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ORIGINAL ARTICLE

Evaluation of the Risk Non-Carcinogenicity of Heavy Metals in Traditional Foods Prepared in Restaurants of Isfahan, Iran

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KEYWORDS

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ABSTRACT: The intake of heavy metals from food in high doses will have adverse effects on human health. In Iran, traditional foods constitute a major portion of peoples' daily diet. Hence, the present study has attempted to evaluate the levels of heavy metals and their carcinogenicity and non-carcinogenicity in traditional foods served in the restaurants of Isfahan, Iran. In this cross-sectional study, 20 different types of food were selected from 19 restaurants. Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) was used to measure the levels of heavy metals such as chromium (Cr), nickel (Ni), lead (Pb), copper (Cu), and iron (Fe) in the prepared samples. Moreover, the risk non-carcinogenicity of heavy metals in traditional foods was determined for children and adults by applying the U.S. Environmental Protection Agency (USEPA) method. Among the heavy metals studied, only Ni and Cu had lower levels than permissible limits. Also, the Pb levels in the examined foods range from 0.05 to 0.79 m m^{-1}; which are higher than the safe limits proposed by FAO/WHO. On the other hand, the mean concentration of Fe was higher than the maximum permissible limit (48 m m^{-1}) in 4 food samples only. The target hazard quotient (THQ) values range from 0.005–53.65 and 0.01–156.50, for adults and children, respectively. Hence THQ for adults and children was found to be above 1 in 64% and 75% of food samples, respectively. This study recommends that food consumers in Iran should be careful about the overconsumption of traditional foods.

INTRODUCTION

Safe and healthy food is a major concern of consumers today. Owing to increased industrial activities, the concentration of heavy metals has increased in the environment as well as in foods. Heavy metals are poisonous elements and their accumulation in food can have adverse effects on human health [1]. Heavy metals can enter the food chain through human activities as well as natural processes and contaminated soil [2]. Both positive and negative effects have been reported for heavy metals. Although heavy metals such as lead (Pb), chromium (Cr) and nickel (Ni) are considered as major food contaminants and the most daunting environmental problem, elements such as iron (Fe), zinc (Zn) and copper (Cu), with potentially positive effects, can also endanger human health at high levels [3]. One of the most important problems with heavy metals is that they are not metabolized in the body. Having entered the body, heavy metals are not excreted;

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instead, they accumulate in fat, muscles, bones and joints, eventually leading to many diseases [4].

Considering the huge amounts of foodstuff consumed globally on a daily basis, the safety of these food products is of great importance. Consumers' health and well-being, however, can be jeopardized when foodstuffs are contaminated by various chemicals, including heavy metals [1]. Recent studies on food contamination with heavy metals indicate an imminent and serious threat to food safety by these contaminants. Although extensive studies have been carried out in different countries to evaluate the effects of heavy metals in edible vegetable oils [5], meat products [6], seafood [7], dairy products, alcoholic beverages, non-alcoholic beverages, cereals, prepared dishes, sweeteners and condiments[8], vegetables[9], and Honey[10, 11], the present research is one of the first studies of traditional foods in Iran. In this work, we have attempted to analyze the amounts of heavy metals (Cr, Ni, Pb, Cu and Fe) in traditional foods served in the restaurants of Isfahan, Iran. Furthermore, the risk non-carcinogenicity of these foods has also been evaluated.

MATERIALS AND METHODS

Sampling

In this cross-sectional study, 20 traditional foods were selected from 19 restaurants in two highly-populated districts of Isfahan. The specifications of the examined dishes, which are highly popular foods in most restaurants, have been presented in Table 1. The total number of food samples was 40, and the experiments were repeated 2 times for each sample. The samples were homogenized and refrigerated in plastic containers [1].

Table 1. Ingredients and recommended amounts per day of the examined traditional foods in the present study.

