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The Effect of Different Cooking Methods on Lead and Cadmium Contents of Shrimp and Lobster

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ABSTRACT: Regular consumption of seafood has been widely recommended by the authorities. However, some species especially benthic crustaceans accumulate heavy metals. In addition, the health risks associated to the consumption of such seafood might increase if the consumers use cooking methods that enhance the concentration of heavy metals. In this study, the effects of different cooking methods (boiling, steaming and frying) on the concentrations of lead (Pb) and cadmium (Cd) in shrimp and lobster were studied. Samples were prepared by wet digestion and the contents of heavy metals were measured by graphite furnace atomic absorption spectrophotometer. Mean concentrations of lead and cadmium for raw samples of shrimp and lobster were 75.67±15.31 and 26.00±8.00 µg/kg and 316.67±66.58 and 195.33±131.46 µg/kg respectively. The findings indicated that the highest contents of lead and cadmium were observed in the fried samples ($p<0.05$), however the differences were not significant for cadmium. According to the results, boiling and steaming are suggested as the best cooking method to provide healthful seafood.

Keywords: *Cooking Methods, Heavy Metals, Lobster, Shrimp.*

Introduction

Seafood has high nutritional value being rich in unsaturated fatty acids (omega 3), essential amino acids, minerals and vitamins and low cholesterol and saturated fatty acids (Ganjavi *et al*., 2010; Sioen *et al*., 2007; Ikem & Egibor, 2005). In addition, fish is an important source of high-quality proteins, vitamins especially vitamin A, E and D and minerals such as potassium, sodium, calcium, magnesium, iron, copper, zinc and manganese (FAO/WHO, 2002; Verbeke *et al*., 2005; Fraga, 2005).

On the other hand, aquatic organisms such as shrimp and lobster are considered to be the major sources of heavy metals for the consumers (Dural *et al*., 2006; Turkmen *et al*., 2006). These elements are stored in the aquatic organisms and will be passed to higher levels of food chain and finally to human beings (Norouzi *et al*., 2012; Palaniappan & Karthikeyan, 2009; Al-Yousuf *et al*., 2000). These contaminants are mainly resulted from natural processes such as earthquake, volcanic activity, etc or caused by human interventions in the nature such as the disposal of sewage, industrial and agricultural sewage, and materials derived from fossil fuels into water sources (Rico, 2007; Dugo *et al*., 2006).

Heavy metals are mostly accumulated in sediments therefore benthic macro invertebrates and bottom-feeding species are potentially affected because they live in or on the sediments. Several studies have demonstrated the ability of benthic

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organisms such as shrimp and lobsters to accumulate heavy metals (Raissy *et al*., 2011; Gonzalez *et al.,* 1999; Burgos & Rainbow, 1998; Ziegler, 1996; Young, 1982). In particular, shrimp and lobster are known to accumulate high concentrations of metals from their environment (Chou *et al*., 1991; Morales *et al*., 2004).

Depending on the nutritional habits, sea food might be prepared in various ways using different cooking procedures such as boiling, frying, baking and grilling (Lee, 1991; Ersoy & Yilmaz, 2003). The mineral content of fish can be affected by different cooking practices (Küçükgülmez *et al*., 2006). Heavy metals such as cadmium and lead are nonessential metals and hazardous to health, even in trace quantities. Therefore, it is important to determine their concentrations in raw and cooked products namely shrimp and lobster in order to evaluate the possible risks of consumption for human (Cid *et al*., 2001).

The aim of this research work is to study the effects of various cooking methods on lead and cadmium concentrations in shrimp and lobster.

Materials and Methods

- *Sample Collection and preparation*

Shrimp and lobster samples were collected from the Persian Gulf during June, 2013 to December, 2013. The samples were stored at -20ºC in propylene bags until required for analysis. The length and weight of the samples were determined (4.57 cm and 18.88 g for shrimp and 20.31 cm and 22.30 g for lobster) and the preparation process consisting of head and shell removals were carried out. In the next step each sample was sliced into four portions and each sample was allocated to one group, totally four groups including one control and three treatments. Cooking procedures consisting of boiling 100±2°C for 15 minutes, steaming at 102±3°C for 115 minutes and frying at temperature of 160±5°C for 10 minutes were applied (Maulvault *et al*., 2011).

- *Reagents and standard*

All the reagents and chemicals used were of analytical grad (Merck, Germany). Stock solutions of lead and cadmium were prepared by diluting the concentrated solutions to a desired level with deionized water (Merck, Germany).

- *Sample digestion and detection of heavy metals*

In order to evaluate lead and cadmium, 5±0.001 g of each sample was weighed into digestion flask and heated with concentrated sulfuric and nitric acids until a clear solution was obtained. (Norouzi *et al*., 2012; Emami Khansari *et al*., 2005). The obtained solution was transferred to a 25 mL flask and made up to the mark with deionized water. Cadmium and lead concentrations were determined by Graphite Furnace Atomic Absorption Spectrophotometry (Perkin Elmer 4100, Germany) employing pyrolytic platform graphite tubes.

