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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 11 (1): 55-61, 2008
ISSN 1028-8880

Chemical Composition of Raw Fish Consumed in Bahrain

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Abstract: Nine species (*Seriolina nigrofasciata*, *Siganus canaliculatus*, *Rhabdosargus haffara*, *Scomberomorus commerson*, *Liza alata*, *Epinephelus areolatus*, *Plectorhinchus sordidus*, *Lethrinus nebulosus* and *Penaeus semislcatus*) of raw fish commonly consumed in Bahrain were analyzed for their proximate, mineral and heavy metal content. The protein content ranged from 17.9-21.8 g/100 g, fat content from 0.80-16.1 g/100 g and energy content from 87.1-216.7 kcal/100 g. The raw fish also had high levels of sodium (82-300 mg/100 g), potassium (210-400 mg/100 g), phosphorous (200-280 mg/100 g), magnesium (23-47 mg/100 g) and zinc (0.0-2.2 mg/100 g). Content of iron, calcium and copper were quite low. The species *Penaeus semislcatus* had low levels of both lead and mercury (<0.02 $\mu g\ g^{-1}$). The maximum level of lead was 0.50 $\mu g\ g^{-1}$ and mercury was 0.20 $\mu g\ g^{-1}$. One species (*Rhabdosargus haffara*) of fish had cadmium levels of 0.03 $\mu g\ g^{-1}$, while the rest of the fish had less than 0.02 $\mu g\ g^{-1}$. Overall, fish available in the market of Bahrain are a good source of some essential minerals. Furthermore, the heavy metal content is below the maximum permitted limits and can be safely consumed by the general public. However, monitoring of heavy metals in fish consumed in Bahrain should be done periodically.

Key words: Bahrain, fish species, nutritive value, proteins, minerals, heavy metals

INTRODUCTION

The beneficial effect on health by including fish in a diet is well known and has been documented in several studies (Damsgaard *et al*., 2006; Mayer *et al*., 2006). Fish is a good source of many important nutrients such as proteins, vitamins and minerals (Dahl *et al*., 2006). Fish intake is associated with improved cardiovascular health and other related health conditions (Mozaffarian *et al*., 2006).

Fish has long been a favorite meal of people living around the Arabian Gulf and has been a major source of food for people living in this region (Al-Jedah and Robinson, 2001). Apart from the beneficial effects, there are also some factors that contribute to risk from fish consumption, mainly due to the potential adverse effects of pesticides and heavy metals like mercury (Burger *et al*., 2004). Increasing pollution in water bodies is directly or indirectly related to increasing urbanization and indiscriminate disposal of agrochemical and industrial effluents (Dua and Gupta, 2005). Heavy metals are well-known environmental pollutants that cause serious health hazards to humans; their effects are not immediate and show up after many years (Boguszewska and Pasternak, 2004).

In the Arabian Gulf, few studies have been carried out to assess the nutrient composition of fish. A study on chemical composition of fish caught off the coast of Qatar indicated that fish was a good source of minerals and many trace elements (Al-Jedah *et al*., 1999). Many of the Arabian Gulf species of fish especially sardines were a good source of omega-3 polyenoic fatty acids (Kotb *et al*., 1991). Crab meat consumed in Bahrain was a good source of high quality protein and minerals (Musaiger and Al-Rumaidh, 2005). Studies to determine the heavy metals concentrations in fish in Saudi Arabia indicated the safety of fish for consumption (Al-Saleh and Shinwari, 2002) and similar results from studies along the Arabian Gulf have been reported by Al-Yousuf *et al*. (2000). Increasing interest in the health gains obtained by regular fish intake has put emphasis on the need for documentation of both nutrients and contaminants in fish and seafood, with a balanced risk assessment (Dahl *et al*., 2006).

As far as our knowledge is concerned, there is no such published literature on the heavy metal content or the nutritive composition of fish commonly consumed in Bahrain. This paper is therefore, an attempt to assess the chemical composition and the heavy metal content in fish (*Seriolina nigrofasciata*, *Siganus canaliculatus*, *Rhabdosargus haffara*, *Scomberomorus commerson*, *Liza alata*, *Epinephelus areolatus*, *Plectorhinchus sordidus*, *Lethrinus nebulosus* and *Penaeus semislcatus*) commonly available in the market of Bahrain.

