Estimation of some heavy metals in different types of canned tuna in the Egyptian market

Abstract

Given the deleterious effects of heavy metals on human health and the prevalence of canned tuna in diets, this study sought to quantify the concentrations of lead, cadmium, nickel, mercury, tin, copper, manganese, and chromium in five international canned tuna brands available in the Egyptian market, including shredded, chunks, and one-piece varieties. The findings were compared with the permitted concentrations during the period 2023-2024. The concentration of heavy metal elements in tuna was found to be below the allowable consumption limits per mg/kg of body weight. Furthermore, the total daily or weekly intake of heavy toxic elements was also below the maximum allowable consumption limit, with the exception of nickel in the shredded sample of the fourth brand, which exceeded the allowable consumption limits per mg/kg of body weight and exceeded the maximum allowable daily or weekly consumption limit of nickel. However, considering each component individually, the target hazard quotient (HQ) value did not exceed the standard value (>1) for any of the five brands or their three types (shredded, chunks, and one-piece), and thus there is no concern or harmful effects associated with the consumption of canned tuna from these five brands in Egypt. The total target hazard quotient (HI) for the different metals was less than 1, meaning that they are not capable of causing carcinogenic risks. Based on the results, it can be concluded that the target consumers may not have significant potential health risks through the consumption of canned tuna from the five brands available in the Egyptian market.

Key words: canned tuna, heavy metals, shredded, chunks, and one-piece

Introduction

Red and white meats, including fish and seafood, are among the most popular foods [1]. The latter is quick and easy to prepare, and it is a traditional dish enjoyed in many regions around the world. Health professionals often recommend it as part of a healthy and balanced diet [2]. Fish and seafood are very nutritious. They have many vitamins, proteins, and essential amino acids. They also contain omega-3 fatty acids and important minerals [3, 4, 5]. Consumption of seafood products is known to have many health benefits, including a reduced risk of cardiovascular and autoimmune disorders [6].The canning process increases the shelf life of the canned product by many years. However, producers, nutritionists, chefs and customers are particularly interested in the composition of fish because they want to know its nutritional contribution to a healthy diet [7]. Canned fish is very popular in Egypt because it is convenient and inexpensive for most working families. In both developed and developing countries around the world, canned fish is the most popular processed fish product. Tuna is one of the most widely consumed fish species used in canned products [8]. This product is manufactured by processing fish meat and preserving it by canning with the addition of edible oils and/or brine and undergoing commercial sterilization according to the Egyptian Standards and Metrology Organization [9]. However, fish are exposed to contaminants from heavy metals in the water due to human activity [10, 11]. Food can contain harmful heavy metals like mercury, tin, cadmium, lead, copper, nickel, manganese, and chromium. These metals are known to negatively affect human health [12, 13] because, they may accumulate in bodily tissues and travel up the food chain to people [14]. According to [15], fish and fish products are the most affected members of the food chain because they are constantly exposed to pollutants such as toxic heavy metals through polluted water, especially tuna because they are predators and have a long life span [16]. Consumption of food polluted with heavy metals can substantially deplete several vital minerals in the human body, causing poor psychosocial behavior, loss in immunological defenses, intrauterine development retardation, high prevalence of upper gastrointestinal cancer and disabilities associated with malnutrition [17]. Over the last decade, significant research has concentrated on detecting levels of heavy and toxic metals in water and food, notably examining contamination of food sources, including canned goods such as tuna, with the goal of assuring food safety [18, 8]. Moreover, it is imperative to assess the concentration of potentially toxic elements in canned fish to guarantee the safety of the fish protein provided to consumers and to elucidate the adverse effects of canned fish consumption on individuals and populations. Given the lack of knowledge about the mineral elements in canned tuna available in the Egyptian market, as well as the close relationship between seafood consumption and associated health effects, whether beneficial or harmful, determining the amounts of harmful heavy metals and essential minerals is critical. The current study was undertaken to give fresh information concerning several heavy metal elements (lead, cadmium, nickel, mercury, tin, copper, manganese, and chromium) in five distinct brands on the Egyptian market. Each brand offers three forms of tuna: Shredded tuna, chunks, and one-piece.

Materials and Methods

Chemicals and reagents

All chemicals utilized were of analytical grade.

