The Fatty Acid Composition of Edible Marine Fish Oils

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Abstract

The body oils of 13 species of marine edible fishes found around the Karachi-Makran coast were studied by gas-liquid chromatography (GLC) for their fatty acid composition. The analyses showed the presence of fatty acids with chain lengths from 10 to 24 carbon atoms and with zero to six double bonds. The oils were found to be rich in polyunsaturated acids, particularly the penta- and hexaenoic. Certain major fatty acids were found to vary widely among the species: myristic acid 2.3 to 13.7%; palmitic 11.6 to 41.2%; stearic 7.2 to 23.2%; oleic 6.9 to 29.6%; eicosapentaenoic 1.4 to 19.0%; docosapentaenoic zero to 10.2%; and docosahexaenoic zero to 36.4%. The linoleic and linolenic acids were present in small amounts in some of the fish oils, and arachidonic acid was present in all of them.

Introduction

THE TELEOSTII (MARINE EDIBLE) fishes, found around the Karachi-Makran coast, form a major constituent in the diet of the indigenous population. The annual catch of edible fishes around the Karachi coast alone is approximately 33,000 tons, out of which 7,000 tons are consumed by the local population and the rest is either cured or utilized for manufacturing fish meal.

In view of the importance of fish oils as the best natural source of highly unsaturated fatty acids, notably those acids with more than three ethylenic groups, this investigation was undertaken to learn what fatty acids are found in the oils of marine edible fishes of this region and to determine the species variation in the pattern of these acids. This is the first time that fatty acid analyses are reported for the fishes caught along the coast near Karachi.

In the present study 13 species of fish consumed by the local population were chosen and arranged in three groups according to their palatability and the price they fetched in the market. No attempt was made to prepare composite samples representative of the variations in particular species from one time of the year to another. In this respect the sampling was representative of the conditions which prevailed at the time of sampling only.

Experimental Procedures

The fishes procured from the local fish harbor were cleaned, and their visceral portion was removed. The entire edible portion of the fish was minced in a mechanical mincing machine, thoroughly mixed with anhydrous sodium sulphate, and repeatedly extracted with ether. The solvent was completely distilled off; the last traces were removed under vacuum. The clear oil thus obtained was stored under nitrogen in a refrigerator.

The oil was saponified with alcoholic KOH, and the unsaponifiable matter was extracted with ether. Fatty acids were liberated from the soap solution with (4 N) hydrochloric acid; nitrogen gas was bubbled through the reaction mixture during this operation. The liberated acids were taken up in ether and washed three times with distilled water to remove the mineral acid. The ether extract was dried over anhydrous sodium sulfate and filtered; the solvent was removed under nitrogen. Methyl esters of the fatty acids were prepared with diazomethane (1). The completion of esterification was ensured by washing the reaction mixture with a dilute solution of potassium carbonate; no soap was formed. The methyl esters were stored in a deep freeze until analyzed.

Gas-Liquid Chromatography

The methyl esters were chromatographed on an EIR gas chromatograph with a Lovelock ionization detector with Sr^{90} as the radioactive source. A U-shaped column, 2.25 meters long and 5 mm I.D., was used. The liquid phase was 15% diethylene glycol succinate (DEGS), coated on a siliconized inert support of 80–110 mesh Gas-Chrom P. Argon was used as carrier gas. The linearity of chromatographic response was checked with fatty acid standards prior to the analyses of unknown samples. Peaks were identified on the basis of co-chromatography with standards and their relative retention time with respect to methyl stearate. Quantitation of the chromatogram was achieved by triangulation of the individual peak areas; the total area was calculated, and the areas of each peak were expressed as a percentage of the total (2).

For all GLC determinations the gas flow was 50 ml Argon/minute; detector sensitivity was 3×10^{-9}

TABLE I

Oils from Various Species of Marine Edible Fish

Group No.	Scientific Name	English Name	Local Name	% Oil in Flesh
1	2	3	4	5
A.	1. Parastromateus Niger	Black Pomfret	Kalachanda	1.97
	2. Stromateus Sinensis	White Pomfret	Paplet	1.63
	3. Polynumus Indicus	Threadfin	Ranwas	0.58
	4. Pelamys Chilensis	Striped Mackerel	Surmai	0.18
B.	1. Clroinemeus Tolooparah	Leather Jacket	Aal	2.05
	2. Mugil Speigleri	Grey Mullet	Boi	0.89
	3. Thynnus thunnina	Tuna	Dawan	1.10
	4. Pristipoma olivaceum	Pomadasid	Dhother	0.50
	5. Lutianus Rivlatus	Snapper	Hira	0.78
	6. Clupea Ilisha	Hilsa	Palla	10.00
	7. Sciaena Dicanthus	Drums and Croakers	Sua	1.10
C.	1. Arius Serratus	Catfish	Khagga	1.14
	2. Otolithas Ruber	Drums and Croakers	Mushka	0.18

