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Heavy Metal Levels in Most Common Available Fish Species in Saudi' Market

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Abstract: Three highly consumed fish in Saudi market were evaluated for their composition of heavy metals. The fish species' were included Spanish mackerel, (*Scomberomorus maculates*), Grouper (*Epinephelus coioides*) and Yellow-spotted trevally (*Carangoides fulvoguttatus*) which, respectively known as Kanad, Hammour and Hammam in Saudi market. The concentration of heavy metals (cadmium, zinc, lead, nickel, vanadium, arsenic and mercury) was determined in the muscle and the head of fish. The level of elements was determined by atomic absorption spectrophotometry (AA). The maximum Cd, Zn, Pb, As, Ni, V and Hg concentrations in fish samples were 49.78, 30.28, 244, 42, 138, 17.49 and 2.84 ng g^{-1}, respectively. The concentration of metals was below the maximum allowed limit by the Saudi and International Legislations for fish human consumption permissible limit.

Key words: Heavy metals, Kanad, hammour, hammam, Saudi market

INTRODUCTION

Fish are excellent low-fat sources of protein and provide many benefits, such as contributing to low blood cholesterol (Anderson and Wiener, 1995). Fish provide omega-3 (n-3) fatty acids that reduce cholesterol levels and the incidence of heart disease, stroke and preterm delivery (Anderson and Wiener, 1995; Daviglus *et al.*, 2002; Patterson, 2002).

Recent years have witnessed significant attention being paid to the problems of environmental contamination by a wide variety of chemical pollutants, including the heavy metals (El-Demerdash and Elegamy, 1996).

Trace metals can be accumulated by fish, both through the food chain and water (Hadson, 1988). Fish living in the polluted water may accumulate toxic trace metals via their food chains. High levels of lead, copper and iron have been to cause rapid physiological changes in fish (Tarrio *et al.*, 1991).

A wide range of metals and metallic compounds found in the marine environment pose risks to human health through the consumption of seafood where contaminant content and exposure are significant (Han *et al.*, 1998; Osfor *et al.*, 1998; Chan *et al.*, 1999).

Of the various sources of water pollution is industrial waste water directly entering aquatic systems. The Arabian Gulf has been subject to inputs of trace metals from a variety of sources and it has been estimated that oil pollution in the Gulf represents 4.7% of the total oil pollution in the world (National Research Council, 1985). This figure has increased even more after the Gulf war where, approximate 11 million oil barrels were discharged into the Gulf (Price and Shepparrd, 1991). Bu-Olayan and Subrahmanyam (1997) investigated the contribution of the 1991 oil spill to heavy metal contamination in marine environment of the Gulf in Kuwait. Significant increase in copper, zinc and nickel concentrations was found in the 1994 snail and oyster samples compare to samples collected in 1990. Refineries and petrochemical industry wastes contribute significantly to metal pollution of the Arabian Gulf marine environment (Sadiq and Zaidi, 1985a) where lead, cadmium and nickel were found in the sediments from the costal region of Saudi Arabia.

Principal among these are the oil prospecting companies with their attendant problems of oil spillages and petroleum hydrocarbons discharged from gas flaring. These precipitate with rain and contaminate the environment and eventually enter the food chain. Heavy metals, such as Cu, Zn, Pp, Hg, As, Cr and Cd are normal constituents of the marine environment and traces are always found in marine organisms. Thus, people who eat large amounts of fish or shelffish from estuarine or coastal areas that are associated with the chemical industry are at risk of heavy metal poisoning.

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

Many studies have been conducted on the contamination of different fish species with heavy metals in different parts of the world (Mat, 1994; Diaz *et al.*, 1994;

Gumgum *et al*., 1994; Tchounwou *et al*., 1996; Farag *et al*., 1998; Romeo *et al*., 1999; Schmitt *et al*., 1999; Chan *et al*., 1999; Miao *et al*., 2000; Karadede and Unly, 2000; Al-Saleh and Shinwari, 2002; Alasalvar *et al*., 2002, Eboh *et al*., 2006; Burger *et al*., 2007; Mendil and Uluozlu, 2007; Yang *et al*., 2007).

