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HEAVY METALS CONTENT IN CANNED TUNA FISH MARKETED IN ASSIUT CITY, EGYPT AND ITS RELATED HUMAN HEALTH RISK ASSESSMENT

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ABSTRACT

Some heavy metals are harmful and dangerous and cause many risks for food and public health. Also accumulated in fish such as tuna fish as a result of contaminated water or during transport, processing or canning. The present study was conducted to measure the concentration of some heavy metals (Pb, Cd, Al, Hg, Ni, Co and Cr) in canned tuna of five brands. **Materials and Methods:** Forty canned tuna samples from five brands were examined to determine their metal concentration. The samples were collected from supermarkets found in Assiut city (Egypt) from June 2017 to November 2017. The metals were determined using Atomic Absorption Spectrometer Perkin Elymer (Analyst 400) for Pb, Cd, Co, Ni and Cr while Hg was estimated by using ICP (iCAP 6200) and Al was determined using Atomic Absorption Spectrometer (ZEEnit700P). **Results:** The results revealed that the levels (ppm wet weight) of metals were as following in the examined five brands: (**1**) **Lead:** 1.984±0.156 (1.378-2.256), 2.581±0.401 (1.305-3.778), 1.804±0.244 (1.190-2.425), 2.030±0.424 (1.144-3.459), 1.752±0.250 (1.200-2.616) while in total samples was 2.030±0.141 (1.144-3.778). (**2**) **Cadmium**: 0.617±0.04 (0.467-0.696), 0.681±0.043 (0.536-0.778), 0.615±0.041 (0.516-0.720), 0.651±0.053 (0.519-0.747), 0.701±0.038 (0.561-0.792) while in total samples was 0.653±0.019 (0.467-0.792). (**3**) **Aluminum**: 3.545±0.017 (3.510-3.605), 3.707±0.058 (3.500-3.858), 3.525±0.125 (3.152-3.938), 3.676±0.044 (3.524-3.799), 3.635±0.159 (3.074-4.049), while in total samples was 3.617±0.042 (3.074-4.049). (**4**) **Mercury**: 6.640±0.075 (6.385-6.807), 5.105±0.025 (5.039-5.171), 6.823±0.077 (6.611-7.035), 2.948±0.120 (2.615-3.281), 1.745±0.156 (1.301-2.189), while in total samples was 4.652±0.413 (1.301-7.035). (**5**) **Nickel**: 2.035±0.148 (1.444-2.202), 1.948±0.155 (1.375-2.302), 1.924±0.159 (1.531-2.250), 1.906±0.215 (1.384-2.352), 1.957±0.127 (1.548-2.283), while in total samples was 1.954±0.067 (1.384-2.352). (**6**) **Cobalt**: 1.322±0.149 (0.765-1.656), 1.757±0.082 (1.515-1.957), 2.089±0.165 (1.607-2.525), 2.511±0.123 (2.160-2.785), 2.719±0.110 2.381-3.072), while in total samples was 2.080±0.16 (0.765-3.072). (**7**) **Chromium**: 0.246±0.100 (0.000-0.573), 0.039±0.03 (0.000-0.156), ND, ND, 0.030±0.023 (0.000-0.120), while in total samples was 0.063±0.027 (ND-0.573). In this study, the Target Health Quotient (THQ) in the total examined tuna samples was 0.219-0.323 (0.254) for Pb, 0.308-0.351 (0.327) for Cd, 0.00176-0.00185 (0.00181) for Al, 2.913-11.380 (7.757) for Hg, 0.047-0.051 (0.049) for Ni, 0.033-0.049 (0.052) for Co and 0.00001-0.000082 (0.000035) for Cr while the Hazard Health Index (HI) for all metals was 11.709for brand 1, 9.268 for brand 2, 12.015 for brand 3, 5.604 for brand 4, 3.601for brand 5, all of these are exceeding 1.

Conclusion: The calculated hazard index (HI) in this study in all examined canned tuna in all brands exceeds 1. The data indicate that the examined canned tuna were polluted with Pb, Cd, Al, Hg and Ni. Hazard indices for the estimated metals in these canned tuna imply that excessive and continuous intake of these tuna could result in chronic adverse health effects on the consumers. However, consumption of large quantities of these canned tuna increases human exposure to the risk especially of Hg toxicity. **Recommendation**: It recommended that more studies for assessment for quality control should be done to help safeguard the health consumers.

***Key words**:* Canned tuna, pollution, heavy metals, health risk assessment, Hazard Index.

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INTRODUCTION

Kazi *et al.* (2009) and Ozden (2010) mentioned that environmental pollution with different pollutants either industrial or agricultural wastes represents a major problem and great challenges all over the world. Today, the rapid progress of many industrial processes resulted in pollution with heavy metals that induce many adverse effects to the human through consumption of food (Yilmaz, 2009). The high levels of metals in the environment can be accumulated in the animal and human tissues because these metals are poorly degraded either in the environment or inside the tissues (Ciesielski *et al.*, 2010).

Fish represent a good source of protein which contains essential amino acids, many elements (calcium, fluorine, iodine and phosphorus) and fats. This fat is a source of energy and rich in fat soluble vitamins and unsaturated fatty acids which have many benefits such as hypocholesterolic effect (anti-atheriosclerosis) (Ismail, 2005). Sirot *et al.* (2010) reported that fish and other sea foods are important food source for human as they considered health and balanced meals.

Fish are good bioindicator for detection of contamination by heavy metals in the aquatic system. Fish can easily absorb the pollutants especially metals from the polluted water and feed and bioaccumulate them in their tissues (Burger *et al.,* 2002). Heavy metals in any chemical form in water can be taken by fish and transported to the human via food chain resulting in much toxicity (Rauf *et al.,* 2009 and Tuzen, 2009).

Tuna is characterized with high metabolic rate, high food intake and high accumulation capacity for metallic pollutants. Tuna is one of the most consumed fish all over the world (Burger and Gochfeld, 2004 and Kojadinovic *et al.,* 2007).

Aluminum (Al) is found in the atmospheric air of most industrialized overcrowded cities (Casarini *et al.,* 2001) and used in treatment of water (Silva *et al.,* 2007 and Camargo *et al.,* 2009). Al induced much toxicity to the marine animals (Correia *et al.*, 2010). The essentiality of the human body to Al is not found. Exposure of human to Al can cause many diseases like Parkinson's disease, Alzheimer's disease and encephalopathy/ dialysis dementia (Narin *et al.,* 2004).

Cadmium (Cd) is a cumulative contaminant and induces many toxic effects. Cd and lead (Pb) have been classified by International Agency for Research on Cancer (IARC) as human carcinogens (IARC, 1993). Exposure to high levels of Cd induces nephrotoxicity, bone effects, neurotoxicity, carcinogenicity, teratogenicity, respiratory, endocrinal and reproductive effects (EFSA, 2009, Ciobanu *et al.,* 2012; Engström *et al.,* 2012, Satarug, 2012 and Sawada *et al.,* 2012).

Lead is an environmental pollutant and results in many adverse health hazards and toxicities. Children are highly susceptible to Pb than adults due to high gastrointestinal uptake, tissue accumulation and high blood brain barrier permeability (Jarup, 2003). Pb causes central nervous system disorders, anemia, learning difficulties, behavioral disturbances, impairment of intellectual capacity, gastrointestinal and hemobiotic disturbances, effects on the renal and musculoskeletal systems as well as genetic effects (Kakkar and Jaffery, 2005; Jomova and Valko, 2011 and Ciobanu *et al.*, 2012).

Mercury (Hg) is present in air, soil and water. Large amounts of Hg are distributed in the environment as a result of anthropogenic and natural activities (WHO, 2008). Mercury accumulates in the fleshy tissue of fish. When consumed induces growth changes in the brain of children and neurological disorders in adults (Commission of the European Communities, 2001; Ikem and Egiebor, 2005).

Nickel (Ni) acts as activator of some enzymatic systems and due to its accumulation in the lungs result in toxicity at high levels. Food can be contaminated with Ni as well as during food processing (cooking and canning in vessels containing Ni. According to the US EPA, the oral reference dose of Ni is 20 μg/kg/day and the provisional maximum tolerable daily intake is 1.2 mg Ni /person/day (Ashraf *et al.,* 2006).

Cobalt (Co) is an essential element and an integral part of vitamin B_{12}. Co enhancing the thyroid functions. High levels of Co induce adverse effects in the heart (congestive heart failure), polycythemia, lung and skin (ATSDR, 2004), while Co deficiency can result in anemia (Jan *et al.,* 2010).

Chromium (Cr) plays an important role as an enzyme cofactor. In spite of its essentiality, it accumulates in the liver and spleen resulting in toxicity (Wagner and Boman, 2003). Cr as an essential nutrient potentiates the action of insulin that influences the metabolism of protein, lipids and carbohydrates. Cr (VI) is carcinogenic (Tuzen, 2007).