Sample collection

Forty-five samples of canned tuna from five brands were examined to determine the concentration of heavy metals in them. The samples were collected from Egyptian supermarkets located in Elshiekh Zayed -Giza (Egypt) during 2023-2024. Canned tuna fish were examined after each can was opened, drained of oil, and then homogenized.

Preparation of the samples for determination heavy metals

The microwave (closed system) was used for digestion of samples according to [19]. Briefly, a 1 g of homogenized sample was weighted and transferred in the PTFE vessels for microwave digestion. Subsequently, 9 ml of nitric acid (69%) and 1 ml H_2O_2 were added to the sample. The vessel was totally and excellently closed before being placed to the microwave till digestion was complete. Digestion was performed in the microwave oven by temperature-controlled program: heating to 200 °C for 15 min, holding time 15 min, cooling to 85 °C for 15 min. After cooling to room temperature, the content of the vessel was transferred to a volumetric flask (25 mL) and diluted with ultrapure water to the mark, then ready for analysis by Atomic Absorption.

Determination of heavy metals

Analysis for investigated heavy metals was performed at Food Toxicology and Contaminants Department, National Research Centre using Atomic Absorption Spectrophotometer ICE 3500 series (Thermo) according to [20].

Human health risk assessment:

The potential health risks associated with heavy metal contamination of canned tuna were estimated as EDI, HQ, and HI.

EDI: Estimated daily intake (mg/day); HQ: Hazard quotient; HI: Hazard index

Estimated Daily Intake (EDI):

For heavy metals detected through fish consumption by the Egyptian population were calculated according to [21] based on the following equation: **EDI (mg/day) = Cm*FIR/BW**

Where:

Cm is the concentration of the tested metal (mg/kg ww)

FIR: is the fish intake rate of the Egyptian consumer (48.57 g/day)

BW: The term "BW" is used to denote the body weight of Egyptian adults, which is typically around 70 kilograms.

The non-carcinogenic hazard quotient (HQ)

HQ for the tested heavy metals was calculated based on the following equation from [22].

$$HQ = (EDI/RFD)*10^{-3}$$

Where:

RFD is the recommended reference dose and its values are shown in **Table 1**.

Table 1 values of recommended reference dose (RFD) for equation 2 according Mistretta and Durkin [23]

Heavy metal	Pb	Cd	Ni	Hg	Sn	Cu	Mn	Cr
RFD	0.0035	0.001	0.002	0.001	0.0003	0.04	0.14	0.003

RFD: oral recommended reference dose

The risk index (HI)

HI was calculated from the following equation: $\mathbf{HI = \sum HQi}$

Where: i represents each metal

Statistical analyses

Duncan's test was used to compare the means of the different species for each brand at ($p < 0.05$) using the statistical program SPSS 16.

3. Results and discussion

Table 2 Heavy metals concentration (mg/kg fresh tuna) in studied tuna brand samples collected from Egypt markets

		Pb	Cd	Ni	Hg	Sn	Cu	Mn	Cr
Brand 1	Shredded (SB1)	$0.049^{C} \pm 0.002$	$0.0024^{b} \pm 0.001$	$0.341^{b} \pm 0.019$	$0.073^{b} \pm 0.002$	$0.119^{a} \pm 0.011$	$1.770^{a} \pm 0.027$	$0.333^{a} \pm 0.008$	$0.111^{b} \pm 0.039$
	Chunk (CB1)	$0.103^{a} \pm 0.007$	$0.005^{a} \pm 0.001$	$0.216^{C} \pm 0.016$	$0.050^{c} \pm 0.002$	$0.098^{b} \pm 0.007$	$0.527^{c} \pm 0.015$	$0.074^{b} \pm 0.006$	$0.123^{a} \pm 0.041$
	One piece (OB1)	$0.070^{b} \pm 0.002$	$0.002^{b} \pm 0.000$	$0.452^{a} \pm 0.021$	$0.093^{a} \pm 0.001$	$0.070^{c} \pm 0.005$	$0.596^{b} \pm 0.024$	<d.l.	$0.113^{b} \pm 0.042$
Brand 2	Shredded (SB2)	<d.l.	<d.l.	$0.164^{a} \pm 0.010$	<d.l.	$0.022^{b} \pm 0.002$	$0.874^{a} \pm 0.021$	$0.303^{a} \pm 0.008$	$0.122^{c} \pm 0.037$

