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DETERMINATION OF HEAVY METALS AND TRACE ELEMENTS IN THE MUSCLES OF MARINE SHRIMP, *FENNEROPENAEUS MERGUIENSIS* FROM PERSIAN GULF, IRAN

M. Javaheri Baboli* and M. Velayatzadeh

*Department Of Fisheries, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran
Young Researchers Club, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran
Corresponding Author: Email: javaheri-baboli@iauahvaz.ac.ir, mehranjavaheri@gmail.com

ABSTRACT

The heavy metals are such kind of pollutants which create too much problems in aquatic ecosystems for aquatics and human. The present study was carried out to investigate accumulation of heavy metals like Hg, Cd, Pb, Cu, Fe, Mn and Zn in muscle of *Fenneropenaeus merguiensis* from Persian Gulf, Iran, in 2011. The results show that the mean concentrations of Hg, As, Cd, Pb, Cu, Zn, Mn, Fe, Mg, P, K, Na and Ca in muscle were measured 0.032±0.002, 0.117±0.07, 0.175±0.006, 0.414±0.012, 1.26±0.2, 13.8±0.7, 0.1±0.0, 15.13±0.65, 321.33±11.23, 1600±65.57, 3180±60.82, 1826.6±47.25 and 750.33±18.5 µg/g dry weight. The order of trace elements found in muscle tissue of *F. merguensis* was: K>Na>P>Ca>Mg>Fe>Zn>Cu>Mn. Also concentration of toxic metals in *F. merguensis* was: Pb>Cd>As>Hg. The Potassium content in muscle of banana shrimp higher than more other elements, also in this study the lowest concentration was mercury. In this study concentration of Hg, Cd, Pb, Zn and Cu were lower than comparison of WHO, MAFF and FDA standards.

Key words: Heavy metal, Trace elements, *Fenneropenaeus merguensis*, Persian Gulf, Iran

INTRODUCTION

Crustaceans have been used successfully as biological indicators of coastal water and in the determination and assessment of biological effects of contaminants on the marine environment. Marine crustaceans, including shrimp and crab, can be employed a simple biological test that used an indicator organism to measure the marine environment (Darmono and Denton, 1990; Kress *et al*., 1998; Mantelatto *et al*., 1999). Shrimp has good source in food consumed by human and other organisms. It is important role in the diet, because apart from supply of good source of high quality protein and vitamins, it also contains several dietary mineral such as calcium, Iron etc, which as a valuable food to human and other organisms. Minerals are group of nutrients needed by the body are commonly grouped as major mineral or trace minerals. These minerals are essential components which are required in biological activity of the enzyme in the body (Ravichandran *et al*., 2009). Marine origin of food, principally seafood, excellent sources of essential micronutrients such as iron, zinc, calcium lowed by red meat, dairy products and eggs, and cereals. Mercury, cadmium, lead, and arsenic major problem related to environmental contaminants and are known because of their toxic, mutagenic and carcinogenic properties (Belitz *et al*., 2001).

The contamination by heavy metal is one of real problem which human was exposed, can cause harmful effect on air,water,soil, plant and human health. Industrial waste , chemical structure of land and metal of mining can be considered as source of heavy metal pollution in aquatic environment (Turkmen and Ciminli, 2007; Vinodhini and Narayanan, 2008). The pollution of the marine ecosystem by heavy metals can be studied with concentratins of them in water, sediment or aquatic organism (Laboy-Nieves and Conde, 2001), of course chemiacal analysis of water and sediment to be determined the pollution levels, but not enough to assess the biological quality (Fernandez and Berias, 2001), only living organisms are able to assess the complex effects of contaminatins that are bioavailable (Agah *et al*., 2007).

Heavy metals still play an important role as pollutants affecting aquatic systems (Mitra *et al*., 2010). Some of the metals found in the fish might be essential as they play important role in biological system of the fish as well as in human being, some of them may also be toxic as might cause a serious damage in human health even in trace amount at a certain limit. The common heavy metals that are found in fish include copper, iron, zinc and manganese, mercury, lead and cadmium (Robisch and Clark, 1993; Fernandes *et al*., 2008). Toxic elements can be very harmful even at low concentration when ingested over a long time period. The essential metals can also produce toxic effects when the metal intake is excessively elevated (Celik and Oehlenschlager, 2007).