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MATERIALS AND METHODS

All fish 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 (Table 1). A brief description of the fish used is as follows:

Seriolina nigrofasciata belongs to the family carangidae, order perciformes and class actinopterygii. It has a maximum size of 70.0 cm TL with maximum published weight of 5,200 g. Color is bluish grey to black dorsally, white to dusky below; 5-7 dark oblique bands or blotches on young disappear with age. It is an excellent food fish marketed both fresh and dried salted (Fig. 1)

Siganus canaliculatus belongs to the family Siganidae, order Perciformes and class Actinopterygii. It has a maximum size of 30.0 cm TL. Body is silvery gray above, silvery below; a touch of olive green on nape and upper surface of head; fright pattern mottled with pale cream and dark brown; usually fish display a dark patch just below origin of lateral line (Fig. 2).

Rhabdosargus haffara belongs to the family Sparidae, order Perciformes and class Actinopterygii. It has a maximum size of 35.0 cm TL. The fish inhabits shallow waters, mainly around coral reefs and over sandy or mud-sandy bottoms (Fig. 3).

Scomberomorus commerson belongs to the family Scombridae, order Perciformes and class Actinopterygii. It has a maximum size of 240 cm FL and maximum published weight of 70.0 kg. It has large oval dark spots on body; middle third of first dorsal fin white, rest of fin black (Fig. 4).

Liza alata belongs to the family Mugilidae, order Perciformes and class Actinopterygii. It has a maximum size of 75.0 cm TL. It has dark scale margins with bright yellow or orange pelvic fins (Fig. 5).

Epinephelus areolatus belongs to the family Serranidae, order Perciformes and class Actinopterygii. It has a maximum size of 47.0 cm TL and maximum published weight of 1,400 g (Fig. 6).

Plectorhinchus sordidus belongs to the family Haemulidae, order Perciformes and class Actinopterygii.

Table 1: Local, common and scientific names of Arabian Gulf fish species included in the study

Local name	Common name	Scientific name
Hamman	Blackbanded Trevally	*Seriolina nigrofasciata*
Safai	Pearlspotted Rabbitfish	*Siganus canaliculatus*
Qurqufan	Haffara Bream	*Rhabdosargus haffara*
Kanad	Narrow-barred Spanish mackerel	*Scomberomorus commerson*
Maid	Diamond Mullet	*Liza alata*
Hammour	Grouper	*Epinephelus areolatus*
Yanam	Grey Grunt	*Plectorhinchus sordidus*
Shari	Spangled Emperor	*Lethrinus nebulosus*
Rubian	Tiger Shrimp	*Penaeus semislcatus*

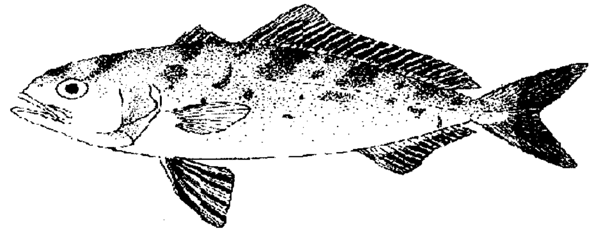

Fig. 1: Diagrammatic representation of *Seriolina nigrofasciata* (De Bruin *et al*., 1995)

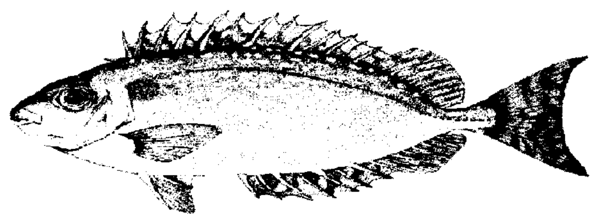

Fig. 2: Diagrammatic representation of *Siganus canaliculatus* (Carpenter *et al*., 1997)