The discharge of effluents into the lakes due to rapid urbanization and industrialization is a big concern worldwide now days (Akan *et al.,* 2012). A number of toxic pollutants are added to the aquatic environment. Due to their action and persistence in biological amplification, heavy metals are particularly more dangerous (Erdogrul and Erbilir 2007, Honggang *et al.,* 2010, Babatunde *et al.,* 2012). Atmospheric deposition, mining wastes and erosion of the geological matrix are the main sources through which metals can enter the aquatic environment. Even at quite low concentrations most of the toxic metals are harmful to the living organisms but some are biologically essential and natural constituents of aquatic ecosystems, they can cause hazards at very high concentrations (Abida *et al.*, 2008, Bahnasawy *et al.*, 2011).

From the previously mentioned, the aim of this study is (1) to estimate the levels of different heavy metals such as Al, Cd, Pb, Hg, Ni and Cr in different brands of canned tuna, (2) to estimate the intake (daily and weekly) of these metals due to consumption of these canned tuna and (3) to calculate the health risk hazard and comparing them to the professional tolerable weekly intake (PTWI) and professional tolerable daily intake PTDI as well as the total target hazard quotient (TTHQ) for these metals as recommended by various agencies..

MATERIALS AND METHODS

(1) Chemicals: All the chemicals used were of analytical grade. To avoid contamination with metals the glassware and the containers used were cleaned by soaking in a 10 % nitric acid solution for up to 24 hours and then rinsed three times with bi-distilled water before use. Standard stock solutions of Pb, Cd, Al, Hg, Ni, Co and Cr were prepared from Titrasol (1000 mg/L) and were diluted to the related metal solution.

(2) Samples:
A- Samples collection: Forty canned tuna samples from five brands were examined to determine their metal concentration. The samples were collected from supermarkets found in Assiut city (Egypt) from June 2017 to November 2017. The examined canned tuna fish are:
Brand **1**: Skipjacks (*Katsuwonus Pelamis*), Brand **2**: Skipjacks (*Katsuwonus Pelamis*), Brand **3**: Bonito fish (Sarda sarda: *Scomber palmitus*, *Scomber ponticus*, *Scomber mediterraneus* and *Thynnus brachypterus*). Brand **4**: Skipjacks (*Katsuwonus Pelamis*), Brand **5**: Common Dolfin fish (*Coryphaena hippurus*)

B- Samples preparation: After opening each can, oil was drained off and the meat was homogenized thoroughly in a food blender with stainless steel cutters. About one gram from each sample was weighed into 25 ml Erlenmeyer flasks, 5 ml pure nitric acid (65%; from Merck, Germany) was added to each sample, and the samples were left overnight. Thereafter, 2.5 ml perchloric acid (72%; from Merck, Germany) was added to each sample. The samples were then placed on a hot plate and allowed to digest until a transparent and clear solution was obtained. Samples were allowed to cool and then diluted to 50 ml with double distilled water. The concentrations of metals in the samples are presented as mg/kg wet weight. Samples were digested according to methods described by Du Preez and Steyn (1992).

(3) Metals analysis: Heavy metals in this study were measured using the following instruments: (**1**) Pb, Cd, Co, Ni and Cr were determined using Atomic Absorption Spectrometer Perkin Elymer (Analyst 400), Atomic Absorption Unit, Fac. Of Science, Sohag University. (**2**) Al was determined using Atomic Absorption Spectrometer (ZEEnit700P) with graphite tube, Central lab., Fac. Of Veterinary Medicine, Assiut University. (**3**) Hg was determined using ICP (Inductively Coupled Plasma Emission Spectrometer, iCAP 6200), Central lab for Chemical Analysis, Fac. Of Agriculture, Assiut University.

(4) Statistical analyses: Data were analyzed via one-way analysis of variance (ANOVA). All statistical analyses of data were performed by SPSS 16.0 (SPSS Inc., Chicago, IL, USA) software (SPSS, 2001).

(5) Health Risk Assessment:
[1] The estimated daily and weekly intakes: The estimated daily intakes (EDI) or weekly intakes (EWI) and EWI/provisional tolerable weekly intake (PTWI) ratio for estimated heavy metals in canned tuna. The EDI or EWI for investigated heavy metals in canned tuna samples were estimated according to the following equation:

$$\textbf{EDI} = \frac{\text{Metal concentration in sample (ug/kg)} \times \text{Food intake (fish kg/day)}}{\text{Body weight (70 kg for adult person)}}$$

Where C metal is the average concentration of Pb and Cd in fish; W represents the daily average consumption of marine fish and bw is body weight, set to 70 kg. PTWI standard levels were provided by the European Food Safety Authority (EFSA, 2009; Song et al. 2009). EDI is measured in (mg/kg body weight/day)

[2] Target Hazard Quotient (**THQ**): Potential non-carcinogenic effects were evaluated by calculating a target hazard quotient (THQ). For a single compound, the target hazard quotient (THQ) is the ratio of the EDI to a reference dose:

$$THQ\ (mg/kg) = \frac{EDI\ (mg/kg)}{RfD\ (mg/kg)}$$

Where: EDI is estimated daily intake (mg/kg/day); RfD is reference dose.

The Hazard Health Index (HI) of heavy metals for fish is the sum of the following composition according to USEPA (1991):

HI = THQ (Pb) + THQ (Cd) + THQ (Al) + THQ (Hg) + THQ (Ni) + THQ (Co) + THQ (Cr).

RESULTS

The results of this study were summarized in the following tables (1-7) and figures. The results here were in mean ± SE.

Table 1: Heavy metals concentrations (ppm) in the different brands of examined canned tuna samples.

Tuna brands		Pb	Cd	Al	Hg	Ni	Co	Cr
Brand 1	mean ± SE	1.984 ± 0.156	0.617 ± 0.040	3.545 ± 0.017	6.640 ± 0.075	2.035 ± 0.148	1.322 ± 0.149	0.246 ± 0.100
	Range	1.378-2.256	0.467-0.696	3.510-3.605	6.385-6.807	1.444-2.202	0.765-1.656	0.000-0.573
Brand 2	mean ± SE	2.581 ± 0.401	0.681 ± 0.043	3.707 ± 0.058	5.105 ± 0.025	1.948 ± 0.155	1.757 ± 0.082	0.039 ± 0.030
	Range	1.305-3.778	0.536-0.778	3.500-3.858	5.039-5.171	1.375-2.302	1.515-1.957	0.000-0.156
Brand 3	mean ± SE	1.804 ± 0.244	0.615 ± 0.041	3.525 ± 0.125	6.823 ± 0.077	1.924 ± 0.159	2.089 ± 0.165	ND
	Range	1.190-2.425	0.516-0.720	3.152-3.938	6.611-7.035	1.531-2.250	1.607-2.525	ND
Brand 4	mean ± SE	2.030 ± 0.424	0.651 ± 0.053	3.676 ± 0.044	2.948 ± 0.120	1.906 ± 0.215	2.511 ± 0.123	ND
	Range	1.144-3.459	0.519-0.747	3.524-3.799	2.615-3.281	1.384-2.352	2.160-2.785	ND
Brand 5	mean ± SE	1.752 ± 0.250	0.701 ± 0.038	3.635 ± 0.159	1.745 ± 0.156	1.957 ± 0.127	2.719 ± 0.110	0.030 ± 0.023
	Range	1.200-2.616	0.561-0.792	3.074-4.049	1.301-2.189	1.548-2.283	2.381-3.072	0.000-0.120
Total samples	mean ± SE	2.030 ± 0.141	0.653 ± 0.019	3.617 ± 0.042	4.652 ± 0.413	1.954 ± 0.067	2.080 ± 0.116	0.063 ± 0.027
	Range	1.144-3.778	0.467-0.792	3.074-4.049	1.301-7.035	1.384-2.352	0.765-3.072	ND-0.573
FAO (1983)		--------	--------	--------	--------	10 ppm	--------	--------
WHO (1989)		--------	--------	60 mg/day	--------	--------	--------	--------
FAO/WHO (1989)		--------	--------	60 mg/day	--------	--------	--------	--------
CIFA (1992)		0.35 ppm	--------	--------	0.5 ppm	--------	--------	--------
FAO/WHO (1992)		0.5 ppm	0.5 ppm	--------	--------	--------	--------	--------
EOSQC (1993)		--------	0.1 ppm	--------	--------	--------	--------	--------
EC (2001)		0.2 ppm	--------	--------	--------	--------	--------	--------
USEPA (2002)		--------	--------	--------	--------	1 ppm	--------	8 ppm
IAEA-407 (Wyse et al., 2003)		0.12 ppm	0.19 ppm	--------	--------	0.6 ppm	--------	0.73 ppm
EOS (2005)		0.1 ppm	--------					
EU (2005)		--------	--------	--------	0.5 ppm	--------	--------	--------
EC (2006)		0.3 ppm	0.1 ppm	--------	1 ppm	--------	--------	--------
WHO (2008)		--------	--------	--------	--------	0.5-0.6 ppm	--------	0.2 ppm
Demirel et al. (2008)		--------	--------	15 ppm	--------	--------	--------	--------

Table 2: The significant difference of metals in the different brands of examined tuna.

