

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

Abstract

Fish is a high-quality food, but it can contain toxic heavy metals that accumulate in its tissues, posing a risk to human health as it is at the end of the food chain. These metals threaten public health due to their toxicity and ability to accumulate in tissues, leading to the depletion of essential nutrients, psychological and social problems, weakened immunity, delayed growth, increased risk of gastrointestinal cancer, and disabilities resulting from malnutrition. This study aimed to measure and compare the content of heavy metals (lead, cadmium, nickel, mercury, tin, copper, manganese and chromium) in five brands of canned tuna and its three types (shredded, chunks, and one-piece) in the Egyptian market. Heavy metal concentrations were generally below safe limits except for nickel in one of the samples, but HQ (the target hazard quotient) and HI (the total target hazard quotient) still showed no significant health risk. Based on the results, it can be concluded that no major health risks were identified for consumption of canned tuna from these five brands in the Egyptian market.

Key words: Canned tuna, heavy metals, lead, cadmium, nickel, dietary risk, Egyptian market

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 during 2023-2024 from Egyptian supermarkets located in Elshiekh

Zayed -Giza (Egypt) due to the region's dense population, canned tuna is consumed in large quantities there. 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 H₂O₂ were added to the sample. The vessel was securely sealed and placed in the microwave until 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

Heavy metals like Pb, Cd, Ni, Sn, Cu, Mn and Cr were determined using atomic absorption spectrophotometer ICE 3500 series (Thermo) at Food Toxicology and Contaminants Department, National Research Centre according to [20]. Hg was determined using ICP (Inductively Coupled Plasma Emission Spectrometer, iCAP 6200, Central Laboratory - National Research Center.

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: $EDI \text{ (mg/day)} = C_m * FIR / BW$

Where:

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

FIR is the rate of fish intake by the Egyptian population, which established at 48.57 g/day [22].

BW: adult Egyptian body weight is 70 kg.

The non-carcinogenic hazard quotient (HQ)

HQ (hazard quotient for each element) for the tested heavy metals was calculated based on the following equation from [23].

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

Where:

RFD is the oral 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 [24]

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 carcinogenic hazard quotient (HI)

HI (the total target hazard quotient or cancer-causing risk quotient for all elements under study) was calculated from the following equation: $HI = \sum HQ_i$

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 ± 0.002	0.0024 ^b ± 0.001	0.341 ^b ± 0.019	0.073 ^b ± 0.002	0.119 ^a ± 0.011	1.770 ^a ± 0.027	0.333 ^a ± 0.008	0.111 ^b ± 0.039
	Chunk (CB1)	0.103 ^a ± 0.007	0.005 ^a ± 0.001	0.216 ^c ± 0.016	0.050 ^c ± 0.002	0.098 ^b ± 0.007	0.527 ^c ± 0.015	0.074 ^b ± 0.006	0.123 ^a ± 0.041
	One piece (OB1)	0.070 ^b ± 0.002	0.002 ^b ± 0.000	0.452 ^a ± 0.021	0.093 ^a ± 0.001	0.070 ^c ± 0.005	0.596 ^b ± 0.024	<d.l.	0.113 ^b ± 0.042
Brand 2	Shredded (SB2)	<d.l.	<d.l.	0.164 ^a ± 0.010	<d.l.	0.022 ^b ± 0.002	0.874 ^a ± 0.021	0.303 ^a ± 0.008	0.122 ^c ± 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 one 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: Shredded, 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. **Table 2** data indicate that lead concentrations in five tuna brands ranged from (<d.l.) to 0.103 mg/kg, without exceeding the permissible limit (0.3 mg/kg) according to EC regulations [25]. Based on the daily intake of lead (calculated on an idealized body weight of 70 kg and a daily consumption of 48.5 g tuna), the maximum daily dose (0.071 mg/day) was less than one-third of the permissible limit (0.3 mg/day), confirming the safety of the brands. Elevated levels of lead may be due to water pollution caused by mining and industrial activities, which can cause serious health effects on the heart, kidney, and nervous system with chronic consumption [26, 27].

The cadmium concentrations in the samples ranged from (< dL) to 0.00723 mg/kg, which is well below the maximum permissible limit (0.05 mg/day) according to the regulations [25], so all samples from Egyptian brands were within safe limits. Cadmium is a highly toxic pollutant [28], as the European Union sets a maximum limit for it in fish ten times lower than mercury, as it poses a serious health risk due to its accumulation in tissues, which affects the kidneys and bones, damages the nervous and respiratory systems, and disrupts endocrine and reproductive functions. It also increases the risk of cancer and birth defects.

Nickel concentrations were measured in canned tuna, ranging from 0.022 to 1.017 mg/kg. The lowest level of nickel was recorded in canned tuna grade 3 (single piece) at 0.022 mg/kg, while the highest level was recorded in canned tuna grade 4 (shredded) at 1.017 mg/kg. Although the human body only absorbs about 10% of the nickel found in food, high levels of this metal may negatively affect the absorption of essential nutrients such as magnesium, manganese and zinc. According to the studies, the concentration of nickel in canned tuna from Saudi Arabia was between 0.09 and 0.48 mg/kg, while in Turkish fish it ranged from 0.03 to 0.63 mg/kg. In Iraq, the concentration of nickel in canned fish was very low, ranging from 0.0001 to 0.0003 mg/kg [29], while in Iraqi fish muscle it was between 0.11 and 0.31 mg/kg [30]. In summary, nickel concentrations in tuna and canned fish vary depending on the source and variety, and high levels may affect human health.

