Research article

Heavy Metal Contamination in Meat and Crustaceans Products from Thailand Local Markets

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Abstract The aim of this study was to investigate heavy metal contaminations (cadmium, chromium, and lead) in meat and crustaceans products from three markets of Pathumthani province, Thailand. Heavy metals from beef, pork, chicken, scallop, and prawn were analyzed by using ICP-OES. The results showed that the heavy metal concentrations ranges found in meat and crustaceans' products were 0.002-0.032 mg/kg for cadmium, 0.003-0.040 mg/kg for chromium, and 0.006-0.200 mg/kg for lead. The levels of heavy metal contamination in all products are still below the food safety standard of Thailand. The maximum levels of metals in meat and crustaceans products were found as follows: lead > chromium > cadmium, in the three markets. The results of this study provide valuable information to livestock and aquaculture production for food-safety products, and for protection of human health.

Keywords heavy metals, meat and crustaceans products, local markets, food safety

INTRODUCTION

Human diet, meat, fish, and crustacean's products provide well-known proteins, minerals, vitamins, and trace element contents. Concerning about the effects of anthropogenic pollution, and heavy metal contamination, it is a serious threat because of the toxicity, bioaccumulation, and biomagnification in food chain (Eisler, 1998). Not only do heavy metals have important positive roles in human life, but also there are negative roles as well. Some of the heavy metals are considered essential, and these include iron, zinc, and copper, while some other metals such as mercury, cadmium, lead, and arsenic have toxic roles in biochemical reactions of our body (Divrikli et al., 2006). Non-essential elements

such as Pb, Cd, Cr, Ni considered as toxic and their presence in the body can cause profound biochemical and neurological changes in the body (Nielsen, 1982). All metals are toxic at certain levels of intake, however, in contrast to elements such as arsenic chromium, copper, selenium, and zinc that have useful biological functions, cadmium, lead, and mercury play no useful role and their intake should be limited to avoid organ damage (Parekhan et al., 2014; Kramer et al., 1983).

In recent years, there are several studies that focus on the contamination of heavy metals, pesticide, and other toxic in raw food and environment (Iwegbue et al., 2008; Khalafalla et al., 2011; Pakvilai et al., 2012; Hussain et al., 2012; Aitbek, 2013). Samples of beef, veal, pork, chicken, and horsemeat were analyzed for Ca, Cu, Fe, Mg, Mn, Ni, Zn, Cd, and Pb by Hecht and Kumpulainen (1995). Furthermore, Mn, Cu, Zn, Cd, Hg, and Pb concentrations were determined in liver, kidney, and muscle meat of ducks, geese, chicken, rabbits, and sheep slaughtered in northern of Poland (Falandysz, 1991). Under certain environmental conditions, heavy metals might accumulate up to toxic concentrations. Thus, heavy metals acquired through the food chain, as a result of pollution, are potential chemical hazards threatening consumers.

The aim of this study was to assess heavy metal contamination, including Cd, Cr and Pb concentrations, in meat and crustaceans products from local markets in Pathumthani province, Thailand. Moreover, the data were assessed by comparing with the food safety standard of Thailand.

OBJECTIVE

The purpose of this work was to investigate heavy metal contaminations in meat products which were purchased from three local markets in Pathumthani province, Thailand.

METHODOLOGY

Sample Collection

A total of 45 samples of meat and crustaceans products (beef, pork, chicken, scallop, and prawn) were collected randomly from local markets in Pathumthani province. At each location, meat samples were collected from three different local markets to provide replicate samples of each meat. According to their types, all collected samples were stored in clean polythene bags and brought to the laboratory for preparation and treatment. All samples were stored at -10^{o}C until analysis (Parekhan et al., 2014).

Sample Preparation

Before being analyzed, meat and crustaceans products samples were put outside to melt at a room's temperature. All samples were washed with distilled water to remove any contaminated particles. Then samples were chopped to small pieces using a ceramic knife, thoroughly mixed; weight 1-gram of meat was placed in a test tube for the analysis. The meat was later digested by 5 ml concentration nitric acid (69%) in a water bath at 80^{o}C for 15 minutes and cooled down to room temperature; the samples were dried in an oven at 135^{o}C and cooled down to room temperature. One milliliter of Hydrogen peroxide acid (30%) was added and then filtered the supernatant using No.1 and No.48 filter paper.

The complete volume of the final solution was 50 mL in volumetric flask, and the determination of heavy metal was conducted using an Inductively Coupled Plasma – Optical Emission Spectrometer (ICP-OES) ULTIMA2, HORIBA scientific, FRANCE. The samples were analyzed in triplicated. A statistic using scientific program was used to calculate standard deviation and meanvalues. Linear regression equations and regression coefficients (R^2) of standard are presented in Fig 1.