Tuna brands		Pb	Cd	Al	Hg	Ni	Co	Cr
Brand 1	mean ± SE	1.984± 0.156	0.617± 0.040	3.545± 0.017	6.640± 0.075	2.035± 0.148	1.322± 0.149	0.246± 0.100
	Range	1.378-2.256	0.467-0.696	3.510-3.605	6.385-6.807	1.444-2.202	0.765-1.656	0.000-0.573
Brand 2	mean± SE	2.581± 0.401	0.681± 0.043	3.707± 0.058	5.105± 0.025**a**	1.948± 0.155	1.757± 0.082	0.039± 0.030a
	Range	1.305-3.778	0.536-0.778	3.500-3.858	5.039-5.171	1.375-2.302	1.515-1.957	0.000-0.156
Brand 3	mean± SE	1.804± 0.244	0.615± 0.041	3.525± 0.125	6.823± 0.077**b**	1.924± 0.159	2.089± 0.165**a**	ND **a**
	Range	1.190-2.425	0.516-0.720	3.152-3.938	6.611-7.035	1.531-2.250	1.607-2.525	ND
Brand 4	mean± SE	2.030± 0.424	0.651± 0.053	3.676± 0.044	2.948± 0.120**abc**	1.906± 0.215	2.511± 0.123**ab**	ND **a**
	Range	1.144-3.459	0.519-0.747	3.524-3.799	2.615-3.281	1.384-2.352	2.160-2.785	ND
Brand 5	mean± SE	1.752± 0.250	0.701± 0.038	3.635± 0.159	1.745± 0.156**abc**	1.957± 0.127	2.719± 0.110**abc**	0.030± 0.023**a**
	Range	1.200-2.616	0.561-0.792	3.074-4.049	1.301-2.189	1.548-2.283	2.381-3.072	0.000-0.120
Total samples	mean± SE	2.030± 0.141	0.653± 0.019**a**	3.617± 0.042**ab**	4.652± 0.413**abc**	1.954± 0.067**bcd**	2.080± 0.116**bcd**	0.063± 0.027**acdef**
	Range	1.144-3.778	0.467-0.792	3.074-4.049	1.301-7.035	1.384-2.352	0.765-3.072	ND-0.573

For the brands:
a: Means significant from brand 1 at p≤0.05.
b: Means significant from brand 2 at p≤0.05.
c: Means significant from brand 3 at p≤0.05.

For the total samples:
a: Means significant difference with Pb at p≤0.05. **b**: Means significant difference with Cd at p≤0.05.
c: Means significant difference with Al at p≤0.05. **d**: Means significant difference with Hg at p≤0.05.
e: Means significant difference with Ni at p≤0.05. **f**: Means significant difference with Co at p≤0.05.

Table 3: Estimated Daily Intake (EDI, µg/kg/day) of metals in examined canned tuna samples.

	Pb	Cd	Al	Hg	Ni	Co	Cr
Brand 1	0.992	0.309	1.773	3.320	1.018	0.661	0.123
Brand 2	1.291	0.341	1.854	2.553	0.974	0.879	0.020
Brand 3	0.902	0.308	1.763	3.414	0.962	1.045	NE
Brand 4	1.015	0.326	1.838	1.474	0.935	1.256	NE
Brand 5	0.876	0.351	1.818	0.874	0.979	1.360	0.015
NRC (1989)	-------	-------	-------	-------	-------	60	60
WHO (1989)	-------	-------	60 mg	-------	-------	-------	-------
WHO (1992)	-------	-------	-------	-------	100-300	-------	-------
WHO (2011)	3.57 Canned tuna	0.833 Canned tuna	-------	-------	-------	-------	-------
CAC (2012)	-------	0.833	-------	0.571	-------	-------	-------
FAO/WHO (2013)	-------	0.833	-------	-------	-------	-------	-------

All the values mentioned by agencies and authors were in µg/kg/day.

Table 4: EWI (µg/kg/week) of metals in examined canned tuna samples.

	Pb	Cd	Al	Hg	Ni	Co	Cr
Brand 1	6.944	2.163	12.411	23.240	7.126	4.627	0.861
Brand 2	9.037	2.387	12.978	17.871	6.818	6.153	0.140
Brand 3	6.314	2.156	12.341	23.898	6.734	7.313	NE
Brand 4	7.105	2.282	12.866	10.318	6.545	8.792	NE
Brand 5	6.132	2.457	12.726	6.118	6.853	9.520	0.105
NRC (1989)	-------	-------	-------	------	-------	420	420
WHO (1989)	-------	-------	420 mg	------	-------	-------	-------
WHO (1992)	-------	-------	-------	------	700-2100	-------	-------
WHO (2000)	25	-------	-------	-------	-------	-------	-------
FAO/WHO (2003)	25	5.833	-------	5	-------	-------	-------
WHO (2006)	25	-------	-------	-------	-------	-------	-------
FAO/WHO (2011)	25	5.833	-------	------	-------	-------	-------
CAC (2012)	-------	5.833	-------	4	-------	-------	-------
FAO/WHO (2013)	-------	5.833	-------	-------	-------	-------	-------

All the values mentioned by agencies and authors were in µg/kg/week.

Table 5: EWI/Provisional Tolerable Weekly Intake (PTWI) ratio of metals in examined tuna.

	Pb	Cd	Al	Hg	Ni	Co	Cr
Brand 1	0.278	0.309	$2.954x10^{-5}$	4.648	$10.175x10^{-3}$	0.011	$2.50x10^{-3}$
Brand 2	0.361	0.341	$3.089x10^{-5}$	3.574	$9.740x10^{-3}$	0.015	$3.25x10^{-4}$
Brand 3	0.253	0.308	$2.937x10^{-5}$	4.779	$9.620x10^{-3}$	0.017	NE
Brand 4	0.284	0.326	$3.063x10^{-5}$	2.064	$9.345x10^{-3}$	0.020	NE
Brand 5	0.245	0.351	$3.029x10^{-5}$	1.224	$9.785x10^{-3}$	0.023	$2.50x10^{-4}$

Table 6: Target Health Quotient (THQ) (mg/kg) of metals in examined canned tuna.

		Pb	Cd	Al	Hg	Ni	Co	Cr
Brand 1		0.248	0.309	0.00177	11.067	0.051	0.033	0.000082
Brand 2		0.323	0.341	0.00185	8.510	0.049	0.044	0.000013
Brand 3		0.226	0.308	0.00176	11.380	0.048	0.052	NE
Brand 4		0.254	0.326	0.00184	4.913	0.047	0.063	NE
Brand 5		0.219	0.351	0.00182	2.913	0.049	0.068	0.00001
Total brands	Min-Max.	0.219-0.323	0.308-0.351	0.00176-0.00185	2.913-11.380	0.047-0.051	0.033-0.049	0.0001-0.000082
	Mean ± SE	0.254± 0.016	0.327± 0.008	0.00181± 0.00001	7.757± 1.499	0.049± 0.001	0.052± 0.001	0.000035± 0.000014

Hazard Health Index (HI) for brand 1= 11.709, HI for brand 2= 9.268, HI for brand 3= 12.015, HI for brand 4= 5.604, HIfor brand 5= 3.601

Table 7: Correlation between determined heavy metal in different analyzed canned tuna.

		Pb	Cd	Al	Hg	Ni	Co	Cr
Brand 1	**Pb**	------	-0.205	-0.030	-0.297	- 0.089	-0.013	0.089
	Cd		------	0.598	-0.248	**0.932**	0.809	-0.598
	Al			------	-0.558	0.344	0.355	0.031
	Hg				------	0.025	0.241	-0.557
	Ni					------	**0.932**	-0.830
	Co						------	**-0.917**
	Cr							------
Brand 2	**Pb**	------	0.792	0.118	-0.740	0.679	0.304	0.772
	Cd		------	0.276	-0.531	**0.912**	0.427	0.578
	Al			------	0.052	-0.119	-0.727	0.674
	Hg				------	-0.489	-0.291	-0.510
	Ni					------	0.758	0.235
	Co						------	-0.354
	Cr							------
Brand 3	**Pb**	------	0.426	0.746	**-0.945**	0.586	0.466	ND
	Cd		------	0.816	-0.484	0.877	**0.909**	ND
	Al			------	-0.872	0.665	0.677	ND
	Hg				------	-0.486	-0.425	ND
	Ni					------	**0.952**	ND
	Co						------	ND
	Cr							------
Brand 4	**Pb**	------	0.348	0.371	-0.134	-0.313	-0.107	ND
	Cd		------	0.665	-0.290	**0.964**	**0.958**	ND
	Al			------	-0.295	0.757	0.756	ND
	Hg				------	-0.270	-0.460	ND
	Ni					------	**0.908**	ND
	Co						------	ND
	Cr							------
Brand 5	**Pb**	------	0.478	0.311	-0.323	0.136	**0.937**	0.895
	Cd		------	0.681	0.056	**0.935**	0.661	0.129
	Al			------	-0.612	0.636	0.522	0.169
	Hg				------	0.205	-0.388	-0.536
	Ni					------	0.363	-0.222
	Co						------	0.828
	Cr							------
Total brands	**Pb**	------	0.206	0.349	0.041	0.135	-0.066	0.142
	Cd		------	0.555	-0.315	0.848	0.508	-0.200
	Al			------	-0.268	0.370	0.275	0.047
	Hg				------	0.037	-0.749	0.291
	Ni					------	0.278	-0.126
	Co						------	-0.606
	Cr							------