	Chunk (CB2)	**<d.l.**	**<d.l.**	**0.157^{a} ± 0.006**	**<d.l.**	**0.049^{a} ± 0.003**	**0.679^{c} ± 0.014**	**0.092^{b} ± 0.006**	**0.146^{b} ± 0.031**
	One piece (OB2)	**<d.l.**	**<d.l.**	**0.128^{b} ± 0.004**	**0.024^{a} ± 0.001**	**0.025^{b} ± 0.002**	**0.806^{b} ± 0.017**	**0.005^{c} ± 0.001**	**0.163^{a} ± 0.048**
Brand 3	**Shredded (SB3)**	**0.097^{a} ± 0.003**	**0.007^{a} ± 0.001**	**0.235^{a} ± 0.009**	**0.049^{c} ± 0.001**	**0.073^{b} ± 0.004**	**1.210^{a} ± 0.0230**	**0.036^{b} ± 0.002**	**0.164^{a} ± 0.050**
	Chunk (CB3)	**0.068^{b} ± 0 .002**	**0.005^{b} ± 0.000**	**0.043^{b} ± 0.005**	**0.068^{b} ± 0.001**	**0.091^{a} ± 0.003**	**0.698^{c} ± 0.022**	**<d.l.**	**0.146^{b} ± 0.034**
	One piece (OB3)	**0.049^{c} ± 0.001**	**0.003^{c} ± 0.000**	**0.022^{c} ± 0.003**	**0.074^{a} ± 0.001**	**0.025^{c} ± 0.002**	**0.763^{b} ± 0.011**	**0.076^{a} ± 0.004**	**0.163^{a} ± 0.031**
Brand 4	**Shredded (SB4)**	**<d.l.**	**<d.l.**	**1.017^{a} ± 0.009**	**<d.l.**	**0.044^{c} ± 0.003**	**1.177^{a} ± 0.027**	**0.239^{a} ± 0.010**	**0.144^{b} ± 0.039**
	Chunk (CB4)	**<d.l.**	**<d.l.**	**0.278^{c} ± 0.013**	**<d.l.**	**0.085^{a} ± 0.005**	**0.815^{c} ± 0.014**	**<d.l.**	**0.147^{b} ± 0.031**
	One piece (OB4)	**<d.l.**	**<d.l.**	**0.456^{b} ± 0.014**	**0.025^{a} ± 0.001**	**0.075^{b} ± 0.004**	**1.059^{b} ± 0.029**	**0.127^{b} ± 0.006**	**0.171^{a} ± 0.049**
Brand 5	**Shredded (SB5)**	**0.063^{b} ± 0.002**	**0.004^{b} ± 0.000**	**0.277^{b} ± 0.012**	**0.042^{b} ± 0.001**	**0.042^{a} ± 0.004**	**0.803^{b} ± 0.016**	**0.070^{a} ± 0.005**	**0.154^{b} ± 0.034**
	Chunk (CB5)	**0.093^{a} ± 0.002**	**0.007^{a} ± 0.000**	**0.133^{c} ± 0.005**	**0.023^{c} ± 0.001**	**0.023^{b} ± 0.002**	**0.828^{b} ± 0.013**	**<d.l.**	**0.170^{a} ± 0.044**
	One piece (OB5)	**<d.l.**	**<d.l.**	**0.425^{a} ± 0.007**	**0.071^{a} ± 0.001**	**0.048^{a} ± 0.004**	**1.080^{a} ± 0.019**	**0.042^{b} ± 0.005**	**0.163^{a} ± 0.034**

Different small letters in the same column for on brand indicate significant differences among types ($p<0.05$)

<d.l. below detection limit

This study aimed to estimate heavy metal elements in five brands of canned tuna available in Egyptian markets. All samples were taken during the period 2023-2024, with three types of canned tuna: flaked, chunks, and one-piece. **Table 2** are shown the concentrations of the heavy metals as follows: lead, cadmium, nickel, mercury, tin, copper, manganese, and chromium. Regarding lead, the data in **Table 2** indicate that the concentrations of lead ranged from (<d.l.) to 0.103 mg/kg. The five tuna brands did not exceed the permissible limits for lead, which is evident when calculating the daily intake of lead based on an ideal body weight (70 kg) and the amount of tuna consumed per day for the Egyptian consumer (48.5 g tuna), which did not exceed the maximum allowable limit of 0.3 mg/day). These results agreed with [24], [25], and European Commission regulations [26] that set a maximum limit by 0.3 mg kg^{-1} for lead in fish muscle meat. The highest value of lead in the sample (pieces) from brand 1 (0.103 ppm) gives a daily body dose of 0.071 mg/day of lead, which is less than one-third of the daily limit of 0.3 ppm. Therefore, the five brands can be considered safe in terms of lead concentration. Elevated levels of lead in tuna can be attributed to contamination of fish due to increased mining, smelting, battery manufacturing activities, and discharge of industrial and agricultural wastes into waterways. These elevated levels of lead, when consumed over a long period of time, can cause severe adverse effects on consumers including cardiovascular, blood, renal, reproductive, nervous and developmental disorders [27, 28].

