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Health risk assessment of heavy metals in food products from Iran (Case Study: Shushtar City)

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A B S T R A C T

Heavy metals have toxic effects, pathogenic, carcinogenicity and genetic mutations on human health. The aim of this study was to determine the health risk assessment of heavy metals in 24 food products of some commercial canned samples from Shushtar city (Khuzestan province). From each product, 6 samples were randomly prepared in 2019. The highest amount of Pb was obtained in vegetable stew canned 0.47 ± 0.005 mg/kg ($p < 0.05$). Also, the highest amount of As was observed in canned sweet com 0.20 ± 0.006 mg/kg ($p < 0.05$). The average amount of Hg was present only in canned fish roe. The range of Cd was 0.01-0.01 mg/kg. The highest and lowest levels of Fe in potato stew canned and canned fish roe were 4.61 ± 0.12 and 0.09 ± 0.05 mg/kg, respectively ($p < 0.05$). The highest amount of Sn in canned mushroom was 7.14 ± 0.05 mg/kg and the lowest amount of this metal was in potato stew canned and canned fish roe 0.10±0.002 mg/kg ($p < 0.05$). The highest levels of Zn and Cu were 0.44 ± 0.03 and 1.77 ± 0.08 mg/kg in canned potato stew and canned broth peas ($p < 0.05$). The amount of metals studied in food products was lower than the allowable threshold of national and international standards. The carcinogenic risk of mercury, lead, cadmium and arsenic in food samples was lower than 10^{-4}. According to the results, it seems that the consumption of food products does not pose a problem for consumers.

Keywords: Hazard quotient; Health food; Health risk assessment; Heavy metals pollution

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1. Introduction

Accumulation of toxins in food, water, land and air is one of the current and dangerous discussions of toxins for environmental and human health (Fiamegos et al., 2016). One of the main ways of absorbing and exposing heavy metals is through food (Hashemi et al., 2017). Toxicology of heavy metals and toxic elements in food is very important (Onwuka et al., 2019). Foods contain a wide range of metallic elements (metals) such as sodium, potassium, iron, calcium, cobalt, magnesium, selenium, copper and zinc. These elements are essential in small amounts to maintain cellular processes (Sobhanardakani, 2018). Other metal elements have no functional effect on the body and can be harmful to health if consumed with foods containing them regularly in the diet. Most metals are natural components of the earth's crust. Metals and other elements can be present naturally in food or enter food as a result of human activities such as industrial and agricultural processes (Mansour, 2014; Romero et al., 2022).

Absorption and intake of heavy metals in high concentrations through the consumption of foods such as vegetables, canned products and fruits may lead to accumulation and chronic effects which in turn can cause complications in the heart, Nerves, liver, kidneys, blood, lungs, bones and spleen such as mutagenesis and carcinogenesis (Massadeh & Al-Massadeh, 2018). Numerous cases of human diseases, disorders, deformities and limb fractures due to heavy metal poisoning have also been reported (Ghasemi Dehkordi et al., 2018; Parkar & Rakesh, 2018) Among the heavy metals lead, arsenic, mercury, cadmium and tin can be considered as major threats to human health (Shahsavani et al., 2017; Fakhri et al., 2018). Mercury is one of the most dangerous heavy metals that affect the brain, spinal cord and central nervous system. This metal is highly toxic and exists in the form of organic and inorganic compounds in the environment (Akan et al., 2013). Accumulation

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of the heavy metals lead and cadmium can cause skeletal damage, cancer, reproductive defects, brain damage, kidney function and poisoning. These metals are also toxic and have no metabolic or biological role in the body of living organisms (Ademoroti, 1994; Ahmadi & Ziarati, 2015). Arsenic also has dangerous effects on the human body such as hematological, skin, gastrointestinal, respiratory, neurological, cardiovascular, reproductive, carcinogenic and mutagenic changes (Anwar et al., 2015; Eleboudy et al., 2016). Tin, as a hazardous and toxic substance, is on the list of hazardous substances in the world's safety and environmental organizations that can enter food through cans that do not have a proper inner coating and threaten the health of the consumer. There may be some tin in the consumption of food stored in cans, which high levels of tin can corrode and destroy the can (Tarley et al., 2001). An important source of tin metal contamination in canned foods is the dyeing of cans. Over-absorption of tin may cause heartburn, diarrhea, vomiting, nausea, anemia, kidney and liver problems, and burning and itching of the eyes and skin (ATSDR, 2004).

In the case of canned food, there are risks due to the migration of heavy metals from metal packaging materials into food products (Adel et al., 2016; Jafari et al., 2018). Determination of heavy metals in food is important and necessary in terms of nutrition and food health. Also, studies of heavy metals in canned foods and comparing their amounts with the allowable limit of international standards have been done (Maduabuchi et al., 2006; Khalafalla et al., 2016; Tajik et al., 2021; Gholami-Ahangaran et al., 2021). Ghafari and Sobhanardakani (2017) investigated pollution and health hazards due to the heavy metals cadmium and lead and trace elements copper and zinc in dairy products (butter and cheese). Concentrations of heavy metals including lead, zinc, chromium, nickel, copper, arsenic and cadmium in various types of canned vegetables and fruits, including canned tomatoes, sauces (ketchup), canned green beans, canned carrots and canned water Fruit (pineapple) that entered the Jordanian market (Onwuka et al., 2019). In the other study of cadmium, mercury, tin, lead, arsenic and aluminum in 72 samples (36 samples for fruit juice and 36 samples for canned fruit) in three different brands including peach, orange, cherry and pineapple (18 samples per fruit) They evaluated the market offered in Tehran. The amounts of aluminum, tin, arsenic, cadmium, mercury and lead in fruit juices were reported to be 340.62, 72.33, 3.76, 2.12, 0.351 and 40.86 μg kg^{-1} respectively. The target hazard quotient (THQ) pattern of heavy metals was reported in adults and pediatric based on Al > Sn > As > Pb > Cd > Hg (Ebadi Fathabad et al., 2018). Vella and Attard (2019) examined the levels of trace elements and toxic elements in infant formula. Baby foods may contain toxic substances and elements that can be environmental contaminants or can be obtained from raw or processed ingredients. Tsegay et al. (2019) investigated the content of major, minor and toxic trace elements in edible and canned mushrooms in Tigray in northern Ethiopia.