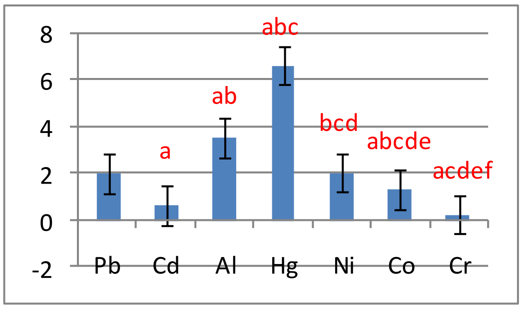


Fig. 1

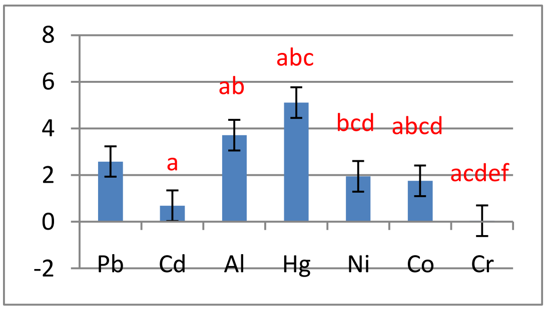
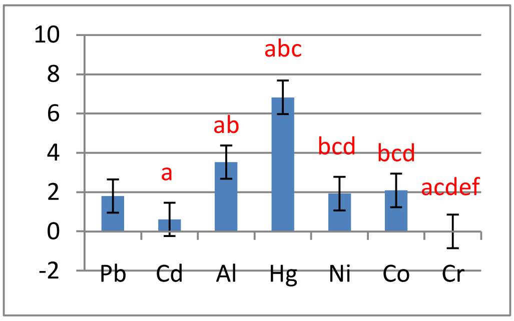


Fig. 2



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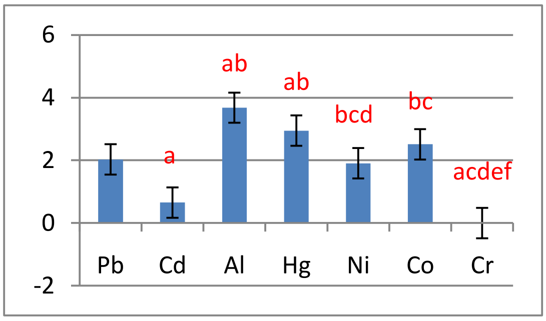

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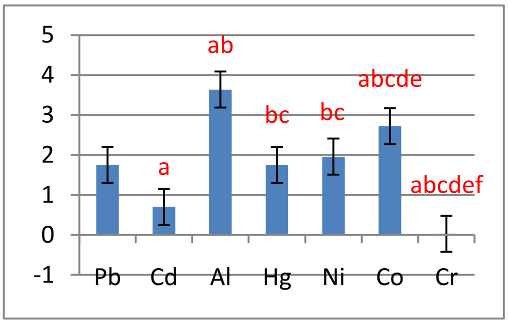

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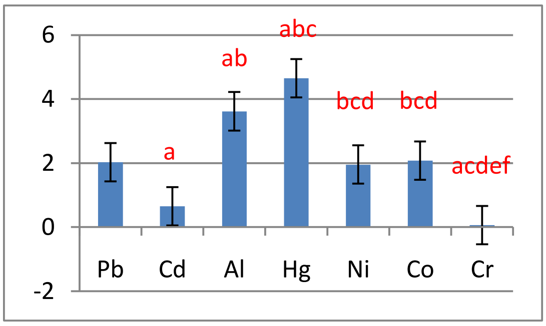


Fig. 6

Figure 1: Showing the concentrations (ppm) of metals in the samples of canned tuna in the brand 1.
Figure 2: Showing the concentrations (ppm) of metals in the samples of canned tuna in the brand 2.
Figure 3: Showing the concentrations (ppm) of metals in the samples of canned tuna in the brand 3.
Figure 4: Showing the concentrations (ppm) of metals in the samples of canned tuna in the brand 4.
Figure 5: Showing the concentrations (ppm) of metals in the samples of canned tuna in the brand 5.

Figure 6: Showing the concentrations (ppm) of metals in the total samples of canned tuna in all brands.
a: means significant difference with Pb at $p \leq 0.05$.
b: means significant difference with Cd at $p \leq 0.05$.
c: means significant difference with Al at $p \leq 0.05$.
d: means significant difference with Hg at $p \leq 0.05$.
e: means significant difference with Ni at $p \leq 0.05$.
f: means significant difference with Co at $p \leq 0.05$.

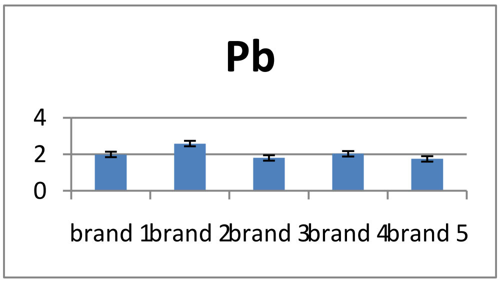


Fig. 7

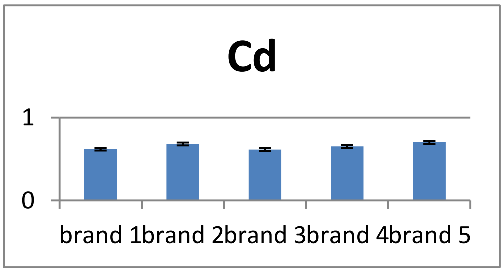
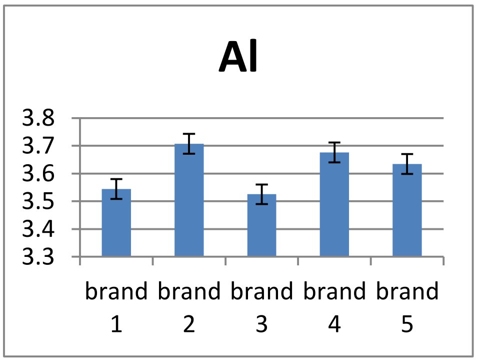


Fig. 8



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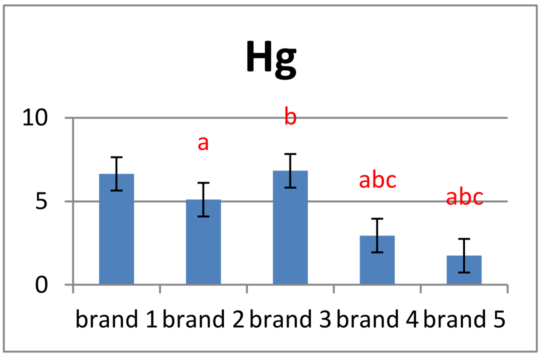

Fig. 10

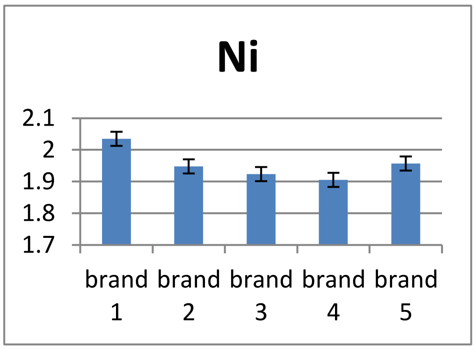

Fig. 11

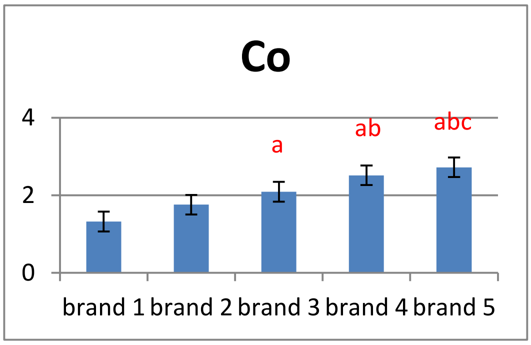

Fig. 12

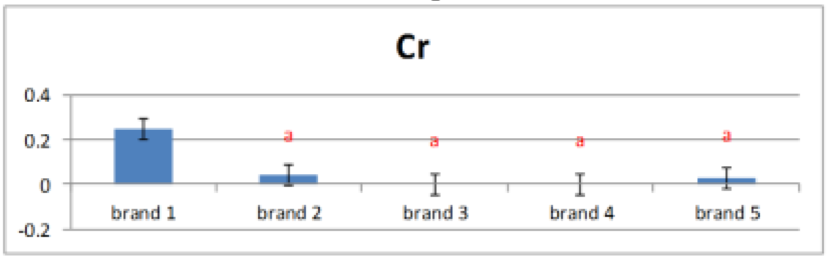

Fig. 13

Figure 7: The concentrations (ppm) of Pb in the samples of canned tuna in all brands.
Figure 8: The concentrations (ppm) of Cd in the samples of canned tuna in all brands.
Figure 9: The concentrations (ppm) of Al in the samples of canned tuna in all brands.
Figure 10: The concentrations (ppm) of Hg in the samples of canned tuna in all brands.

