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Full Length Research Paper

Fishes (raw and cooked) Fatty acid profile consumed in Bahrain

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The objective of this study was to determine the fatty acid profile of raw and cooked (grilled, curried and fried) fish commonly consumed in Bahrain. Four most popular species of fish were purchased from the local market in Manama city, the capital of Bahrain. Fatty acids in raw and cooked fish were separated and quantitatively determined by gas liquid chromatography (GLC) using standard methods. The findings revealed that the predominant fatty acids in raw fish were palmitic, stearic, oleic, palmitoleic and linoleic acid (30.5 to 30.50, 3.6 to 8.8, 13.4 to 22.6, 6.7 to 14.1 and 1.3 to 2.0 mg/100 g respectively). With regard to cooking, curried and fried Pearlspotted Rabbitfish showed predominant changes in their fatty acid profiles. In the omega-3 and omega-6 families the dominant fatty acids were eicosapentaenoic acid (EPA) (2.9 to 6.4 mg/100 g), docosahexaenoic acid (DHA) (1.5 to 14.8 mg/100 g) and arachidonic acid (AA) (2.0 to 5.2 mg/100 g). There was no consistent trend in the EPA/DHA ratio in all the four species of fish. Cooking increased polyunsaturated fatty acid (PUFA), the most noticeable increase was again in Pearlspotted Rabbitfish. PUFA increased from 21.8 mg/100 g to 50.0 mg/100 g in curried and 49.5 mg/100 g in the fried variety.

Key words: Arabian Gulf, fish, cooking, fatty acid profile.

INTRODUCTION

Lipid requirements of fish in diet came under investigation only in the 1960s and the most significant finding has been the requirement for n-3 fatty acids (March, 1993). It is now widely accepted that n-3 polyunsaturated fatty acids (PUFAs), which are rich in fish oils protect against several types of cardiovascular diseases such as myocardial infarction, arrhythmia, atherosclerosis, or hypertension EPA and DHA may be the active biological components of these effects (Hirafuji et al., 2003). A great amount of evidence from epidemiological studies and clinical trials supports a protective effect against coronary heart disease for fish consumption and intake of marine omega-3 fatty acids (Alonso et al., 2003).

Studies on fatty acid composition of fish consumed in the Arab Gulf countries are limited. Kotb et al. (1991) found that many of the Arabian Gulf species of fish especially sardines were a good source of omega-3 polyenoic fatty acids thereby making valuable contribution towards the diet. Al-Arrayed et al. (1999) studied the fatty acid content of some edible fish from the Bahrain waters and found that warm water temperatures and salinity were the main reasons for the lowering of the n3-polyunsaturated fatty acids in Bahraini fish. Other researchers have carried out studies to assess the nutritional profile of fish in the Arabian Gulf (Ewaidah, 1993; Al-Jedah et al., 1999) but an extensive study to assess the impact of popular modes of cooking on the fatty acid profile of fish is not yet available. Hence we have made an attempt to assess the fatty acid profile of the most commonly consumed fish and determine the change in fatty acid in fish subjected to different cooking processes commonly employed in Bahraini households.

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MATERIALS AND METHODS

All fishes were purchased from the local market in Manama city, the capital of Bahrain. Only the most commonly consumed fish consumed in Bahrain were included in the study. They are: Diamond Mullet, Grey Grunt, Narrow-barred Spanish mackerel and Pearlspotted Rabbitfish. The local, common and scientific names of

Table 1. Common, local, and scientific names of fish used in the study.

Common name	Local name	Scientific name
Pearl spotted Rabbitfish	Safai	*Siganus canaliculatus*
Narrow-barred Spanish mackerel	Kanad	*Scomberomorus commerson*
Diamond Mullet	Maid	*Liza alata*
Grey Grunt	Yanam	*Plectorhinchus sordidus*

these fishes are presented in Table 1. The fishes were divided into two divisions, raw and cooked. The method of cooking was obtained from a standardized recipe book for Bahrain (Musaiger, 1988). Three common methods used for cooking the fish namely: grilling, frying and cooking in curry. The fishes were cleaned and all bones were removed, except small bones, especially in small fish and then frozen at -20°C for two days until analysis. The oil used for frying was corn oil, because it is the common oil used in frying and cooking in Bahrain. Fatty acids were separated and quantitatively determined by gas liquid chromatography (GLC) as their methyl esters using the methods of AOAC (1990). The oil was extracted using 3 g of tissue by 2:1 chloroform : methanol mixture and methyl esters of fatty acids were then prepared using boron trifluoride as a catalyst. A gas liquid chromatograph (Packard model 430) equipped with a flame ionization detector and a glass column (2 m × 2 m i.d.) packed with 10% DEGS was used. The column temperature was programmed to retain 150°C for 3 min and then raised to 200°C for 5 min. Both detector and injector temperature were kept at 250°C. Nitrogen was used as a carrier gas at a flow rate of 25 ml/min. The flow rates for hydrogen and air were 25 and 250 ml/min, respectively. The various fatty acids were identified and quantitated by comparison with known amounts of standard fatty acid methyl esters (Sigma, USA). Fatty acid content was then calculated as mg/100g of edible portion.