TABLE II

Fatty Acid Composition of the Oils of Marine Edible Fishes (Weight Percentage of Total Fatty Acids)[a]

Fatty acid	Name of Fish													Marine Edible Fishes from Bombay Waters (Weight percentage)		
	Black Pomfret	Thread-fin	Striped Mack-kerel	White Pomfret	Leather Jacket	Grey Mullet	Tuna	Poma-dasid	Snapper	Hilsa	Drums and Croak-ers (Sci-aena (Dican-thus)	Cat-fish	Drums and Croak-ers (Oto-lithas Ruber)	Kharkhanis et al. (4)		
														Black Pomfret	White Pomfret	Hilsa
	1	2	3	4	5	6	7	8	9	10	11	12	13	1	2	3
10:0	—	—	Tr	—	—	—	—	—	—	Tr	Tr	×	0.7	×	×	×
12:0	—	1.2	Tr	—	—	Tr	—	0.2	—	0.4	0.3	×	0.1	×	×	×
14:0	5.1	13.7	3.6	8.7	3.3	9.0	5.2	7.1	3.6	7.0	6.0	2.3	5.0	4.37	4.75	5.32
14:1	—	—	—	—	—	—	—	—	—	—	—	—	—	2.44	1.40	1.29
15:0	1.7	1.4	0.4	0.8	0.4	0.5	0.1	Tr	0.3	0.3	0.6	Tr	0.4	×	×	×
16:0	11.6	27.5	22.7	18.8	25.9	20.5	32.0	23.2	28.1	25.2	15.8	41.2	25.4	13.29	20.57	23.48
16:1	Tr	4.1	Tr	1.2	4.2	8.5	Tr	Tr	3.8	3.6	1.4	4.9	1.6	18.80	9.19	6.82
Unknown	0.2	×	Tr	0.3	×	×	×	—	×	×	0.1	×	Tr	×	×	×
17:0	1.1	×	Tr	2.4	0.6	×	—	×	0.9	Tr	Tr	Tr	—	×	×	×
Unknown	Tr	0.8	Tr	—	—	2.0	—	—	0.5	Tr	0.2	Tr	—	×	×	×
18:0	18.9	9.2	14.6	14.0	7.2	7.4	12.0	23.2	7.7	13.2	11.6	11.8	10.6	7.26	11.15	8.87
18:1	6.9	9.4	10.5	23.3	22.5	8.0	15.5	13.4	16.8	21.0	7.6	29.6	12.7	33.16	33.16	32.88
18:2	Tr	0.7	Tr	Tr	Tr	2.0	0.5	0.3	Tr	Tr	1.0	Tr	Tr	0.44	3.56	1.68
18:3	Tr	×	×	—	Tr	6.2	—	1.0	—	Tr	×	—	—	1.73	3.62	9.67
20:0	0.6	0.5	×	0.8	—	Tr	×	Tr	—	Tr	0.9	×	—	0.46	×	0.02
20:1	4.2	0.9	Tr	8.2	Tr	Tr	×	1.8	5.7	Tr	2.3	1.8	0.7	4.53	7.54	9.01
20:4	9.6	4.8	4.3	3.1	3.3	2.0	1.8	5.5	3.8	4.8	6.8	4.5	6.3	6.74	5.06	0.48
20:5	10.9	13.4	6.4	1.4	8.0	19.0	6.5	8.1	5.0	7.3	11.0	2.8	7.9	×	×	×
22:0	×	×	×	5.2	×	×	×	—	Tr	×	×	×	×	×	×	×
22:1	×	×	×	×	×	×	×	×	×	×	×	×	×	3.39	×	×
22:5	10.2	5.0	×	1.9	Tr	4.2	×	5.9	Tr	4.0	5.0	—	3.1	3.39	×	0.48
22:6	14.2	5.5	36.4	9.0	24.6	9.8	26.4	10.0	23.8	13.2	23.8	—	25.5	×	×	×
24:0	4.3	2.1	×	—	—	0.9	×	0.3	×	×	5.1	1.1	—	×	×	×
24:1	0.5	×	1.1	0.9	—	×	×	—	—	×	0.5	×	×	×	×	×

[a] Tr = present in traces.
— = present in very small traces.
× = not detectable.

amperes, and a voltage of 750 was applied across the detector cell. The sample inlet, column, and detector cell temperatures were kept at 200C, 190C, and 200C respectively.