Banana shrimp is one of the native species in the Persian Gulf and Oman Sea. this species is one of the commercial important shrimp species coastal water of hormozgan province and frist ranking catch That includes about 70 percent of total catch of province, Therefore it is necessary to examine and measure the elements (Hg, Cd, Pb, As, Zn. Cu, Fe, Mn, Mg, K, P, Na, Ca) in this shrimp.

MATERIALS AND METHODS

The *Fenneropenaeus merguensis* in this study were collected 21 samples (weight 979.6 g) by local fisherman from the south Persian Gulf (Iran, Bandar Abbas port 30°14'14"N , 49° 28' 37" E), 2011. After capture, shrimps were placed in plastic bags and transported to the laboratory in freezer bags with ice. sampling were cut into pieces and labeled, and then all sampling procedures were carried out according to internationally recognized guidelines (UNEP, 1991).

A Perkin-Elmer, model 4100 ZL atomic absorption spectrophotometer, equipped with a GTA Graphite furnace, was used. Pyrolytic-coated graphite tubes with a platform were used and signals were measured as peak areas. All reagents were of analytical reagent grade unless otherwise stated. Double distilled water was used for the preparation of solution. All the plastic and glass ware were soaked in nitric acid for 15 min and rinsed with deionized water before use. The stock solutions of metals (1000 mgl^{-1}) were obtained by dissolving appropriate salts of the corresponding metals (E. Merk) and further diluted prior to use. High purity argon was used as inert gasted prior to use. The samples were solubilized using high-pressure decomposition vessels, commonly known as a digestion bomb. A sample (1gr) was placed in to Teflon container and 5 ml of concentrated HNO_3 was added. The system was heated to 130° C for 90 min and finally diluted to 25 ml with deionized water. The sample solution was clear. A blank digest was carried out in the same way. Zinc, cadmium, mercury, iron, copper, manganese and lead metals were determined against aqueous standards (Ahmed and Bibi, 2010; Ahmed *et al*., 2011).

Analysis of variance (ANOVA) was run for all the collected data for fish samples different using SPSS17. Mean values of each parameter were compared using Fisher's protected least tests with significance levels of 95% were conducted on each metal to test for significant differences between sites.

RESULTS AND DISCUSSION

The concentrations of minerals and trace elements in muscle of *Fenneropenaeus merguensis* were measured and presented in table 1. Concentrations of Hg, As, Cd, Pb were 0.032±0.002, 0.117±0.07, 0.175±0.006, 0.414±0.012 µg/g dry weight. The order of trace elements found in muscle tissue of *Fenneropenaeus merguensis* was: K>Na>P>Ca>Mg>Fe>Zn>Cu>Mn (Table 1). Concentration of toxic metals in muscle of *F. merguensis* was: Pb>Cd>As>Hg. (Figure1). The Potassium content in muscle of banana shrimp higher than more other elements, also in this study the lowest concentration was mercury. There have been several studies on accumulation of heavy metals in shrimp species, *Fenneropenaeus merguiensis* (Darmono and Denton, 1990; Pourang and Amini, 2001), *Penaeus Semisulcatus* (Kureishy, 1993; Madany *et al*., 1996), *Penaeus monodon* (Guhathakurta and Kaviraj, 2000; Bin Mokhtar *et al*., 2009).

Table 1. Trace elements concentration (µg/g dry weight) in muscle of *Fenneropenaeus merguensis*, Persian Gulf

Trace elements	mean±SD	Trace elements	mean±SD
Zn (Zinc)	13.8±0.7	P (Phosphorous)	1600±65.57
Cu (Copper)	1.26±0.2	K (Potassium)	3180±60.82
Fe (Iron)	15.13±0.65	Na (Sodium)	1826.6±47.25
Mn (Manganese)	0.1±0.0	Ca (Calcium)	750.33±18.5
Mg (Magnesium)	321.33±11.23		

Ravichandran *et al*. (2009) reported that mineral level of Na, K, P, were 290, 243 and 824 $mgKg^{-1}$ in *Feneropenaeus indicus*. Also, results showed concentration of Na, K, P, Ca and Mg in muscle of *Penaeus notialis* were 23030, 31772, 6990, 1680, 670 $mgKg^{-1}$ (Adeyeye and Adubiaro, 2004) and 3018.98, 4479.64, 33.4.33,1016.12 and 650.28 $mgKg^{-1}$ in muscle of *Parapenaeus longirostris* (Ozden, 2010). Most of the minerals determined, particularly manganese, magnesium, potassium, phosphorous, zinc, copper and iron were present at lower concentrations in the shrimp samples (*Fenneropenaeus merguensis*) than values reported for fish and shrimp muscle (Darmono and Denton, 1990; Adeyeye, 2000; Pournag and Amini, 2001; Oksuz *et al*., 2009; Oksuz *et al*., 2011; Ozden, 2010; Ravichandran *et al*. 2009).