Figure 11: The concentrations (ppm) of Ni in the samples of canned tuna in all brands.
Figure 12: The concentrations (ppm) of Co in the samples of canned tuna in all brands.
Figure 13: The concentrations (ppm) of Cr in the samples of canned tuna in all brands.
a: Means significant from brand 1 at p≤0.05.
b: Means significant from brand 2 at p≤0.05.
c: Means significant from brand 3 at p≤0.05.

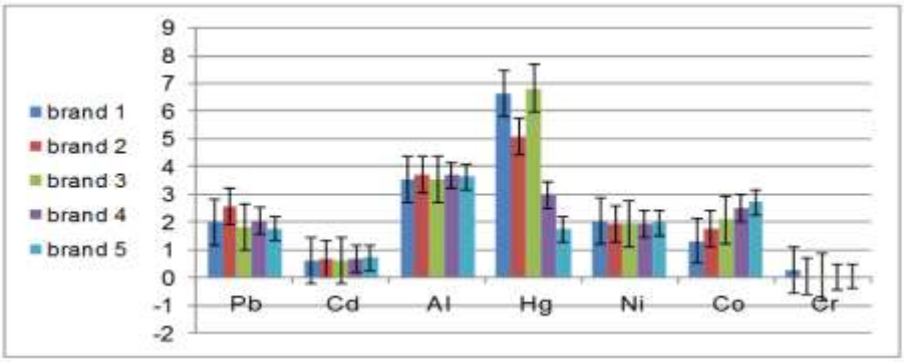

Figure 14: The concentrations (ppm) of metal in the samples of canned tuna in all brands.

DISCUSSION

When heavy metals pollute the aquatic environment induce health hazards due to the accumulation of these pollutants in fish. Fish are more sensitive to pollutants than invertebrates, so it is a good indicator for detection of aquatic pollution (Moiseenko *et al.,* 2008 and Mendil *et al.*, 2010). The organisms in the aquatic environment exposed to high amounts of metals via gills either from the contaminated water or feed and accumulate these pollutants inside the fish tissues. These pollutants reach to the human upon consumption of these polluted fish resulting in many health troubles and toxicities to the human (Ahmad and Othman, 2010).

[1] Lead: Lead concentrations (ppm) in all examined canned tuna samples in the five brands were 1.984±0.156 (1.378-2.256), 2.581±0.401 (1.305-3.778), 1.804±0.244 (1.190-2.425), 2.030±0.424 (1.144-3.459), 1.752±0.250 (1.200-2.616) respectively, while in total samples was 2.030±0.141 (1.144-3.778) (table1, figures 1-5).

All these levels of Pb were higher than the maximum acceptable limits (ppm) recommended by different authorities and agencies such as CIFA (1992) as 0.35 in canned fish; FAO/WHO (1992) as 0.5 in fish, EC (2001) as 0.2 in canned fish, IAEA-407 (Wyse *et al.*, 2003) as 0.12; EOS (2005) as 0.1 mg/kg and EC (2006) as 0.3 mg/kg. So, consumption of large amounts of these canned tuna for long time can cause adverse health effects in the consumers.

Lead values (mg/kg wet weight) recorded in this study in examined canned tuna were higher than that reported by other literatures as 0.18-0.40 in Libya (Voegborlo *et al.*, 1999), 1.985 in Egypt (Abdelgwad 2003); 0.0-0.03 in USA (Ikem and Egiebor, 2005), 0.002-0.84 in Saudi Arabia (Ashraf, 2006), 0.076-0.314 in Turkey (Celik and Oehlenschlager, 2007), 0.09-0.40 in Turkey (Tuzen, 2007), 0.329-0.537 (average 0.337) in Egypt (Ahdy *et al.*, 2009), 0.007-0.51 (average 0.0746) in Iran (Zarei *et al.*, 2010), 0.06 in Italy (Storelli *et al.*, 2010), 0.15 in Iran (Ganjavi *et al.*, 2010), 0.11-0.30 in Iran (Malakootian *et al.*, 2011), 0.09-0.45 in Turkey (Mol, 2011), 0.011-0.089 in India (Canadian and Indian made tuna) (Mahalakshmi *et al.*, 2012), 0.011 in Canadian canned tuna and 0.089 in Indian canned tuna (Kumar *et al.*, 2013), 0.127 in Egypt (Morshady *et al.*, 2013), 0.016-0.310 (average 0.162) in canned skipjack Tuna Fish (Sika *et al.*, 2014), 0.01-0.242 in Tabriz (Iran) (Pourjafar *et al.*, 2014), 0.01-0.27 (average 0.13) in one brand and 0.02-0.44 (average 0.19) in the other brand in Egypt (Saad *et al.*, 2014), 0.346 in India (Dhaneesh *et al.*, 2014), 0.03-0.60 (average 0.239) in canned skipjack tuna in Libya (Abolghait and Garbaj, 2015), 0.0043-0.0856 (average 0.0201) in Morocco (Adil *et al.*, 2015) and <0.001-0.010 in Italy (Pappalardo *et al.*, 2017).

The estimated weekly intake (µg/kg bw/week) values for Pb in this study in the examined canned tuna from the five brands were as following 6.944, 9.037, 6.314, 7.105 and 6.132 respectively (table 4). These estimated values were lower than that recommended by FAO/WHO (2003, 2011); WHO (2000, 2006) as 25 µg/kg bw/week. The provisional tolerable intake for Pb is suggested as 3 mg/kg by FAO and WHO while The maximum level of lead in the food that admitted to children or babies is 200 µg/kg (CIFA, 1992).. For children under 6 years or pregnant or nursing women, consumption of one can per week do not induce a problem for them (Zhou *et al.*, 1998).

The high levels of Pb in these examined tuna may be attributed to the contamination of fish as a result of increased mining activities, discharges of wastes either industrial or agricultural into the water streams. These high levels of Pb when consumed for long time can lead to severe adverse effects to the consumers.

As Pb causes many health hazards, inorganic Pb compounds have been classified as carcinogenic for group 2A humans (related mainly to the stomach cancer) while Pb classified as carcinogenic for group 2B humans (IARC, 2014).

[2] Cadmium: Cd concentrations (ppm) in all examined canned tuna samples in the five brands were 0.617±0.04 (0.467-0.696), 0.681±0.043 (0.536-0.778), 0.615±0.041 (0.516-0.720), 0.651±0.053 (0.519-0.747), 0.701±0.038 (0.561-0.792) respectively, while in total samples was 0.653±0.019 (0.467-0.792) (table1, figures 1-5). All these concentrations of Cd were higher than the maximum acceptable limits (ppm) recommended by different authorities and agencies such as FAO/WHO (1992) as 0.5 in fish, EOSQC (1993) as 0.1 in fish, IAEA-407 (Wyse *et al.*, 2003) as 0.19 and EC (2006) as 0.1. From these obtained results, eating more of this type of canned tuna can result in health problems in human.

The estimated weekly intake (µg/kg BW/week) for Cd in this study in the examined canned tuna from the five brands were as following 2.163, 2.387, 2.156, 2.282 and 2.457 respectively (table 4). These estimated values were lower than that permitted by FAO/WHO (2003, 2011) as 7 and CAC (2012) and FAO/WHO (2013) as 5.33 µg/kg bw/week.

Cd values (mg/kg wet weight) in this study in examined canned tuna were higher than that reported by other literatures as 0.09-0.32 (with average 0.18) in Libya (Voeghorlo *et al.*, 1999), 0.0046–0.0720 (0.022) in canned tuna fish in Iran (Emami-Khansari *et al.*, 2005), 0.0-0.05 in canned fish (Ikem and Egiebor, 2005), 0.16 (0.08-0.66) in Saudi Arabia (Ashraf, 2006), 0.025-0.494 in Turkey (Celik and Oehlenschlager, 2007), 0.06-0.25 from Turkey (Tuzen, 2007), 0.169-0.181 (average 0.173) in Egypt (Ahdy *et al.*, 2009), 0.002-0.070 (0.0246) in Iran (Zarei *et al.*, 2010), 0.04 in Italy (Storelli *et al.*, 2010), 0.01-0.02 in Turkey (Mol, 2011), 0.05 to 0.16 (0.3519) in Iran (Malakootian *et al.*, 2011), <0.001 in Ghana (Boadi *et al.*, 2011), 0.020-0.025 in canned tuna fish in India (Canadian and Indian made tuna)(Mahalakshmi *et al.*, 2012), 0.020 in Canadian canned tuna and 0.025 in Indian canned tuna (Kumar *et al.*, 2013), 0.022 in Egypt (Morshdy *et al.*, 2013), 0.002-0.0.092 (0.015) in canned skipjack Tuna Fish (Sika *et al.*, 2014), 0.03-0.12 in Tehran (Iran) (Fathabad *et al.*, 2015), 0.079 (0.01-0.19) in canned skipjack tuna (Abolghait and Garbaj, 2015), 0.0032-0.0834 (0.0295) in Morocco

(Adil *et al.,* 2015); and 0.010-0.060 for canned tuna with olive oil in Italy and <0.003-0.030 in canned tuna with brine (Pappalardo *et al.,* 2017).

High Cd concentration in the water sediments is reflected in Cd content of prey (Eisler, 2010). Biomagnification of Cd in muscle of predator fish such as skipjack (average concentration 0.23 mg/kg dw) is depending on the function of the trophic position (Ruelas-Inzunza *et al.,* 2014). Cd occurs naturally at low levels in the environment. Industrial processes can increase the concentration of Cd in the environment (Ahmed *et al.,* 2015).