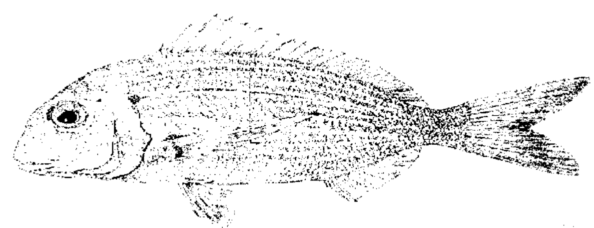

Fig. 3: Diagrammatic representation of *Rhabdosargus haffara* (Carpenter *et al*., 1997)

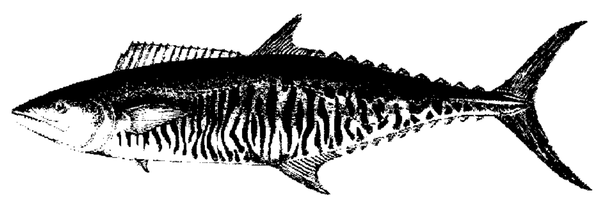

Fig. 4: Diagrammatic representation of *Scomberomorus commerson* (Bauchot, 1987)

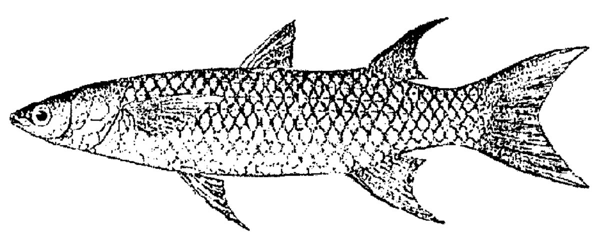

Fig. 5: Diagrammatic representation of *Liza alata* (Smith and Smith, 1986)

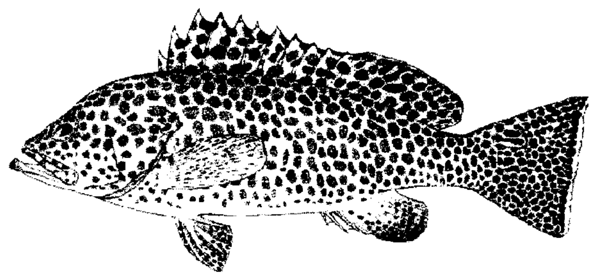

Fig. 6: Diagrammatic representation *Epinephelus areolatus* (Heemstra and Randall, 1986)

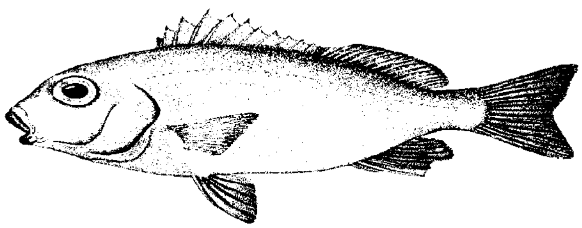

Fig. 7: Diagrammatic representation of *Plectorhinchus sordidus* (McKay, 1984)

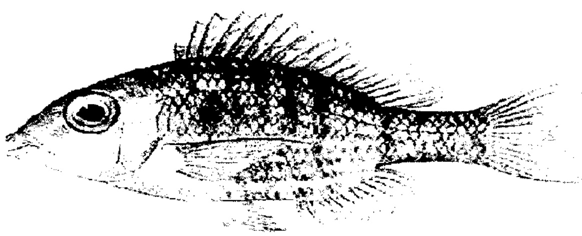

Fig. 8: Diagrammatic representation of *Lethrinus nebulosus* (De Bruin *et al*., 1995)

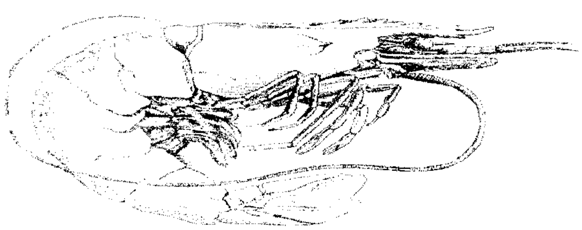

Fig. 9: Diagrammatic representation of *Peneaus semislcatus*

It has a maximum size of 60.0 cm TL. The adult fish are dark grey with orange-red lips and opercle edge; fins dark, membrane at front of dorsal fin narrowly black (Fig. 7).