RESULTS AND DISCUSSION

Results of the fatty acid profile of the raw and cooked fish are presented in Tables 2 and 3 respectively. The predominant fatty acids were palmitic, stearic, oleic and palmitoleic acids. The level of individual fatty acids in fish depends on the total fat content and the percentage distribution of fatty acids changes as the fat content of the fish rises and falls (Al-Jedah et al., 1999). In the omega-3 and omega-6 families EPA, DHA and AA were dominant.

When the fatty acid content of the individual fish was studied palmitic acid was the predominant fatty acid with values ranging from a high of about 30.5 mg/100 g in the Pearlspotted Rabbitfish to a low of about 23.0 mg/100 g in the Grey Grunt. Stearic acid was the second predominant fatty acid; the highest amount was in the Narrow-barred Spanish mackerel (8.8 mg/100 g) and lowest in the Diamond Mullet (3.6 mg/100 g). Amongst all the fish, the Grey Grunt was a rich source of oleic acid (22.6 mg/100 g) while the rest of the fishes had comparable levels, the least being in the Diamond Mullet (13.4 mg/100 g). The Diamond Mullet on the other hand had a high content of palmitoleic acid (14.1 mg/100 g) while the lowest levels were in the Narrow-barred Spanish mackerel (6.7 mg/100 g). Of all the fatty acids studied, linoleic acid was present to a much lower extent in all the fishes.

The results of our study are similar to those reported by Saify et al. (2000) on fish oil from two marine species where palmitic and stearic acids were the major fatty acids. Among unsaturated fatty acids monoenoic (oleic and palmitoleic) acids were the major constituents and traces of dienoic and trienoic fatty acids were also found. Romero et al. (2000) demonstrated that palmitic acid was the most important among saturated fatty acids, while oleic acid was the main fatty acid among the monounsaturated group with considerable amount of fatty acids from the omega 3 and 6 fatty acid groups (EPA, DHA, and AA).

Cooking caused a change in the fatty acid profile of fish especially in case of the Pearlspotted Rabbitfish which showed a dramatic increase in the linoleic acid levels from 2.0 mg/100 g to 41.2 mg/100 g as a result of cooking in curry and 40.3 mg/100 g as a result of frying. This increase in linoleic acid is due to the absorption of oil added in the curry or absorption of vegetable oil by the fish muscles during frying with some fish muscles absorbing more fat than others (Ewaidah, 1993). Astorg et al. (2004) showed that the main source of linoleic acid was vegetable oils. This aspect is of importance since the Pearlspotted Rabbitfish is one of the most commonly consumed fish in Bahrain and the Arabian Gulf, and studies indicate that linoleic acid is the major PUFA comprising 84 to 89% of the total PUFA energy in the diets of the adult population (Kris-Etherton et al., 2000). Palmitoleic acid level decreased in the Pearlspotted Rabbitfish from 11.0 to 2.8 mg/100 g and 3.4 mg/100 g in carried and fried, respectively and similar was the case with palmitic acid. The other species of fish did not exhibit much of a change in the fatty acid profile and the only major change was in the linoleic acid level in the Narrow-barred Spanish mackerel, which increased from 1.6 mg/100 g as a result of cooking in curry. This decrease in the palmitic and palmitoleic acid levels in the Pearlspotted Rabbitfish is important since the cholesterol-raising effect of dietary saturated fatty acids is largely accounted for by lauric, myristic, and palmitic acids (Zock et al., 1994), and palmitoleic acid is known to behaves like a saturated and not a monounsaturated fatty acid in its effect on LDL cholesterol (Nestel et al., 1994).

The composition of polyunsaturated fatty acids (PUFA) present in fish, especially Omega-3 and Omega-6, are

Table 2. Fatty acid profile of raw fish (mg/100 g).