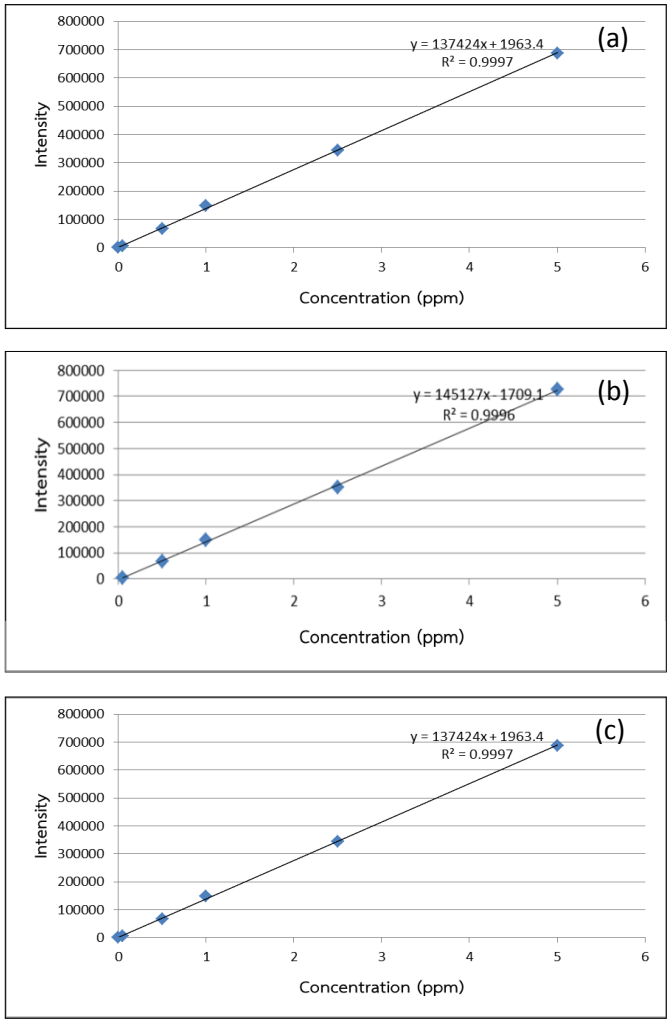

Fig. 1 Calibration curve for determination of (a) cadmium (b) chromium (c) Lead

RESULTS AND DISCUSSION

The result for determination of the heavy metal residues in wet weight are shown in Table 1. Meat and crustaceans products residue samples shown in Table 1 representing the heavy metals ranged from 33 to 100% of samples analysis while the samples were detected 100% of chromium and lead. Cadmium found 33 % in pork, 44 % in scallop and prawn, and 56% in beef, respectively.

Table 1 Positive percentage of heavy metal residues in meat product samples

Meat and crustaceans products	Cd	Cr	Pb
Beef (n=9)	56	100	100
Pork (n=9)	33	100	100
Chicken (n=9)	nd	100	100
Scallop (n=9)	44	100	100
Prawn (n=9)	44	100	100

The result of the study showed that 33-100% of Cd, Cr, and Pb concentrations were found in all meat products, Cd concentration was not found in chicken. Although, their concentrations are below the food safety standard of Thailand, heavy metals can be harmful due to their potential to accumulate in different parts of human body. Even in low concentrations, they can cause adverse health effects (Ikeda et al., 2000). Cadmium may accumulate in the human body and may induce kidney dysfunction, skeletal damage, and reproductive deficiencies (Commission of European Communities, 2001). Lead is known to induce reduced cognitive development and intellectual performance in children, and increased blood pressure and cardiovascular disease in adults (Commission of European Communities, 2001). Chromium is an essential element helping body to use sugar, proteins, and fat; at the same time it is carcinogenic for organisms, thus excessive amount of Cr may cause adverse health effects (Parekhan et al., 2014).

Table 2 Mean concentration and standard deviation of heavy metal in meat and crustaceans products samples (mg/kg)

Meat and crustaceans products	Cd	Cr	Pb
Beef (n=9)	0.024±0.018	0.020±0.010	0.040±0.049
Pork (n=9)	0.008±0.004	0.019±0.009	0.032±0.034
Chicken (n=9)	nd	0.015±0.008	0.032±0.018
Scallop (n=9)	0.004±0.003	0.018±0.007	0.167±0.096
Prawn (n=9)	0.009±0.006	0.029±0.014	0.100±0.091

In Table 2, the results are presented as mean concentrations of a triplicate analysis of the sample extracted. The Cd concentrations ranged from 0.004±0.003 to 0.024±0.018 mg/kg. Among the analysis of meat and crustacean product, the highest Cd level was found in beef sample at 0.024±0.018 mg/kg but not found in chicken. The Cd concentration followed the order: beef > prawn > pork > scallop. The study of Rahimi (2013) determined the Cd concentrations in goat, cow, sheep, and buffalo milks collected from different regions in Iran. The study reported the amount of 0.74 ng/mL. Another study of Pimonwan (2009) reported that the Cd concentration in seafood from Maung district, Rayong province ranged from 0.009 to 0.31 mg/kg. But in comparison of a maximum Cd content of 0.05-0.1 mg/kg of the European Union (2008), the Cd content of this study was exceeded the standard allowance. In general, Hech (1983) stated that Cd concentrations in meat increased with the age of animal and depended on the concentrations of Cd in the feed.

