International Food Research Journal 24(1): 191-201 (February 2017)
Journal homepage: *http://www.ifrj.upm.edu.my*

Macro and micronutrients of selected marine fishes in Tuticorin, South East coast of India

Lilly, T.T., Immaculate, J.K. and *Jamila, P.

Suganthi Devadason Marine Research Institute, 44 - Beach Road, Tuticorin, Tamil Nadu, India

Article history

Received: 11 August 2015
Received in revised form: 28 March 2016
Accepted: 12 April 2016

Keywords

Sea food
Fish
Body composition
Macro and micro nutrients

Abstract

The levels of macro and micro nutrients in the edible portions of some commercially important fin fishes were determined using the methods recommended by Association of Official Analytical Chemists (AOAC). All the fish species investigated were fairly high in macronutrient protein (18 - 21%), while the lipid content was less than 3%. All the fish were observed to contain no carbohydrate and the moisture and ash content varied within a narrow range. The levels of minerals varied from one fish species to the other. The most abundant micro nutrient was potassium followed by phosphorus, sodium, magnesium, calcium, zinc, iron, copper and manganese respectively. The micro and macro nutrient of all the samples did not exceed the recommended safety limits of sea foods specified by the World Health Organization (WHO, 2013). Considering the result of the present study, it can be concluded that all the species are rich in food value.

Introduction

Vital nutrients, which are needed for human growth and development, are present in sea foods. Macro and micro nutrients available in seafood makes it better compared to other protein sources. The macro and micronutrients of food is vital for good health. Malnutrition has been defined as inadequate or excess intake of one or more nutrients. An inadequate intake of dietary nutrients causes growth retardation (Mora *et al*., 1981; Rivera and Martorell, 1988; Habicht *et al*., 1995). Growth retardation is highly prevalent in developing countries (De Onis, 2000) and is associated with several adverse health effects throughout the lifetime (Martorell, 1995). Moreover, nutrient deficiencies may have an indirect effect on the growth by increasing prevalence or severity of morbidity and anorexia. The role of specific nutrient deficiencies in the etiology of growth retardation has gained attention more recently (Allen, 1994; Gibson and Hotz, 2001; Brown *et al*., 2002).

Fish is an important constituent of human diet (Dore, 1984). Fish is safer and healthier to be consumed as whole food because protein / fat ratio is high compared to the meat of goat, lamb, buffalo and chicken. Moisture, protein, lipids, ash and minerals are the most important micro and macro nutrient components that act as sources of nutritive value of fish meat (Steffens, 2006). Minerals are essential nutrients; they are the components of many enzymes metabolism and contribute to the growth of the fish (Glover and Hogstrand, 2002). The human body usually contains small amount of the minerals and the deficiency in these principal nutritional elements induces lot of malfunctioning, as it reduces productivity and causes diseases (Mills, 1980). Sea food as a whole food has a wide variety of nutrients that are easily absorbed in the digestive system and is one of the best dietary sources (Bourre and Paquotte, 2008) of food.

Marine fishes that are exposed to heavy metals are being consumed and they are the connecting pathway for the transfer of toxic heavy metals to human beings. Therefore, it is often mandatory to check chemical contaminants in foods from aquatic environment to understand their hazard levels. Various studies have been carried out worldwide on the metal contamination in different edible fish species (Kamaruzzaman *et al*., 2010). Moreover consuming sea food results in reduction of heart attack, stroke, obesity and hypertension (Balshaw *et al*., 2007). Therefore, it is essential to know the nutritional value of fish, in order to quantify its health benefits.

Body composition of the fish is a good indicator for the dietary intake of nutrients and contaminants. This study quantifies the macro and micro nutrient content of seafood. Wide range of macro and micronutrients in seafood has been analyzed with a view to promote the consumption of fish and seafood as whole foods that are highly valuable for a balanced diet. The information presented in this paper is useful

*Corresponding author.
Email: *jamilapat@sdmri.in*
Tel: +91 461 2336488; Fax: +91 461 232569

to the consumers for choosing fish as a part of food based on their nutrient values. The fish species studied are *Sardinella albella, Dussumieria acuta, Arius subrostratus, Hemiramphus far, Cephalopholis boenak, Carangoides chrysophrys, Lutjanus fulvus, Parupeneus indicus* and *Valamugil seheli*. They are chosen based on consumer preference of the locality. The significance of the study is to illustrate the diversity in nutrient content of fish species and in particular the rich nutrient composition of small indigenous species, which should guide policy and programmes to improve food and nutrition security among the people.

Materials and Methods

Sample preparation

Nine fresh fish samples namely, *Sardinella albella, Dussumieria acuta, Arius subrostratus, Hemiramphus far, Cephalopholis boenak, Carangoides chrysophrys, Lutjanus fulvus, Parupeneus indicus* and *Valamugil seheli,* were purchased from Tharuvaikulam fish landing centre (09°53.729’ N, 78° 09.958’ E) in November 2014. They were transported to the laboratory in an ice box and were washed thoroughly. In the laboratory, the fishes were sorted based on the species variations and identified up to species level using Food and Agriculture Organization (FAO) species identification sheets (FAO, 1984). The morphometric data such as total length (TL) and body weight (BW) measurement was obtained using vernier caliper and weighing balance respectively. The bone and skin were separated and the meat was minced and placed in plastic bags and sealed and kept in freezer at -20^{o}C until taken for analysis. Prior to analysis the mince was thawed in the refrigerator at 4^{o}C for overnight.

Macronutrient analysis

The macronutrients of the fish samples were analyzed according to standard procedures of Association of Official Analytical Chemists (AOAC). Moisture was determined by keeping fish samples in a hot air oven at 105˚C for 24 hours (AOAC, 1975). The folin- Ciocalteu phenol method (Lowry, 1951) was adopted for the estimation of total protein in the fish. The lipid was estimated by following the method proposed by Folch *et al.* (1957) and ash content was determined by igniting the samples in a muffle furnace at 450˚C overnight (AOAC, 1975). Total Carbohydrate was estimated by the phenol sulphuric acid method (Dubois *et al*., 1956).

Micronutrient analysis

Micronutrients such as calcium, copper, iron, magnesium, potassium, sodium, manganese, phosphorus and zinc were determined quantitatively by atomic absorption spectrophotometer method (AOAC, 1999).

