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Fatty-acid composition of three commercially important fish of the Arabian Gulf

Tarik N. Rawdah & M. Zamil El-Faer

Department of Chemistry, King Fahd University of Petroleum and Minerals, Dhahran 31261, Saudi Arabia

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The fatty-acid compositions of Hamour (*Epinephelus chlorostigma*), Hamrah (*Lutjanus campechanus*), and Shaour (*Lethrinus lentjan*) were determined. Fish samples were obtained from the Arabian Gulf each month over a period of one year, and equal numbers of these fish were mixed to yield three pooled samples for analysis, representing a one-year cycle for each fish species. The same fatty acids were found in the muscle tissues (fillet) of the three fish species, with no major differences in the percentages of these acids. The fish species exhibited high degrees of unsaturation (63–68%). The polyunsaturated components constituted almost half of the total fatty acids, and the majority of these belonged to the nutritionally important linolenic and linoleic families. The monoenoic and saturated acids consisted of normal and branched chains and were dominated by C_{18} and C_{16} fatty acids.

INTRODUCTION

The countries of the Arabian Gulf import almost all of their food requirements with the exception of seafood. Yet very little is known about the nutritional values of the seafood resources of the Gulf (Kadidi *et al.*, 1988).

The marine fisheries of the Arabian Gulf are characterized by the occurrence of a large number of species (Kuronuma & Abe, 1986). However, only a few of the species have commercial value (Wray, 1979). The Hamours (Groupers, *Epinephelidae*), Hamrahs (Snappers, *Lutjanidae*) and Shaours (Emperors, *Lethrinidae*) are among the most economically valuable fish of the Gulf (Rawdah *et al.*, 1988). We have recently reported on the mineral and proximate composition of these three, as well as other fish species of the Arabian Gulf (El-Faer *et al.*, 1992). The muscle tissues (fillet) of Hamour, Hamrah and Shaour have been found to contain about 20% protein, whereas their lipids were about 1% or less. The levels of nine minerals in the three fish species were comparable (Rawdah *et al.*, 1988; El-Faer *et al.*, 1992). The authors now report on the fatty-acid constituents of the muscle tissues of Hamour, Hamrah and Shaour. These fatty acids have significant nutritional value (Lambersten, 1973; Exler & Weihrauch, 1976) and they have been reported to play a role in the prevention and management of cardiovascular diseases (Nestel, 1987; Driss & Darcet, 1988; Stansby, 1990). Furthermore, fatty acids in fish determine, to a large extent, the storage properties of the fish, owing to the relative ease of oxidation of their polyunsaturated chains (Stansby, 1973; Exler *et al.*, 1975).

MATERIALS AND METHODS

Sampling

All fish samples were caught off the Saudi coast of the Arabian Gulf by means of trawling lines at depths of 30–40 m. Fish were collected from the same location on a monthly basis by a fishing boat of the Saudi Fisheries Company over a period of twelve months from November 1986 to October 1987. A marine biologist accompanied the boat once a month in order to select the required samples of Hamour (*Epinephelus chlorostigma*), Hamrah (*Lutjanus campechanus*) and Shaour (*Lethrinus lentjan*). The weight and length of each fish was measured. The age and sex were also determined by otolith reading and examination of the gonads of each fish, respectively (Table 1). The digestive tract of each fish was removed and later individually examined in the laboratory for the type of food consumed by the fish. Samples were then stored at −30°C until they were pooled and the lipids extracted. Lipids from the three fish species exhibited negligible oxidative deterioration when stored at −30°C for as long as one year.

Preparation of samples

Samples representing a one-year cycle for each of the three fish species were prepared by pooling equal numbers of monthly-harvested fish (Table 1). Hence, for the Hamrah, Hamour and Shaour four, five and seven fillets, respectively, were pooled for each month to result in three pooled samples consisting of 48, 60 and

Table 1. Mean biometric data (± standard deviation of the mean) of three fish species of the Arabian Gulf

Fish species	Number of fish[a] (pooled)	Sex ratio[b] (F/M)	Age (year)	Length (cm)	Weight (g)
Hamour (*E. chlorostigma*)	60	2·3	2·0 ± 0·08	46·6 ± 1·1	2299·3 ± 15·1
Hamrah (*L. campechanus*)	48	2·8	2·3 ± 0·1	48·2 ± 1·3	2695·1 ± 177·1
Shaour (*L. lentjan*)	84	0·8	1·6 ± 0·08	28·3 ± 0·8	641·9 ± 52·7

[a] The same number of fish were pooled each month over a period of twelve months.
[b] Ratio of female to male fish pooled.