- *Statistical analysis*

The results were statistically analyzed by SPSS/20 (SPSS Inc., USA), using ANOVA and Duncan's MRT. The presence or absence of a significant difference was specified at 95% confidence interval and significance level of p=0.05. In addition, Excel software was used for the charts adjustments.

Results and Discussion

The results of the work concerned with the levels of lead and cadmium in raw and cooked shrimp and lobster are presented in Tables 1 and 2. The results indicated that the concentrations of lead and cadmium were 75.67and 26.00 µg/kg for raw shrimp and 316.67 and 195.33 µg/kg for raw lobster, respectively. The highest concentrations of lead and cadmium in shrimp and lobster were found in the fried samples. There were significant differences for lead between different cooking procedures based on Duncan's MRT ($P<0.05$). Although the differences were statistically significant for lead, no statistical relationship was found between different cooking methods and cadmium content.

A comparison between the concentrations of lead and cadmium in raw shrimp and lobster with FDA standards revealed that the concentrations of these elements in the examined samples are lower than the maximum permitted values (500 μg kg^{-1}) (FDA, 2000). These findings are comparable with those reported previously by Rahimi *et al*. (2014), Maulvault *et al*. (2011), Firat *et al*. (2008), Olmedo *et al*. (2013) regarding Iran, Portugal, Turkey and Spain respectively. In a previous study, the concentrations of cadmium and lead in lobster from the Persian Gulf were found to be 629.4 μg/kg and 250.6 μg/kg, respectively (Raissy *et al*., 2011). The results indicated that although the concentration of cadmium was within the recommended limit for human consumption but lead content was found to be above the acceptable level.

In this study, the effects of common cooking methods on the concentration of lead and cadmium have been studied. According to the results, the concentrations of lead increased in fried samples showing significant differences for lead as compared to the steamed and boiled shrimp and boiled lobster ($P<0.05$).

In agreement with the results of this study, Maulvault *et al.* (2011) have similarly reported an increase in cadmium concentration of fried crab as compared to the raw samples. Perello *et al*. (2008) indicated that the concentrations of lead in

Table 1. Mean and SD of lead and cadmium concentrations in raw, fried, steamed and boiled shrimp samples (μg kg^{-1} wet weight)

Shrimp	Lead (Mean)	SD (μg kg^{-1})	Cd (Mean)	SD (μg kg^{-1})
Uncooked	75.67^{ab}	15.31	26.00^{a}	8.00
Fried	100.33^{b}	23.16	40.67^{a}	8.62
Steamed	66.00^{a}	14.18	26.67^{a}	9.87
Boiled	49.67^{a}	7.02	28.33^{a}	79.02

* Means of different groups shown by different letters have significant difference ($P<0.05$).

Table 2. Mean and SD of lead and cadmium concentrations in raw, fried, steamed and boiled lobster samples (μg kg^{-1} wet weigh)

Lobster	Lead (Mean)	SD (μg kg^{-1})	Cd (Mean)	SD (μg kg^{-1})
Uncooked	316.67^{ab}	66.58	195.33^{a}	131.46
Fried	409.33^{b}	23.50	200.33^{a}	99.31
Steamed	335.33^{ab}	63.04	164.00^{a}	114.38
Boiled	274.67^{a}	40.27	194.67^{a}	131.06

Table 3. Recoveries of Pb and Cd (μg kg^{-1}) in shrimp and lobster samples

Metal	Concentration of added (μg kg^{-1})	Concentration of recovered (μg kg^{-1})	Recovery (%)
Lead	50	47.66	95.32
	50	48.20	96.4
	50	47.19	94.38
Cadmium	50	48.33	96.66
	50	49.44	98.88
	50	46.81	93.62

sardine and tuna were higher in fried samples as compared to the raw samples. Ersoy *et al*. (2006) in contrast with Bassey *et al*. (2014) indicated no significant change in the lead content of fried fish.

Ganjavi *et al*. (2010) studied the effects of different steps of canned tuna production processes including thawing, cooking and sterilizing by autoclave on heavy metal concentrations. Their findings indicate a significant decrease in the concentration of heavy metals such as lead and cadmium in tuna fish during different production procedures.

The investigations of Ersoy *et al*. (2006) on lead and cadmium concentrations in seabass under four treatments also showed that lead concentrations in the baked and microwaved fish were significantly decreased. In another study, the concentrations of lead in fish decreased as the result of baking and steam-blanching (Atta *et al*., 1997).

Although the reasons behind such differences are not quite clear, it indicates this fact that the aquatic organism species is also an effective factor for the increased or decreased concentrations of cadmium in the tissues as the result of cooking process (Ganjavi *et al*., 2010).

In this study, the main factor for increasing lead in the fried samples might be due to water losses as the result of frying at high temperature. Many factors such as the initial concentration of heavy metals in the meat, aquatic species, can affect the reduction or increase of these elements in the flesh as the result of cooking processes.

Conclusion

This research work has indicated that heavy metal concentrations namely lead and cadmium have been increased in shrimp and lobster as the result of frying, a method that is quite popular in Iran for preparation of fish dishes. The increase might be mainly due to water losses when the shrimp and lobster are subjected to the high temperature of frying.

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