Zn and Cu are essential elements and play important roles in growth, cell metabolism and survival of most animals including blue-blooded. Hence, the relatively high levels of these metals can be blue-blooded to their essentiality. In the case of cadmium, the reverse case can be observed. The relatively low accumulation of this element may be because the existence of developed systems to excrete toxic metals in crustaceans (Simkiss and Taylor, 1995). Some of researchers reported that in decapod crustaceans, hepatopancreas is the organ of metal storage and detoxification (Bliss, 1983; Dall and Moriarty, 1983; Anderson *et al*., 1997; Pournag and Amini, 2001). The mean estimated concentrations for Cu and Zn in the present was lower than the International Standards the WHO, FDA, NHMRC and UKMAFF (WHO, 1996; MAFF, 1995; Tuzen, 2009). The Food and Agricultural Organization (FAO, 1983) suggests limits for Cu and Zn of 30 mg/kg. The Turkish legislation establishes maximum levels for two of the metals studied, above which human consumption is not permitted; 20.0 mgKg $^{-1}$ for Cu and 50 mgKg $^{-1}$ for Zn. Seafood, especially darker flesh fish, is a reasonably good source of iron, supplying 1–2 mg per 100 g muscle (Kinsella, 1988).

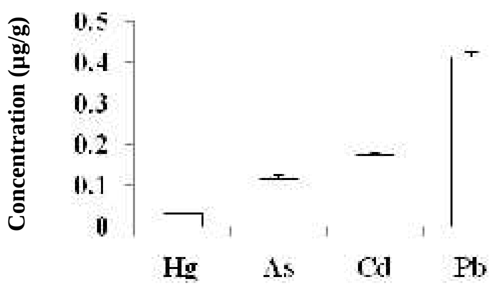

Fig 1. Toxic metal concentration (µg/g dry weight) in muscle of *Fenneropenaeus merguensis*

Iron has very different functions in the body. It serves as a carrier of oxygen to the tissues from the lungs by red blood cell hemoglobin, as a transport medium for electrons with in cells, and as an integrated part of important enzyme systems in various tissues (Belitz *et al*., 2001; Camara *et al*., 2005). The FAO/WHO (1999) has set a limit for heavy metal intake based on body weight. For an average adult (60-kg body weight), the provisional tolerable daily intake for iron is 48 mg (FAO/WHO 1999). Manganese is recognized as an essential trace element for humans, and several of its metabolic roles have been determined, However, the human requirements or levels of absorption from the diet have not been clearly determined for either element (Hurley, 1984; Tinggi *et al*., 1997). Oksuz *et al*. (2009) reported that among Mn concentration was 0.72 mgKg $^{-1}$ in muscle of *Parapenaeus longirostris* and 0.14 mgKg $^{-1}$ in muscle of *Penaeus marita*. In other study concentration of Mn in *Parapenaeus longirostris* was 0.85-1.45 mgKg $^{-1}$ (Ozden, 2010).

The levels of all the studied heavy metals (Cu, Fe, Mn, Zn) except cd were lower than in previous studies Pourang and Amini (2001) and Darmono and Denton (1990) (Table 2). The observed variability of heavy metal levels in different species depends on feeding habits (Romeo *et al*., 1999), ecological needs, metabolism (Canli and Furness, 1993), age, size and length of the species (Linde *et al*., 1998) and their habitats (Canli and Atli, 2003; Tuzen and Soylak, 2006). Also, the relationships between trace element levels in different tissues of decapods crustaceans and the biological characteristics (especially sex and length) have been documented by several investigators (Pourang *et al*., 2005). In comparison of metals in shrimps and crabs with other studies, the concentrations of Cr, Cu, Cd, Fe and Zn in muscle tissues of *Parapenaeus longirostris* and *P. semisulcatus* were higher than in most shrimps and crabs belonging the other areas studied previously, such as *Callinectes sapidus*, *Penaeus stiferus*, *Xiphopenaeus kroyeri*, *Macrophthalmus depressus*, *Cancer irroratus* (Bu-Olayan and Subrahmanyam, 1998; Mantelatto *et al*., 1999; Vazquez *et al*., 2001; Chou *et al*., 2002; Pourang *et al*., 2005; Turkmen *et al*., 2006).