Related studies showed that large predatory fish such as tuna are important sources of human exposure to toxic forms of mercury [31]. 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 [32]. 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 [33]. 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 [34].

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.

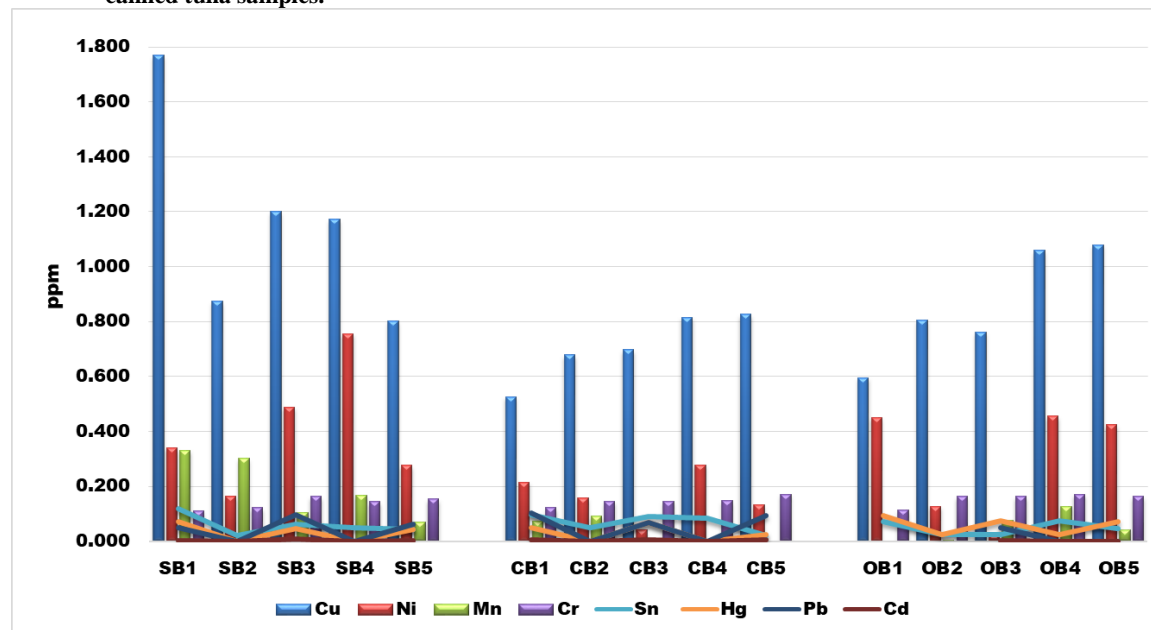


Figure 1 shows the differences in the content of heavy elements in tuna samples between the different types (shredded, chunk, and one-piece) of the five tuna brands under study. For the three elements that represent the highest concentration in tuna, namely copper, followed by nickel and manganese, it is noted that the concentration of these elements is higher in the shredded types than in one-piece samples. While the chunk samples were the lowest in the concentration of the three elements. Although the concentration of copper was the highest among all heavy metal elements, its concentration was lower than the UK Ministry of Agriculture and Food's reference value of 30 mg Cu/kg [35]. It is considered a vital element for optimal health; however, excessive intake can lead to adverse health effects, including liver and kidney damage [36]. As for the other five elements, namely chromium, tin, mercury, lead and cadmium, their concentration varied from one species to another as shown in the figure, and generally their concentration was less than 0.2 ppm in tuna samples of the three different types (shredded, chunk, and one-piece).

Table 3 shows the estimated intake by mg /kg body weight of 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}

^aEC(2006) ^bFAO (2006), ^cWHO (2008), ^dEOS(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 [27]. 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 [37].

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}

^aEC(2006) ^bFAO (2006), ^cWHO (2008), ^dEOS(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}

^aEC(2006) ^bFAO (2006), ^cWHO (2008), ^dEOS(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 [25,38, 27, 39], 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 [27]. 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 HQ (the target hazard quotient or non-cancer risk quotient) calculation. If the HI (the total target hazard quotient or cancer-causing risk quotient) is less than 1, the food does not cause acute adverse health effects [40]. 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 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 a staple of a healthy human diet, but they can sometimes carry health risks due to the heavy metals they contain. Tuna is one of the most prominent predatory fish that is a major source of these metals in the human diet. The concentrations of heavy metals were analyzed in five different brands of tuna available in the Egyptian market, where each brand included three different types of tuna. The results showed that the concentration of heavy metals in all samples did not exceed the permissible limits (>1) for the non-carcinogenic risk quotient value for each element individually (HQ) or for the carcinogenic risk quotient value for the total elements (HI) under study in all five brands and their three types (shredded, chunks, and one piece). Thus, there are no health risks or adverse effects associated with the consumption of canned tuna from these brands in Egypt, as they do not pose a threat of developing any chronic diseases or cancers.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Competing interests

Authors have declared that no competing interests exist.

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