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Article

Spectroscopic analysis of heavy metal in frozen shrimp from different seafood processing plants of Chittagong, Bangladesh

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Abstract: This study is carried out to determine the level of three common heavy metals i.e. mercury (Hg), lead (Pb) and cadmium (Cd) from different branded frozen shrimp samples from different processing plants in Chittagong Metropolitan Area, Bangladesh. The level of heavy metals is investigated by using Atomic Absorption Spectrophotometer (AAS) in twenty different frozen shrimp samples from four different processing plants. The range of mean level of concentration (mg/kg) of mercury (Hg), lead (Pb) and cadmium (Cd) are 0.011-0.042 mg/kg, 0.065-0.087 mg/kg and 0.024-0.081 mg/kg respectively. Lead (Pb) has the highest mean concentration of 0.087 mg/kg while mercury has the lowest mean of 0.011 mg/kg. The mean concentration of mercury (Hg), lead (Pb) and cadmium (Cd) in shrimps was observed within the range of BSTI (Bangladesh Standards and Testing Institution) standards for aquatic foods.

Keywords: frozen shrimps; heavy metals; AAS

1. Introduction

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. 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). Mercury, cadmium and lead 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 *et al.*, 2007; Vinodhini *et al.*, 2008). The pollution of the marine ecosystem by heavy metals can be studied with concentrations of them in water, sediment or aquatic organism (Laboy-Nieves *et al.*, 2001), only living organisms are able to assess the complex effects of contaminations 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 *et al.*, 1993; Fernandes *et al*., 2008). Toxic elements can be very harmful even at low concentration when ingested over a long time period.

Heavy metals are defined as all metals of atomic weight greater than sodium with specific gravity of more than 5.0. The term ‘heavy metal’ has been used extensively to describe metals that are environmental pollutants (Walker *et al.*, 1982). Even though some metals are essential when taken up by organisms, their excessive presence will reverse the effect so that benefit becomes toxicity. Heavy metals can be critically important to the life processes of marine organisms. The non-essential heavy metals include cadmium, gold, lead, mercury, silver, and metals (including radio nuclides) of higher atomic weight (Rainbow, 1985).

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.

Cadmium is a relatively rare earth element that is almost uniformly distributed in the earth’s crust with an average concentration of 0.15-0.2 mg/kg and ubiquitously present in food, water and air (Passwater *et al.*, 1983). Cadmium circulates in the blood primarily bound to the red cells. It is evidently bound partly to hemoglobin and partly to metallothionein. Cadmium is very efficiently retained in the organism and normally only a very small quantity is excreted daily. The main route of excretion is via the urine. Excretion is low, less than 0.01% of the total body burden per day. Cadmium can also be excreted through other routes (feces, saliva, and hair) but at a much lower rate than in the urine (Piscator, 1979). Long-term exposures with daily intakes of 300-480 μg of cadmium may cause renal tubular dysfunction.

In addition, the low solubility of lead salts restricts movement across cell membranes. Tetramethyl lead could be accumulated rapidly from water by the rainbow trout (Wong, 1975). Highest residues were found in the intestinal fat, skin and gills. There was no relation between species, feeding habits and size of fish and concentration of tetraalkyl lead in tissues (Moore *et al.*, 1984).

2. Materials and Methods

2.1. Sample collection

About 20 frozen shrimp samples were collected from 4 different seafood processing plants under Chittagong Metropolitan Area, Bangladesh. Then the samples were supplied directly for laboratory analysis.

2.2. Sample preparation

For analysis, the frozen shrimp sample were defrosted for 2 h, it was then weighed into a pre weighed petri-dish, and then dried at 80ºC in hot air oven. The dried samples weight were taken and recorded at intervals of 4 h until a constant weight was obtained. Then the dried sample was transferred into a pre-heated muffle furnace at 550ºC for ashing. Then the ash was mixed into nitric acid (HNO_3) solution. 200 Perkin Elmer atomic absorption spectrophotometer model was used to analyze the concentration (mg/kg) of heavy metals (Hg, Pb and Cd).

2.3. Analytical procedure

2.3.1. Mercury (Hg)

The mercury standard calibration plot (0, 2.5, 5, and 10 mg/L) was prepared in 10 mL of acid mixture containing 1.5% HNO_3 and 1.5% H_2SO_4. Nine milliliters of acid mixture were added to 1 mL of digested sample. Mercury was determined using an aqueous solution of 3% (w/v) $NaBH_4$ in a 1% (w/v) NaOH solution freshly prepared and filtered as reducing agent. One to two drops of silicon antifoaming was dispensed into a reaction flask before introducing any solution. All solutions were stabilized by adding 500 μL of 5% $KMnO_4$ solution before starting the determination.

2.3.2. Lead (Pb)

A calibration curve (0, 5, 10 and 20 mg/L) was prepared in 0.2% HNO3 and samples were diluted 1:4. Aliquots of 10 μL of digested samples were introduced directly into the graphite furnace with an equal volume of matrix modifier (10 g/L of $NH_4H_2PO_4$ prepared in 0.2% (v/v) nitric acid and 0.1% Triton X-100).

2.3.3. Cadmium (Cd)

A calibration curve (0, 1, 3, and 5 mg/L) was prepared in 0.2% HNO_3 and samples were diluted 1:4. Aliquots of 20 µL of digested samples were introduced directly into a graphite furnace with an equal volume of matrix modifier (a mixture of 3.3% Pd and 0.03% Mg as nitrates in 0.2% HNO_3).

3. Results

3.1. Mercury (Hg)

In this study, SS-I (Shrimp sample-I) had the lowest average level of mercury (Hg) concentration 0.011 mg/kg while the SS-II (Shrimp sample-II) had the highest average level 0.042 mg/kg. The mean value of average mercury (Hg) concentration was 0.026±0.01.