The aim of this study was to asses the concentration of cadmium, lead, nickel, vanadium, arsenic, zinc and mercury in three different fish species, which monitors the pollution in the Arabian Gulf. Further, the daily intake levels of such elements were calculated and discussed.

MATERIALS AND METHODS

Preparation of fish samples: Fresh samples of three species included Spanish mackerel, (*Scomberomorus maculates*), Grouper (*Epinephelus coioides*) and Yellow-spotted trevally (*Carangoides fulvoguttatus*) which known in Saudi' market as Kanad, Hammour and Hammam, respectively.

The local population in Saudi Arabia commonly consumes these species. Total fish individuals (muscle and head) were analyzed for cadmium, zinc, lead, nickel, vanadium, arsenic and mercury. A composite sample for each species was prepared and homogenized in a food processor and 50 g test portions were stored at -20°C. Metal contents were expressed as ng g^{-1} or µg g^{-1} wet wt. of fresh fish.

Reagents: De-ionized water was used to prepare all aqueous solutions. All mineral acids and oxidants used were of the highest quality (Merck, Germany). All the plastic and glassware was cleaned by soaking overnight in a 10% (w/v) nitric acid solution and then rinsed with deionized water.

Apparatus: Unicom Analytical System Model 919, Cambridge, UK atomic absorption spectrophotometer was used in this study.

Chemical analyses: Ten grams of tissue homogenate (muscle and head) were weighted into a 150 mL air-tight quick flask with glass stopper. Five mL of conc. HNO_3 and 3 mL of 60% perchloric acid were added to each sample and digested in a temperature controlled waterbath at 85°C. After digestion, the samples were separately filtered using an ashless filter paper and the volumes made up to 100 mL with 0.5% HNO_3, then used for the determination of heavy metals (Eboh *et al*., 2006).

RESULTS AND DISCUSSION

The average concentrations of cadmium, zinc, lead, nickel, vanadium, arsenic and mercury in each fish species in the muscle and in the head are summarized in Table 1. According to these results, zinc has the highest concentration followed by nickel and lead. Regarding to the distribution of investigated metals inside fish, the results indicated that the concentrations of cadmium, zinc, lead, nickel, vanadium and arsenic in the three fish species were higher in heads than in muscles except of mercury. The fact that toxic metals are present in high concentrations in fish is of particular importance in relation to the FAO/WHO (1976) standards for Pb and Cd as toxic metals. In the present study, zinc values in fish species varied from 4.22- 30.28 µg g^{-1}. The minimum zinc level was observed in the muscle of Kanad (*Scomberomorus maculates*) while the maximum zinc level found in their heads. In the study of Mendil and Uluozlu (2007) zinc values varied from 13.9-48.6 µg g^{-1} in *C. tinca* and *C. carpio*, respectively. Nickel concentration in the muscle and head was found to be 18.02-79.15 and 40.0-138.0 ng g^{-1}, respectively. These values are below to the literature value of Mendil and Uluozlu (2007) who determine trace metal in fish species from lakes in Turkey. The maximum lead level was found in the head of Hammour (*Epinephelus coioides*) and the muscle of Kanad (*Scomberomorus maculates*). Our Pb concentration are lower than the literature results (Tariq *et al*., 1991; Mendil and Uluozlu, 2007). The maximum level of cadmium was found to be 8.03, 49.78 ng g^{-1} in the muscle and head of Hammam (*Carangoides fulvoguttatus*).

Vandium concentration was found to be between 2.44-17.49 ng g^{-1}. Such traces could be result of oil spills and/or transportation in the region, as oil contains small amounts nickel and vanadium (Sadiq and Zaidi, 1985a, b).