The aim of this study was to determine the level of heavy metal contamination in the food products of some commercial canned samples and compare the amounts of heavy metals with the allowable limit of Iranian national standard and international standards. Also, the health risk assessment of heavy metals in food products of some commercial canned samples was another goal of this study.

2. Material and Methods

2.1. *Sampling*

In this study, the food products of some commercial canned samples from shushtar city include canned peas, canned sweet corn, canned beans, canned oyster mushrooms, canned lentils, canned pinto beans with tomato sauce, canned pinto beans with mushrooms, canned eggplant, canned Minced with potatoes, canned stewed vegetables, canned mixed vegetables, canned pea broth, canned pasta sauce with soy, pickle cabbage, port pickled, pickled garlic cloves, pickled garlic, pickled peppers, mixed pickles, shallots, pickles, olives, Canned fish roe sample was done fraternity. From each product, 6 samples were randomly prepared simultaneously from a production period in 2019.

2.2. *Measurement of heavy metals*

Wet acidic digestion method was used for chemical digestion of samples. For chemical digestion, food samples were digested in the presence of heat in the presence of concentrated nitric and hydrochloric acids. In this method, 5 g of the homogeneous sample is weighed in a 250 ml Erlenmeyer flask with a precision balance and heated with 65% nitric acid and oxygenated water on an electric heater for 2 to 3 hours to obtain a clear solution. The acid was then evaporated and diluted with deionized water (ASTM, 1994).

Atomic absorption method is used for the necessary assurance and accuracy in the analysis of heavy and toxic metals in food, because it has a high level of detection and sensitivity. Heavy metals were measured by atomic absorption spectrometry using the American-made AA420FS Varian. The accuracy of metal element detection in the atomic absorption device is ppm with flame and graphite furnace technique and ppb with generator furnace and hydride technique. Metals of cadmium, lead, tin, copper were measured by graphite furnace method and zinc by flame method. The accuracy of the obtained data was checked using the reference standard (Standard Reference Materials; SRM). To do this, first 5 different concentrations of standard heavy metals were made and after injection into the atomic absorption device, the calibration curve of the elements was drawn. The prepared samples were then injected into the device and the desired concentration was read. In order to detect mercury and arsenic by atomic absorption spectroscopy with hydride vapor, the analytic was first converted to volatile hydride element type or metallic state in mercury using sodium boron, hydride and then hydride vapors were transported to the atomizer for analysis using carrier gas. It was guided by an atomic absorption spectrometer. The atomizer is a thin T-shaped quartz tube that holds the generated vapor in front of the light spectrum for some time (Soylak et al., 2012).

2.3. *Health risk assessment*

The US Environmental Protection Agency (EPA) risk assessment guidelines were used to assess the daily uptake and risk of metals for the health of the human population consuming food products. For this purpose, the risk to human health was calculated as the potential hazard (HQ) by comparing the estimated daily intake (EDI) of each metal with its reference dose (RFD) (USEPA, 2000).

Table 1. Average metals of Pb, As, Cd and Hg (mg/kg) in food products of some commercial canned samples (Shushtar city).

Food products	Pb	As	Cd	Hg
Port pickle	0.01±0.004[a]	ND	ND	ND
Pickled garlic cloves	0.07±0.005[b]	ND	ND	ND
Pickled garlic flower	0.01±0.002[a]	0.01±0.003[a]	ND	ND
Pearl garlic pickle	ND	ND	ND	ND
Pickled pepper	0.03±0.005[c]	ND	ND	ND
Pickle cabbage	0.01±0.003[a]	ND	ND	ND
Mixed pickles	0.04±0.006[c]	0.01±0.005[a]	ND	ND
Pickled shallots	0.01±0.003[a]	0.01±0.002[a]	ND	ND
Pickled cucumber	0.41±0.005[d]	ND	ND	ND
Salted olives	ND	ND	0.04±0.005[a]	ND
Vegetable stew canned	0.47±0.005[e]	ND	ND	ND
Potato stew canned	0.30±0.006[f]	ND	ND	ND
Broad bean canned	ND	ND	ND	ND
Canned eggplant feed	0.01±0.004[a]	0.03±0.004[b]	ND	ND
Canned lentil feed	ND	ND	ND	ND
Canned pinto bean feed with tomato sauce	ND	0.02±0.005[b]		ND
Canned pinto bean feed with mushrooms	0.03±0.004[a]	0.03±0.002[b]	0.01±0.002[b]	ND
Canned sweet corn	ND	0.20±0.006[c]	ND	ND
Canned mixed vegetables	0.05±0.002[g]	0.02±0.001[b]	ND	ND
Canned pasta sauce with soy	ND	ND	ND	ND
Canned mushrooms	ND	ND	ND	ND
Canned fish roe	0.05±0.004[g]	ND	ND	0.01±0.003
Canned peas	0.01±0.004[a]	ND	ND	ND
Canned broth peas	0.04±0.002[c]	ND	0.01±0.002[b]	ND

Unnamed letters in each column showed a significant difference ($p < 0.05$). ND: The amount of metal has been immeasurable.