The cadmium concentrations in all samples ranged from (<d.l.) to 0.00723 mg/kg. All these values did not allow exceeding the maximum daily dose of cadmium of 0.05 mg/day for tuna according to the regulations [26]. Thus, all samples had cadmium content well below this limit. The accumulation of cadmium in muscle is lower. However, cadmium is highly toxic [29] and for this reason, the limit for cadmium in fish muscle for human consumption as set by the European Union (EU) is 10 times lower than the limit for total mercury in tuna. For cadmium, all samples of the five brands available in the Egyptian market were found to be well below the permissible limits for the presence of cadmium in canned tuna. Cadmium is a potent pollutant that poses serious health risks due to the accumulation of its toxic effects over time, damaging the kidneys and bones. The nervous system suffers, with impaired peripheral and central functions. Exposure to cadmium increases the risk of cancer and can cause birth defects. It also damages the respiratory system and disrupts endocrine and reproductive processes [30, 31].

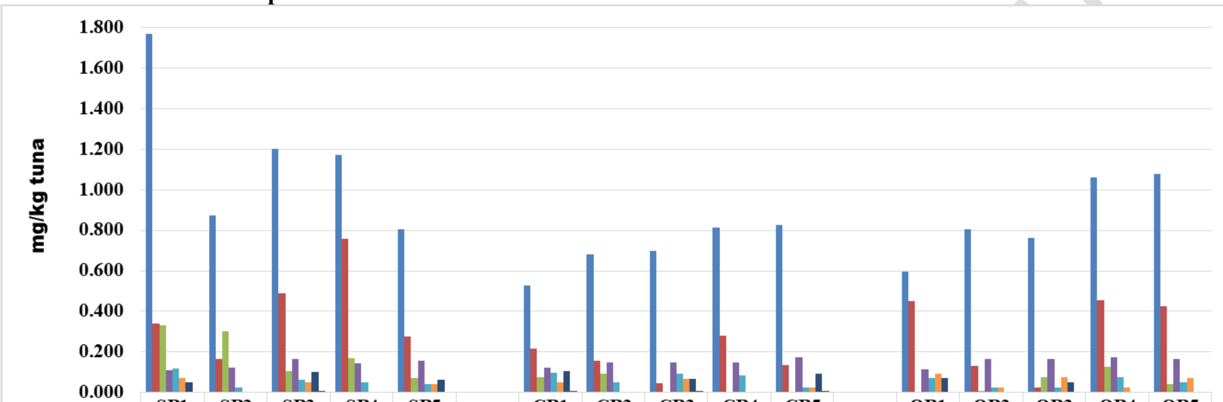
Nickel concentrations in canned tuna ranged from 0.022 to 1.017 mg/kg^{-1}. The lowest and highest recorded nickel levels were 0.022 mg/kg in brand 3 one piece and 1.017 mg/kg in brand 4 shredded, respectively. Although the human body absorbs approximately 10% of the nickel present in food, high levels of this metal have been shown to reduce the levels of other essential elements, including magnesium, manganese, and zinc. As documented in the literature, the concentration of nickel in canned tuna from the Kingdom of Saudi Arabia was found to be in the range of 0.09–0.48 mg/kg, while in the muscles of fish from Turkey, it was observed to be between 0.03–0.63 mg/kg [32]. In canned fish from Iraq, the concentration ranged between 0.0001 to 0.0003 mg/kg [33], and, it was found to be between 0.11–0.31 mg/kg in muscles from Iraq [34].