Lethrinus nebulosus belongs to the family Lethrinidae, order Perciformes and class Actinopterygii. It has a maximum size of 87.0 cm TL and maximum published weight of 8,400 g. Body color is yellowish or bronze, lighter below. Centers of many scales have a white or light blue spot. Three blue streaks or series of blue spots radiate forward and ventrally from the eye. The fins are whitish or yellowish; the pelvic dusky, the edge of the dorsal fin is reddish (Fig. 8).

Peneaus semislcatus belongs to the family Penaeidae, order *Decapoda* and class *Malacostraca*. Usually have a long rostrum which is much longer than the antennal scales. Generally dark colored with carapace and abdomen transversely banded with black and white; rest of body variable from light brown to blue or red; some smaller specimens show a dull red dorsal strip from rostrum to sixth abdominal segment (Fig. 9).

About 5 kg of each kind of fish was obtained and the fish were cleaned by scaling and gutting and removing the internal organs. Most bones except small bones were removed (especially in small fish); fish were washed with distilled water and dried using filter paper. The cleaned and dried tissue was frozen at -20°C until analysis. All the fish samples were analyzed at the Department of Zoology, Stockholm University, Sweden.

Proximate analysis: Proximate analysis was carried out using the standard procedures as specified by AOAC (1990). Briefly, for moisture content, the sample was dried in a vacuum oven at 100°C and dried to a constant weight (approximately 5 h). Protein and other organic nitrogen in the sample were converted to ammonia by digesting the sample with sulfuric acid containing a mercury catalyst mixture. The acid digest was made alkaline and the ammonia was distilled and titrated with standard acid. The percent nitrogen was determined and converted to protein using the factor 6.25. For fat, the sample was hydrolyzed in a water bath using 8 M hydrochloric acid after addition of ethanol to liberate fat. The fat was extracted using ether and hexane. The extract was washed with a dilute alkali solution and filtered through a sodium sulfate column. The remaining extract was evaporated, dried and weighed. Carbohydrate was calculated using the standard equation 100% - (% protein + % fat + % ash + % moisture) and the energy evaluation was done by multiplying the protein, carbohydrate and fat by the factors 4, 4 and 9, respectively.

Mineral composition: The samples was weighed into a borosilicate calibrated flask to which 4 mL of concentrated HNO_3 and 1 mL of 30% H_2O_2 were added and microwave digested. The samples were cooled and made up to volume before analysis and the mineral elements measured using a flame system (Air acetylene flame). Pyrolytically coated graphite tubes in an inert atmosphere of argon were used in the furnace. Mineral composition was determined by the Atomic Absorption Spectrophotometry (AAS) and graphite furnace (GFAAS) (AOAC, 1990).

Heavy metal analysis: One fillet consisting of muscle tissue was selected for each species and macerated in a high-speed blender. Duplicate sub-samples were extracted for estimation of mercury, lead and cadmium. About 0.5 g of the homogenate was digested under pressure with HNO_3. Lead and Cadmium were determined by graphite furnace AAS using Perkins Elmer ™ Zeeman 3030 spectrophotometer. For mercury, the prepared samples were analyzed using a Perkins Elmer ™ mercury analyzer system. All concentrations were reported on a wet weight basis ($\mu g\ g^{-1}$). Each analytical run was carried out in duplicates for each of the sample.

The accuracy of the trace element determinations was confirmed with certified standard reference materials (DOLT-2: dogfish liver) obtained from the National Research Council of Canada. Precision and accuracy and percentage recovery and the results of quality control show a good agreement with certified data. Analyte recovery to within 10% of the certified value was used as the batch validation criterion. Duplicate analytical blanks were included in each sample batch to monitor contamination during digestion and sample preparation. Blank signals exceeding the absorbance of the analyte detection limit invalidated the batch. The mean of two measurements performed for each sample were accepted only when the relative standard deviation was less than 10%.

