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Proximate Composition and Fatty Acids Profiles in Most Common Available Fish Species in Saudi Market

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Abstract: Three highly consumed fish in Saudi market were evaluated for their proximate composition in the muscle and in the head and their fatty acids. The fish species were included Spanish mackerel, (*Scomberomorus maculates*), Grouper (*Epinephelus coioides*) and Yellow-spotted trevally (*Carangoides fulvoguttatus*) which respectively known as Kanad, Hammour and Hammam in Saudi market. The moisture, protein, total lipids and ash of the muscle tissue and head of the three fish species were found to be between 71.20 to 78.23, 16.19 to 20.20, 0.24 to 4.10 and 1.10 to 8.00%, respectively. The fatty acids composition in the muscle of fish species was evaluated. 16:0 and 18:0 were the main saturated fatty acids (SFA), 18:1 ω-9, 16:1 ω-7 the main monounsaturated fatty acids (MUFA), while 22:6 ω-3 (DHA), 20:5 ω-3 (EPA) were the main polyunsaturated fatty acids (PUFA). The ω3/ω6 ratio was between 2.05 to 7.39 and the EPA/DHA ratio was approximately 0.30.

Key words: Proximate analysis, fatty acids, SFA, MUFA, PUFA

INTRODUCTION

Fish is known for its high nutritional value. The chemical composition of fish regarding other foods is unique taking into consideration (Steffens, 1997; Simopoulos, 2002). Fish tissue is the main source of long chain polyunsaturated fatty acids especially the ω-3 and ω-6, fatty acids. These fatty acids have particular importance in fish, since their consumption contributes in the reduction of appearance of cardiovascular diseases (Nordov *et al*., 2001; Turkmen *et al*., 2005) and improvement of learning ability (Yonekubo *et al*., 1994; Suzuki *et al*., 1998).

Polyunsaturated fatty acids (PUFA) of the ω-6 and especially of ω-3, family recognized essential biochemical components of human diet. These acids prevent neural and some diseases and play a very important role in ontogenesis (Arts *et al*., 2001; Lauritzen *et al*., 2001; Silvers and Scott, 2002; Aktas and Halperin, 2004). Since ω-3-PUFAs, such as α-linolenic acid (18:3 ω3, ALA), eicosapentaenoic (20:5ω3, EPA) and docosahexaenoic (22:6 ω3, DHA), are effectively synthesized only by aquatic organisms, humans can obtain these essential components by marine and freshwater products (Perretti *et al*., 2007; Sushchik *et al*., 2007).

Researches have shown that ω-3 can reduce the risk of heart disease and high blood pressure, prevent blood clots, protect against cancer and even alleviate depression (Shahar *et al*., 1994; Von Schacky *et al*., 1999). Furthermore, DHA found in the cell membrane of various tissues throughout the body, can represent about 36% of its total fatty acid content and can be found in high concentration especially in the retina, brain and sperm (Connor, 2000). However, in industrialized societies the intake of these important acids has changed in the last decades. An increased consumption

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of vegetable oils rich in ω-6 fatty acids and a reduced consumption of foodstuffs (fish, flaxseed, algae) rich in ω-3 fatty acids has determined a significant change in the ω-6 to ω-3 fatty acids ratio in the human diet, with negative effects on consumers health. Fish oil is the main source of ω-3 fatty acids, therefore, the fatty acids composition of fish oil is very important for its functional properties (Von Schacky *et al*., 1999; Nestel, 2000) and in particular, the correct ratio between ω-3 and ω-6 fatty acids is very important (Perretti *et al*., 2007). The use of a dietary supplement containing essential fatty acids in a correct ratio provides the body with useful assistance in dealing with a large number of systemic and cutaneous disorders, thank to an anti-inflammatory, vasodilating and anti-platelet action. Furthermore, with regard to cholesterol prevention, a higher concentration of EPA is required in comparison with DHA, while the opposite relative concentration is required during pregnancy or for retina protection (DHA>EPA) (Shahar *et al*., 1994; Maes *et al*., 2000).