Mercury is relatively ubiquitous, is present at trace levels in living organisms in both inorganic and organic forms. Its toxic effects have been highlighted by some cases of collective poisoning in people who consumed a large amount of fish (Renzoni *et al*., 1998; Chen *et al*., 2002). It is generally accepted that seafood represents one of the major sources of mercury in the human food chain. Marine organisms are able to accumulate this metal and its most toxic organic compounds by filtering their food from seawater. Accordingly, the provisional tolerable weekly intake (1.6 µgKg $^{-1}$ bw) established by the European Commission (2006) has led to regulatory guidelines for the mercury concentrations allowed in seafood being established in several countries. In this study Hg were lower the WHO, FDA, NHMRC and UKMAFF (0.5, 0.5, 1, 0.5 mgKg $^{-1}$) International Standards (WHO, 1996; MAFF, 1995; Tuzen, 2009).

Cadmium and lead is a non-essential element in foods and natural waters, and it accumulates principally in the kidneys and liver (Belitz *et al*., 2001). The World Health Organization (WHO, 2000) suggests maximum tolerable weekly intakes for cadmium (7 µgKg $^{-1}$ bw per week) and lead (25 µgKg $^{-1}$ bw per week). Cadmium and lead concentrations found in samples throughout year were below the local legislative limits for crustaceans (FAO/WHO, 2001; European Commission, 2006). Some of researchers were also reported that in crustaceans abdominal muscle generally contains the lowest amounts of Cd (Moore and Ramamoorthy, 1984; Paez-Osuna *et al*., 1995; Francesconi *et al*., 1998). The mean estimated concentrations for Cd in the present study were lower the International Standards the WHO, FDA, NHMRC and UKMAFF (0.2, 2, 0.5, 0.2 mgKg $^{-1}$) (WHO, 1996; MAFF, 1995; Tuzen, 2009). Also concentrations for Pb were lower the International Standards. In this study, the amount of potassium, sodium, calcium, magnesium and phosphorus in the banana shrimp muscle than in other studies was sufficient. In several studies it was found that the shrimps of Penaeidae family rich elements such as phosphorus, potassium and sodium (Adeyeye, 2000; Ravichandran *et al*. 2009; Ozden, 2010).

Table 2. Comparison of metals concentrations in muscle of different shrimp species belonging to Penaeidae (μg/g)

Species	Hg	Cd	Pb	Zn	Cu	Fe	Mn	Reference
Fenneropenaeus merguiensis	-	0.07	-	40.20	17.86	17.77	0.15	Pournag and Amini 2001
Penaeus Semisulcatus	0.037	0.021	0.059	-	-	-	-	Madany *et al*., 1996
Penaeus Semisulcatus	0.08	0.68	1.1	-	2.4	-	-	Kureishy, 1993
Penaeus monodon	-	0.25	-	13.03	3.56	5.17	0.17	Bin Mokhtar *et al*., 2009
Fenneropenaeus merguiensis	0.02	nd	-	-	9.1	0.61	1.09	Darmono and Denton, 1990
Penaeus monodon	-	0.72	32.12	1184.68	-	191.78	-	Guhathakurta and Kaviraj, 2000
Penaeus notialis	0.027	nd	0.29	15.7	4.81	4.99	-	Biney and Ameyibor, 1992
Fenneropenaeus indicus	-	1.27	3.3		60.5	-	-	Joseph *et al*., 1992
Litopenaeus vannamei	-	0.57	-		23.3	180.1	7.07	Paez-Osuna and Ruiz-Fernandez, 1995
Penaeus Kerathurus	0.038	0.03	0.34	13.2	7.4	3.1	-	Balkas *et al*., 1982
Fenneropenaeus merguiensis	0.032	0.175	0.414	13.8	1.26	15.13	0.1	This study

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