84 fish (Table 1). Lipids of the pooled samples were extracted by chloroform : methanol according to a modified procedure of Bligh and Dyer (Christie,1982). Fatty-acid methyl esters (FAME) were prepared by the saponification of the total lipids in potassium hydroxide and the subsequent methylation of the resulting fatty acids with 7% BF_3 in methanol (Nicolaides *et al.*, 1981; Rawdah & El-Faer, 1994). All operations involving lipids or their constituent fatty acids were conducted in an atmosphere of prepurified nitrogen in order to minimize oxidation of the polyunsaturated chains.

Analysis of samples

Individual FAME were analyzed by gas–liquid chromatography (GLC) on a Vista 6000 chromatograph (Varian, PaloAlto, CA, USA) equipped with a WCOT fused-silica CP-Sil 88 (Chrompack, Middleburg, The Netherlands) capillary column (50 × 0·22 mm i.d.). Helium was employed as the carrier gas (split ratio 100: 1), and the injector and detector (FID) temperatures were kept at 240 and 260°C, respectively. The column temperature was maintained at 150°C for 3 min and then increased at 1·5°C/min to 230°C and kept at this temperature for 30 min. Peaks were recorded and integrated by a Varian DS-1 data system connected to a thinkjet printer/plotter. Quantitative FAME standards (Supelco, Bellefonte, PA, USA and Applied Science, State College, PA, USA) were routinely chromatographed in order to determine the response of the detector to different methyl esters (Ackman *et al.*, 1967). Assignments of the chains and ω-values were made by comparing the relative retention times with those of standard FAME. Comparison of GLC-retention data of a sample, both before and after hydrogenation, and observing peak disappearances and growths verified structure assignments (Christie, 1989). Further confirmations of peak assignments were accomplished by the separation of the FAME into groups according to their degree of unsaturation by argentation thin-layer chromatography (TLC), and the subsequent analysis of each group before and after hydrogenation (Christie, 1989).

Argentation TLC was performed on preparative plates (Adsorbosil-5-Prekotes; Applied Science) which were washed with ethyl acetate, immersed in 10% $AgNO_3$ in acetonitrile for 30 min and activated just before use at 100°C for 30 min. Development was in benzene–hexane (5:2), and the bands were visualized with Rhodamine 6G. Bands corresponding to saturates, monoenes, dienes and trienes were scraped off the plate and extracted successively with hexane, hexane–chloroform (1 : 1) and chloroform. The combined extracts were then analyzed by GLC. All operations involving argentation TLC were carried out avoiding light whenever possible. The hydrogenation of unsaturated fatty acids was carried out according to published procedures (Christie, 1982).

RESULTS AND DISCUSSION

The fatty-acid compositions of Hamour (*Epinephelus chlorostigma*), Hamrah (*Lutjanus Campechanus*) and Shaour (*Lethrinus Lentjan*) are listed in Table 2. The same fatty acids are found in the muscle tissues (fillet) of the three species, with no major differences in the percentages of the corresponding acids. This is not altogether unexpected, since the three species are lean, with lipid contents of 1% or less (Rawdah *et al.*, 1988; El-Faer *et al.*, 1992). Furthermore, all the fish utilized in this work are demersal and were collected from the same location in the Arabian Gulf and from the same depths (Table 1). Examination of the digestive tract of each fish revealed that in general, the three fish species consumed more or less the same type of food (Rawdah *et al.*, 1988).