Table 2. Average metals of Fe, Zn, Cu and Sn (mg/kg) in food products of some commercial canned samples (Shushtar city).

Food products	Fe	Zn	Cu	Sn
Port pickle	ND	ND	ND	ND
Pickled garlic cloves	ND	ND	ND	ND
Pickled garlic flower	ND	ND	ND	ND
Pearl garlic pickle	ND	ND	ND	ND
Pickled pepper	ND	ND	ND	ND
Pickle cabbage	ND	ND	ND	ND
Mixed pickles	ND	ND	ND	ND
Pickled shallots	ND	ND	ND	ND
Pickled cucumber	ND	ND	ND	ND
Salted olives	0.33±0.06[a]	ND	ND	ND
Vegetable stew canned	3.70±0.15[b]	0.35±0.05[a]	0.26±0.04[a]	0.14±0.002[a]
Potato stew canned	4.61±0.12[b]	0.44±0.03[b]	0.51±0.03[b]	0.10±0.002[a]
Broad bean canned	1.24±0.07[c]	0.27±0.06[c]	0.50±0.07[b]	0.23±0.004[b]
Canned eggplant feed	0.27±0.05[d]	0.01±0.007[d]	0.53±0.06[b]	2.12±0.03[c]
Canned lentil feed	ND	ND	ND	0.16±0.001[a]
Canned pinto bean feed with tomato sauce	0.36±0.05[a]	0.01±0.009[d]	0.81±0.07[c]	2.91±0.04[c]
Canned pinto bean feed with mushrooms	0.36±0.03[a]	0.02±0.007[d]	0.97±0.05[d]	2.48±0.01[c]
Canned sweet corn	ND	ND	ND	ND
Canned mixed vegetables	0.58±0.04[e]	0.26±0.02[c]	0.22±0.03[a]	0.28±0.001[d]
Canned pasta sauce with soy	0.28±0.05[d]	ND	1.36±0.08[f]	3.10±0.05[c]
Canned mushrooms	ND	ND	ND	7.14±0.05[e]
Canned fish roe	0.09±0.05[f]	0.06±0.01[e]	0.12±0.02[g]	0.10±0.002[a]
Canned peas	ND	ND	ND	4.53±0.06[f]
Canned broth peas	1.17±0.09[c]	0.36±0.01[a]	1.77±0.08[f]	0.15±0.002[a]

Unnamed letters in each column showed a significant difference ($p < 0.05$). ND: The amount of metal has been immeasurable.

Table 3. Assessing the health risk of Pb in food products of some commercial canned samples (Shushtar city) for adult and children consumption.

	Adult				Children			
Food products	CDA (mg/kg/day)	HQ	CR_{kim} (g/day)	Cr	CDA (mg/kg/day)	HQ	CR_{kim} (g/day)	Cr
Port pickle	7.14×10^{-6}	0.002	24.5	6.07×10^{-6}	2×10^{-5}	0.005	8.75	1.7×10^{-5}
Pickled garlic cloves	1.92×10^{-4}	0.055	0.907	1.63×10^{-4}	5.4×10^{-4}	0.154	0.324	4.59×10^{-4}
Pickled garlic flower	7.14×10^{-6}	0.002	24.5	6.07×10^{-6}	2×10^{-5}	0.005	8.75	1.7×10^{-5}
Pickled pepper	2.14×10^{-5}	0.006	8.16	1.82×10^{-5}	6×10^{-5}	0.017	2.916	5.1×10^{-5}
Pickle cabbage	7.14×10^{-6}	0.002	24.5	6.07×10^{-6}	2×10^{-5}	0.005	8.75	1.7×10^{-5}
Mixed pickles	2.85×10^{-5}	0.008	6.125	2.42×10^{-5}	8×10^{-5}	0.022	2.187	6.8×10^{-5}
Pickled shallots	7.14×10^{-6}	0.002	24.5	6.07×10^{-6}	2×10^{-5}	0.005	8.75	1.7×10^{-5}
Pickled cucumber	2.92×10^{-4}	0.083	0.597	2.48×10^{-4}	8.2×10^{-4}	0.234	0.213	6.97×10^{-4}
Vegetable stew canned	1.10×10^{-3}	0.287	0.521	8.56×10^{-4}	2.82×10^{-3}	0.805	0.186	2.39×10^{-3}
Potato stew canned	6.42×10^{-4}	0.183	0.816	5.46×10^{-4}	1.8×10^{-3}	0.514	0.291	1.53×10^{-3}
Canned eggplant feed	2.14×10^{-5}	0.006	8.16	1.82×10^{-5}	6×10^{-5}	0.017	8.75	5.1×10^{-5}
Canned mixed vegetables	7.14×10^{-6}	0.02	4.9	6.07×10^{-5}	2×10^{-6}	0.057	1.75	1.7×10^{-4}
Canned fish roe	7.14×10^{-6}	0.02	4.9	6.07×10^{-5}	2×10^{-6}	0.057	1.75	1.7×10^{-4}
Canned pinto bean feed with mushrooms	4.28×10^{-5}	0.012	16.8	3.64×10^{-5}	1.2×10^{-4}	0.034	2.916	1.02×10^{-4}
Canned peas	5.71×10^{-5}	0.016	6.125	4.85×10^{-5}	1.6×10^{-4}	0.045	2.187	1.36×10^{-4}
Canned broth peas	1.42×10^{-5}	0.004	24.5	1.21×10^{-5}	4×10^{-5}	0.011	8.75	3.4×10^{-5}

CDA: Concentration daily intake absorption; HQ: Hazard Quotient; $CR_{kim:}$ Maximum allowable daily intake; Cr: Carcinogenic risk.