Cd accumulated in the human tissues can induce infertility, skeletal damage, renal dysfunction and lung fibrosis (ATSDR, 2012). Cd is classified as carcinogen for group 1 humans especially for cancers in kidneys, prostate, pancreas, bladder and lung (IARC, 2014).

[3] Aluminum: Al concentrations (ppm) in all examined canned tuna in the five brands were 3.545±0.017 (3.510-3.605), 3.707±0.058 (3.500-3.858), 3.525±0.125 (3.152-3.938), 3.676±0.044 (3.524-3.799), 3.635±0.159 (3.074-4.049) respectively, while in total samples was 3.617±0.042 (3.074-4.049) (table1, figures 1-5). These results were lower than that mentioned by WHO (1989), FAO/WHO (1989) as they set a limit of 60 mg per day is the MPL for Al; and Demirel *et al.* (2008) who found Al level in some foods as 15 mg/kg.

The Al values (mg/kg wet weight) recorded in this study in examined canned were higher than that reported by other literatures as Mahalakshmi *et al.* (2012) who found Al content in examined canned tuna fish in India (Canadian and Indian made tuna) was (1.806 to 3.161 µg/g), Kumar *et al.* (2013) found that Al level (µg/g) was 1.806 in Canadian canned tuna and 3.161 in Indian canned tuna, while Dhaneesh *et al.* (2014) found Al content in different types of canned tuna in India was 15.96 ± 0.625 ug/g, while in muscles of fresh fish was 10.69 ± 0.498 ug/g. Al content in canned fish samples from Tehran (Iran) were (µg/g) 0.49-2.15 (Fathabad *et al.,* 2015), 0.032–5.346 µg/g wet weight in fish fillets baked and grilled in Al foil (Ranau *et al.,* 2001), Turkmen *et al.* (2005), Al content was 0.02-5.41 µg/g dry weight in fish species from Iskenderum Bey, northern east Mediterranean sea, Turkey.

The estimated weekly intake (µg/kg bw/week) values for Al in this study in the samples examined canned tuna from the five brands were as following 12.411, 12.978, 12.341, 12.866 and 12.726 respectively (table 4). These estimated values were lower than that permitted by WHO (1989) as the maximum acceptable weekly intake is 420 mg.

[4] Mercury: Mercury contents (ppm) in examined canned tuna in the five brands were 6.640±0.075 (6.385-6.807), 5.105±0.025 (5.039-5.171), 6.823±0.077 (6.611-7.035), 2.948±0.120 (2.615-3.281), 1.745±0.156 (1.301-2.189) respectively, while in total samples was 4.652±0.413 (1.301-7.035) (table1, figures 1-5). All these concentrations of Hg were higher than the maximum acceptable limits (ppm) recommended by different authorities and agencies such as CIFA (1992) as 0.5 in canned fish, EU (2005) as 0.5 and EC (2006) as 1 in fish. High Hg content in these examined canned tuna can represent a risk health effects for the consumers if eaten for long periods.

Hg values (mg/kg wet weight) recorded in this study in examined canned were higher than that reported by other literatures as 0.29 (0.20-0.66) tuna in Libya (Voegborlo *et al.,* 1999), 0.0430-0.253 in Iran (Khansari *et al.,* 2005), 0.18-0.86 in Saudi Arabia (Ashraf, 2006), 0.01-0.24 in canned fish (Islam *et al.,* 2010), 0.102-0.400 in Ghana (Boadi *et al.,* 2011), 0.06- 0.30 in Turkish canned tuna (Mol, 2011), 0.26 in Mexico (Ruelas-Inzunza *et al.,* 2011), 0.023-0.529 (0.146) in Iran (Rahimi and Behzadnia, 2011), 0.60 in Canadian canned tuna and 0.62 µg/g in Indian made canned tuna (Mahalakshmi *et al.,* 2012), 0.60 in Canadian canned tuna and 0.62 in Indian canned tuna (Kumar et al., 2013), 0.1-0.205 in Tabriz (Iran) (Pourjafar *et al.,* 2014), 0.09-1.02 (0.49) in brand A and 0.13-1.25 (0.57) in the brand B (Saad *et al.,* 2014), 0.085 in different types of canned tuna in India (Dhaneesh *et al.,* 2014), 0.03-0.12 in different brands of canned tuna (Fathabad *et al.,* 2015), 0.373 (0.08-0.75) (Abolghait and Garbaj, 2015), 0.0378- 0.5243 (0.2087) (Adil *et al.,* 2015), 0.170-0.240 incanned tuna with olive oil and 0.060-0.480 in canned tuna with brine in Italy (Pappalardo *et al.,* 2017).

The estimated weekly intake (µg/kg BW/week) for Hg in this study in the samples examined canned tuna from the five brands were as following 23.240, 17.871, 23.898, 10.318 and 6.118 respectively. These estimated values were higher than that permitted by FAO/WHO (2003) as 5 and CAC (2012) as 4 µg/kg bw/week.

All the examined tuna samples showed that Hg levels were higher than acceptable limit as o.5 mg/kg (FAO, 1983 and EU, 2005). These levels of Hg can result in effects on the kidneys and on the developing fetus. Mercury is categorized as a possible human carcinogen (Occupational Safety and Health Administration, 2004).

Canned tuna consists of large species of tuna (e.g. albacore and yellowfin tuna), contains moderate amounts of Hg, whereas, canned tuna consists of smaller species (e.g. skipjack), contains around one-third the Hg level of albacore and yellowfin tuna (Bratt, 2010). In heavily polluted marine areas the concentrations of Hg in the muscle of the fish is above the permissible limits for human consumption and accompanied with severe health disorders (Denton and Burdon-Jones, 1986; Chen *et al.*, 2014). Kehrig *et al.* (1998), Havelková *et al.* (2008) and Farkas *et al.* (2003) recorded that metals concentration in fish muscle can be detected in areas with low or absent sources of pollution.

[5] Nickel: Nickel concentrations (ppm) in all examined canned tuna in the five brands were 2.035±0.148 (1.444-2.202), 1.948±0.155 (1.375-2.302), 1.924±0.159 (1.531-2.250), 1.906±0.215 (1.384-2.352), 1.957±0.127 (1.548-2.283) respectively, while in total samples was 1.954±0.067 (1.384-2.352) (table1, figures 1-5). All these concentrations of Ni were higher than the maximum acceptable limits (ppm) recommended by different authorities and agencies such as IAEA-407 (Wyse *et al.,* 2003) as 0.6 and WHO (2008) as 0.5-0.6 in fish, while lower than that permitted by USEPA (2002) as 1 ppm, but lower than that proposed by FAO (1983) as the MPL of Ni in fish species is about 10 mg/kg.

The Ni values (mg/kg wet weight) recorded in this study in examined canned were higher than that reported by other literatures as 0.0–0.78 in canned fish (Ikem and Egiebor, 2005), 0.09-0.48 mg/kg (0.16) in Saudi Arabia (Ashraf, 2006), 0.36 in USA, 0.26 in Thailand, and 0.12 in Korea (Islam *et al.*, 2010), 0.0-0.78 in canned fish (Morgano et al., 2011), 0.50-0.85 in canned fish from Turkey (Tuzen, 2007), 0.992-1.236 in examined canned tuna fish market in Egypt (Ahdy *et al.,* 2009), was 0.04-3.26 in Nigeria (Iwegbue *et al.,* 2009), 0.0.271-2.600 in Egypt (El-Sadaawy *et al.*, 2011), 0.14-0.7 (0.24) in southern of Iran (Malakootian *et al.,* 2011), 0.065 in India (Dhaneesh *et al.*, 2014), 0.113-0.589 in Tabriz (Iran)(Pourjafar *et al.*, 2014), 0.18-0.35 (dw) in tuna fish muscles (Ahmed *et al.*, 2015), 0.58-1.04 in canned fish from Tehran (Iran) (Fathabad *et al.,* 2015), 0.14-0.37 in Iran (Hosseini *et al.,* 2015) and 0.14-0.37 (0.22) in Iran (Sobhanardakani *et al.,* 2018).

The estimated weekly intake (µg/kg BW/week) values for Ni in this study in the samples examined canned tuna from the five brands were as following 7.126, 6.818, 6.734, 6.545 and 6.853 respectively (table 4). These estimated values were lower than that permitted by WHO (1992) as the maximum acceptable weekly intake is 700-2100 µg/kg bw. The EDI (µg/kg/day) is lower than that set by WHO (1992) as MPL is 100-300. WHO recommends 100–300 µg Ni for daily intake (WHO, 1994). The upper tolerable intake level of nickel for children (1–3 years old) and males/females (19–70 years old) is 7 and 40 mg/day, respectively (Institute of Medicine, 2003). It is reported that maximum nickel level in some food samples is 0.2 mg/kg (Muchuweti *et al.*, 2006; Tuzen, 2009).

Nickel content in the examined samples in this study is higher than that recorded by Hussein and Khaled (2014) as they found Ni content 0.37 mg/ kg in muscle in tuna fish in the three locations in Egypt.