The muscle tissues of the three fish species are characterized by their high content of unsaturated chains (Table 2). The ratios of the unsaturated fatty acids to the saturated ones are 2·09, 1·90 and 1·71 in Hamour, Shaour and Hamrah, respectively. In particular, the three fish species are rich in polyunsaturated fatty acids (PUFA), and this is generally typical of marine-fish lipids (Exler *et al.*, 1975; USDA, 1987). Hydrogenation of the PUFA fractions of the three fish species revealed the presence of minor amounts of odd-numbered and branched-chain component which, together with traces of unidentified PUFA, constitute slightly more than 1% of the total fatty acids (Table 2). The major fatty acid among the PUFA is docosahexaenoic acid (22:6ω3), which is also the most abundant acid in all three fish species, accounting for more than one-quarter of the total fatty acids. The majority of the PUFA belong to the nutritionally important linolenic and linoleic families of fatty acids with double bonds, located three (ω3) and six (ω6) carbon atoms from the terminal end of the chain, respectively. In Hamrah, Shaour and

Table 2. Fatty-acid composition (as percentage methyl esters) of the muscle tissues (fillet) of three fish species of the Arabian Gulf[a]

Fatty acid	Hamour (*E. chlorostigma*)	Hamrah (*L. campechanus*)	Shaour (*L. Lentjan*)
Normal			
14 : 0	1·10	2·58	0·55
15 : 0	0·31	0·38	0·95
16 : 0	15·7	19·4	18·5
17 : 0	0·56	1·05	0·32
18 : 0	8·99	7·99	9·02
19 : 0	0·44	0·36	0·48
Branched			
i-15 : 0	0·03	0·06	0·19
ai-15 : 0	0·20	0·27	0·26
i-16 : 0	0·30	0·22	0·26
i-17 : 0	0·69	0·72	0·73
ai-17 : 0	0·51	0·78	0·36
i-18 : 0	0·06	0·05	0·09
Unid	3·47	3·03	2·73
T. Sat.	**32·4**	**36·9**	**34·5**
14 : 1 ω 9	0·30	0·34	0·26
16 : 1 ω 9	0·19	0·29	0·16
16 : 1 ω 7	2·60	3·86	2·24
16 : 1 ω 5	0·08	0·08	0·07
17 : 1 ω ?	0·32	0·31	0·36
18 : 1 ω 9	8·73	8·73	8·81
18 : 1 ω 7	2·44	3·32	2·56
18 : 1 ω 5	0·06	0·08	0·04
20 : 1 ω 9	0·39	0·36	0·26
20 : 1 ω 7	0·17	0·23	0·15
Unid	2·60	2·10	2·56
T. Monounsat.	**17·9**	**19·7**	**17·5**
18 : 2 ω 6	0·64	0·61	0·57
18 : 3 ω 3	0·33	0·31	0·34
20 : 3 ω 6	0·37	0·33	0·34
20 : 4 ω 6	7·07	4·83	6·55
20 : 5 ω 3	3·05	3·60	2·92
22 : 4 ω 6	2·79	1·22	2·18
22 : 5 ω 6	3·70	2·90	3·25
22 : 5 ω 3	3·10	2·46	2·81
22 : 6 ω 3	28·0	25·9	27·9
Unid	1·08	1·24	1·21
T. Polyunsat.	**49·8**	**43·4**	**48·1**

[a] Symbols used: Unid = unidentified, i = iso, ai = anteiso, T = total, sat = saturated, unsat = unsaturated.

Hamour, the ratios of linolenic acid metabolites to linoleic acid metabolites (ω3 : ω6) are around 3·3, 2·6 and 2·4, respectively. Hence the consumption of these three fish species is highly desirable in view of the nutritional value of the ω3 fatty acids and the role they play in the prevention and management of cardiovascular diseases (Nestel, 1987; Driss & Darcet, 1988). However, overconsumption may lead to adverse health effects, since the muscle tissues of the three fish species have been reported by us to be contaminated with hydrocarbons of petroleum origin (Rawdah *et al.*, 1988) and toxic metals (Attar *et al.*, 1992).

The monoenoic acids of the muscle tissues of the three fish species are dominated by C_{18} chains. Three 18:1 isomers make up more than 60% of the monoenes. In addition to the monounsaturated acids listed in Table 2, a wide variety of normal and branched monoenoic acids ranging in chain lengths from C_{15} to C_{23} were detected in trace amounts.

The saturated fatty acids of the three fish species constitute about one-third of the total fatty acids. The dominant member of this group is palmitic acid, which is the end product of basic biosynthesis of the fatty acids (Lambertsen, 1973). Some stearic acid is present along with much smaller amounts of other saturated acids, both normal and branched, ranging in chain lengths from C_{14} to C_{23}. Of the branched chains, only those with iso and anteiso configurations have been identified.

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