Table 4. Assessing the health risk of As in food products of some commercial canned samples (Shushtar city) for adult and children consumption.

	Adult				Children			
Food products	CDA (mg/kg/day)	HQ	CR_{kim} (g/day)	Cr	CDA (mg/kg/day)	HQ	CR_{kim} (g/day)	Cr
Pickled garlic flower	7.14×10^{-6}	0.002	21	1.07×10^{-5}	2×10^{-5}	0.006	7.5	3×10^{-5}
Mixed pickles	7.14×10^{-6}	0.002	21	1.07×10^{-5}	2×10^{-5}	0.006	7.5	3×10^{-5}
Pickled shallots	7.14×10^{-6}	0.002	21	1.07×10^{-5}	2×10^{-5}	0.006	7.5	3×10^{-5}
Canned eggplant feed	6.42×10^{-5}	0.021	7	9.64×10^{-5}	1.8×10^{-4}	0.06	2.5	2.7×10^{-4}
Canned pinto bean feed with tomato sauce	2.85×10^{-5}	0.009	10.5	4.28×10^{-5}	8×10^{-5}	0.026	3.75	1.2×10^{-4}
Canned sweet corn	2.85×10^{-4}	0.095	1.05	4.28×10^{-4}	8×10^{-4}	0.266	0.375	1.2×10^{-3}
Canned mixed vegetables	2.85×10^{-5}	0.009	10.5	4.28×10^{-5}	8×10^{-5}	0.026	3.75	1.2×10^{-5}

CDA: Concentration daily intake absorption; HQ: Hazard Quotient; $CR_{kim:}$ Maximum allowable daily intake; Cr: Carcinogenic risk.

Table 5. Assessing the health risk of Cd in food products of some commercial canned samples (Shushtar city) for adult and children consumption.

	Adult				Children			
Food products	CDA (mg/Kg/day)	HQ	CR_{kim} (g/day)	Cr	CDA (mg/Kg/day)	HQ	CR_{kim} (g/day)	Cr
Salted olives	2.85×10^{-5}	0.028	1.75	4.28×10^{-4}	8×10^{-5}	0.08	0.625	1.2×10^{-3}
Canned pinto bean feed with mushrooms	1.42×10^{-5}	0.014	7	2.14×10^{-4}	4×10^{-5}	0.04	2.5	6×10^{-4}
Canned peas	1.42×10^{-5}	0.014	7	2.14×10^{-4}	4×10^{-5}	0.04	2.5	6×10^{-4}

CDA: Concentration daily intake absorption; HQ: Hazard Quotient; $CR_{kim:}$ Maximum allowable daily intake; Cr: Carcinogenic risk.

Table 6. Assessing the health risk of Fe in food products of some commercial canned samples (Shushtar city) for adult and children consumption.

Food products	Adult			Children		
	CDA (mg/kg/day)	HQ	CR_{kim} (g/day)	CDA (mg/kg/day)	HQ	CR_{kim} (g/day)
Vegetable stew canned	7.92×10^{-3}	0.011	13.243	2.22×10^{-2}	0.031	4.729
Potato stew canned	9.87×10^{-3}	0.014	10.629	2.76×10^{-2}	0.039	3.796
Salted olives	3.35×10^{-4}	0.0003	148.484	6.6×10^{-4}	0.0009	53.030
Broad bean canned	1.77×10^{-3}	0.002	39.516	4.96×10^{-3}	0.007	14.112
Canned eggplant feed	5.78×10^{-4}	0.0008	181.481	1.62×10^{-3}	0.002	64.814
Canned pinto bean feed with tomato sauce	5.14×10^{-4}	0.0007	136.111	1.44×10^{-3}	0.002	48.611
Canned mixed vegetables	8.28×10^{-4}	0.001	84.482	2.32×10^{-3}	0.003	30.172
Canned pasta sauce with soy	4×10^{-4}	0.0005	175	1.12×10^{-3}	0.001	62.5
Canned fish roe	1.28×10^{-4}	0.0001	544.44	3.6×10^{-4}	0.0005	194.44
Canned pinto bean feed with mushrooms	5.14×10^{-4}	0.0007	136.111	1.44×10^{-3}	0.002	48.611
Canned broth peas	1.67×10^{-3}	0.002	41.880	4.68×10^{-3}	0.006	14.957

CDA: Concentration daily intake absorption; HQ: Hazard Quotient; $CR_{kim:}$ Maximum allowable daily intake; Cr: Carcinogenic risk.

Table 7. Assessing the health risk of Zn in food products of some commercial canned samples (Shushtar city) for adult and children consumption.