RESULTS

Proximate content: The proximate composition of fresh fish consumed in Bahrain is presented in Table 2. As the water content in fish increased the fat content decreased and hence, *Penaeus semislcatus* and *Lethrinus nebulosus* were high in their moisture content (78.2 g/100 g and 75.2 g/100 g, respectively) and low in their fat content (0.80 and 1.1 g/100 g, respectively). As commonly observed in fish, protein levels were quite high in most species; the highest was in *Seriolina nigrofasciata* (21.8 g/100 g). Carbohydrate was absent or negligible while the maximum ash content was in the *Plectorhinchus sordidus* (5.2 g/100 g). As expected, the energy content depended on the fat content of the fish and hence, *Liza alata* which had high fat content exhibited the highest energy values (216.7 Kcal/100 g), while the *Penaeus semislcatus* which had lower fat content exhibited lower energy values (87.1 Kcal/100 g).

Mineral content: Most of the fish species did not vary to a great extent in their sodium content. However, *Peneaus semislcatu* was found to contain high levels of sodium (300 mg/100g). Potassium levels were considerable in the *Seriolina nigrofasciata* (400 mg/100 g) while the *Epinephelus areolatus* had considerable levels of calcium (79 mg/100 g). Magnesium was predominant in the *Lethrinus nebulosus* (47.0 mg/100 g) while the *Epinephelus areolatus* had the low levels of magnesium (23.0 mg/100 g). The *Lethrinus nebulosus* was also rich in phosphorous (280 mg/100 g) while copper was the highest in the *Penaeus semislcatus* (2.8 mg/100 g) (Table 3).

Heavy metal content: Most species of fish had low levels of lead (<0.02 $\mu g\ g^{-1}$) and the maximum lead level was detected the *Liza alata* (0.5 $\mu g\ g^{-1}$). Mercury levels were also low in most of the fish (<0.02 $\mu g\ g^{-1}$). Some content of mercury was found in the *Epinephelus areolatus*

Table 2: Proximate composition of raw fish commonly consumed in Bahrain (g/100 g wet wt.)

						Energy	
Scientific name	Water	Protein	Fat	Ash	Carbohydrate	KJ	Kcal
Seriolina nigrofasciata	73.9	21.8	3.30	3.7	0.0	492.7	117.8
Siganus canaliculatus	70.9	18.9	7.30	2.8	0.1	593.1	141.8
Rhabdosargus haffara	71.5	19.9	3.70	4.5	0.4	482.0	115.0
Scomberomorus commerson	70.4	19.5	9.30	1.3	0.0	675.6	161.5
Liza alata	63.3	18.3	16.10	3.3	0.0	907.7	216.7
Epinephelus areolatus	76.0	19.3	3.40	1.1	0.2	457.3	109.3
Plectorhinchus sordidus	67.0	17.9	10.40	5.2	0.0	689.1	164.7
Lethrinus nebulosus	75.2	19.7	1.10	4.2	0.0	375.6	89.8
Penaeus semislcatus	78.2	19.7	0.80	1.6	0.0	364.5	87.1

Table 3: Mineral composition of raw fish commonly consumed in Bahrain (mg/100 g wet wt.)

Scientific name	Fe	Na	K	Ca	Mg	P	Cu	Zn
Seriolina nigrofasciata	0.6	120	400	61	40	256	0.5	0.6
Siganus canaliculatus	0.5	160	360	52	37	230	0.4	1.0
Rhabdosargus haffara	1.1	110	360	23	37	240	1.0	2.2
Scomberomorus commerson	0.5	110	350	11	30	240	0.4	0.0
Liza alata	0.6	110	210	33	34	210	1.7	0.9
Epinephelus areolatus	0.3	82	360	79	23	230	0.4	0.5
Plectorhinchus sordidus	1.1	100	300	21	42	200	0.2	1.3
Lethrinus nebulosus	0.4	120	340	37	47	280	1.1	0.2
Penaeus semislcatus	0.1	300	230	61	43	260	2.8	1.3

Table 4: Heavy metal content in raw fish commonly consumed in Bahrain ($\mu g\ g^{-1}$ wet wt.)