Nickel is essential for reproduction and normal growth in animals and human beings. Ni showed carcinogenic effect when taken in high amount (Malik *et al.,* 2010). Major sources of Ni in humans are processed food and uptake from natural resources (Cronin *et al.,* 1998). In the environment, Ni is normally found at very low levels. In high concentrations it can result in pulmonary adverse effects, such as lung inflammation, fibrosis, emphysema, and tumors (Forti *et al.*, 2011). Nickel can accumulate in tuna tissue. Ni can cause respiratory difficulties, nervous and digestive disorders, psychological problems, and also it is carcinogenic (Ikem and Egiebor, 2005; Ashraf *et al.,* 2006). Ni acute toxicity arises from competitive interaction with five major essential elements such as copper, calcium, iron, cobalt and zinc (Moore and Ramamoorthy, 1984).

[6] Cobalt: Co content (ppm) in examined canned tuna samples in the five brands were 1.322±0.149 (0.765-1.656), 1.757±0.082 (1.515-1.957), 2.089±0.165 (1.607-2.525), 2.511±0.123 (2.160-2.785), 2.719±0.110 2.381-3.072) respectively, while in total samples was 2.080±0.16 (0.765-3.072) (table1, figures 1-5).

The Co values (mg/kg wet weight) recorded in this study in examined canned were higher than that reported by other literatures as documented in Masan Bay with an average of 0.01µg/g (Kwon and Lee 2001), Topcuoglu *et al.* (2002) reported concentrations of cobalt with a range <0.05- 0.40 µg/g in the black Sea coast, Suresh *et al.* (2007) recorded Co with a range of 0.05-0.28 µg/g in Parangipettai coast of India, Ozparlak *et al.* (2012) found that Co content in muscles of fish from Beysehir Lake, Turkey was 2.68 mg/kg, Dhaneesh *et al.* (2014) found that Co content in different types of canned tuna in India was 0.173 ± 0.011 ug/g, while in muscles of fresh fish was 0.009 ± 0.006 ug/g, Javed and Usmani (2016) found that Co content in fish in India was 9.06 mg/kg, Zaqoot *et al.* (2017) found that Co content (µg/g wet weight) in fish collected from Gaza fishing harbor in the Mediterranean sea along Gaza coast, Palestine was nd-2.93 (average 0.68) and in muscles of fish from selected rivers in district Charsadda, Pakistan was 0.23-0.25 (mg/kg ww) (Idrees *et al.,* 2017).

The estimated weekly intake (µg/kg BW/week) values for Co in this study in the samples examined canned tuna from the five brands were as following 4.627, 6.153, 7.313, 8.792 and 9.520 respectively (table 4). These estimated values were lower than that permitted by NRC (1989) as the maximum acceptable weekly intake is 420 µg/kg bw.

Cobalt is an essential important element for many enzymes and vitamins such as vitamin B_{12}. When the consumer exposed to high levels of Co from cardiac, pulmonary and skin effects (ATSDR, 2004).

[6] Chromium: Chromium concentrations (ppm) in all examined canned tuna samples in the five brands were 0.246±0.100 (0.000-0.573), 0.039±0.03 (0.000-0.156), ND, ND, 0.030±0.023 (0.000-0.120) respectively, while in total samples was 0.063±0.027 (ND-0.573) (table1, figures 1-5). All these concentrations of Cr were lower than the maximum acceptable limits (ppm) recommended by different authorities and agencies such as WHO (1996) which sets that the total concentrations of Cr have been found in fish to range from 0.01-1.3 µg/g; USEPA (2002) as 8, IAEA-407 (Wyse *et al.,* 2003) as 0.73 and WHO (2006) as 0.2 in fish.

The Cr values (mg/kg wet weight) recorded in this study in examined canned were higher than that reported by other literatures as in the USA was 0.0–0.30 µg/g (Ikem and Egiebor, 2005). Cr content was 0.38 (0.10-0.57) in canned tuna in Saudi Arabia (Ashraf, 2006), 0.97-1.70 in canned fish in Turkey (Tuzen and Soylak, 2007), 9.322-10.022 (average 9.689) in canned tuna in Egypt (Ahdy *et al.,* 2009), 0.02 in canned tuna in Nigeria (Iwegbue *et al.,* 2009), 0.09-1.32 in canned fish (Islam *et al.,* 2010), Islam *et al.* (2010) reported that Cr (µg/g, DW) in canned longtail tuna which was imported from the USA, canned bluefin tuna which was imported from the Thailand and canned bluefin tuna (produced in Korea) were 0.58, 0.32 and 0.25; El-Sadaawy *et al.* (2011) when examined canned tuna fish market in Egypt found that Cr was 0.186-0.322 (average 0.251) µg/g wet weight, while was 0.65-3.24 (2.66 µg/g wet weight) in canned tuna fish in Iran (Sobhanardakani *et al.,* 2018). 0.245 in canned tuna in India (Dhaneesh *et al.,* 2014), 0.90-1.87 µg/g in canned fish from Tehran (Iran) (Fathabad *et al.,* 2015), 1.65-3.24 µg/g in canned fish in Iran (Hosseini *et al.,* 2015), 0.0–0.30 µg/g in canned fish (Ulouzlu *et al.,* 2007, Guerin *et al.,* 2011, Morgano *et al.,* 2011).

The estimated weekly intake (µg/kg BW/week) values for Cr in this study in the samples examined canned tuna from the five brands were as following 0.861, 0.140, NE, NE and 0.105 respectively (table 4). These estimated values were lower than that permitted by NRC (1989) as the maximum acceptable weekly intake is 420 µg/kg bw.

Sobhanardakani *et al.* (2018) reported that the average HRI values for adults and children were 1.23E-04 and 5.73E-04 respectively, and therefore, the non-carcinogenic risks for children are greater than adults. In this regard, Hussein and Khaled (2014) reported that the from the human health point of view, Cr, Cu, and Mn, THQ values were less than 1 and show a situation of no risk for the consumer of the investigated tuna species collected from the Alexandria, Egypt. Ordiano-Flores *et al.* (2011) reported that the estimated THQ values of Hg were <1 in each population group (children and adults) due to consumption of yellowfin tuna collected from the Eastern Pacific Ocean.

Chromium (III) is an essential nutrient that helps the body use sugar, protein, and fat but Cr (VI) is carcinogenic (Institute of Medicine, 2003, Ikem and Egiebor, 2005; Tuzen and Soylak, 2006). Excessive amount of Cr (III) may cause adverse health effects (ATDSR, 2004). Chronic exposure to Cr causes damage to the liver, kidney, circulatory and nerve disorders, as well as skin irritation (Kabata-Pendias, 2010). The US National Research Council recommended daily amount of Cr as 60 µg/day for a 70 kg person (NRC, 1989).

Fish can be contaminated by toxic metals during fish growth, transportation, and storage (Ikem and Egiebor, 2005; Fong *et al.,* 2006). Normally, some factors can affect in the accumulation of pollutants like metals in tissues of fish such as concentration of pollutant in water, chemistry of water in it fish live (such as salinity, pH, hardness, and total dissolved solids), feeding habit of fish, duration of exposure of fish to these pollutants as well as contamination of fish during processing, handling, canning and quality of coating of cans and storage place of fish and cans (Tahán *et al.,* 1995; Hosseini *et al.,* 2013). Fish can accumulate large amounts of heavy metals in gills, liver and muscular tissues (Sobhanardakani *et al.,* 2012) which results in health troubles to fish and consumer (Burger and Gochfeld, 2005).

In this study, the Target Health Quotient (THQ) in the total examined tuna samples was 0.219-0.323 (0.254) for Pb, 0.308-0.351 (0.327) for Cd, 0.00176-0.00185 (0.00181) for Al, 2.913-11.380

(7.757) for Hg, 0.047-0.051 (0.049) for Ni, 0.033-0.049 (0.052) for Co and 0.00001-0.000082 (0.000035) for Cr.

The investigated canned tuna showed that the Hazard Health Index (HI) for brand 1 was 11.709, for brand 2 was 9.268, for brand 3 was 12.015, for brand 4 was 5.604, for brand 5 was 3.601, all of these are exceeding 1. HI exceeding 1 indicates that the metals are toxic and present a hazard to human health (Li *et al.*, 2013).

The difference in concentration of estimated heavy metals in examined tuna may return to the difference sites of rearing, season of catching, sex of fish, age of fish as well as to the length and weight of fish used in preparing of these canned tuna (Kagi and Schaffer, 1998; Agusa *et al.,* 2005 and De Marco *et al.,* 2006).

From these reported results in this study, consumption of these canned tuna represent adverse health problems for the consumers especially for children and elders who are immunological exhausted. Target hazard quotient (THQ) and hazard health index (HI) proposed by USEPA (2015) are parameters for risk assessment which compare the ingestion amount of a pollutant with a standard reference dose and have been widely used in the risk assessment of metals in contaminated foods. The HI value has been recognized as one of the reasonable parameters for the risk assessment of metals associated with the consumption of contaminated fish (Li *et al.,* 2013). A HI below 1 means the exposed population is unlikely to experience obvious adverse effects; whereas a HI above 1 means that there is a chance of harmful effects, with an increasing probability as the value increases (Saha and Zaman, 2012). Storelli (2008) found that THQs for Hg, Cd, and Pb in fish from the Adriatic Sea as of Pb (0.002-0.18), Cd (0.01-0.04) and and Hg (0.08-1.87). Copat *et al.* (2013) estimated the THQ of metals consumed in fish and shellfish from the eastern Mediterranean Sea, and reported that the THQ values for Cd, Cr and Ni were all below 1. Values for THQ<1 were also reported for Cu, Cd, Pb, Hg and Cr in fish from the Eastern Aegean Sea (Yabanli and Alparslan, 2015).