According to analyzed data presented in Table 2, the results ranged from 0.015±0.008 to 0.029±0.014 mg/kg of Cr concentration. Prawn was found the highest Cr level at 0.029±0.014 mg/kg, while the Cr concentrations of other products were prawn > beef > pork > scallop > chicken. The Cr values of the study were below those reported of Kwon and Lee (1999) at 0.18 to 0.25 μg/g of fish tissue in Masan Bay, Korea. Although, Cr^{3+} is an essential element that helps the body use sugar, proteins, and fat; at the same time Cr^{6+} is carcinogenic for organisms (Institute of Medicine, 2003).

Lead is a toxic element that has no biological role and cause carcinogenic effects in marine biota and humans. From the present study, Pb concentration had the highest concentration in the samples as compared to the other elements. The Pb concentration in meat and crustaceans products ranged from 0.032±0.018 to 0.167±0.096 mg/kg. Scallop was found to have the highest Pb value at 0.167±0.096 mg/kg. The concentrations of Pb for other products were scallop > prawn > beef > pork, and chicken. The Pb concentration in scallop (0.167±0.096 mg/kg) was similar to the study of Sankar et al. (2006), which reported that Pb value of *J. dussumerri* was at 0.13 mg/kg. In addition, the study of Sivaperumal et al. (2007) recorded 25% of Pb concentrations in finfish, shellfish, and other fishery products from the EU's Indian coast. However, the EU's acceptable limit for Pb concentration is 0.5-1.0 μg/g. The Pb

concentrations of this study were found to be lower than the acceptable limit suggested by the European Union (2008).

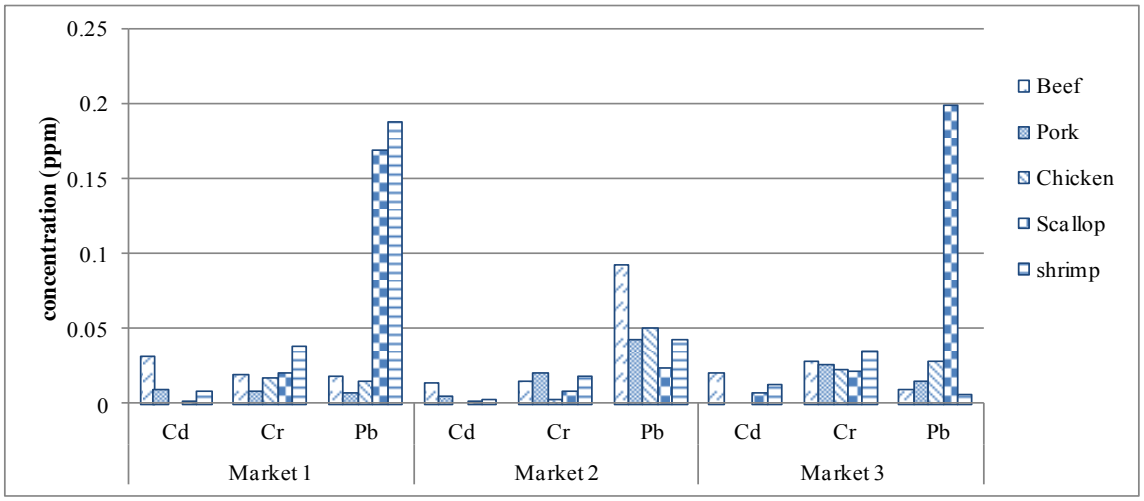

Fig. 2 Comparison of heavy metal residues in meat samples

Fig. 2 shows of the heavy metal comparison by type and market location. Lead presents a higher concentration than another compound in scallop of market 1 and 3, and prawn in market 1. Within prawn samples, it was found higher chromium in markets 1 and 3 than in market 2. Market 3 was found to have higher chromium than other markets except in prawn from market 1. From the study, the Pb levels of all samples were higher than other heavy metals trace. The result of this study indicated that the problem of Pb in food is more widespread.

CONCLUSION

The levels of heavy metal contaminations in meat and crustacean's products from Thailand local markets were determined and assessed by comparing contamination levels with permissible limits of the food safety standard of Thailand. However, all the heavy metal levels of this study were below the allowance of the food safety standard of Thailand. It is necessary to assess human exposure to these vital metals through food consumption, as human is one of the top most consumers in the ecosystem.

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