Scientific name	Lead	Mercury	Cadmium
Seriolina nigrofasciata	<0.02	0.04	<0.02
Siganus canaliculatus	0.38	<0.02	<0.02
Rhabdosargus haffara	0.02	0.03	0.03
Scomberomorus commerson	<0.02	0.10	<0.02
Liza alata	0.50	<0.02	<0.02
Epinephelus areolatus	<0.02	0.20	<0.02
Plectorhinchus sordidus	0.02	0.03	<0.02
Lethrinus nebulosus	<0.02	0.05	<0.02
Penqeus semislcatus	<0.02	<0.02	<0.02

Australian food standards for heavy metals in fish. Lead: 0.5 mg kg^{-1}. Mercury: mean of 0.5 mg kg^{-1}. Cadmium: 0.2 mg kg^{-1}

Table 5: Comparison of measured values of lead, mercury and cadmium ($\mu g\ g^{-1}$ dry wt.) with certified values of standard reference material DOLT-2 dogfish liver ($\mu g\ g^{-1}$ dry wt.) and percentage recovery

Metal	Certified value ($\mu g\ g^{-1}$ dry wt.)	Measured value ($\mu g\ g^{-1}$ dry wt.)	Recovery (%)
Lead	0.22±0.02	Trace	-
Mercury	2.14±0.28	2.21±0.21	98.60
Cadmium	20.8±0.50	18.9±0.04	89.24

species (0.2 $\mu g\ g^{-1}$), followed by the *Scomberomorus commerson* species (0.1 $\mu g\ g^{-1}$). Cadmium levels were <0.02 $\mu g\ g^{-1}$ in all fish species, except for the *Rhabdosargus haffara* which had a concentration of 0.03 $\mu g\ g^{-1}$ (Table 4).

The comparison of measured values of heavy metals with certified values of standard reference material DOLT-2 dogfish liver and percentage recovery are seen in Table 5. The high level of recovery rate for cadmium and mercury suggests that the digestion process released the organic bound metals from the samples. Lead was not recovered due to very low levels in the standards which would require parts per billion testing to recover to recover it instead of parts per million as in this study.

DISCUSSION

Most fish in this study were high in protein and contained considerable levels of fat. This aspect is of dietary advantage to the consumer since it is a known fact that protein is essential for maintaining and building muscle (Bonjour, 2005). The higher fat content in some species of fish is of nutritional value as a great amount of evidence from epidemiological studies and clinical trials in Spain supports a protective effect against coronary heart disease for fish consumption and intake of marine omega-3 fatty acids (Alonso *et al*., 2003). Omega-3 fatty acids reduce serum lipids and lipoproteins, impair platelet aggregation, increase cell membrane fluidity and lower blood pressure in humans (Malasanos and Stacpoole, 1991). One of the biggest health problems faced by the Arab Gulf countries today is the rising levels of chronic non-communicable diseases such as coronary heart disease (CHD), diabetes, hypertension and cancer (Musiager, 2002). Studies on the food consumption pattern of in the Arab countries indicate that in recent years a shift from traditional foods to more westernized foods, which are characterized by high fat, high cholesterol, high sodium and low fiber has occurred in this region (Musaiger, 2004). It has been previously reported that elderly people were more likely to consume traditional foods such as fish and laban (diluted yoghurt) than young people (Musiager and Abuirmeileh, 1998). In view of the rising health consequence as a result of the dietary shift it is suggested that an emphasis be laid towards reverting back to traditional foods consisting of regular intake of fish.