The relative abundance and low-cost of fish, increased awareness, advertising and studies demonstrating the beneficial effects of these fatty acids has increased the consumption of foods rich in these fatty acids. However, not all fish products contain appreciable of n-3 fatty acids (Lovell, 1988; Kris-Etherton *et al*., 2002). Extraction and characterization of fish lipids would provide information on the lipid profile of commercially available fish species.

Total fishery production of the Kingdom of Saudi Arabia in 2003 was 67109 metric tones where the production in the Arabian Gulf was 29300 metric tones (Fisheries Statistics of Saudi Arabia, 2003).

Many studies have been conducted on the lipid composition of different fish species in different parts of the world (Alasalvar *et al*., 2002; Dayhuff and Wells, 2005; Eboh *et al*., 2006; Shirai *et al*., 2006; Zmijewski *et al*., 2006; Miniadis-Meimaroglou *et al*., 2007; Perretti *et al*., 2007; Sushchik *et al*., 2007).

The aim of this study was to evaluate the proximate composition, fatty acid profiles of three selected important fish species consumed largely in Saudi Arabia.

MATERIALS AND METHODS

Fish Samples

Fresh samples of three species included Spanish mackerel, (*Scomberomorus maculates*), Grouper (*Epinephelus coioides*) and Yellow-spotted trevally (*Carangoides fulvoguttatus*) which known in Saudi' market as Kanad, Hammour and Hammam, respectively. These species are commonly consumed by the local population in Saudi Arabia. The fish was purchased in a local market in Riyadh. Two-four fish specimens were transported to the laboratory and each fish specimen was beheaded, eviscerated and filleted all manually. Muscle tissues (fillets) were below the dorsal fin were taken as the samples. A composite sample for each species was prepared and homogenized in a food processor and test portions were stored at -20°C until required.

Determination of Proximate Composition

Water content was determined by the sample drying technique at a temperature of 105°C, crude protein content with the use of the Kjeldahl method with 6.25 multiplier, fat content with the Soxhlet method (with petroleum ether as the solvent) and ash content by sample mineralization at a temperature of 550-600°C (AOAC, 1990).

Determination of Fatty Acid Profile

Cold extraction of tissue lipids according to Folch *et al*. (1957) was used for quantitative and qualitative analysis of fatty acid composition. The fatty acids of fish samples were converted to methyl esters (FAME) by heating in 7% BF_3-methanol, according to the procedure reported by AOAC (1996).

FAME were identified on a Shimadzu GC-MS QP5050A system (Japan). The carrier gas (helium) had a flow rate of 20 mL min^{-1}, split ratio 40. A sample was injected on a 60 m × 0.25 mm × 0.2 μm df Non-bonded SP-2340/silar 10 CP (US Patent) capillary column.

RESULTS AND DISCUSSION

Proximate Composition

The moisture content was found to be 73.77, 78.23 and 77.82% in the tissue and 75, 71.20 and 71.77% in the head of Spanish mackerel (Kanad), Grouper (Hammour), Yellow-spotted Trevally (Hammam), respectively (Table 1). The protein content and the fat content were 20.20 and 4.10% in the tissue of Spanish mackerel while 19.14, 0.75, 19.97 and 0.24% in the tissue of Grouper and Yellow-spotted Trevally. In the head Yellow-spotted Trevally had the highest protein content (18.80%) but the lowest fat content (1.80%), whereas the protein content were 16.19 and 16.77% and the fat content were 3.70 and 3.73% in Spanish mackerel and Grouper, respectively. The result indicate that the ash content of the head was high especially in Grouper and Yellow-spotted Trevally (8 and 7%). The ash content in the tissue ranged between 1.10 and 1.50%.

Spanish mackerel contained significantly higher amount of fat. The varied content of fat was compensated by the content of water. The results obtained by Zmijewski *et al*. (2006) found a reverse correlation between the fat and water contents, which is common for many fish species. The content of protein in the muscle was similar for the three species and ranged from 19.14 to 20.20%. In addition, the ash level in the three species was similar and was approximately 1% (Table 1).