Results and Discussion

The common name of the selected experimental fishes and their sample size weight and photographs were presented in Table 1 and Figure 1. All the species used in this study are economically low valued fishes rated less than 50 rupees/kg. Mean percentage for macro nutrients such as moisture, protein, fat and ash content of fishes are given in Table 2 and Figure 2. The major macro component of fish muscle is moisture that support metabolism. Moisture content of flesh is a good indicator of its relative content of energy, protein and lipid (Aberoumad and Pourshafi, 2010). In the present study the selected fishes had moisture content ranging from 75.05 to 79.40%. Moisture content in all the species were within the range (70 – 83%) reported in literature (Gallagher *et al.*, 1991). Since the moisture, protein, lipid and ash contents of the finfish were independently determined; the sum of the percentages of these constituents would not necessarily be equal to 100%.

Protein

Among the macro nutrient composition, protein in fish is an excellent source, because of the amino acid composition and degree of digestibility (Louka *et al.*, 2004). Eyo (2001) reported that lack of sufficient protein is one of the most widespread nutritional deficiencies in many tropical countries. Generally, fish contain a good quality of protein within the range between 18 - 20% (Chilma, 2006). Protein and fat are the major nutrients in fish and their levels define the nutritional status of the particular organism. The chemical composition of fish varies greatly from one to another depending on age, sex, environment and season with protein levels ranging from 16 - 21%, lipids 0.1 - 25%, ash 0.4 - 1.5% and moisture 60 - 81%. Even very high moisture content of 96% has also been reported (Muraleedharan *et al*., 1996). The results of this analysis showed that there is high level of crude protein found in the fish species studied. Among the species studied *Velamugil seheli* and *Carangoides chrysophrys* had the high and low protein content of 18.6 and 21.8 g/100g respectively. Protein contents of the fish species in this study were higher than the protein content of beef, lamb and pork. The results confirm the fact that the fish species

Table 1. Summary of the morphometric data

Fishes	Common names	Sample size (cm)	Sample weight (g)
Sardinella albella	White sardinella	8	10
Dussumieria acuta	Rainbow sardine	12	16
Arius subrostratus	Shovelnose sea catfish	19	50
Hemiramphus far	Black barred halfbeak	28	310
Cephalipholis boenak	Chocolate hind	23	225
Carangoides chrysophrys	Longnose trevally	19	100
Lutjanus fulvus	Blacktail snapper	20	80
Parupeneus indicus	Indian goatfish	14	25
Velamugil seheli	Bluespot mullet	32	300

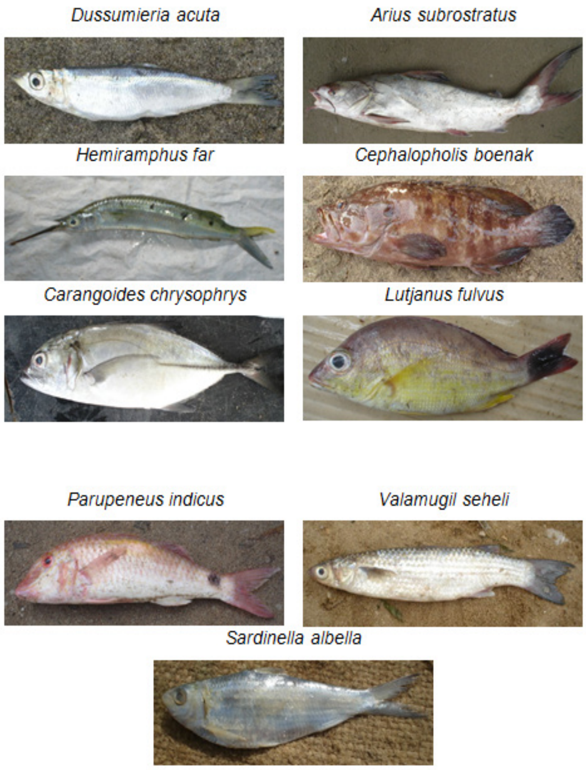

Figure 1. Fishes used in this study

are very important resources of dietary protein for the inhabitants of the area in general and for men in particular as they need more protein than women. The differences observed in crude protein and other nutrients in the fish samples could be the result of varying fish consumption or absorption capabilities and conversion potentials of essential nutrients from their diets or their local environment into such biochemical attributes needed by their body (Onyia *et al*., 2010).

Lipid

The relative lipid content varied from one fish to the other, but all the fish showed lipid values below 3%. Lipid contents of muscle tissues of fish vary with the season of the year (Lambertsen, 1983) and are affected by such diverse factors as age, sex, spawning cycle and environmental conditions (Exler *et al.*, 1975). According to Ackman (1989), generally fish can be grouped into four categories according to their fat content: lean fat (<2%), low fat (2-4%), medium fat (4-8%), and high fat (>8%). However, fish with less than 5% fat are classified as 'lean' and they store their fat in the liver, they are generally not expected to exhibit significant seasonal variations in lipid content of muscle tissues. In the present study, out of the nine fishes studied, two species namely *Sardinella albella, Parupeneus indicus* are low fat fish and all the remaining fishes are categorized as lean fish. None of the fishes is coming under the high fat fish. High lipid fishes had less water and more protein than low lipid fishes. Likewise, the species examined also contained appreciable concentrations of potassium, phosphorus, sodium and calcium suggesting that these species could be used as good sources of minerals. Ayyappan *et al*. (1976) estimated protein, lipid and ash content of miscellaneous edible fish from shrimp trawlers and recorded a range of 16.02 - 20.77% for protein, 0.3 - 5.31% for lipid and 3.2 - 5.6% for ash.

Ash

In the present study, the highest ash content was found in *Arius subrostratus* (1.99 g/100g) and it was low in *Sardinella albella* (0.30g/100g). The values of ash in selected fish were different from the findings of Salam *et al.* (1995), Nobi and Hossain (1989) and Salam (2002). It may be due to lesser amount of skeleton in small indigenous fish species. According to Stansby (1954), Salam *et al.*, (1995) and Jacquot (1961), variation in proximate composition of fish flesh may vary with species variation, season, age and the feeding habit of the fish. The chemical composition of fresh fish may vary largely between and within species (Jacquot, 1961). Here the differences may be due to the difference in the fish species used. The range for the ash content gave an indication that the fish samples may be good sources of minerals such as calcium, potassium, zinc, iron and magnesium. The present findings state that the ash contents of the selected fish species such as *S.albella, D.acuta, A.subrostratus, H.far, C.boenak, C.chrysophrys, L.fulvus, P.indicus* and *V.seheli* (0.30 – 1.47%) are less than that of other fishes such as Gray eel cat fish, golden snapper, Indian threadfin,

Table 2. Macro nutrients (mean g/100g wet tissue) (± standard error) of commercially important fishes

