Research article

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Heavy metals contamination in fresh fish and canned fish distributed in local market of Tehran

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Abstract

Background and objective: Contamination of foods with heavy metals has been a controversial issue in health agencies. It is a great concern in seafood due to contamination of seawater with industrial pollutants. The current study aimed to measure concentration of heavy metals in fresh fish and canned fish distributed in Tehran, capital city of Iran. In addition, evaluation of their arisen risk was also done based on national and international determined levels.

Materials and methods: Total number of 46 samples including 34 fresh fish and 12 canned fish in three replicates were randomly collected from Tehran. Concentration of heavy metals in the samples was determined by atomic absorption spectrophotometer. Assessment of heavy metals' risk caused by consumption of canned fish was done by calculation of estimated daily intake of heavy metals in the consumers, which further compared to reference dose determined by health agencies (known as hazard quotient formula).

Results and conclusion: Concentration of Cd, Hg, and Pb were less than the maximum permissible levels determined by national standard of Iran and FAO/WHO in all fresh fish samples. In comparison, heavy metals concentration in 4% of canned fish samples was higher than the maximum permissible levels. Hazard quotients of 1.9×10^{-1}, 2.2×10^{-2}, 6×10^{-3}, and 6.09×10^{-4} were respectively achieved for Hg, Pb, Cd, and As by consumption of canned fish in the consumers. Therefore, our evaluation confirmed safety of the samples so that no concern was seen with respect to concentration of heavy metals in fresh fish and canned fish samples distributed in local markets of Tehran.

Keywords: Canned fish, fish, hazard quotient, heavy metal, risk assessment

1. Introduction

Seafood has a large share in food basket of people in the world, especially in the Mediterranean region. Fish is important source of omega-3 essential fatty acids, which help better function of the brain and nervous system [1]. In addition, consumption of marine foods reduces risk of cardiovascular disease [2].

In 2012, approximately 92.7% of global fish production was done by 15 countries. Although,

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the highest consumption of seafood is reported for Asia and the Pacific regions [3,4]. Per capita consumption of fish in Iran was 9.2 kg in 2016, which was significantly lower than the average per capita consumption of fish in the world (22 kg) [5-7]. However, such as many other countries, consumption of canned fish in Iran is interested due to its convenient use [8]. Along with the increasing demand for seafood products, contamination of marine ecosystems with heavy metals has become a challenge because it seriously threats the consumers' health through the food chain system [9]. Lead, cadmium, arsenic, and mercury are of great concerns which accumulate in the foods and adversely affect human health [10]. These heavy metals are stable in the system and not decomposed in the environment by chemical or biological processes [11]. Consumption of marine foods contaminated with heavy metals may lead to several cancers, neurological disorders, Alzheimer, nervous system defects, skeletal disorders, bronchitis, emphysema, and anemia [12-14].

It was reported that some large species such as tuna fish, swordfish, and spearfish are prone to accumulate high concentration of mercury [15]. The US Food and Drug Administration (USFDA) reported that canned fish contains more lead than other foods such as milk, eggs, and canned meat [16].

Due to bioaccumulation of heavy metals in foods and increasing demand of seafood products in Iran, we conducted the current study to evaluate the risk arisen from heavy metals ingested by fresh fish and canned fish in the consumers of Tehran, Iran.

2. Materials and methods

2.1. Sampling

Fresh fish and canned fish samples were collected from February 2020 to May 2021. For this, 46 samples including 34 fresh fish and 12 canned fish were randomly collected from local market of Tehran (capital city of Iran). They were transferred to laboratory of Tehran Food and Drug Administration and kept at 4 °C until analysis.

2.2. Sample preparation in the laboratory

Before instrumental analysis, the cans were opened and their oil was removed. The fish flesh was homogenized by a meat grinder. Then, 10 g of grinded sample was placed in oven at 65 °C for 120-150 min [17,18]. The dried sample was further moved to a furnace at 500 °C for 4 h [19]. The remained ash was cooled at ambient temperature followed by addition of 1-3 ml deionized water. Then, it was transferred to water bath to evaporate the added water. In the next step, 50 ml hydrochloric acid 6 M was added and left for 1-2 h at 70 °C until the acid was evaporated. To completely dissolve the content, 10-30 ml nitric acid 0.1 M and 25 ml sulfuric acid 0.1 M was added. The final solution was carefully transferred to 100-ml volumetric flask and made up with deionized water for injection to the instrument [18,20,21]. To measure Hg, other than sulfuric acid and nitric acid, potassium permanganate and potassium persulfate were also added to the mixture and left overnight at room temperature [19]. Fresh fish samples were prepared in a similar way in the laboratory.

2.3. Heavy metal analysis

Atomic absorption spectrophotometer (WFX-210, China) equipped with graphite furnace was used for analysis of Hg, Pb, and Cd at 235, 283, and 288 nm, respectively [21]. In addition, As was determined by hydride generation atomic absorption spectroscopy at 193 nm [21].

2.4. Risk assessment studies

Hazard quotient (HQ) formula is commonly used in assessing the risk arisen from a deleterious agent. It is a ratio of estimated daily intake (EDI) of a hazard to its reference dose (RfD). For this, the EDI of each metal was calculated according to Eq. 1 [22,23].

$$EDI = (C \times IR) / BW \quad \text{Eq. 1}$$

EDI is amount of a hazard ingested by specific food(s) per kg body weight in a day (μg $kg^{-1}day^{-1}$); C is average concentration of a hazard in specific food(s) (μg g^{-1}); IR is ingestion rate or amount of specific food(s) ingested in a day (g day^{-1}); BW is average body weight (usually accounted as 70 kg).