Fatty Acids

GC-MS was used to establish the chemical identities of fatty acids extracted from Spanish mackerel, Grouper, Yellow-spotted Trevally (Fig. 1). The percentage of total unsaturated fatty acids was high in the three types of fish however, total monoenoic content was higher in spanish mackerel and Grouper compared with Yellow-spotted Trevally. The percentage of polyenoic acids was higher in Yellow-spotted Trevally than the other two types of fish and higher than the percentage of total monoenoic acids. The major saturated fatty acids identified in the three types of fish were 16:0 (palmitic), 18:0 (stearic) and 14:0 (myristic). Whereas, the major unsaturated fatty acids were 18:1 ω-9 (oleic acid), 16:1 ω-7 (palmitoleic), 22-6 ω-3 (docosahexaenoic). Spanish mackerel contained significantly ($p<0.05$) higher proportions of 16:0, 17:0, 18:1 ω-9, Yellow-spotted Trevally contained significantly ($p<0.05$) higher proportions of 9:0, 18:0, 20:5 ω-3 and 22:6 ω-3 whereas, Grouper contained significantly ($p<0.05$) higher proportions of 12:0, 13:0, 15:0, 18:2 ω-6, 20:3 ω-6 and 24:4 (Table 2, 3).

Palmitic acid was the primary saturated fatty acid (SFA), contributing 57.05, 45.04 and 47.21% in the total SFA content of the lipids for Spanish mackerel, Grouper and Yellow-spotted Trevally, respectively. Eboh *et al*. (2006) reported that palmitic acid was the most prevalent in all species with mean values of 8.5% (catfish), 31.9% (tilapia), 36.2% (ilisha), 37.5% (bonga fish) and 9.94% (mudskipper). The total SFA content of lipids were 41.8% in Spanish mackerel, 45.74% in Grouper and 41.09% in Yellow-spotted Trevally. Thus, the remaining fatty acids found in the three types of fish (about 60%) were mono- and polyunsaturated fatty acids (MUFA + PUFA).

In general, fish are relatively low in SFA (<30%), except for certain species (Ackman, 1989; Nettleton and Exler, 1992). This increase in SFA in this study is probably due to the rising of water temperature in Saudi Arabia. In the study of Shirai *et al*. (2006), the SFA percentage of Tobiko was higher than those of the other fish roe samples in total lipids and each lipid class fraction. The SFA percentage of fish lipid increases with rising water temperature (Reiser *et al*., 1963), therefore, the fatty

Table 1: Proximate composition of muscles and heads of fish samples

Samples	Moisture (%)	Protein (%)	Lipid (%)	Ash (%)
In the tissue				
Kanad	73.77[a]	20.20[a]	4.10[a]	1.21[a]
Hammour	78.23[b]	19.14[a]	0.75[b]	1.10[a]
Hammam	77.82[c]	19.97[a]	0.24[c]	1.50[a]
In the head				
Kanad	75.00[d]	16.19[b]	3.70[d]	3.43[b]
Hammour	71.20[e]	16.77[b]	3.73[d]	8.00[c]
Hammam	71.77[e]	18.80[c]	1.80[e]	7.00[d]

All values are means of three replications. Different letter(s) in each column indicate significant differences