CONCLUSION

Potential health risk assessments based on PTWI values, EDI, and THQ indicated that the intakes of metals by consuming these fish species do not result in an appreciable hazard risk for the human body. The HI calculated was higher than 1 for all the species. However, the results indicate that the high concentrations of Pb, Cd, Al and Hg in fish are alarming and do present an appreciable hazard risk to human health. Regular monitoring for the heavy metals especially Hg contamination in fish and fishery products is important to protect susceptible vulnerable population such as children, pregnant females and elders.

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محتوى المعادن الثقيلة في أسماك التونة المعلبة التي يتم تسويقها في مدينة أسيوط ، مصر وما يتصل بها من تقييمات لمخاطر صحة الإنسان

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الهدف: بعض المعادن الثقيلة ضارة وخطيرة وتسبب الكثير من المخاطر على الغذاء والصحة العامة. يمكن أن تتراكم المعادن الثقيلة في الأسماك. قد تتلوث أسماك التونة بكميات كبيرة من هذه المعادن التي تأتي من الماء أو أثناء النقل أو المعالجة أو التعليب. أجريت الدراسة الحالية لقياس تركيز بعض المعادن الثقيلة (Pb ، Cd، Al، Hg، Ni، Co، Cr) في سمك التونة المعلب من خمس علامات تجارية.

المواد والطرق: تم فحص ٣٥ عينة من سمك التونة المعلب من خمس علامات تجارية لتحديد تركيز المعدن فيها. تم جمع العينات من محلات السوبر ماركت الموجودة في مدينة أسيوط (مصر) من يونيو ٢٠١٧ إلى نوفمبر ٢٠١٧. تم تحديد المعادن باستخدام مقياس الامتصاص الذري Perkin Elymer (Analyst 400)لـ Pb و Cd و Co و Ni و Cr بينما تم تقدير Hg باستخدام ICP (iCAP 6200) و Al باستخدام مطياف الامتصاص الذري (ZEEnit700P).

النتائج: كشفت نتائج التحليل أن مستويات (جزء في المليون للوزن الرطب) من المعادن كانت في العلامات التجارية الخمس على النحو التالي: ١- الرصاص: ١,٩٨٤±٠,١٥٦ (١,٣٧٨-٢,٢٥٦)، ٢,٥٨١±٠,٤٠١ (١,٣٠٥-٣,٧٧٨)، ١,٨٠٤±٠,٢٤٤ (١,١٩٠-٢,٤٢٥)، ٢,٠٣٠±٠,٤٢٤ (١,١٤٤-٣,٤٥٩)، ١,٧٥٢±٠,٢٥٠ (١,٢٠٠-٢,٦١٦) بينما في جميع العينات كانت النسب ٢,٠٣٠±٠,١٤١ (١,١٤٤-٣,٧٧٨). ٢- الكادميوم: ٠,٦١٧±٠,٠٤ (٠,٤٦٧-٠,٦٩٦)، ٠,٦٨١±٠,٠٤٣ (٠,٥٣٦-٠,٧٧٨), ٠,٦١٥±٠,٠٤١ (٠,٥١٦-٠,٧٢٠), ٠,٦٥١±٠,٠٥٣ (٠,٥١٩-٠,٧٤٧), ٠,٧٠١±٠,٠٣٨ (٠,٥٦١-٠,٧٩٢) بينما في جميع العينات كانت النسب ٠,٦٥٣±٠,٠١٩ (٠,٤٦٧-٠,٧٩٢). ٣- الالومنيوم: ٣,٥٤٥±٠,٠١٧ (٣,٥١٣-٣,٦٠٥)، ٣,٧٠٧±٠,٠٥٨ (٣,٥٠٠-٣,٨٥٨)، ٣,٥٢٥±٠,١٢٥ (٣,١٥٢-٣,٩٣٨)، ٣,٦٧٦±٠,٠٤٤ (٣,٥٢٤-٣,٧٩٩)، ٣,٦٣٥±٠,١٥٩ (٣,٠٧٤-٤,٠٤٩), بينما في جميع العينات كانت النسب ٣,٦١٧±٠,٠٤٢ (٣,٠٧٤-٤,٠٤٩). ٤- الزئبق: ٦,٦٤٠±٠,٠٧٥ (٦,٣٨٥-٦,٨٠٧)، ٥,١٠٥±٠,٠٢٥ (٥,٠٣٩-٥,١٧١), ٦,٨٢٣±٠,٠٧٧ (٦,٦١١-٧,٠٣٥)، ٢,٩٤٨±٠,١٢٠ (٢,٦١٥-٣,٢٨١)، ١,٧٤٥±٠,١٥٦ (١,٣٠١-٢,١٨٩)، بينما في جميع العينات كانت النسب ٤,٦٥٢±٠,٤١٣ (١,٣٠١-٧,٠٣٥). ٥- النيكل: ٢,٠٣٥±٠,١٤٨ (١,٤٤٤-٢,٢٠٢)، ١,٩٤٨±٠,١٥٥ (١,٣٧٥-٢,٣٠٢)، ١,٩٢٤±٠,١٥٩ (١,٥٣١-٢,٢٥٠)، ١,٩٠٦±٠,٢١٥ (١,٣٨٤-٢,٣٥٢)، ١,٩٥٧±٠,١٢٧ (١,٥٤٨-٢,٢٨٣)، بينما في جميع العينات كانت النسب ١,٩٥٤±٠,٠٦٧ (١,٣٨٤-٢,٣٥٢). ٦- الكوبلت: ١,٣٢٢±٠,١٤٩ (٠,٧٦٥-١,٦٥٦)، ١,٧٥٧±٠,٠٨٢ (١,٥١٥-١,٩٥٧)، ٢,٠٨٩±٠,١٦٥ (١,٦٠٧-٢,٥٢٥)، ٢,٥١١±٠,١٢٣ (٢,١٦٠-٢,٧٨٥)، ٢,٧١٩±٠,١١٠ (٢,٣٨١-٣,٠٧٢)، بينما في جميع العينات كانت النسب ٢,٠٨٠±٠,١٦ (٠,٧٦٥-٣,٠٧٢). ٧-الكروم: ٠,٢٤٦±٠,١٠٠ (٠,٠٠٠-٠,٥٧٣)، ٠,٠٣٩±٠,٠٣ (٠,٠٠٠-٠,١٥٦)، غير ملحوظ ، غير ملحوظ ، ٠,٠٣٠±٠,٠٢٣ (٠,٠٠٠-٠,١٢٠)، بينما في جميع العينات كانت النسب ٠,٠٦٣±٠,٠٢٧ (غير ملحوظـ٠,٥٧٣). في هذه الدراسة ، كان مجموع الصحة المستهدفة (THQ) في إجمالي عينات التونة التي تم فحصها ٠,٢١٩-٠,٣٢٣ (٠,٢٥٤) للرصاص ، ٠,٣٠٨-٠,٣٥١ (٠,٣٢٧) للكادميوم ، ٠,٠٠١٧٦-٠,٠٠١٨٥ (٠,٠٠١٨١) للالومنيوم ، ٢,٩١٣-١١,٣٨٠ (٧,٧٥٧) للزئبق ، ٠,٠٤٧-٠,٠٥١ (٠,٠٤٩) للنيكل ، ٠,٠٣٣-٠,٠٤٩ (٠,٠٥٢) للنحاس ، و ٠,٠٠٠٠١-٠,٠٠٠٠٨٢ (٠,٠٠٠٠٣٥) للكروم بينما كان مؤشر المخاطر الصحية لجميع المعادن كالتالي: ١١,٧٠٩ للعلامة التجارية الاولي ، ١,٩٢٦٨ للعلامة التجارية الثانية ، ١٢,٠١٥ للعلامة التجارية الثالثة ، ٥,٦٠٤ للعلامة التجارية الرابعة ، ٣,٦٠١ للعلامة التجارية الخامسة ، جميعهم تعدي الواحد الصحيح.

الخلاصة: في هذه الدراسة تجاوز مؤشر الخطر المحسوب (HI) في جميع التونة المعلبة المدروسة في جميع العلامات التجارية. وتشير البيانات إلى أن التونة المعلبة المدروسة ملوثة بالـ Pb و Cd و Al و Hg و .Ni كما تشير مؤشرات المخاطر للمعادن المقدرة في هذه التونة المعلبة إلى أن الإفراط في تناول هذه التونة كميات كبيرة وبشكل مستمر يمكن أن يؤدي إلى آثار صحية ضارة ومزمنة على المستهلكين.

التوصية: أوصت بإجراء مزيد من الدراسات الخاصة بتقييمات مراقبة الجودة للمساعدة في حماية المستهلكين الاصحاء.