Table 1: Mean values for heavy metal concentrations in the muscle and head of the fish samples

Fish samples	Location	Cadmium (Cd) (ng g^{-1})	Zinc (Zn) (µg g^{-1})	Lead (Pb) (ng g^{-1})	Arsenic (As) (ng g^{-1})	Nickel (Ni) (ng g^{-1})	Vanadium (V) (ng g^{-1})	Mercury (Hg)(ng g^{-1})
Kanad	Muscle	2.56[a]	4.22[a]	31.0[a]	42.00[a]	31.00[a]	3.73[a]	2.61[a]
	Head	8.70[b]	30.28[b]	74.0[b]	37.21[b]	138.00[b]	9.96[b]	2.43[a]
Hammour	Muscle	4.21[c]	6.32[c]	22.0[c]	24.61[c]	18.02[c]	2.44[c]	2.84[a]
	Head	8.56[b]	28.32[b]	244.0[d]	39.05[b]	94.00[d]	17.49[d]	1.07[b]
Hammam	Muscle	8.03[b]	6.99[c]	30.0[a]	35.11[d]	79.150[e]	7.04[e]	1.67[b]
	Head	49.78[d]	21.81[d]	160.0[e]	35.22[b]	40.000[f]	8.39[b]	1.50[b]

All values are means of three replications. Different letters in each column indicate significant differences

Table 2: The daily intake of metals in fish muscles by humans in Saudi family per day

Sample	Cadmium(Cd) (ng day^{-1})	Zinc(Zn) (μg day^{-1})	Lead (Pb) (ng day^{-1})	Arsenic (As) (ng day^{-1})	Nickel (Ni) (ng day^{-1})	Vanadium (V) (ng day^{-1})	Mercury (Hg) (ng day^{-1})
Kanad	4.25	7.01	51.50	69.77	51.50	6.20	4.34
Hammour	6.99	10.50	36.55	39.87	29.93	4.05	4.71
Hammam	13.34	11.61	49.84	58.32	131.48	11.69	2.77

No significant difference was found between mecury concentration in the muscle and head of Kanad (*Scomberomorus maculates*) and Hammam (*Carangoides fulvoguttatus*). In many developed countries, limits of concentrations in fish have been set in order to safeguard public health. Saudi Arabia has set a maximum limits of contaminants for lead, cadmium and arsenic in fish and shellfish of 2, 0.5 and 1 μg g^{-1}, respectively (SASO, 1997). The European Commission (EC) has proposed limits for cadmium of 0.05 and 0.5 μg g^{-1} for lead in fish (Commission of the European Communities, 1997).

To asses' public health impact of metals in fish, it is essential to calculate the daily intake of metals by humans expressed as ng day^{-1} or μg day^{-1}. This can be obtained by multiplying the average quantity of fish consumed per Saudi family per day (9.967g) by the concentration of metal in studied fish (Al-Nozha *et al.*, 1991) an divided by 6 (the average Saudi family members). The estimated maximum total dietary intakes of cadmium, zinc, lead, arsenic, nickel, vanadium and mercury in fish muscle from these study were 13.34, 11.61, 51.50, 69.77, 131.48, 11.69 and 4.71 ng g^{-1}, respectively (Table 2). These estimates are below the Joint Expert Committee on Food Additives of Food and Agriculture organization (JECFA) Provisional maximum Tolerable Daily Intake (PTDI) for cadmium, lead and arsenic of 0.06, 0.21 and 0.12 mg day^{-1}, respectively for a 60 kg adult (WHO, 1993). In addition, it is lower than the maximum acceptable daily and weekly intake of cadmium, lead and arsenic in Saudi Arabia (SASO, 1997). As per Saudi legislation, maximum acceptable weekly intake of cadmium and lead are 0.0067-0.083 mg kg^{-1} body weight, respectively. Maximum acceptable arsenic daily intake is 0.002 mg kg^{-1} body weight.

The maximum permissible doses for an adult are 3 mg Pb and 0.5 mg Cd per week, but the recommended doses are only one-fifth of those quantities (FAO/WHO, 1976). Exposure to environmental contaminants can lead to immunosuppression and increased susceptibility to disease in salmonids and other fish (Miller *et al.*, 2002). (The Joint FAO/WHO (1999) has set a limit for heavy metal intake based on body weight.

The estimated maximum total dietary intakes of cadmium, lead and arsenic from the study of Al-Saleh and Shinwari (2002) were 0.07, 0.13 and 0.12 μg day^{-1}, respectively.

The World Health Organization (WHO, 1993) has set a Tolerable Daily Intake (TDI) of 0.3 mg day^{-1} for nickel for a 60 kg person. The estimated maximum total dietary intake of nickel from Al-Saleh and Shinwari (2002) survey was 0.73 μg day^{-1}. The safe and adequate intake of vanadium is not known.

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