Fatty acid	Pearlspotted rabbitfish	Narrow-barred Spanish mackerel	Diamond Mullet	Grey Grunt
Lauric acid	0.3	0.1	0.1	0.1
Myristic acid	5.1	4.7	5.5	3.1
Myristoleic acid	0.1	-	0.1	0.2
Pentadecanoic acid	1.1	1.4	3.6	0.8
Pentadecenoic acid	-	-	0.2	-
Palmitic acid	30.5	23.4	29.4	23.0
Palmitoleic acid	11.0	6.7	14.1	6.9
Margaric acid	0.8	1.5	0.9	1.2
Heptadecenoic acid	0.6	0.6	2.0	0.6
Stearic acid	5.1	8.8	3.6	5.9
Oleic acid	14.3	14.3	13.4	22.6
Linoleic acid	2.0	1.6	1.4	1.3
Linolenic acid	0.8	1.1	1.1	0.6
Linolenic acid	-	0.4	0.9	0.3
Octadecatetraenoic acid	0.9	0.8	1.8	0.3
Arachidic acid	0.2	0.5	0.2	0.5
Eicosenoic acid	0.4	0.6	0.2	1.2
Eicosadienoic acid	0.2	0.3	0.1	0.5
Eicosatrienoic acid	0.8	0.3	0.3	0.5
Arachidonic acid (AA)	4.5	2.5	2.0	5.2
Eicosapentaenoic acid (EPA)	2.9	3.5	5.4	6.4
Docosanoic acid	0.1	0.5	0.3	0.3
Eicosenoic acid	0.1	0.2	0.3	0.4
Adrenic acid	1.3	0.8	0.2	2.0
Docosapentaenoic acid (DPA)	4.8	1.3	1.8	2.6
Docosahexaenoic acid (DHA)	4.4	14.8	1.5	4.3
Tetracosanoic acid	0.1	0.5	0.1	0.1
Cis-tetracosenoic acid	0.1	0.8	0.2	0.1

important from health point of view, as they contribute to the reduction of incidence of cardiovascular disease (Chin et al, 2007; Din et al., 2008; Myhrsbad et al., 2011). This disease represents 30% of total death in Bahrain (MOH, 2010). Saturated fatty acids (SFA) were predominant in the Diamond Mullet (43.7 mg/100 g) while MUFA was high in the Grey Grunt (40.0 mg/100 g) (Table 4). Saturated fatty acid levels were halved in the Pearl spotted Rabbit fish due to cooking. Thus, the values decreased to 22.4 and 23.3 mg/100 g in the curried and fried varieties, respectively. The other fish did not show much of a change in the saturated fatty acid level as a result of cooking. The level of MUFA also did not change much and the most noticeable change was in the grilled Grey Grunt where the values decreased from 40.0 to 31.4 mg/100 g. This loss could be a result of loss in the cooking drip during grilling. Pena and Samperio (2004) by their study on the effects of frying and grilling on the fat content of common foods have shown that deep frying or pan frying of meat induces fat loss.

All species of fish studied also contained several fatty acids of the omega-3 and omega-6 polyunsaturated group with omega-3 being predominant and is in accordance to findings by Corser et al. (2000) that unsaturated fatty acids (omega 3) were the most common found for all the spices of fish. A study on the lipid fraction of Adriatic sardine filets showed that the polyunsaturated fatty acid n3 (PUFA-n3) represented on average 20.9%, always higher than PUFA-n6 and C20:5n3 eicosapentaenoic acid, (EPA) and C22:6n3 docosahexaenoic acid (DHA) were the (most) abundant PUFA-n3 (De Leonardis and Macciola 2004). Similar results were seen in our study where the Narrow-barred Spanish mackerel showed high levels of C22:6. Omega-3 fatty acids may be effective in epilepsy, cardiovascular disorders, arthritis, and as mood stabilizers for bipolar disorder (Mirnikjoo et al., 2001). In the Omega-6 family, AA was the most predominant fatty acid. The highest level of AA was seen in the Grey Grunt (5.2 mg/100 g) and the least was in the Diamond Mullet (2.0 mg/100 g). In addition, cooking did not have much

Table 3. Fatty acid profile of cooked fish (mg/100g).