Food products	Adult			Children		
	CDA (mg/kg/day)	HQ	CR_{kim} (g/day)	CDA (mg/kg/day)	HQ	CR_{kim} (g/day)
Vegetable stew canned	7.5×10^{-4}	0.002	60	2.1×10^{-3}	0.007	21.428
Potato stew canned	9.42×10^{-4}	0.003	47.727	2.64×10^{-3}	0.008	17.045
Broad bean canned	3.85×10^{-4}	0.001	77.777	1.08×10^{-3}	0.003	27.777
Canned eggplant feed	2.14×10^{-5}	0.00007	2100	6×10^{-5}	0.007	750
Canned pinto bean feed with tomato sauce	1.42×10^{-5}	0.00004	2100	4×10^{-5}	0.0002	750
Canned sweet corn	3.71×10^{-4}	0.001	80.796	1.04×10^{-3}	0.003	28.846
Canned fish roe	8.57×10^{-5}	0.0002	350	2.4×10^{-4}	0.0008	125
Canned pinto bean feed with mushrooms	2.85×10^{-5}	0.00009	1050	8×10^{-5}	0.0002	375
Canned broth peas	5.14×10^{-4}	0.002	58.333	1.44×10^{-3}	0.004	20.833

CDA: Concentration daily intake absorption; HQ: Hazard Quotient; $CR_{kim:}$ Maximum allowable daily intake; Cr: Carcinogenic risk.

Table 8. Assessing the health risk of Cu in food products of some commercial canned samples (Shushtar city) for adult and children consumption.

Food products	Adult			Children		
	CDA (mg/kg/day)	HQ	CR_{kim} (g/day)	CDA (mg/kg/day)	HQ	CR_{kim} (g/day)
Vegetable stew canned	5.57×10^{-4}	0.015	9.961	1.56×10^{-3}	0.042	3.557
Potato stew canned	1.09×10^{-3}	0.029	5.078	3.06×10^{-3}	0.082	1.830
Broad bean canned	7.14×10^{-4}	0.019	5.180	2×10^{-3}	0.054	1.850
Canned eggplant feed	1.13×10^{-3}	0.030	4.886	3.18×10^{-3}	0.085	1.745
Canned pinto bean feed with tomato sauce	1.15×10^{-3}	0.031	3.197	3.24×10^{-3}	0.087	1.141
Canned sweet corn	3.14×10^{-4}	0.008	11.772	8.8×10^{-4}	0.023	4.204
Canned mixed vegetables	1.94×10^{-3}	0.052	1.904	5.44×10^{-3}	0.147	0.680
Canned fish roe	1.71×10^{-4}	0.004	21.580	4.8×10^{-4}	0.104	7.708
Canned pinto bean feed with mushrooms	1.38×10^{-3}	0.037	2.670	3.88×10^{-3}	0.170	0.953
Canned broth peas	2.52×10^{-3}	0.068	1.463	7.08×10^{-3}	0.191	0.522

CDA: Concentration daily intake absorption; HQ: Hazard Quotient; $CR_{kim:}$ Maximum allowable daily intake; Cr: Carcinogenic risk.

Table 9. Assessing the health risk of Sn in food products of some commercial canned samples (Shushtar city) for adult and children consumption.

Food products	Adult			Children		
	CDA (mg/kg/day)	HQ	CR_{kim} (g/day)	CDA (mg/kg/day)	HQ	CR_{kim} (g/day)
Vegetable stew canned	3×10^{-4}	0.003	4.300	8.4×10^{-4}	0.009	1.535
Potato stew canned	2.14×10^{-4}	0.002	6.020	6×10^{-4}	0.007	1.150
Broad bean canned	3.28×10^{-4}	0.003	2.617	9.2×10^{-4}	0.010	0.934
Canned eggplant feed	4.54×10^{-3}	0.052	0.382	1.27×10^{-2}	0.147	0.101
Canned lentil feed	3.42×10^{-4}	0.003	3.762	9.6×10^{-4}	0.011	1.343
Canned pinto bean feed with tomato sauce	4.15×10^{-3}	0.048	0.206	1.16×10^{-2}	0.135	0.073
Canned mixed vegetables	4×10^{-4}	0.004	2.150	1.12×10^{-3}	0.013	0.767
Canned pasta sauce with soy	4.42×10^{-3}	0.051	0.194	1.24×10^{-2}	0.144	0.069
Canned mushrooms	1.02×10^{-2}	0.118	0.084	2.85×10^{-2}	0.332	0.030
Canned fish roe	1.42×10^{-4}	0.001	6.020	4×10^{-4}	0.004	2.150
Canned pinto bean feed with mushrooms	3.54×10^{-3}	0.041	0.242	9.92×10^{-3}	0.115	0.086
Canned broth peas	2.14×10^{-4}	0.024	4.013	6×10^{-4}	0.006	1.433
Canned peas	6.47×10^{-3}	0.075	0.132	1.81×10^{-2}	0.210	0.047

CDA: Concentration daily intake absorption; HQ: Hazard Quotient; $CR_{kim:}$ Maximum allowable daily intake; Cr: Carcinogenic risk.

Table 10. Health risk assessment of Hg in canned fish roe of some commercial canned samples (Shushtar city).

Age	CDA (mg/kg/day)	HQ	CR_{kim} (g/day)	Cr
Adult	1.42×10^{-5}	0.142	0.7	2.85×10^{-4}
Children	4×10^{-5}	0.4	25	8×10^{-4}

CDA: Concentration daily intake absorption; HQ: Hazard Quotient; $CR_{kim:}$ Maximum allowable daily intake; Cr: Carcinogenic risk.