Related studies showed that large predatory fish such as tuna are important sources of human exposure to toxic forms of mercury [35]. Mercury is a heavy metal known to be toxic. Aquatic organisms that grow in polluted waters contain it in their tissues. Mercury poisoning or ingestion can have serious consequences for the brain, immune system, digestive system, lungs, and kidneys and can be fatal. When ingested, inorganic mercury salts can poison the kidneys and damage the skin, eyes, and digestive system [36]. It also has some other harmful consequences, including decreased hearing and vision, dizziness, nausea, muscle weakness, allergies, weakened immune system, kidneys, and cardiovascular system, brain damage, and even death [37]. Mercury concentrations ranged from below the limit of detection (<d.l.) to 0.0933 mg/kg. The highest amount of mercury in this study was 0.093 mg/kg in the one-piece sample from Brand 1, which is four times higher than the lowest amount of 0.023 mg/kg recorded in Brand 5 chunk.

The tin concentration ranged from 0.022 to 0.098 mg/kg in different tuna samples. This may be attributed to corrosion of the can material, which results in the leaching of tin into the fish flesh and subsequently into the human body. Tin has been demonstrated to induce metabolic disruptions in essential elements, including zinc (Zn), copper (Cu), and iron (Fe). Additionally, it has been shown to diminish the calcium content of bones and to cause damage to organs, particularly the kidneys [38].

Copper concentrations exhibited a range of 0.527 to 1.771 mg/kg, while manganese concentrations demonstrated a range of < d.l. to 0.333 mg/kg. Chromium concentrations also exhibited a range of 0.111 to 0.171 mg/kg. It was found that none of the brands or types exceeded the maximum permissible limits for any of the other heavy metal elements, namely copper, manganese, or chromium.

Figure 1. Comparing shredded, chunk, one piece, heavy metals concentrations (ppm) for different brands of examined canned tuna samples.



	SB1	SB2	SB3	SB4	SB5		CB1	CB2	CB3	CB4	CB5		OB1	OB2	OB3	OB4	OB5
Cu	1.770	0.874	1.200	1.172	0.803		0.526	0.680	0.698	0.815	0.827		0.596	0.806	0.763	1.059	1.080
Ni	0.341	0.164	0.490	0.756	0.277		0.216	0.157	0.043	0.278	0.133		0.452	0.128	0.022	0.456	0.425
Mn	0.333	0.303	0.106	0.168	0.070		0.075	0.092	0.000	0.000	0.000		0.000	0.005	0.076	0.127	0.042
Cr	0.111	0.122	0.164	0.145	0.154		0.123	0.146	0.147	0.147	0.171		0.113	0.163	0.163	0.171	0.164
Sn	0.119	0.022	0.063	0.051	0.042		0.098	0.049	0.091	0.085	0.023		0.070	0.025	0.025	0.075	0.048
Hg	0.073	0.000	0.048	0.000	0.042		0.050	0.000	0.068	0.000	0.023		0.093	0.024	0.074	0.025	0.071
Pb	0.049	0.000	0.098	0.000	0.063		0.103	0.000	0.068	0.000	0.093		0.070		0.049	0.000	0.000
Cd	0.002	0.000	0.008	0.000	0.004		0.005	0.000	0.005	0.000	0.007		0.002		0.003	0.000	0.000

Figure 1 illustrates a comparison of the concentration of heavy elements in three types of canned tuna: shredded, chunk, and one-piece, across five distinct brands. As illustrated in the figure, the highest concentration of elements in the shredded samples of the five brands is copper. The highest concentration is observed in the shredded sample of brand 1, while shredded samples from brands 3 and 4 have a nearly similar concentration. In contrast, brand 5 exhibited the lowest concentration of copper. Copper is a vital element for optimal health; however, excessive intake can result in adverse health effects, including liver and kidney damage [39]. The copper concentrations in the canned fish samples analyzed were below the UK Ministry of Agriculture and Food's reference value of 30 mg Cu/kg [40]. Nickel was the most abundant element after copper in the shredded tuna cans, followed by manganese, chromium, and tin. In general, the last five elements, chromium, tin, mercury, lead, and cadmium, were less than 0.2 mg/kg in the shredded tuna samples. In comparing the chunk samples from the five brands with the shredded samples, a general decrease in the concentration of heavy elements is observed. In general, the concentration of copper and nickel increased in the one-piece samples compared to the chunk samples. The last six elements remained below 0.2 mg/kg in both the chunk and one-piece samples for the five brands.