Fishes	Protein	Fat	Moisture	Ash	Carbohydrate
Sardinella albella	18.9 ± 1.10	2.70 ± 0.14	79.40 ± 0.87	0.30 ± 0.26	-
Dussumieria acuta	20.6 ± 0.72	0.96 ± 0.09	77.8 ± 1.50	1.08±0.18	-
Arius subrostratus	21.30 ± 1.57	1.22 ± 0.23	79.1 ± 0.85	1.99±0.17	-
Hemiramphus far	19.4 ± 0.80	0.55 ± 0.26	75.05 ± 0.96	1.26±0.25	-
Cephalipholis boenak	19.60 ± 0.70	1.04 ± 0.02	78.27 ± 0.64	1.39±0.28	-
Carangoides chrysophrys	21.8 ± 0.87	1.97 ± 0.14	76.70 ± 1.15	1.40±0.35	-
Lutjanus fulvus	20.5 ± 0.87	1.84 ± 0.22	75.87 ± 0.31	1.36± 0.24	-
Parupeneus indicus	20.0 ± 0.56	2.1 ± 0.13	78.52 ± 0.56	1.28± 0.45	-
Velamugil seheli	18.6 ± 0.53	1.55 ± 0.20	75.47 ± 0.49	1.47± 0.45	-

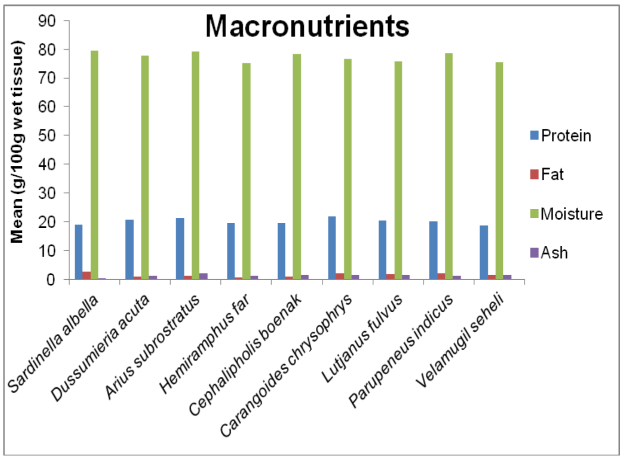

Figure 2. Macronutrients in fishes

moon fish, Malabar red snapper (0.9-2.1%) reported by Nurnadia *et al*., 2011.

Several studies on macronutrients composition of fish have been made from different parts of the world. Desilva and Rangoda (1979) analysed the chemical characteristics of fresh and salt dried product of *Tilapia mossambica* of Sri Lanka and found the range of protein, lipids, ash and moisture as 20 - 22%, 0.09 - 26%, 0.1 - 2.2% and 70 - 80% respectively. Wimalasena and Jayasuriya (1996) carried out nutritional analysis of some fresh water fish from Narammala, Ibbagamuva and Nikaveratiya in Sri Lanka. The study reported the moisture, carbohydrates, proteins, lipids and ash content as 66-84%, 0-2.9%, 15-20%, 0.1-20%, 0.8-2% respectively. The mean value of protein, fat , moisture and ash content was found as 14.87%, 7.90%, 73.49% and 3.74% respectively for different fresh water fishes specifically Magur *(Clarias batrachus)*, shingi *(Heteropneustes fossilis)*, koi *(Anabas testudineus)*, Foli *(Notopterus notopterus)* in Bangladesh (Kamal *et al*., 2007). The proximate composition of moisture, protein, fat in matured eggs of crab *Portunus sanguinolentus* were found to be 59.70, 21 and 7.58% respectively (soundarapandian and Dey, 2008). Tawfik (2009) studied the proximate composition of fatty acid profile in most commonly available fish species in Saudi market. Total lipid and ash contents of fish are reported to vary significantly with gradual increase in the weight and length of the fish and also due to seasonal changes aside from the available nutrients in varied habitats (Hassan, 1996). The moisture, protein, fat and ash content were 77.82%, 19.97, 0.24 and 1.50% respectively in the tissue of Yellow-spotted travally, *Carangoides fulvoguttatus* (Tawfik, 2009). The nutritive value of *Tranchinotus carojinus* fish from florida was found to be 74.76% moisture, 20.31% protein, 1.16% ash content and 5.17% lipid (Gall *et al*., 1983). Hale (1984) observed 74.06% moisture, 21.64% protein, 2.52% lipid and 3.12% ash content for round scad from Florida. The proximate composition of fish species greatly varies during the catching season due to physiological reasons and changes in environmental conditions (Boran and Karacam, 2011).

Carbohydrate

The carbohydrate content in fish is generally very low and practically considered zero (Payne *et al*., 1999; Anthony *et al*., 2000). Carbohydrate was not present in all the 9 species of this study. The low values of carbohydrates recorded in the present study suggest that glycogen in many marine animals does not contribute significantly to the total reserves of the body.

Micronutrients

Micronutrients present in food can be essential,

Table 3. Mean (mg/100g, wet tissue) micro nutrients (± standard error) of commercially important fishes

Fishes	Ca	Cu	Fe	Mg	K	Na	Mn	P	Zn
Sardinella albella	58.1± 2.40	BDL	0.65± 0.10	0.52± 0.03	355± 8.66	159.2± 0.75	0.002± 0.03	340± 9.00	0.38± 0.80
Dussumieria acuta	61.20 ± 0.77	0.21± 0.21	0.14± 0.03	0.39± 0.01	339± 7.74	63.8± 1.59	0.011± 0.02	211.0± 9.85	1.21± 0.02
Arius subrostratus	30.0± 1.00	0.01± 0.01	0.30± 0.10	0.47± 0.03	340± 10.00	55.7± 2.11	0.018± 0.01	188.0± 2.0	0.41± 0.35
Hemiramphus far	28.30± 0.75	0.17± 0.02	0.16 ± 0.04	0.42± 0.03	414± 10.39	62.3± 1.76	0.001± 0.01	147.0± 3.0	0.29± 0.08
Cephalipholis boenak	47.33± 1.53	0.22± 0.02	0.22± 0.03	0.22±0. 03	298± 10.44	47.0±1. 0	0.021± 0.01	251.0± 9.64	1.80± 0.04
Carangoides chrysophrys	14.1± 0.88	0.47 ± 0.10	0.14± 0.03	0.41± 0.12	168± 8.19	185.8± 1.13	0.005± 0.00	219.0± 8.54	0.30± 0.09
Lutjanus fulvus	33.2± 0.73	0.22 ± 0.02	0.35± 0.04	0.30± 0.05	350± 40.0	27.40± 0.53	0.007± 0.12	235.0± 6.0	0.28± 0.03
Parupeneus indicus	35.6 ± 0.53	BDL	0.11±0. 02	0.33± 0.08	339± 18.25	74.8± 1.31	0.011± 0.02	180.0± 19.08	0.34± 0.03
Velamugil seheli	42.0 ± 1.32	0.02± 0.03	0.21±0. 01	0.39± 0.05	410± 11.36	75.7± 0.61	0.009±0 0	230.0± 10.0	0.42± 0.04