Food name	Recommended amount per day (gr)	Ingredients
Kashk and eggplant	130	Fried eggplant, kashk, fried onion, garlic, mint, oil, walnut, salt, black pepper and turmeric
Eggplant halim	100	Rice, eggplant, kashk, fried onion, lentil, lamb, saffron, mint, oil, walnut, salt, black pepper, turmeric and cinnamon
Halim	140	Wheat, onion, lamb, meat, butter, cinnamon and salt
Adasi	130	Lentil, onion, potatoe, water, oil, salt, pepper and turmeric
Lentil halim	100	Meat, rice, kashk, onion, fried onion, lentil, mint, oil, walnut, saffron, salt and black pepper
Abgosht	100	Meat, pea, bean, onion, tomato sauce, tomato, potato, salt, black pepper and turmeric
Kaleh pache	100	Kaleh pache of lamb, pea, water, salt, black pepper and turmeric
Barbecue chicken	100	Chicken, onion, butter, lemon, saffron, olive oil, salt, black pepper and ginger
Kubideh kebab	50	Minced meat, onion, saffron, black pepper and salt
Beriani	100	Meat, onion, mint, oil, bread, salt, black pepper, turmeric and cinnamon
Kofteh Tabrizi	250	Minced meat, cotyledon, rice, egg, onion, vegetable, tomato sauce, salt, black pepper and turmeric
Chicken tah-chin	100	Rice, chicken breast, yogurt, egg, onions oil, saffron, salt, black pepper, turmeric and cinnamon
Chicken stew	285	Chicken thigh or breast, carrot, plum, onion, oil, tomato sauce, fried potato, salt, black pepper and turmeric
Fesenjan stew	110	Chicken breast, walnut powdered , onion, pomegranate sauce, sugar, saffron, salt, black pepper and turmeric
Gheymeh stew	142.5	Meat, cotyledon, tomato sauce, onion, cinnamon, lemon, oil, fried potato, saffron, salt, black pepper and turmeric
Ghormeh sabzi stew	142	Meat, bean, vegetable, lemon, oil, salt, black pepper and turmeric
Sholeghalamkar ash	123.4	Pea, bean, lentil, rice, wheat, meat, tarragon, onion, mint, salt, black pepper and cinnamon
Ashe reshteh	115	Pea, bean, lentil, oil, spinach, parsley, dill, coriander, turmeric, noodle, garlic, peppermint, onion, salt, black pepper and kashk
Barley soup	68	Onion, carrot, chicken breast, parsley, barley, tomato sauce, salt, black pepper and turmeric

Sample preparation

Wet digestion was applied to determine the concentration of metals. First, 5 grams of each sample was placed in an oven at 100°C for 2 hr. Around 6-8 ml of nitric acid (HNO_3) and hydrochloric acid (HCl) in proportions of 1 part HNO_3 to 3 parts HCl was poured on the sample to dissolve the metals. The mixture was heated at 110°C until the metals were completely dissolved. After 30 minutes, the solution was poured into another flask through a whatman paper 42 and finally transferred to a centrifuge tube for measurement of heavy metal concentration [7]. The standard heavy metal solutions (1000 mg l^{-1}) for Cr, Ni, Pb, Cu and Fe, and the required acids were provided by the Merck Co. and used for diluting the samples and calibrating the measuring device. Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) was employed to measure the concentration of heavy metals by a VISTA-PRO model device (made in Germany) with a radio frequency power of 1 kHz, plasma flow rate of 0.15 l min^{-1}, fluid flow rate of 1.5 l min^{-1}, pump spin velocity of 15 RPM, and a nebulizer flow rate of 0.75 l min^{-1}.