Table 3 shows the estimated intake by mg /kg body weightof toxic elements per day and its comparison with the permissible limits

		Estimated intake by mg /kg body weight /d							
		Pb	Cd	Ni	Hg	Sn	Cu	Mn	Cr
Brand 1	Shredded (SB1)	0.0005	0.0000	0.0034	0.0007	0.0012	0.0176	0.0033	0.0011
	Chunk (CB1)	0.0010	0.0001	0.0021	0.0005	0.0010	0.0052	0.0007	0.0012
	One piece (OB1)	0.0007	0.0000	0.0045	0.0009	0.0007	0.0059	0.0000	0.0011
Brand 2	Shredded (SB2)	0.0000	0.0000	0.0016	0.0000	0.0002	0.0087	0.0030	0.0012
	Chunk (CB2)	0.0000	0.0000	0.0016	0.0000	0.0005	0.0067	0.0009	0.0014
	One piece (OB2)	0.0000	0.0000	0.0013	0.0002	0.0002	0.0080	0.0000	0.0016
Brand 3	Shredded (SB3)	0.0010	0.0001	0.0023	0.0005	0.0007	0.0120	0.0004	0.0016

	Chunk (CB3)	**0.0007**	**0.0000**	**0.0004**	**0.0007**	**0.0009**	**0.0069**	**0.0000**	**0.0015**
	One piece (OB3)	**0.0005**	**0.0000**	**0.0002**	**0.0007**	**0.0002**	**0.0076**	**0.0008**	**0.0016**
Brand 4	**Shredded (SB4)**	**0.0000**	**0.0000**	**0.0101**	**0.0000**	**0.0004**	**0.0117**	**0.0024**	**0.0014**
	Chunk (CB4)	**0.0000**	**0.0000**	**0.0028**	**0.0000**	**0.0008**	**0.0081**	**0.0000**	**0.0015**
	One piece (OB4)	**0.0000**	**0.0000**	**0.0045**	**0.0002**	**0.0007**	**0.0105**	**0.0013**	**0.0017**
Brand 5	**Shredded (SB5)**	**0.0006**	**0.0000**	**0.0027**	**0.0004**	**0.0004**	**0.0080**	**0.0007**	**0.0015**
	Chunk (CB5)	**0.0009**	**0.0001**	**0.0013**	**0.0002**	**0.0002**	**0.0082**	**0.0000**	**0.0017**
	One piece (OB5)	**0.0000**	**0.0000**	**0.0042**	**0.0007**	**0.0005**	**0.0107**	**0.0004**	**0.0016**
Maximum permissible limits daily intake		**0.004[ad]**	**0.001[a]**	**0.007-0.008[c]**	**0.007[cd]**	**0.004[cd]**	**0.429[b]**	**0.029-0.071[d]**	**0.003-0.005[ad]**

[a]EC(2006) [b]FAO (2006), [c]WHO (2008), [d]EOS(2010)

It is clear from Table 3 that all heavy metal elements in tuna were below the permissible limits for consumption per mg/kg of body weight, except for the element nickel in the shredded sample of the brand four (0.0101 mg/kg), which exceeded the permissible limits per kg of body weight by (0.007-0.008 mg/kg) according to [28]. Exceeding the permissible limits leads to the possibility of considering the possibility of allergic reactions or eczema caused by sudden oral exposure. Differences in immune response between individuals with nickel allergy should be taken into account [41].

Table 4 Estimated daily intake (EDI, mg/day) of heavy metals in examined canned tuna samples collected from Egypt markets