2.4. Chronic Daily Absorption

To calculate the Chronic Daily Absorption and the risk of non-carcinogenicity of heavy metals in humans based on the daily consumption of each food product by the weight of each adult 70 kg and child 14.5 kg and the weight of each food product contracted 70 g The day was considered, finally this factor was calculated based on the Eq. 1. CDA: Chronic Daily Absorption (mg/kg/day), C: Metal concentration in food (mg/kg), DI: Average daily food intake (kg/day) (Consumption of various pickle cabbage, port pickled, pickled garlic cloves, pickled garlic, pickled peppers, pickled mixed pickles 0.05 kg/day, canned Minced with potatoes, canned stewed vegetables, canned eggplant and canned lentil feed 0.15 kg/day and canned peas, canned sweet corn, canned beans, canned oyster mushrooms, canned lentils, canned pinto beans with tomato sauce, canned pinto beans with mushrooms, canned mixed vegetables, canned pea broth, canned pasta sauce with soy and various of canned fish 0.1 kg/day), BW: Body weight (70 kg for Adult and 14.5 kg for children) (USEPA, 2000):

$$CDA = C \times DI / BW \tag{1}$$

2.5. Hazard Quotient

The Hazard Quotient (HQ) is actually the ratio between the exposure to heavy metals and their reference dose used to express non-toxic effects. The following equation (Eq. 2) was used to calculate the non-carcinogenic risk of metals from food consumption. HQ: Risk share, RFD: Reference dose for metal (mg/kg/day) (USEPA, 2009):

$$HQ = CDA / RfD \tag{2}$$

2.6. Total Hazard Index

The Total Hazard Index is the total hazard index of the studied heavy metals, which was calculated using the following Eq. 3. THI: Total risk index, THQCd: Cadmium risk ratio, THQPb: Lead risk ratio, THQAs: Arsenic risk ratio, THQHg: Mercury risk ratio, THQZn: Zinc risk ratio, THQCu: Copper risk ratio, THQFe: Iron risk ratio, THQSn: Tin risk ratio (USEPA, 2000):

$$THI = THQ_{Cd} + THQ_{Pb} + THQ_{As} + THQ_{Hg} + THQ_{Sn} + THQ_{Fe} + THQ_{Zn} + THQ_{Cu} \tag{3}$$

2.7. Amount of consumption

For the consumption of food products of this factory by the natives of the region, the permissible consumption per day was obtained from the Eq. 4. CR: Maximum allowable daily intake (kg/day), R_{fD}: Reference dose or total allowable daily absorption of metals, BW: Body weight (70 kg for an adult and 14.5 kg for children), C: Average concentration of metal in food (micrograms per gram) (USEPA, 2000):

$$CR_{kim} = (RFD \times BW) / C_m \tag{4}$$

2.8. Carcinogenic risk

The carcinogenic risk (CR) has been estimated to increase a person's risk of cancer over a lifetime. The carcinogenic risk (CR) in local individuals due to exposure to the risk of carcinogenicity was calculated by multiplying the median daily intake (CDA) by the cancer slope factor (SF= Cd: 15; Pb: 0.85; As: 1.5; Hg: 20) based on the following Eq. 5 (Soylak et al., 2012):

$$CR = CDA \times SF \tag{5}$$

2.9. Statistical method

In this study, the experiments were performed completely randomly. SPSS 24 software was used for statistical analysis and analysis of mean differences in different treatments. Excel software will be used to draw charts and tables. Shaper-Wilk test was used to test the normality of the data. LSD test, one-way analysis of variance (ANOVA), two-way analysis of variance and Duncan test were used to compare and find significant differences in the groups.

3. Results

The average levels of Hg, As, Cd and Pb in the studied food products are shown in Table 1. The highest amount of Pb was obtained in vegetable stew canned 0.47 ± 0.005 mg/kg ($p < 0.05$). Also, the highest amount of As was observed in canned sweet corn 0.20 ± 0.006 mg/kg ($p < 0.05$). The average amount of Hg was present only in canned fish roe. The range of Cd was 0.01-0.01 mg/kg. The highest and lowest levels of Fe in potato stew canned and canned fish roe were 4.61 ± 0.12 and 0.09 ± 0.05 mg/kg, respectively ($p < 0.05$). The highest amount of Sn in canned mushroom was 7.14 ± 0.05 mg/kg and the lowest amount of this metal was in potato stew canned and canned fish roe 0.10 ± 0.002 mg/kg ($p < 0.05$). The highest levels of Zn and Cu were 0.44 ± 0.03 and 1.77 ± 0.08 mg/kg in canned potato stew and canned broth peas ($p < 0.05$) (Table 2).

The highest daily uptake of Pb was obtained in vegetable stew canned for adults and children 1×10^{-3} and 2.82×10^{-3} mg/kg/day. Hazard Quotient of Pb in foods studied for use in adults and children than more 1 were observed. The highest and lowest levels of Hazard Quotient for Pb were in canned vegetable stew (HQ = 0.805) and in some other products were 0.005, respectively. According to the obtained results, the permissible consumption of meals of the studied products is presented in Table 3 and Table 4. The carcinogenic risk of Pb was observed for adults from 6.07×10^{-6} to 8.56×10^{-4} and for children from 1.7×10^{-5} to 2.39×10^{-3} (Table 3).

The highest daily absorption of As in canned sweet corn for adults and children was 2.85×10^{-4} and 8×10^{-4} mg/kg/day. As risk index values were observed in the studied foods for consumption of adults and children less than 1. The highest and lowest levels of arsenic metal hazard index were in canned sweet corn (HQ = 0.266) and garlic pickle, mixed pickle and shallot pickle (HQ = 0.002), respectively. According to the obtained results, the permissible consumption of meals of the studied products is presented in Table 4. The carcinogenic risk of As was observed for adults from 1.07×10^{-5} to 4.28×10^{-5} and for children from 1.2×10^{-5} to 1.2×10^{-3}. The highest daily uptake of Cd in salted olives for adults and children was 2.85×10^{-5} and 8×10^{-5} mg/kg/day. Cd risk index values were observed in the studied foods for consumption of adults and children less than 1. The highest and lowest Cd risk indices were in salted olives (HQ = 0.08) and canned pinto beans with mushrooms and canned peas (HQ = 0.014), respectively.