Fatty acid	Diamond Mullet (Grilled)	Grey Grunt (Grilled)	Narrow-barred Spanish mackerel (Curried)	Pearlspotted Rabbitfish (Curried)	Pearlspotted rabbitfish (Fried)
Lauric acid	0.1	0.1	0.0	0.1	0.1
Myristic acid	5.2	2.9	3.7	1.3	1.8
Myristoleic acid	0.1	0.2	-	-	-
Pentadecanoic acid	3.2	0.9	1.0	0.3	0.3
Palmitic acid	27.8	21.9	18.6	14.8	15.2
Palmitoleic acid	13.0	6.4	4.6	2.8	3.4
Margaric acid	0.9	1.3	1.1	0.3	0.3
Heptadecenoic acid	1.7	0.8	0.4	0.2	0.1
Stearic acid	3.7	5.8	7.6	4.6	4.6
Oleic acid	13.2	21.3	14.8	19.9	19.6
Linoleic acid	1.9	3.2	13.6	41.2	40.3
Linolenic acid	1.2	0.6	1.0	0.6	0.4
Linolenic acid	0.9	0.3	0.3	0.3	0.3
Octadecatetraenoic acid	2.0	0.4	0.8	0.3	0.3
Arachidic acid	0.2	0.4	0.4	0.3	0.3
Eicosenoic acid	0.2	2.3	0.5	0.2	0.2
Eicosadienoic acid	0.1	0.5	0.2	0.1	0.1
Eicosatrienoic acid	0.4	0.5	0.3	0.3	0.3
Arachidonic acid	2.5	4.9	2.2	1.9	2.1
Eicosapentaenoic acid	6.1	5.6	3.4	1.1	1.1
Docosanoic acid	0.1	0.3	0.5	0.5	0.5
Docosenoic acid	0.3	0.3	0.2	-	-
Adrenic acid	0.3	2.2	0.7	0.5	0.7
Docosapentaenoic acid	2.2	2.8	1.2	1.9	2.2
Docosahexaenoic acid	1.8	6.1	14.1	1.8	1.7
Tetracosanoic acid	0.1	0.1	0.4	0.2	0.2
Cis-tetracosenoic acid	0.2	0.1	0.6	0.1	-

effect on the AA levels. Studies by Romero et al. (2000) on fatty acids composition and proximate of 7 fish species showed that omega-6 family showed a higher content in AA, with values between 1.9 and 10%.

EPA was predominant in the fresh Grey Grunt (6.4 mg/100 g) and low in the fresh Pearlspotted Rabbitfish (2.9 mg/100 g). The values of DHA ranged between 1.5 to 14.8 mg/100 g between the Diamond Mullet and the Narrow-barred Spanish mackerel respectively. There was no consistent trend in the EPA/DHA ratio in all the four species; the ratio was in favor of EPA in the Diamond Mullet and the Grey Grunt (3.6:1 and 1.4:1 respectively) while the ratio was in favor of DHA in the Pearlspotted Rabbitfish and the Narrow-barred Spanish mackerel (1.5:1 and 4.2:1 respectively).

On the whole the PUFA level in raw fish was highest in the Narrow-barred Spanish mackerel (28.4 mg/100 g) and low in the Diamond Mullet (16.7 mg/100 g) and the Pearlspotted Rabbitfish (22.6 mg/100 g). Cooking caused the PUFA levels to rise in all the species of fish but the most noticeable increase was in the Pearlspotted Rabbitfish, where the PUFA level increased from 22.6 mg/100 g to 50.0 and 49.5 mg/100 g in the curried and the fried varieties respectively. This is important from a dietary point of view since, PUFA is known to cause significant decreases in total and LDL cholesterol (Gardner and Kraemer 1995). The rise in the PUFA levels as a result of cooking is due to the addition of external oil during cooking and alpha linoleic acid is present in marked amounts in commonly-consumed oils such as rapeseed and soyabean oils (Williams and Burdge, 2006).

The values obtained in this study for PUFA are in general lower than those reported earlier for edible fish from the Bahrain waters (Al-Arrayed et al., 1999) and for popular species of Arabian Gulf fish (Kotb et al., 1991). The reason for the difference could be attributed to seasonal variation, size or location of the catch and sea water temperature. Previous study by Budge et al. (2002) on variability in fatty acid signatures of marine fish indicates that a number of species exhibit changes in fatty

Table 4. Fatty acids in raw and cooked fish consumed in the Arabian Gulf (mg/100 g).

Fish	SFA	MUFA	PUFA
Diamond Mullet			
Raw	43.7	30.5	15.5
Grilled	41.3	28.7	19.4
Grey Grunt			
Raw	35.0	40.0	24.0
Grilled	33.7	31.4	27.1
Narrow-barred Spanish Mackrel			
Raw	35.2	23.2	27.4
Curried	33.4	21.1	37.8
Pearlspotted rabbitfish			
Raw	43.3	26.6	21.8
Curried	22.4	23.2	50.0
Fried	23.3	23.3	49.5

SFA, Saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids.

acid signatures with increasing size. Furthermore, location effects were also observed and were probably due to broad-scale variations in prey assemblages and phytoplankton composition. Aidos et al. (2002) by their study on the seasonal changes in crude and lipid composition of herring fillets, found monthly statistical differences in the fat content and the lowest values of the total amount of PUFA in the oil coincided with the post-spawning and starvation period.

This study thereby indicates that all the species of fish analyzed had considerable level of PUFA but the beneficial effects of PUFA should not mean over consumption of fish since contamination of fish by heavy metals should also be considered. Cooking also influenced the fatty acid profile of fish to a large extent the changes in our study being beneficial in nature. By adopting suitable modes of cooking and consuming moderate level of fish, the contribution fish towards the diet can be exploited to the maximum.

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