As for the minerals, potassium and phosphorus levels were considerable in many of the fish analyzed, indicating the nutritive value of fish. Evidence suggests that dietary potassium may play a role in decreasing blood pressure and is involved in nerve function and muscle control and blood pressure (Anderson *et al*., 2005) while phosphorus is needed for bone and teeth formation (Laberge, 2007). The higher levels of potassium may be due to the fact that the main store of intracellular potassium in fish is in the skeletal muscle (Rotllant *et al*., 2005), while phosphorous is reported to be the most concentrated mineral in fish with a mean value of 238.13 mg/100g (Corser *et al*., 2000). These values are also in good agreement with our present study values. Though copper levels were low in most of the species of fish, the values for magnesium and zinc were quite high and close to those reported for fish in the Arabian Gulf region (Harris, 1989). The high values of zinc are important since zinc deficiency affecting the growth of the children and adolescents in the Arab Middle East countries including the Gulf States have also been reported (Musaiger and Miladi, 1996). The low calcium values in most of the fish species is because the main reservoirs for calcium in fish are the scales as well as bone, which are lost in the process of cleaning (Rotllant *et al*., 2005). The mineral composition of fish in this study is close to those reported by other investigators in the region (Harris, 1989; El-Faer *et al*., 1992). Although there was a slight variation in the mineral content the most noticeable variation was seen in copper and calcium levels. In general, the deficiency in some of the minerals could be due preponderance of these minerals on the surface and/or in the gut (Kadar *et al*., 2006) leading to loss of these minerals as a result of termination of these organs.

The general population is primarily exposed to heavy metals via food, fish and contaminated water and the several adverse effects to health from heavy metals have been known for a long time (Järup, 2003). Present results for heavy metals indicate low levels in most of the species of fish studied. As in the case of minerals, the storage site is important and could influence the final outcome of heavy metals in fish. Reports indicate that cadmium levels are greatest in liver, followed by muscle, which in turn is followed by skin (Al-Yousuf *et al*., 2000) which could explain the low level of cadmium in our study. Studies on the heavy metals distribution in fish showed that mercury was higher in muscle while concentrations of cadmium and lead are below analytical detection limits in almost all muscle samples (Ashraf, 2005). This could justify the need for greater concern about mercury contamination since the organs such as liver and heart generally are discarded during cooking, thereby reducing the chances of ingesting lead and cadmium. In addition, although the general population does not face a significant health risk from methyl mercury, certain groups with high fish consumption may attain blood levels associated with a low risk of neurological damage to adults. Since there is a risk to the fetus in particular, pregnant women should avoid a high intake of certain fish and fish shark, swordfish and tuna) and fish taken from polluted fresh waters should especially be avoided (Järup, 2003).

Another important factor is that the concentration of metals is significantly affected by the sampling site and the fish species (Al-Saleh and Shinwari, 2002). Though we had detectable levels of lead in our study, it was below 2.0 mg kg^{-1} of fish, which is regarded as the upper limit (Al-Jedah and Robinson, 2001). The low levels of heavy metals indicate benefits to the consumer since, fish containing heavy metals levels above the legal limits for mercury (0.5 mg kg^{-1} of fish) have been reported (Rao and Ahmed, 1995).

The main reasons for heavy metal contamination of fish in the Arabian Gulf is due to the slow movement of Gulf water towards the ocean and no strong regulation concerning oil spillage and washing oil tanks. In addition, there is a lack of regulation for controlling marine pollution and dumping municipal waste directly into the Gulf waters (Harris, 1989). Although the present study indicates no particular heavy metal contamination, supporting responsible coastal restoration and regulation of commercial fishing by recommending careful inspection, selection and preparation of seafood is of importance.

Although the present data indicates that marine fish available in the market of Bahrain are nutritious and have heavy metals below the maximum allowed levels, it would be advisable to monitor heavy metals periodically. Further, all the species of fish studied were high in protein and in some essential minerals such as phosphorous and potassium thereby proving to be beneficial to the consumer. Since some of the minerals were found deficient, balancing the diet with other foods such as vegetable, fruits and cereals could help to overcome these deficiencies.

RECOMMENDATION FOR FURTHER STUDIES

The risk of sea water contamination from industrial effluents and municipal wastes continues to remain. It is suggested that periodic monitoring of the fish species for their safety and suitability for human consumption is carried out on a regular basis.

ACKNOWLEDGMENT

The author thanks the FAO Species Identification and Data Programme for providing pictures of the various fish species.

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