BDL- below detectable level

non-essential or toxic to human beings. Minerals such as iron, copper, zinc and manganese are essential and play important roles in biological systems. However, essential minerals can also produce toxic effects at high concentrations (Sivaperumal *et al*., 2007). Micronutrients in animal source foods also tend to be more readily available than micronutrients from plant foods. Among the nine fishes investigated, the most abundant micronutrient in fin fishes was potassium followed by phosphorus. Potassium was observed to dominate mineral range (333 - 441 mg/100g) in all the fish species reported by Elagba *et al.* (2010). Potassium is directly connected with sodium and ensures proper water balance of organism, is the main cation of intracellular liquid, enzyme ingredient, occurs in digestive juices, regulates water balance (cellular volume, intracellular osmotic pressure), affects acid-base equilibrium, ensures appropriate functioning of nerves and muscles, increases permeability of cell membranes (an antagonist of calcium), and increases activity of secreting glands. The concentrations of potassium were quite high for all samples (Table 3). The lowest was in *Carangoides chrysophrys* fish with potassium content of 168 mg/100g wet sample, which was significantly lower when compared with finding of Lourenco *et al*. (2009) at 289 mg/100g sample. Oksuz *et al.* (2009) reported potassium levels of 99.60 mg/100 g samples (french rose shrimp) and 64.49 mg/100 g samples (red shrimp), which were lower than that of *Hemiramphus far* (414 mg/100g wet sample) in the current study. Besides, Erkan and Ozden (2007) also reported significantly higher values compared to the current findings; at the mean average of 459.7 mg/100g (sea bass) and 393.8 mg/100g (sea bream). The richness in phosphorus level in the fish species can also be attributed to the fact that phosphorus is a component of protein. Phosphorus is an ingredient of bones, teeth, high-energetic compounds, nucleic acids, kephalin, lecithin, cell membranes and blood. It takes part in build and keep of current state of teeth and bones, and in regulation of acid-base equilibrium. It fulfills a very big role in processes of anabolism and catabolism, participates in glucose combustion.

Potassium is primarily an intracellular cation, in large part this cation is bound to protein and with sodium influences osmotic pressure and contributes to normal pH equilibrium. Potassium and sodium are widely distributed in foods with plant containing less than animal sources. When the amounts of these minerals were compared with the suggested values all the nine samples can be considered as good sources of these minerals. In contrast calcium concentration is appreciably dominated other minerals in all fish species reported by Adeyeye and Ayoola (2010). Calcium is important for developing and maintaining bones and teeth as well as supporting the healthy functioning of muscles, nerves and the heart. Skeletal calcium serves as a reservoir for the supply of calcium for other body functions such as intracellular messaging and as such after a long latency period, calcium deficiency results in osteoporosis (Heaney, 2003). Adequate dietary calcium is required throughout life to prevent low bone mineral density, decrease risk of fragility fractures and osteoporosis at a mature age. Bony fish such as sardines and tinned salmon are very rich in calcium. Intakes of seafood greater than 250g per week have been associated with greater bone mineral density (Zalloua *et al.*, 2007). It can be construed from evidence that seafood can promote bone density when consumed within an otherwise healthy diet due to the susceptibility of calcium to macro and micro nutrient interactions. The range of calcium content in all samples was between 28.30 and 61.20 mg/100g wet sample. The amount of calcium varied from one fish species to the other with the maximum value (61.20 mg/100 g) found in *Dussumieria acuta* and the minimum value (28.30 mg/100g) observed in *Hemiramphus far*. Meanwhile, Irwandi and Farida (2009) showed calcium concentration in the range of 0.57 - 3.03 mg/100g sample; with significantly lower calcium values in five common samples of golden snapper (0.57 mg/100g), Indian mackerel (1.51 mg/100g), sixbar grouper (3.03 mg/100g), japanese threadfin bream (1.04 mg/100g) and spanish mackerel (1.02 mg/100g); compared to the current findings of 21.36, 33.42, 57.99, 16.76, and 19.70 mg/100g wet samples, respectively. However, the calcium contents in shellfish samples in the current study were in agreement with values reported for rose shrimp (49.5 mg/100g) and red shrimp (32.25 mg/100g) in French (Oksuz *et al.*, 2009).

Considerable amounts of sodium were found in fish and, in the case of *Sardinella albella* and *Carangoides chrysophrys*, the levels of sodium were actually slightly higher than that of potassium. The sodium contents in samples ranged between 27.40 to 185.8 mg/100g of wet samples; with most of the samples showed values not less than 40 mg/100 g in wet samples. Lourenco *et al.* (2009) showed the same trend as sodium was found to be considerably higher in shellfish than in fish.

Magnesium is an activator of many enzyme systems and maintains the electrical potential in nerves (Shils, 1973). Magnesium varied within a relatively narrow range (0.22- 0.33 mg/100g) in some fish species *(Cephalipholis boenak, Lutjanus fulvus, Parupeneus indicus)* and was present in higher concentrations in (0.39 - 0.52 mg/100g) some fishes (*Velamugil seheli, Dussumieria acuta, Carangoides chrysophrys, Hemiramphus far, Arius subrostratus,* and *Sardinella albella)*. Magnesium takes part in build of bones and teeth, metabolism, synthesis of nucleic acids and proteins and thermoregulation. It participates in the process of vision and activates some of the enzymes. It also plays a important role in transferring information between muscles and nerves, and inhibits blood coagulation (protects against thrombi in vessels and in heart - protection against infarction). Overall, magnesium was found to be the mineral with highest concentration in all samples compared to all minerals analyzed. The mean concentrations of the mineral ranged between 618.38 and 1534.80 mg/100g in wet samples. FAO and World Health Organization (FAO/WHO, 2004) reported mineral requirement in preschool aged children, adult women and pregnant women was 19, 44.6 and 57.35 mg/100g respectively in daily diet. The weekly intake of these metals per Kg of body weight was calculated to be 27.45mg taking 68.48 Kg as the average weight of the Indian population (WHO, 1989). Oksuz *et al.* (2009) reported magnesium values of 38.2 and 57.9 mg/100 g in wet samples of rose shrimp and red shrimp samples, which were significantly lower compared to the current findings. Erkan and Ozden (2007) also reported magnesium values at 32.6 mg/100g (seabass) and 22.2 mg/100g (seabream); which were significantly lower compared to all samples in the current study. This could be due to the difference of species, seasons, area of catch and many other physical and environmental conditions in these studies.