Results and Discussion

In this investigation studies have been confined to the marine edible fishes available in Karachi waters. The species were chosen and arranged in three categories according to their taste and the price they fetched in the local market. Table I represents the various species of Teleostii fish and their percentage of total oil in the body. It may be seen from the table that the oil varies from 0.18 to 10%. The level of fat was relatively higher in Hilsa and Leather Jacket, both of which belong to Group B.

The fatty acid composition of the various fish oils are listed in Table II. The data indicate that the amount of constituent fatty acids varied widely among some species. The wide range of the often most prominent fatty acids in the fish oils was notably 2.3 to 13.7% myristic; 11.6 to 41.2% palmitic; 7.2 to 23.2% stearic; traces to 8.5% palmitoleic; 6.9 to 29.6% oleic; traces to 8.2% eicosenoic; 1.8 to 9.6% arachidonic; 1.4 to 19.0% eicosapentaenoic; zero to 10.2% docosapentaenoic; zero to 36.4% docosahexaenoic acid.

Whereas no relation could be derived between the fatty acid composition and the arbitrary classification of the fishes under consideration, some interesting conclusions can be drawn from Table II. The percentages of saturated acids varied from 40 to 56; those of the monounsaturated varied from 12 to 36, and of the polyunsaturated acids from 7.3 to 47.6. Among the saturated acids, palmitic and stearic were the main constituents although in Threadfin, White Pomfret, and Grey Mullet, myristic was also present in appreciable amounts. The main bulk of the polyunsaturated acids comprises acids with 20 and 22 carbon numbers averaging from 3.0 to 36.4%. Eicosatetraenoic and eicosapentaenoic range from 1.8–9.6% and 1.4 to 13.4%; the docosapentaenoic and docosahexaenoic range from zero to 10.2% and traces to 36.4% respectively.

The content of saturated fatty acids, in general, was observed to be high as compared with those present in marine oils of colder regions (3). These differences are probably owing largely to differences in the respective dietary habits of these fishes and, to some extent, may also be attributed to the high temperatures of Pakistani waters (4). Linoleic acid was present in quite small amounts, a finding also observed by Gruger et al. (3,5) on salt-water fishes from the Atlantic coast.

The effect of feeding habits on the fatty acid composition of fishes becomes evident when the fatty acid composition of Hilsa and of Black and White Pomfrets from Bombay and Karachi waters (Table II) is compared (4). The values differ markedly from one another, and in spite of this vast difference it is observed that the amount of palmitic acid (C_{16}:0) in all the three fishes is nearly the same. A similar observation has been made by Ackman and Eaton (6) on Atlantic, Pacific, and European herring oils. This particular fatty acid (16:0) is evidently a key metabolite in fish in which this level is relatively independent of diet (7).

Oils from three species of fish need special consideration as they differ markedly from other fish oils. Catfish oil consists of the highest amount of saturated (56.4%) and the least amount of polyunsaturated acids (7.3%). The main constituents of the saturated acids are palmitic (41.2%) and stearic (11.8%) whereas the polyunsaturated acids are the arachidonic (4.5%) and eicosapentaenoic (2.8%). It is interesting to note that 92.7% of the total fatty acids are only saturated and monounsaturated. Among the monounsaturated the predominant fatty acid is oleic (29.6%). This oil is therefore distinguished from other fish oils by having the highest percentage of palmitic and oleic acids.

The body oil of Grey Mullet seems to be the best from the nutritional point of view. It contains 40.3% saturated, 16.5% monounsaturated, and 43.2% polyunsaturated acids and has all the essential fatty acids, namely, linoleic (2.0%), linolenic (6.2%), and arachidonic (2.0%).

Pomadasid oil, like that of the Grey Mullet, consists of all the essential fatty acids (arachidonic 5.5%), but at the same time it is nearly as rich as catfish oil in saturated acids (54.0%). The predominant saturated acids are palmitic and stearic (23.2% each), and the percentages of monounsaturated and polyunsaturated acids are 15.2 and 30.8 respectively.

The analytical data reveal that, despite their high unsaturation, these fish oils do not serve as a source of essential fatty acids. This fact has also been reported by other workers (8). They are however rich in polyunsaturated acids, particularly penta- and hexaenoic acids, which have been shown to play an important role in maintaining normal blood cholesterol levels and thereby preventing deposition of excess cholesterol (9–11). With the exception of catfish, which is deficient in the polyunsaturated acids, it is concluded that the flesh of these fish may serve as a normal dietary control against hypercholesteraemia.

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