		Estimated daily intake (EDI)of heavy metals(mg/d)							
		Pb	**Cd**	**Ni**	**Hg**	**Sn**	**Cu**	**Mn**	**Cr**
Brand 1	**Shredded (SB1)**	**0.034**	**0.002**	**0.237**	**0.050**	**0.083**	**1.229**	**0.231**	**0.077**
	Chunk (CB1)	**0.071**	**0.004**	**0.150**	**0.035**	**0.068**	**0.365**	**0.052**	**0.086**
	One piece (OB1)	**0.049**	**0.002**	**0.314**	**0.065**	**0.049**	**0.414**		**0.079**
Brand 2	**Shredded (SB2)**			**0.114**		**0.015**	**0.607**	**0.210**	**0.085**
	Chunk (CB2)			**0.109**		**0.034**	**0.472**	**0.064**	**0.101**
	One piece (OB2)			**0.089**	**0.017**	**0.017**	**0.559**	**0.003**	**0.113**
Brand 3	**Shredded (SB3)**	**0.067**	**0.005**	**0.163**	**0.034**	**0.051**	**0.840**	**0.025**	**0.114**
	Chunk (CB3)	**0.047**	**0.003**	**0.030**	**0.047**	**0.063**	**0.485**		**0.102**
	One piece (OB3)	**0.034**	**0.002**	**0.015**	**0.051**	**0.017**	**0.530**	**0.053**	**0.113**
Brand 4	**Shredded (SB4)**			**0.705**		**0.031**	**0.817**	**0.166**	**0.100**
	Chunk (CB4)			**0.193**		**0.059**	**0.566**		**0.102**
	One piece (OB4)			**0.317**	**0.017**	**0.052**	**0.735**	**0.088**	**0.119**
Brand 5	**Shredded (SB5)**	**0.044**	**0.003**	**0.192**	**0.029**	**0.029**	**0.557**	**0.049**	**0.107**
	Chunk (CB5)	**0.064**	**0.005**	**0.092**	**0.016**	**0.016**	**0.574**		**0.119**
	One piece (OB5)			**0.295**	**0.049**	**0.033**	**0.749**	**0.029**	**0.114**
Maximum tolerable daily intake		**0.3[ad]**	**0.1[a]**	**0.5-0.6[c]**	**0.5[cd]**	**0.3[cd]**	**30[b]**	**2.0-5.0[d]**	**0.2-0.5[ad]**

[a]EC(2006) [b]FAO (2006), [c]WHO (2008), [d]EOS(2010)

Table 5 Estimated weekly intake (EWI mg/kg/week) of metals in examined canned tuna samples collected from Egypt markets

		Estimated weekly intakes							
		Pb	**Cd**	**Ni**	**Hg**	**Sn**	**Cu**	**Mn**	**Cr**
Brand 1	**Shredded (SB1)**	**0.238**	**0.012**	**1.656**	**0.353**	**0.579**	**8.600**	**1.615**	**0.540**
	Chunk (CB1)	**0.499**	**0.025**	**1.049**	**0.242**	**0.476**	**2.558**	**0.362**	**0.599**
	One piece (OB1)	**0.340**	**0.011**	**2.195**	**0.453**	**0.342**	**2.896**	**0.000**	**0.551**
Brand 2	**Shredded (SB2)**	**0.000**	**0.000**	**0.795**	**0.000**	**0.107**	**4.246**	**1.470**	**0.593**
	Chunk (CB2)	**0.000**	**0.000**	**0.764**	**0.000**	**0.238**	**3.301**	**0.448**	**0.710**
	One piece (OB2)	**0.000**	**0.000**	**0.623**	**0.118**	**0.119**	**3.916**	**0.024**	**0.794**
Brand 3	**Shredded (SB3)**	**0.471**	**0.035**	**1.143**	**0.236**	**0.355**	**5.878**	**0.175**	**0.798**
	Chunk (CB3)	**0.330**	**0.022**	**0.210**	**0.332**	**0.442**	**3.392**	**0.000**	**0.712**
	One piece (OB3)	**0.240**	**0.012**	**0.107**	**0.358**	**0.121**	**3.707**	**0.371**	**0.794**
Brand 4	**Shredded (SB4)**	**0.000**	**0.000**	**4.938**	**0.000**	**0.215**	**5.718**	**1.161**	**0.703**
	Chunk (CB4)	**0.000**	**0.000**	**1.350**	**0.000**	**0.414**	**3.960**	**0.000**	**0.716**
	One piece (OB4)	**0.000**	**0.000**	**2.216**	**0.121**	**0.364**	**5.144**	**0.617**	**0.831**
Brand 5	**Shredded (SB5)**	**0.306**	**0.020**	**1.344**	**0.205**	**0.204**	**3.902**	**0.341**	**0.750**
	Chunk (CB5)	**0.450**	**0.034**	**0.644**	**0.112**	**0.112**	**4.020**	**0.000**	**0.830**
	One piece (OB5)	**0.000**	**0.000**	**2.062**	**0.343**	**0.231**	**5.246**	**0.205**	**0.795**
Maximum tolerable weekly intake		**2.1[ad]**	**0.7[a]**	**3.5-4.2[c]**	**3.5[cd]**	**2.1[cd]**	**210.0[b]**	**14-35[d]**	**1.4-3.5[ad]**