According to the obtained results, the permissible consumption of meals of the studied products is presented in Table 5. The carcinogenic risk of Cd for adults and children was observed from $6×10^{-4}$ to $1.2×10^{-3}$. The highest daily absorption of Fe in Potato stew canned for adults and children was $9.87×10^{-3}$ and $2.76×10^{-2}$ mg/Kg/day, respectively. Fe risk index values were observed in the studied foods for consumption of adults and children less than 1. The highest and lowest levels of Fe risk index were in Potato stew canned (HQ = 0.039) and canned fish roe (HQ = 0.001), respectively (Table 6). The highest daily intake of Zn in potato stew canned for adults and children in the $9.42×10^{-4}$ and $2.64×10^{-3}$ mg/Kg/day was obtained. Zn risk index values were observed in the studied foods for consumption of adults and children less than 1. The highest and lowest Zn risk index were in potato stew canned (HQ = 0.008) and canned pinto bean feed with tomato sauce (HQ = 0.00004), respectively (Table 7). The highest daily intake of Cu in canned broth peas for adults and children was $2.52×10^{-3}$ and $7.08×10^{-3}$ mg/Kg/day, respectively. Cu risk index values were observed in the studied foods for consumption of adults and children less than 1. The highest and lowest Cu risk indices were in canned broth peas (HQ = 0.191) and canned fish roe (HQ = 0.004), respectively (Table 8). The highest daily intake of Sn in canned broth peas for adults and children respectively $1.02×10^{-2}$ and $2.85×10^{-2}$ mg/kg/day was obtained. Sn risk index values were observed in the studied foods for consumption of adults and children less than 1. The highest and lowest Sn risk index were in canned mushrooms (HQ = 0.332) and canned fish roe (HQ = 0.016), respectively (Table 9). Concentration of Hg was measured only in canned fish roe. The risk index values of this product for Hg in adults and children were 0.142 and 0.4, respectively. The carcinogenic risk of Hg for adults and children was calculated to be $2.85×10^{-4}$ and $8×10^{-4}$, respectively (Table 10).

4. Discussion

Pb in pearl garlic pickle, salted olives, broad bean canned, canned sweet corn, canned lentil feed, canned pinto bean feed with tomato sauce, canned mushrooms and canned pasta sauce with soy it was immeasurable. The highest average amount of Pb in pickles was obtained in pickled garlic cloves and the lowest amount of this metal was observed in port pickles and pickled garlic flower. The highest levels of Pb in canned products were also among in canned mixed vegetables and canned fish roe. The lowest amount of Pb was obtained in canned products of canned broth peas and canned eggplant feed. Pb is one of the heavy metals that causes environmental pollution in various ways and as a result causes acute or chronic toxicity in humans (Barati et al., 2012). Long-term contact with this metal causes it to accumulate in the body and is considered a carcinogen (Onkawa et al., 2019). The solder of cans and, in some cases, cans contains lead, and food storage in these cans, especially in the case of acidic foods, causes lead to form in food (Ogamba et al., 2016; Okyere et al., 2015). Food is an important source of Pb detection. Other sources include air (mainly lead from gasoline) and drinking water. Plant foods may be contaminated with lead due to absorption from the environment and soil. Animals may become infected with lead after consuming plants. In humans, lead intake may be through the consumption of lead-infected plants or lead-infected animals (Rodriguez-Mendivi et al., 2019; Fouladi et al., 2021).

Concentration of As in food products, port pickle, garlic pickle, pearl garlic pickle, lettuce pickle, pepper pickle, pickled cucumber, salted olives, vegetable stew canned, potato stew canned, broad bean canned, canned lentil feed, canned pasta sauce with soy, canned fish roe, canned mushrooms, canned peas and canned pea broth it was immeasurable. The highest amount of As was obtained in canned sweet corn. Studies and research on As in food show that fish and seafood have high levels of As and high levels of this element have often been measured in crabs. In general, white meat contains more As than brown meat (Shah et al., 2009; Tang et al., 2020). The concentration of As in various brands of canned vegetables and fruits, including canned tomatoes, sauces (ketchup), canned green beans, canned carrots and canned juices (pineapple), which has entered the Jordanian market, is 0.5-5.10 mg/kg has been reported (Massadeh & Al-Massadeh, 2018). As in 72 samples (36 samples for fruit juice and 36 samples for canned fruits) in three different brands including peach, orange, cherry and pineapple (18 samples per fruit) marketed in Tehran was 3.76 µ/kg. The average As in canned fruits is 3.92 µg/kg (Ebadi Fathabad et al., 2018).

Cd levels in salted olives were higher than in canned beans with mushrooms and canned broth peas. In other food products, the amounts of Cd were undetectable. Only mineral Cd salt is present in food and organic cadmium compounds are very unstable. In contrast, cadmium ions are readily absorbed by plants (Bogdanovic et al., 2014; Sabet Aghlidi et al., 2020). Cd is absorbed through the roots of plants and edible leaves and fruits and seeds. During the growth of grains such as wheat and rice, cadmium taken from the soil is concentrated in the kernel (Korfali & Abou Hamdan, 2013; Milend Mbeh et al., 2019).