3.2. Lead (Pb)

In SS-I (Shrimp sample-I) no detectable level of lead (Pb) was observed. The SS-II (Shrimp sample-II) had the highest average level of lead (Pb) concentration 0.087 mg/kg while the SS-IV (Shrimp sample-IV) had the lowest 0.065 mg/kg. The mean value of average lead (Pb) concentration was 0.077±0.01.

3.3. Cadmium (Cd)

The SS-I (Shrimp sample-I) had the highest average level of cadmium (Cd) concentration 0.081 mg/kg while the SS-III (Shrimp sample-III) had the lowest 0.024 mg/kg. The mean value of average cadmium (Cd) concentration was 0.043±0.02.

The overall observation on the heavy metal level of these selected frozen shrimp as in table 1 and table 2 showed that all the samples fell below the BSTI recommended level of heavy metal concentrations. The mean value of these heavy metal concentrations can be shown by graphical representation as Figure 1.

Table 1. Evaluated concentrations of heavy metals in total frozen shrimp.

Sample ID	Mercury (Hg) mg/kg	Lead (Pb) mg/kg	Cadmium (Cd) mg/kg
1. SS-Ia	0.01	**Nil**	0.08
2. SS-Ib	0.01	**Nil**	0.085
3. SS-Ic	0.005	**Nil**	0.08
4. SS-Id	0.02	**Nil**	0.082
5. SS-Ie	0.01	**Nil**	0.079
6. SS-IIa	0.049	0.09	0.088
7. SS-IIb	**Nil**	0.085	0.01
8. SS-IIc	**Nil**	0.088	0.011
9. SS-IId	0.04	0.081	0.015
10. SS-IIe	0.037	0.089	0.014
11. SS-IIIa	0.03	0.08	0.017
12. SS-IIIb	0.031	0.082	0.022
13. SS-IIIc	0.033	0.081	0.025
14 SS-IIId	0.033	0.075	0.029
15. SS-IIIe	0.03	0.079	0.025
16. SS-Iva	0.022	0.065	0.04
17. SS-IVb	0.02	**Nil**	0.045
18. SS-IVc	0.023	0.06	0.038
19. SS-IVd	0.022	**Nil**	0.035
20. SS-IVe	0.02	0.069	0.041

Table 2. The mean value of average concentration of heavy metals in frozen shrimp.

Heavy Metals	Samples				Mean±SD
	SS-I	SS-II	SS-III	SS-IV	
Mercury (Hg)	0.011	0.042	0.031	0.021	0.026±0.01
Lead (Pb)	Nil	0.087	0.079	0.065	0.077±0.01
Cadmium (Cd)	0.081	0.028	0.024	0.040	0.043±0.02

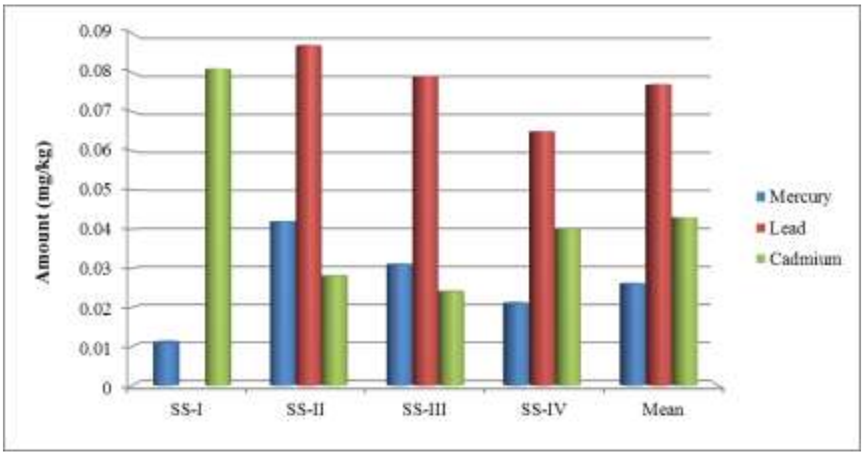

Figure 1. Mean value of heavy metal concentration.

4. Discussion

The levels of heavy metals in these frozen shrimp samples followed a uniform pattern as some confirmed to the BSTI permissible levels for heavy metals in food samples. The SS-I (Shrimp Sample-I) contained no lead (Pb) content in the flesh. The mean level of concentration (mg/kg) of mercury (Hg), lead (Pb) and cadmium (Cd) are 0.026±0.01 mg/kg, 0.077±0.01 mg/kg and 0.043±0.02 mg/kg respectively. However, these low levels do not exclude the risk of bioaccumulation in these crustaceans which are known to be bioaccumulative species. Heavy metals are major contaminants of the marine environment. Some, called trace elements (Fe, Cu, Zn, Mn, Mo, Co) are essential to the functioning of metalloenzymes, but can become toxic at high concentrations. Others, such as Hg, Cd and Pb, are only known for their toxic effects. Heavy metals can alter the physiology of organisms in several ways, either by their binding to soluble biomolecules (enzymes, DNA) or membrane (phospholipids) or reacting with thiol groups (SH) biomolecules.

This study result revealed that the maximum level of mercury (Hg), lead (Pb) and cadmium (Cd) of these selected frozen shrimp samples were 0.042 mg/kg, 0.087 mg/kg and 0.081 mg/kg respectively which fell below the BSTI recommended level.

5. Conclusions

The result found in this elemental analysis was under the BSTI permissible limit. Hence the heavy metal compositions of the selected shrimp samples, might not pose any immediate serious health effect given their accumulation in the human body but long time accumulation of these metals could lead to health issues.

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Conflict of interest

None to declare.

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