[a]EC(2006) [b]FAO (2006), [c]WHO (2008), [d]EOS(2010)

Table 4, 5 shows the estimated daily amounts and estimated weekly intakes of potential toxic elements (in milligrams per day/week) in the five most popular canned tuna fish in the Egyptian market, which were included in our study. The results indicate that the total daily or weekly amount of heavy toxic elements was below the maximum allowable limit for consumption according [26,42, 28, 24], except for the nickel in shredded sample of brand 4 was increased about the maximum tolerable daily or weekly intake of nickel (0.5-0.6 mg daily) or (3.5-4.2mg weekly) according to [28]. Although the estimated total daily intake was low due to low consumption of canned fish, long-term consumption of contaminated canned fish may lead to significant health repercussions. Due to the low consumption of canned fish in Egypt (48.5 grams per day), the estimated daily/weekly intake was below the maximum allowable consumption limit.

Table 6 The health risk assessment of heavy metals due to consumption of tuna samples collected from Egypt markets

		HQ								HI
		Pb	Cd	Ni	Hg	Sn	Cu	Mn	Cr	
Brand 1	Shredded (SB1)	0.008	0.001	0.118	0.050	0.019	0.031	0.002	0.026	0.255
	Chunk (CB1)	0.017	0.002	0.075	0.035	0.016	0.009	0.000	0.029	0.182
	One piece (OB1)	0.011	0.001	0.157	0.065	0.011	0.010		0.026	0.282
Brand 2	Shredded (SB2)			0.057		0.004	0.015	0.002	0.028	0.105
	Chunk (CB2)			0.055		0.008	0.012	0.000	0.034	0.109
	One piece (OB2)			0.045	0.017	0.004	0.014	0.000	0.038	0.117
Brand 3	Shredded (SB3)	0.016	0.004	0.082	0.034	0.012	0.021	0.000	0.038	0.206
	Chunk (CB3)	0.011	0.002	0.015	0.047	0.015	0.012		0.034	0.136
	One piece (OB3)	0.008	0.001	0.008	0.051	0.004	0.013	0.000	0.038	0.123
Brand 4	Shredded (SB4)			0.353		0.007	0.020	0.001	0.033	0.415
	Chunk (CB4)			0.096		0.014	0.014		0.034	0.158
	One piece (OB4)			0.158	0.017	0.012	0.018	0.001	0.040	0.246
Brand 5	Shredded (SB5)	0.010	0.002	0.096	0.029	0.007	0.014	0.000	0.036	0.194
	Chunk (CB5)	0.015	0.003	0.046	0.016	0.004	0.014		0.040	0.138
	One piece (OB5)			0.147	0.049	0.008	0.019	0.000	0.038	0.261

The literature suggests a high likelihood of human exposure to pollutants from food, which can be evaluated using the target hazard quotient (HQ) calculation. If the HI is less than 1, the food does not cause acute adverse health effects [43]. In **Table 6** considering each element individually, the value of the target risk quotient (HQ) did not exceed the standard value (>1) for any of the five brands or types (shredded, chunks, and one piece), therefore no concern or adverse effects are associated with the consumption of canned tuna from these five brands or types in Egypt. The total target hazard quotient (HI) for the various metals was less than 1, which means they are not capable of causing non-carcinogenic risks. Based on the results, the concentrations of the heavy metals under study are within the permissible limits for lead, cadmium, mercury, mercury, nickel, tin, copper, manganese, and chromium. The HI values for all metals were also below the safe limits. Therefore, it can be concluded that the target population may not have potential significant health risks through the consumption of canned tuna fish.

Conclusion

Fish products are crucial components of human health and food; but, under some conditions, they can expose people to environmental toxins such as heavy metals. Tuna is a top predator. These fish are a major source of heavy metals for humans .Heavy metal concentrations were determined in five brands of tuna accessible on the Egyptian market, each with three varieties. Considering each heavy metal element separately, the target hazard quotient (HQ) value did not exceed the standard value (>1), and the total target hazard quotient (HI) for the various metals was less than 1 for any of the five brands or their three varieties (shredded, chunks, and one piece).Thus, there is no concern or adverse effects associated with the consumption of canned tuna from these five brands in Egypt, as they are not capable of causing non-carcinogenic risks. Therefore, the target consumers does not have a significant potential health risk from consuming canned tuna from the five brands available in the Egyptian market.

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