The amount of Fe in broad bean canned was higher than other food products and the lowest amount of this metal was obtained in canned fish roe. In one study it was reported that the amount of iron in canned products is high (Al-Rajhi, 2014) which is one of the problems of food packaged in tin cans. Accumulation of metals such as iron and tin in food content as a result of corrosion of the inner wall is a can (Onkawa et al., 2019). Corrosion rate varies according to the characteristics of the tin sheet, the way the food is processed, the storage conditions and the type of packaged food. Excessive amounts of iron cause adverse changes in color, taste (metallic taste) and transparency of food products (Nagy et al., 1980; Qiong et al., 1999).

The amount of Zn in canned eggplant feed and canned pinto beans had the lowest levels. The highest amount of this metal was observed in potato stew canned. Plants are an important part of the food chain and the absorption of Zn by them and the accumulation of this element, in addition to having harmful effects on the plant, cause a variety of diseases and poisoning for humans and other organisms (Seow et al., 1984). Different species of plants act differently in terms of the amount of absorption of Zn and their distribution in their tissues due to genetic differences and different environmental factors, including the interaction of Zn with essential plant nutrients. Also, the ability to move and transfer elements in the plant depends on the type of element, plant organ and its age (Zalewska et al., 2015).

The amount of Cu in canned broth peas was higher than other food products and the lowest amount of this metal was obtained in canned fish roe. Cu is one of the essential elements in human and animal nutrition (Al Zabadi et al., 2018) and is effective in small amounts in the production of hemoglobin in the blood (Sobhanardakani, 2018). In large quantities, it causes side effects and poisoning in food. The standard for copper in most countries is 20 mg/kg in most foods, and in beverages and fruit juices it is 2 mg/kg. The presence of copper in milk as a catalyst is effective in accelerating fat oxidation and changing the taste of milk, and the amount of 2 mg/kg of Cu in milk or butter reduces the shelf life of these substances (Zalewska et al., 2015; Borojerdnia et al., 2020).

The amount of Sn in canned mushroom was higher than other food products and the lowest amount of this metal was obtained in potato stew canned and canned fish roe. In other food products, especially spices and salty products studied, the amounts of this metal were undetectable. The concentration of metals in mushroom is mainly affected by soil type, acidic substances and type of mushrooms, and increasing the concentration of heavy metals in mushroom is different in many ways from other plants (Schaanning et al., 2019). However, it should be noted that mushroom tissue is very suitable for the absorption and accumulation of heavy metals (Cocchi et al., 2006). Some studies have also reported the accumulation of heavy metals in edible mushrooms (Isildak et al., 2004; Mendil et al., 2004; Chen et al., 2009). Sn as a toxic substance has been included in the list of hazardous substances in the safety and environmental organizations of the world (Yin et al., 2012). Consumption of food stored in cans may contain some tin, which is high enough to corrode and destroy the can (Tarley et al., 2001). An important source of tin metal contamination in canned foods is dyeing cans (ATSDR, 2004).

The amount of Hg in all the studied food products was immeasurable, only in canned fish roe. The constant presence of Hg in the environment and its transfer to the water chain and its amounts in various foods has made mercury the most dangerous metal in the human food chain. The most important source of mercury in the human body is food. Fish and seafood have the highest levels of dietary methyl (Araujo & Cedeno-Macias, 2016; Fisera et al., 2019).

HQ values of Pb, As, Cd, Fe, Zn, Cu and Sn in the foods products for adults and children less than 1 were observed. The highest and lowest levels of Pb HQ were in canned vegetable stew (HQ = 0.805) and in some other products were 0.005, respectively. The highest and lowest levels of As HQ were in canned sweet corn (HQ = 0.266) and garlic pickle, mixed pickle and shallot pickle (H = 0.002), respectively. The highest and lowest Cd HQ were in salted olives (HQ = 0.08) and canned pinto bean feed with mushrooms and canned peas (HQ = 0.014), respectively. The HQ values of canned fish roe for Hg in adults and children were 0.142 and 0.4, respectively. The highest and lowest levels of Fe HQ were in potato stew canned (HQ = 0.039) and canned fish roe (H = 0.001), respectively. The highest and lowest Zn HQ were in potato stew canned (HQ = 0.008) and canned pinto bean with tomato sauce (HQ = 0.00004), respectively. The highest and lowest Cu HQ were in canned broth peas (HQ = 0.191) and canned fish roe (HQ = 0.004), respectively. The highest and lowest Sn HQ were in canned mushrooms (HQ = 0.332) and canned fish roe (HQ = 0.016), respectively. A higher HQ ratio than 1 indicates a higher risk of non-cancerous diseases and a score less than 1 indicates that the consumption of the studied foods does not have an acute and harmful effect on human health (USEPA, 2000; USEPA, 2009; Storelli & Barone, 2013). The carcinogenic risk of mercury, lead, cadmium and arsenic in food samples was lower than 10^{-4}. Carcinogenic risk of heavy metals in food is a factor used to assess potential health risks to humans (Zeng et al., 2015; Hedayatzadeh & Hassanzadeh, 2020). The carcinogenic risk values in this study showed that the consumption of food products does not pose a particular problem (Cao et al., 2015).

5. Conclusion

Pb had higher levels than other metals in pickle products. Sn had higher levels than other metals in canned products. Hg was obtained only in canned fish roe, the amounts of which were very small. The HQ of the studied metals in food products for adults and children was less than 1. The amount of metals studied in food products was lower than the allowable threshold of national and international standards. The carcinogenic risk of mercury, lead, cadmium and arsenic in food samples was lower than 10^{-4}. According to the results, it seems that the consumption of food products of some commercial canned samples from shushtar city does not pose a problem for consumers.

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Conflict of interest

The authors of the article declare that there is no conflict of interest for the results and data of this article.

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