Other elements (such as zinc, iron and copper) varied in concentration among the studied species. Most of these microelements are equally important in trace amounts as observed, but they tend to become harmful when their concentrations in the tissues exceed the metabolic demands (Hogstrand and Wood, 1996; Ako and Salihu, 2004). The copper concentrations were similar to other studies (Yilmaz, 2003; Rejomon *et al*., 2010). However, higher than reported by Kamaruzzaman *et al*. (2010); Dural and Bickici, (2010); Raja *et al.* (2009); Turkmen *et al*. (2008); Naim and Ahmed, (2008) and Wen-Bin Huang, (2003), but lower than earlier report from this area (De *et al*., 2010) and fishes from Gresik coastal waters of Indonesia (Agoes and Hamami, 2007). The higher accumulation of copper may be due to its relationship with molecular weight proteins (metallothionein -like). The values of the element in this study were compared with WHO standard values of permissible limit (WHO, 1998). Asuquo *et al.* (2004) remarked that higher values of element above WHO standard are possible potential health hazards and should be avoided. This by implication that most of the imported fish species particularly the mackerels, have lost their food value and are no longer suitable for human consumption, especially in concerns high concentration of copper and it carcinogenic nature in human system (WHO, 1998). Because copper is essential for human health but an overdose can cause adverse events such as liver and kidney damage (Tuzen, 2009).

The zinc and copper were found in relatively less concentrations in selected fish species in the range of 0.28 - 1.80 mg/100g and BDL - 0.47 mg/100g respectively. However, since marine animals are more susceptible to pollutants in the marine environment, the high levels of zinc and copper might be due to contamination and also due to its relationship with molecular weight proteins (metallothionein-like). Observations on zinc were similar to other studies (Dural *et al*., 2007; Ahmad *et al*., 2008; Turkmen *et al.*, 2008; Raja *et al*., 2009; De *et al*., 2010), although, higher than fishes from eastern Taiwan (Wen-Bin Huang, 2003), Malaysia (Kamaruzzaman *et al*., 2010), Turkey (Dural and Bickici, 2010), but lower than from south west coast of India (Rejomon *et al*., 2010), Indonsia (Agoes and Hamami, 2007) and Iran (Fariba et al., 2009).

Zinc is essential for the synthesis of DNA and RNA, proteins, insulin and sperm, essential for proper functioning of immunity system and for activation of over 80 enzymes. It takes part in metabolism of carbohydrates, fats, proteins and alcohol. It is necessary in protective process against free radicals. It also influences the taste and smell feeling and the appearance of hair and nails. Widespread zinc deficiency is an issue affecting Australian arable land (Alloway, 2009), and thus crops raised in Australia may not continue to contribute significantly to human zinc requirements. Consequently, alternative sources such as zinc rich food should be consumed so that optimal zinc levels are met and maintained. As zinc binds to protein, foods such as seafood, which are sources of both zinc and protein, optimize bioavailability of dietary zinc (Alloway, 2009). Oysters are known to be one of the richest natural sources of zinc. However, oyster was found to contain zinc higher than the permissible limit set by Malaysian Food Regulations (1985) (100 mg/100g). The zinc content in fish samples of this study ranged between 0.28 - 1.80 mg/100g in wet samples. The zinc content in *Sardinella albella, Dussumieria acuta, Arius subrostratus, Hemiramphus far, Cephalopholis boenak, Carangoides chrysophrys, Lutjanus fulvus, Parupeneus indicus* and *Valamugil seheli*, are 0.38, 1.21, 0.41, 0.29, 1.80, 0.30, 0.28, 0.34 and 0.42 mg/100g of wet samples respectively. These are lower compared to the mean zinc concentration of 0.89, 0.63, 0.70, 0.93 and 0.81 mg/100g of samples in golden snapper, Indian mackerel, sixbar grouper, japanese threadfin bream and spanish mackerel respectively (Irwandi and Farida, 2009). All samples contained zinc lower than the limit set by FAO/WHO (1984) (150 mg/100g). Iron was found in low amounts (Table. 3). The reported iron in this study were higher than in the samples from Nigeria and Turkey (Turkmen *et al.*, 2008; Dural and Bickici, 2010), gulf of Aquaba and Red sea (Naim *et al.*, 2008), but lower than fishes from south west coast of India (Rejomon *et al.*, 2010), Caspian sea (Fariba *et al*., 2009). Manganese is very important in processes of reproduction and correct functioning of central nervous system. Only traces of manganese were detected in all the fish investigated. The fish samples of this study contained low manganese contents (0.001- 0.021 mg/100g wet samples); which were significantly lower compared to previous finding in fresh fish in Saudi Arabia (15.1 mg/100g wet sample) (Ganhi, 2010). Meanwhile, the manganese contents in oyster (18.92 mg/100g wet sample) and cockles (29.50 mg/100g wet samples) were higher compared to other samples; but were still significantly lower when compared with previous local findings, ranged between 16 - 35 mg/100g in wet samples (Irwandi and Farida, 2009). The content of manganese in all samples was found to be lower than the permissible limit set by FAO / WHO (1984), 40 mg/100 g food. Ahmad *et al.* (2008) reported the similar concentration of manganese in muscle tissue of fish, while Huang *et al*. (2003) observed the lower Mn content in fish tissue. However, fishes from West Bengal coast accumulate high level of manganese than the fish from Turkey (Dural and Bickici, 2010), red sea (Naim *et al*., 2008), south east coast of India (Raja *et al.*, 2009), and Mediterranean seas (Turkmen *et al*., 2008). It is an element essential in marginal amounts for correct functioning because manganese participates in build of enzymes metabolizing glucose and fatty acids, is a structural element of bones and skin.