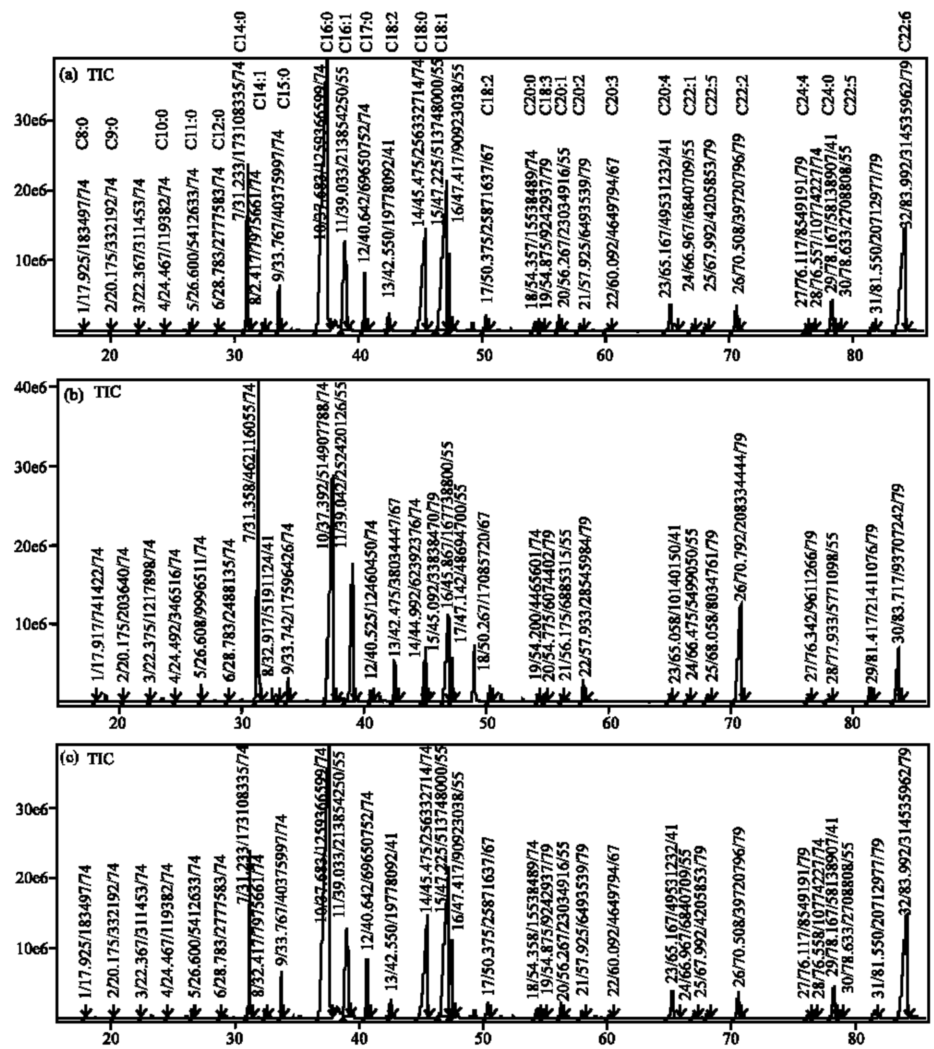

Fig. 1: The GC-MS chromatogram of fatty acids extracted from most common fishes in Saudi Arabia. (a) Kanad, (b) Hammour and (c) Hammam

acid composition of Tobiko may differ from the other fish roe because it was caught in Indonesia. Miniadis-Meimaroglou *et al*. (2007) reported that the sum of saturated fatty acids of the examined frozen red porgy (Senegal marine region, east Atlantic Ocean) was quite similar to the one reported for

Table 2: Saturated fatty acids in the muscle of fish samples (% of total fatty acids)

Fatty acids (%)	Kanad	Hammour	Hammam
C8:0	0.01[a]	0.03[a]	0.05[a]
C9:0	0.02[a]	0.06[a]	0.25[b]
C10:0	0.01[a]	0.06[a]	0.07[a]
C11:0	0.00[a]	0.01[a]	0.02[a]
C12:0	0.19[a]	0.75[b]	0.23[a]
C13:0	0.10[a]	0.22[b]	0.06[a]
C14:0	5.50[a]	9.39[b]	4.80[c]
C15:0	1.30[a]	2.74[b]	0.81[c]
C16:0	23.85[a]	20.60[b]	19.40[b]
C17:0	2.16[a]	1.67[b]	1.94[b]
C18:0	7.87[a]	9.68[b]	12.92[c]
C20:0	0.47[a]	0.44[a]	0.26[b]
C24:0	0.32[a]	0.16[b]	0.38[a]
Total	41.80	45.74	41.09

All values are means of three replications. Different letter(s) in each raw indicate significant differences

Table 3: Unsaturated fatty acids in the muscle of fish samples (% of total fatty acids)

