black Sea anchovy oil, 16:0 (18.8%), 16:1 (8.7%), 18:1 (21.2%), 20:5 (7.4%), and 22:6 (12.3%) fatty acids were the major components. The saturated fatty acid content of anchovy oil was 30.5%. The mono-, di-, and polyunsaturated fatty acids accounted for 32.9, 5.4, and 28.1%, respectively. Turkish anchovy oil contained 7.4% EPA and 12.3% DHA, the two polyunsaturated fatty acids considered to be of major importance in terms of human health. In contrast to other anchovy oils, Black Sea anchovy oil has high proportions of 18:1 and 22:6 fatty acids and more 22:6 than 20:5, as seen in Table 2.

The fatty acid profile of the Turkish rainbow trout (*S. gairdneri*) fits into the typical pattern for freshwater fish, where oleic acid is usually the major constituent (13): 16:0 (18.3%), 16:1 (5.8%), 18:1 (23.5%), 18:2 (11.5%), and 22:6 (15.0%) were the most abundant fatty acids. Table 2 shows that both Turkish and Italian rainbow trout samples contained considerably large amounts of linoleic acid, 11.5 and 14.33%, respectively. Among rainbow trout samples listed in Table 2, there were great differences in fatty acid compositions, especially in respect to percentage fatty acids with specific numbers of double bonds. Rainbow trout caught in Cayuga Lake (Ithaca, New York) consisted mostly of polyunsaturated fatty acids (40.6%) (11), whereas Turkish and Italian fish samples contained 22.5 and 15.0%, respectively. On the other hand, South-European rainbow trout samples were richest in the saturated, mono-, and diunsaturated fatty acids. The observed variations in fatty acids within rainbow trout species are influenced by the differences in environmental conditions (such as season, temperature, diet) (7).

The fatty acid composition of the pond-raised salmon fish (*S. salar*) analyzed in this study presented high proportions of 16:0 (19.0%), 16:1 (5.7%), 18:1 (35.4%), 18:2 (11.6%), and 22:6 (16.7%) fatty acids. Only modest levels of 20:1 (3.1%) and 22:1 (1.1%) acids were detected in salmon, whereas the Canadian cultured salmon contained 13.9% 20:1 and 14.4% 22:1 acids (14). However, salmon fatty acids rather resemble those of the freshwater salmon sample (11) included in Table 2. Furthermore, there was a close similarity between Turkish salmon and rainbow trout in their fatty acid compositions.

In conclusion, Turkish anchovy, rainbow trout, and salmon fish species are low-fat type fish. Palmitic (16:0), palmitoleic (16:1), oleic (18:1), and docosahexaenoic (22:6) acids were the most abundant fatty acids in all species. EPA (20:5) was twice as high in the anchovy oil as in the rainbow trout and salmon oils. Significant quantities of linoleic (18:2) and DHA (22:6) were found in both rainbow trout and salmon samples. The individual fatty acid data obtained from rainbow trout and salmon are similar to each other. Anchovy, rainbow trout, and salmon species contained high levels (23.4, 22.5, and 23.6%, respectively) of n-3 polyunsaturated fatty acids, which have been reported to have beneficial effects in human health (2-5). Therefore, all three fish would

be suitable for inclusion in the formulation of low-fat highly unsaturated diets.

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