Present study confirms that fish contain most important micro minerals; therefore consumption of fish is good for people's health. Most of the mineral elements are beneficial at reasonable concentrations. They tend to become harmful when their concentrations exceed metabolic demands. Excessive amounts may lead to physiological and biochemical complications. Excessive iron content for example leads to heamochromatosis and in severe cases to thalassaemia (Hovinga *et al.*, 1993). Zinc toxicity results in vomiting and diarrhea, while excessive intake of manganese is characterized by a syndrome called manganism which involves both psychiatric symptoms and features of Parkinson disease (Dobson *et al*., 2004). The heavy metals detected had their concentrations well below the tolerance limits for each metal in the fish species. This could be due to the fact that accumulation of metal toxicants from the aqueous environment by fish depends upon the availability and persistence of the metals in water and fish diet, as the less available the metals in these media, the less they are accumulated in the fish species.

The results generally accepted that appropriately processed sea foods are nutritionally adequate for individuals during all stages of the life cycle and combating micronutrient deficiencies. When some large fish are exported to overseas, small and economical selected species of this study will be increasing the consumer demand after known this fact.

Conclusion

Macro and micronutrients in the fish species are acceptable for human consumption from the nutritional and toxicity point of view. However, it should be taken into consideration that there are other dietary sources for these nutrients. Based on the samples collected and recognizing the inferential limitation of the sample size of this study, the metal concentrations found are below the proposed limit values for human consumption. These results can be used to understand the nutritional quality of these fish species and evaluate the potential risks associated with their consumption. Apart from the prevailing choice of fish as a high protein source; it becomes necessary to consider the mineral status of the fish species in relation to body needs. The fish species showed themselves as good sources of animal protein and metals. If the toxicity of the heavy metals is below the tolerance limits, then the fish is extremely good for the consumption. This study provides valuable information on nutrient composition of fish species studied in order to distinguish their nutritional value and make a choice based on that information from a consumer point of view. The study recommended that an integrated approach of research and capacity building activities within the fields of human nutrition and specific objectives spanning many different aspects have led to the success of eradicating malnutrition.

Acknowledgement

The authors are thankful to Dr. J.K. Patterson Edward, Director, Suganthi Devadason Marine Research Institute, India for providing us the facilities to carry out the work.

References

Aberoumad, A. and Pourshafi, K. 2010. Chemical and proximate composition properties of different fish species obtained from Iran. World Journal of Fish and Marine Sciences 2(3): 237-239.

Ackman, R. G. 1989. Fatty acids: In: Ackman, R. G. (Ed.), Marine biogenic lipids, fats and oils. CRC press, p. 103 - 138.

Adeyeye, A. and Ayoola, P. B. 2010. Proximate composition, mineral and heavy metal contents of some freshwater fishes from Ikosi Dam, Ogbomosa, Nigeria, Electronic Journal of Environmental, Agricultural and Food Chemistry 10(9): 2883-2890.

Agoes, S. and Hamami, D. 2007. Trace metal concentrations in shrimp and fish collected from Gresik coastal waters, Indonesia Science Asia 33: 235-238.

Ahmed, F., Coyne, T., Dobson, T. and McClintock, C. 2008. Iron status among Australian adults: findings of a population based study in Queensland, Australia. Asia Pacific Journal of Clinical Nutrition 17(1): 40 - 47.

Ako, P.A. and Salihu, S.O. 2004. Studies on some major and trace metals in smoked and over-dried fish. Journal of Applied Science and Environmental Management 8: 5-9.

Allen, L. H. 1994. Nutritional influences on linear growth: a general review. Eurasian Journal of Clinical Nutrition 48: S75 - S89.

Alloway, B. J. 2009. Soil factors associated with zinc deficiency in crops and humans. Environmental Geochemical Health 31: 537-548.

Anthony, J.A., Roby, D.D. and Turco, K.R. 2000. Lipid content and energy density of forage fishes from the Northern Gulf of Alaska. Journal of Experimental Marine Biology and Ecology 248: 53-78.

AOAC, 1975. Official methods of analysis, 12th ed. Association Analytical Chemicts, Washington, D.C.

AOAC, 1990. In: Helrich, K. (Ed.), Official Methods of Analysis ,15th edn.Association of Official Analytical Chemists, Section 969.33.Airlington

AOAC, 1999. Official Methods of Analysis, 16th editin Gaithersburg, Maryland, USA.

Asuquo, F.E., Ewa-Oboho, E.F. Asuquo, I. and Udo, P.J. 2004. Fish species used as biomarkers for heavy metal and Hydrocarbon contamination for Cross River, Nigeria. The Environment 24: 29-36.

Ayyappan, M. P. K., Shenoy, A. V. and Gopakumar, K. 1976. Proximate composition of 17 species of Indian fish. Fishery Technology 13(2): 153-155.

Balshaw, S., Edwards, J., Daughtry, B. and Ross, K. 2007. Mercury in seafood: mechanisms of accumulation and consequences for consumer health. Reviews on Environmental Health 22: 91-113

Boran, G. and Karacam, H. 2011. Seasonal changes in proximate composition of some fish species from the black sea. Turkish Journal of Fisheries and Aquatic Sciences 11:1-5.

Bourre, J. and Paquotte, P. 2008. Seafood (Wild and Farmed) for the Elderly: Contribution to the Dietary

Intakes of Iodine, Selenium, DHA and Vitamins B12 and D. The Journal of Nutrition, Health and Aging 12(3): 186-92.

Brown, K.H., Peerson, J. M., Rivera, J. and Allen, L.H. 2002. Effect of supplemental zinc on the growth and serum zinc concentrations of prepubertal children: a meta-analysis of randomized controlled trials. American Society of clinical Nutrition 75: 1062–1071.

Chilima, D.M., 2006. World Fish Center, Zambia.

De Onı´s, M. 2000 Measuring nutritional status in relation to mortality. Bulletin World Health Organization 78: 1271-1274.

De, T. K., De, M., Das, S., Ray, R. and Ghosh, P. B. 2010. Level of heavy metals in some edible marine fishes of mangrove dominated tropical estuarine areas of Hooghgly River, north east coast of Bay of Bengal, India. Bull. Environmental Contamination Toxicology 85: 385-390.

DeSilva, S.S. and Rangoda, M. 1979. Some chemical characteristics of fresh water and salt dried Tilapia Mossambica peter. Journal of Nature Science 6: 417-428.

Dobson, A.W., Erickson, K. M. and Aschner, M. 2004. Annals of the New York Academy of Science volume 1012: 115-128.

Dore, I. 1984. Fresh Seafood, the Commercial Buyer's Guide. Osprey Books, New York.

Dubois, M., Gilles, K.A., Hamilton, J.K., Rebers, P.A. and Smith, F. 1956. Colorimetric method for determination of sugars and related substances. Analytical Chemistry 28: 350-356.