HQ formula provided by health agencies [24] is according to Eq. 2.

$$HQ = EDI / RfD \quad \text{Eq. 2}$$

RfD is determined by international health agencies for each hazard, specifically. Importantly, when HQ is greater than or equal to 1, it refers to a high risk in the consumers.

2.5. Statistical analysis

Data analysis was done by Excel 2013 software and the results are expressed as percentage frequency. Analysis was done in duplicate.

3. Results and discussion

Marine animals accumulate heavy metals distributed in aquatic ecosystem during their lifespan [25]. Such bioaccumulation varies between fish species or fish tissues. Indeed, fish can transport large amount of toxic heavy metals in the liver, gills, and muscle tissue [25,26]. Some factors significantly affect heavy metals' absorption in the flesh and their further accumulation in the organs. They are included to chemical composition of water, time of contamination, concentration of contaminant in water, eating habit of fish, contact time of fish with contamination, and cross-contamination of fish during transport and canning process [27-29]. Amount and activity of heavy metals in canned fish depends on oxygen concentration in head-space, quality of coating, and storage condition [25,30, 31].

Obviously, heavy metal contamination poses risk to fish themselves and the consumers. According to Table 1, all canned fish samples were contaminated with Pb, Hg, Cd, and As. However, Pb and Hg contaminations in 96% of samples were less than the maximum permitted levels determined by Iran regulation [32] and international regulations [33,34]. Zazouli et al. in 2016 reported that concentration of Hg, Cd, and Pb in canned tuna fish distributed in Mazandaran province was less than FAO/WHO recommended levels [35]. Mansouri et al. also reported that concentrations of Cd, Hg, and Pb in canned fish available in Iranian market were below the EU permissible levels [31]. In the current study, concentration of Cd in all canned fish samples was lower than the permissible levels determined by international regulations [33,34]. It is presumed that Cd has lower affinity to bioaccumulation in fish flesh compared to the other heavy metals investigated in our study.

Table 1- Comparison of heavy metals' concentration in canned fish distributed in Tehran market to the maximum permitted levels

	Cd	Pb	Hg	Ref.
Within permitted limit	100%	96%	96%	
Out of permitted limit	0	4%	4%	
Maximum permitted levels (mg/kg)				
FAO/WHO	2	0.3	0.5	[33]
Eu regulation	0.1	0.4	1	[34]
Iran regulation	-	-	0.5	[32]

According to Table 2, all fish samples contained heavy metals but the contamination did not exceed the maximum permitted levels. Although, fish species is an effective factor in metal bioaccumulation. In this regard, Rodriguez-Mendivil et al. reported that the highest Hg concentration was found in mako shark (*Isurus oxyrinchus*) and soupfin shark (*Galeorhinus galeus*) [36]. Moreover, Djedjibegovic et al. reported that concentrations of Hg in mackerel fish and Cd in squid fish were higher than the maximum residual level set by EU, and HQ of Hg in Bluefin tuna and mackerel fish was near to 1 [37]. Islamoglu et al. showed that As and Cd concentration was high in anchovy fish and Pb was highly accumulated in canned tuna [38].

Table 2- Comparison of heavy metals' concentration in fish samples distributed in Tehran market to the maximum permitted levels

	Cd	Pb	Hg	Ref.
Within permitted limit	100%	100%	100%	
Out of permitted limit	0	0	0	
Maximum permitted levels (mg/kg)				
FAO/WHO	2	0.3	0.5	[33]
Eu regulation	0.1	0.4	1	[34]
Iran regulation	0.05	0.3	-	[32]

According to Table 3, calculated HQ was less than 1 for all heavy metals, which shows that consumption of canned fish does not pose the consumers at risk of attributed diseases. Similar result was observed in the study of Herrera-Herrera et al. Their investigation revealed that there is no risk for Colombian consumers after consumption of imported fish within a short term. However, heavy metals' contamination in the products may be a concern in the habitats and tourists in prolonged time because of their bioaccumulation in the body and also high intake of fish species in the region [30]. In contrast to our results, HQ of Cd and Pb was greater than 1 in fish samples collected from Dezful (Iran) in the study of Salemi and Hosseini, which was serious threat for the consumers [39]. Given the adverse effects of heavy metals in human body after chronic exposure, strict monitoring is required in the regions subjected to high contamination and corrective actions should be implemented by the environmental health authorities.

Table 3- Risk assessment of heavy metals ingested by canned fish in habitats of Tehran (Iran)

Heavy metals	Concentration in canned fish (μg g^{-1})	Average daily consumption of canned fish (g day^{-1}) [32]	RfD* (μg kg^{-1} day^{-1})	EDI (μg kg^{-1} day^{-1})	HQ
Hg	0.95	8	0.57	0.109	0.19
Pb	0.68	8	3.57	0.08	0.022
Cd	0.04	8	0.83	0.005	0.006
As	0.016	8	3	0.0018	6.09×10^{-4}

*RfDs were determined by the world health organization (WHO) available at https://apps.who.int/food-additives-contaminants-jecfa-database/search.aspx

4. Conclusion

Our study provides information about contamination of fresh fish and canned fish distributed in Tehran market with heavy metals of Cd, Hg, Pb, and As. Concentration of heavy metals in fresh fish samples was significantly lower than the maximum permitted national and international levels. Due to the more consumption of canned fish compared to fresh fish by habitants of Tehran and also possible migration of trace elements from metal surface to the content, risk assessment was just done on heavy metals of canned fish samples. In this regard, daily intake of heavy metals through consumption of canned fish distributed in local market of Tehran was significantly lower than the reference doses determined by health agencies. In conclusion, there was no concern about intake of heavy metals by consumption of fish and canned fish samples in habitants of Tehran (capital city of Iran).

5. Conflict of interest

The authors declare that there is no conflict of interest.

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