Fatty acids (%)	Kanad	Hammour	Hammam
C14:1	0.18[a]	0.15[a]	0.05[b]
C16:1 ω-7	6.75[a]	10.66[b]	2.68[c]
C18:1 ω-9	18.59[a]	14.18[b]	10.90[c]
C18:1 ω-7	4.76[a]	5.30[a]	2.97[b]
C18:2 ω-6	0.80[a]	1.48[b]	1.03[b]
C18:2	2.61[a]	3.43[b]	2.98[ab]
C18:3 ω-3	1.28[a]	1.60[a]	1.15[a]
C20:1 ω-9	2.70[a]	2.29[a]	1.15[b]
C20:2 ω-6	1.20[a]	1.37[a]	1.08[a]
C20:3 ω-6	0.14[a]	0.36[b]	0.13[a]
C20:4 ω-3	1.48[a]	2.05[b]	1.92[b]
C22:1 ω-9	1.21[a]	1.09[a]	1.07[a]
C20:5 ω-3	3.13[a]	1.40[b]	6.07[c]
C22::2	1.18[a]	1.15[a]	1.50[b]
C24:4	0.25[a]	1.20[b]	0.27[a]
C24:1 ω-9	1.74[a]	0.63[b]	1.94[a]
C22:5 ω-6	0.63[a]	1.44[b]	1.74[b]
C22:6 ω-3	9.57[a]	4.48[b]	20.28[c]
Total	58.20	54.26	58.91
Total monoenoic	35.93	34.30	20.76
Total polyenoic	22.27	19.96	38.15
Σ ω-3	15.46	9.53	29.42
Σ ω-6	2.77	4.65	3.98
Σ ω-3/Σ ω-6	5.58	2.05	7.39
EPA/DHA	0.33	0.31	0.30

All values are means of three replications. Different letter(s) in each raw indicate significant differences

Sardinella maderensis, *S. aurita* and *Cephalopoholis taeniops* (47.3, 43.6 and 49.4%), respectively (fish from the east Atlantic Ocean) (Nijinkoue *et al*., 2002) and this is probably due to the fact that the SFA tend to increase in fish leaving in warm water (Ackman, 1989).

Oleic acid was identified as the primary monoenoic fatty acid in the three types of fish and significantly ($p<0.05$) higher in Spanish mackerel than in Grouper and Yellow-spotted Trevally. Among ω-6 series of the fatty acids Yellow-spotted Trevally and Grouper had higher level of 18:2 ω-6 than Spanish mackerel. Among n-3 series, Yellow-spotted Trevally was a good source of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (Table 2). The percentages of EPA and DHA in Yellow-spotted Trevally were significantly ($p<0.05$) higher than Spanish mackerel and both were higher than Grouper. The lipids of marine fish are characterized by their high proportion of polyunsaturated fatty acids, such as the nutritionally important EPA and DHA, which are highly susceptible to autoxidation because of their high degree of unsaturation (Gunstone and Norris, 1983).

The result of this study show that the fish samples contained levels of (1.40 to 6.07%) of EPA and levels of (4.48 to 20.28%) of DHA. According to Lovell (1988), not all fish products contain appreciable quantities of EPA.

Regarding the total percentage ω-3 polyunsaturated fatty acids, it is higher than ω-6 in the three species. The ratio of ω-3 to ω-6 fatty acids was higher in Yellow-spotted Trevally (7.39) and Spanish mackerel (5.58) than Grouper (2.05). As referred in earlier research reports, fish contain high amounts of ω-3 and low amounts of ω-6 PUFA, a fact that has been connected, among other factors, to the type of their diet, which varies in the different marine regions (Ackman, 1989; Lavniegos and Lopez-Cortes, 1997). It has been reported that the type and amount of fatty acids in fish tissues vary mainly with what the fish eat, but other factors may also influence their fatty acid composition. Size or age, reproductive status, geographic location and season all influence fat content and composition of fish muscle (Ackman, 1989; Nettleton, 1985; Satio *et al*., 1999).

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