Dural, M. and Bickici, E. 2010 Distribution of trace elements in the Upeneus pori and Upeneus molucensis from the eastern coast of Mediterranean, Iskenderun Bay. Turkey Journal of Animal and Vetinary Advances 9: 1380-1383.

Dural, M., Goksu, M.Z.L. and Ozak, A.A. 2007. Investigation of heavy metal levels in economically important fish species captured from Tuzla lagoon. Food Chemistry 102: 415-421.

Elagba, H.A.M., Rable, A.M. and Mohamed Mansour, H. 2010. Proximate composition, amino acid and mineral contents of five commercial Nile fishes in Sudan, African Journal of Food Science 4(10): 650-654.

Erkan, N. and Ozden, O. 2007. Proximate composition and mineral contents in aqua cultured sea bass *(Dicentrarchus labrax)*, sea bream (Sparus aurata) analyzed by ICP-MS. Food Chemistry 102(3): 721-725.

Exler, J., Kinsella, J.E. and Watt, B.K. 1975. Lipids and fatty acids of important finfish. New data for nutrient tables. Journal of American Oil Chemists' Society 52: 154-159.

Eyo, A.A. 2001. Fish processing Technology in the Tropics. University of Ilorin Press, Ilorin, Nigeria.

FAO, 1984. FAO species identification sheets for fishery purposes. Western Indian Ocean (Fishing Area 51). FAO Fisheries Department. Rome.

FAO / WHO1984. List of maximum levels recommended for contaminants by the Joint FAO/ WHO Codex Alimentarius Commission. Second Series. CAC/FAL, Rome 3: 18.

FAO / WHO, 2004. Vitamin and Mineral Requirements in Human Nutrition: Report of a Joint FAO/WHO Expert Consultation, 2nd ed. Food and Agriculture Organization of the United Nations, World Health Organization, Geneva, Switzerland.

Fariba, Z., Hossein, T., Siamak, A.R., Meshkini, A.A. and Mohammad, R. 2009. Determination of copper, zinc and iron levels in edible muscle of three commercial fish species from Iranian coastal waters of the Caspian Sea. Journal of Animal and Veterinary Advances 8(7): 1288-2009.

Folch, J., Lees, M. and Sloane-Stanley, G. H. 1957. A simple method for the isolation and purification of total lipids from animal tissues. Journal of Biological Chemistry 226: 497-509.

Gall, K.L., Otwell, J.A., Koburger, J.A., Koburger, H. and Appledorf, H. 1983. Effects of four cooking methods on the proximate, mineral and fatty acid composition of fish fillets. Journal of Food Science 48: 1068-1074.

Gallagher, M.L., Harrel, M.L. and Rulifson, R.A. 1991. Variation in lipid and fatty acid contents of Atlantic Croaker, Stiped Mullet and Summer Flounder. Transactions of the American Fisheries Society 120: 614-619.

Ganhi, H.H.A. 2010. Heavy metals pollution level in marine hammour fish and the effect of popular cooking methods and freezing process on these pollutants. Journal of Dairy and Food Sciences 5(2): 119-126.

Gibson, R.S. and Hotz, C. 2001. Dietary diversification/ modification strategies to enhance micronutrient content and bioavailability of diets in developing countries. British Journal of nutrition 85: 159-166.

Glover, C.N. and Hogstrand, C. 2002. Amino acids of in vivo intestinal zinc absorption in fresh water rainbow trout. Journal of Experimental Biology 205: 151-158.

Habicht, J.P., Martorell, R. and Rivera, J.A. 1995. Nutritional impact of supplementation in the INCAP longitudinal study: analytic strategies and inferences. Journal of Nutrition 125:1042S-1050S.

Hale, M.B. 1984. Proximate chemical composition and fatty acid composition of three coastal pelagic fishes. Marine Fisheries Review 46: 19 - 21.

Hassan, M. 1996. Influence of pond fertilization with broiler dropping on the growth performance and meat quality of major carps. Ph.D. Thesis University of Agriculture. Faisalabad. P.195.

Heaney, R.P. 2003. Long-latency deficiency disease: insights from calcium and vitamin D. American Journal of Clinical Nutrition 78(5): 912-918.

Hogstand, C. and Wood, C.M. 1996. The physiology and toxicology of Zink in fish, In E.W. Tayor (Ed.), Toxicology of aquatic pollution cambridge: University press, pp: 61- 84.

Hovinga, M.E., Sowers, M. and Humphrey. H. E. 1993. Archives of Environmental Health 48: 98-104

Huang, G., Li, G. and Zhou, L. 2003. Study on the requirement dose of lysine during stages of growth of *Ctenopharyngodon idellus*. Ecologic Science 22: 147-

149.

Irwandi, J. and Farida, O. 2009. Mineral and heavy metal contents of marine fin fish in Langkawi Island, Malaysia. International Food Research Journal 16: 105-112.

Jacquot, R. 1961. Organic constituents of fish and other aquatic animals: Fish as food. Borgstorm Academic Press, N. Y. and London. pp. 145-209.

Kamal, D., Khan, A.N., Rahman, M.A. and Ahmad, F. 2007. Biochemical composition of some small Indigenous fresh water fishes from the river Mouri, Khulna, Bangladesh. Pakistan Journal of Biological Science 10: 1559-1561.

Kamaruzzaman, B.Y., Ong, M.C., Rana, S.Z. and Joseph, B. 2010. Levels of some heavy metal in fishes from Pahang river estuary, Pahang, Malaysia. Journal of Biological Science 10(2): 157-161.

Lambertsen, G. 1983. Some comments on the analysis of fat soluble vitamins in fish products by HPLC-chromatography. Proceedings, 12th scand. Lipid Symp, (Ed. R. Marcuse) p. 21-26. Gothenburgh, Sweden.

Louka, N.F., Juhel, V., Fazilleau, G. and Loonis, P. 2004. A novel colorimetry analysis used to compare different drying fish processes. Food control 15: 327-334.

Lourenco, H.M., Anacleto, P., Afonso, C., Ferraria, V., Martins, M.F., Calvarho, M.L., Lino, A.R. and Nunes, M.L. 2009. Elemental composition of cephalopods from Portuguese continental waters. Food Chemistry 113(4): 1146-1153.

Lowry, O.H., Rosenbrough, N.J., Farr, A.L. and Randall, R.J. 1951. Protein measurement with the Folin Phenol reagent. Journal of Biological chemistry 193: 265-275.

Malaysian Food Regulations, 1985. In Hamid Ibrahim, Nasser and Yap ThiamHuat. Malaysian law on food and drugs. Kuala Lumpur: Malaysia Law Publisher.

Martorell, R. 1995. Results and implications of the INCAP follow-up study. Journal of Nutrition 125: 1127S-1138S.

Mills, C.F. 1980. The mineral nutrition of livestock. E.J. Underwood, (Ed.), , Common Wealth Agriccultural Bureaux. p.90.

Mora, J. O., Herrera, M. G., Suescun, J., de Navarro, L. and Wagner, M.1981. The effects of nutritional supplementation on physical growth of children at risk of malnutrition. American Journal of Clinical Nutrition 34: 1885-1892.

Muraleedharan, V., Antony, K.P., Perigreen, P.A. and Gopakumar, K. 1996. Utilization of unconventional fish resources for surimi preparation. Proceedings of the fish resources for surimi preparation. Proceedings of the second workshop on scientific results of FORV Sagar sampada, Dept of Ocean development, New Delhi, (India), p: 539-543.

Nabi, R.M. and Hossain, M.A. 1989. Seasonal variation in the chemical composition and caloric content of Macrognathus aculeatus (Bloch) from the Chalan Beel water. Journal of Asiatic Social Bangladesh (Sc.) 15 (2): 103-110.

Naim, S., Ismail, M., Ahmed, H. and Abu, H. 2008. Heavy metals in three commonly available coral reef fish species from the Jordan Gulf of Aquaba, Red sea. Jordan Journal of Biological Science 1(2): 61-66.

Nurnadia, A.A., Azrina, A. and Amin, I. 2011. Proximate composition and energetic value of selected marine fish and shellfish from the West coast of Peninsular Malaysia. International Food Research Journal 18: 137-148.

Oksuz, A., Ozyilmaz, A., Aktas, M., Gercek, G. and Motte, J. 2009. A Comparative Study on Proximate, Mineral and Fatty Acid Compositions of Deep Seawater Rose Shrimp Parapenaeus longirostris, Lucas 1846) and golden Shrimp (Plesionika martia, A. Milne-Edwards, 1883). Journal of Animal and Veterinary Advances 8(1): 183-189.

Onyia, L. U., Milan, C., Manu, J.M. and Allison, D.S. 2010. Proximate and mineral composition in some freshwater fishes in Upper River Benue, Yola Nigeria. Continental Journal of Food Science and Technology 4: 1- 6.

Payne, S.A., Johnson, B.A. and Otto, R.S. 1999. Proximate composition of some North-Eastern Pacific forage fish species. Fish Oceanography 8(3): 159-177.

Raja, P., Veerasingam, S., Suresh, G., Marichamy, G. and Venkatachalapathy, R. 2009. Heavy metal concentration in four commercially valuable marine edible fish species from Parangipettai coast, south east coast of India. Journal of Animal and Veterinary Advances 1(1): 10-14.

Rejomon, G., Nair, M. and Joseph, T. 2010. Trace metal dynamics in fishes from the southwest coast of India. Environmental Monitoring Assessment 167 (1- 4): 243-255.

Rivera, J. and Martorell, R. 1988. Nutrition, infection and growth. Part I: Effects of infection on growth. Clinical Nutrition 7: 156-162.

Salam, M.A. 2002. Seasonal changes in the biochemical composition of body muscles of a freshwater catfish, Heteropneustes fossilis. Bangladesh Journal of Life Science 14 (1&2): 47-54.

Salam, M.A., Alam, N., Nasiruddin, M., Nabi, R. and Howlader, M.Z.H. 1995. Biochemical composition of body muscles and its caloric contents of tawes (*Puntius gonionotus*, Bleeker). Bangladesh Journal of Scientific Research 13(2): 205-211.

Shills, M.E. 1973. Magnesium. In: Introduction to Nutrition, Fleck, H. (Ed.). 3rd Edn., MacMillian Publishing Co. Inc., New York, USA., ISBN: 00-233-82805, p: 215.

Sivaperumal, P., Sankar, T.V. and Viswanathan Nair, P.G. 2007. Heavy metal concentrations in fish, shellfish and fish products from internal markets of India vis-à-vis international standards. Food Chemistry 102(3): 612-620.

Soundrapandian, P. and Dey, S.S. 2008. Proximate composition of the eggs of commercially important crab *Portunus sanguinolentus* (Herbst). Journal of Fisheries and Aquatic Science 3: 60-65.

Stansby, M.Z. 1954. Composition of certain species of freshwater fish. Food Research 19: 231-236.

Tawfik, M.S. 2009. Proximate composition and fatty acids profiles in most common available fish species in Saudi market. Asian Journal of Clinical Nutrition 1: 50-57.

Turkmen, M., Aysun, T. and Yalqin, T. 2008. Metal contaminations in five fish species from Black, Marmara, Aegean and Mediterranean seas, Turkey. Journal of Chilean Chemical Society - On-line version 53(1). doi: 10.4067/S0717 7072008000100021.

Tuzen, M. 2009. Toxic and essential trace elemental contents in fish species from the black Sea, Turkey. Food and Chemical Toxicology 7(8): 1785-1790.

Wen- Bin Huang, J. 2003. Food and Drug Analysis 11(4): 324-330.

WHO, 1989. "Toxicological evaluation of certain food additives and contaminants" in Proceedings of the 30th meeting of the Joint FAO/WHO Expert committee on food additives, WHO Food additives Series: 24, Cambridge University Press, Cambridge, UK.

WHO, 1998. Guidelines for drinking water quality: Health criteria and supporting information. World Health Organization (WHO), Geneva.

World Health Organization. 2013. Mercury and health (Fact sheet No.361). Geneva. *http://www.who.int/mediacentre/factsheets/fs361/en/*

Wimalasena, S. and Jayasuriya, M.N.S. 1996. Nutrient analysis of some fresh water fish. Journal of Nature Science council Sri Lanka 24: 21-26.

Yilmaz, A. B. 2003. Levels of heavy metals (Fe, Cu, Ni, Cr, Pb and Zn) in tissue of *Mugil cephalus* and *Trachurus mediterraneus* from Iskenderum Bay, Turkey Environmental Reserch 92: 277-281.

Zalloua, P.A., Hsu, Y.H., Terwedow, H., Zang, T., Wu, D., Tang, G., Li, Z., Hong, X., Azar, S.T., Wang, B., Bouxsein, M.L., Brain, J., Cummings, S.R., Rosen, C.J. and Xu, X. 2007. Impact of seafood and fruit consumption on bone mineral density. Maturitas 56: 1-11.