Risk assessment

Estimated daily intake (EDI) is a common formula for measuring the amount of a metal transferred from food to human consumers. The formula proposed by the U.S. Environmental Protection Agency [12], was used to calculate the risk potential of heavy metals as related to non-cancerous diseases. First, the daily amount of heavy metal absorbed through food, per kilogram of body weight, was determined from the following formula.

$$EDI = (CF \times IR \times FI \times EF \times ED) / (BW \times AT) \quad (1)$$

In the above formula, EDI is the estimated daily intake of heavy metals through food (m m^{-1}/day), CF is a conversion factor
(m m^{-1}) and IR is the ingestion rate (m m^{-1}). The recommended daily intake of traditional foods was obtained from the information printed on the traffic light labels on food packaging (Table 1) [13]. Also, FI is the fraction ingested from a contaminated food source; with an average value of 0.25 and a maximum value of 0.40. In this study, we used a FI value of 0.40, which corresponds to a hazard probability of 0.95. EF is the exposure frequency (days/years), and ED is the exposure duration (years), which was considered to be 14 years for children and 70 years for adults. BW is the average body weight (kg). In this study, average body weights of 24 and 70 kg were considered for children and adults, respectively. And finally, AT is the average exposure time (365 days/year × ED).

The target hazard quotient (THQ) is the measure of the potential exposure to a substance where no adverse effects are expected. The THQ is obtained by equation (2), where RFD is the oral reference dose (m m^{-1}/day), with values of 1.5, 0.02, 0.004, 0.04 and 0.7 for Cr, Ni, Pb, Cu and Fe, respectively. This indicator is used for estimating the potential and long-term health risks of ingesting heavy metals through food. If THQ < 1, carcinogenic effects in consumers will be unlikely, and if THQ > 1, there will be a high risk of chronic toxicity [14].

$$THQ = EDI/RFD \quad (2)$$

The hazard index (HI) is obtained by summing the THQ values for each element and for both groups of adults and children. A HI higher than 1 indicates an increased risk of non-cancerous diseases. THQ is the ratio of the potential exposure to a substance to the level of that substance at which no adverse effects are expected. So, if an element has an HI value of greater than 1, its systemic effects will be of concern [14].

$$HI = \sum_{n=1}^{i} THQ_n \quad (3)$$

Statistical analysis

The obtained data were analyzed by the SPSS (v. 25) software, using the ANOVA test, to compare the mean concentrations of heavy metals in the foods tested. In this study, the significance level was considered as 0.05.

RESULTS

Table 2 shows a summary of measured data statistics for Cr, Ni, Pb, Cu, and Fe elements found in restaurant traditional foods. Among the traditional foods tested, only Halim had a Cr concentration (0.05 m m^{-1}) that was less than the limit set by (Food and Agriculture Organization / World Health Organization) FAO/WHO. The Ni and Cu concentrations in all the purchased foods were below the safe permissible levels issued by FAO/WHO. In the present investigation, the Pb levels in the examined traditional foods range from 0.05 to 0.79 m m^{-1}; which are higher than the safe limits proposed by FAO/WHO. On the other hand, the mean concentration of Fe was higher than the maximum permissible limit (48 m m^{-1}) in 4 food samples only (Adasi, Lentil halim, Beriani, and Chicken stew).

Table 3 shows the THQ values of heavy metals ingested through traditional foods, for both age groups. According to this table, the THQ values range from 0.005–53.65 and 0.01–156.50, for adults and children, respectively. The THQ of Fe was estimated to be higher than that of the other metals. In addition, Fe ingestion through Chicken stew showed a greater health risk potential for both age groups.

In this survey, the THQ values of heavy metals were found to be less than 1 for 36% of adults and greater than 1 for the remaining 64%; while they were smaller than 1 for only 25% of children and larger than 1 for 75% of them. Among the studied samples, the THQ values of all heavy metals (except Fe) in Kubideh kebab were smaller than 1 for adults. The THQ values of Cr, Ni, and Cu were found to be lower than 1 only in Kashk and eggplant, Eggplant halim, kubideh kebab, and Barley soup. For children, the THQs of Cr and Cu were smaller than 1 only in Kashk and eggplant, Eggplant halim, Barley soup, and Milk soup. Also, for both age groups, the THQ values of Pb, Cu and Fe were greater than 10 in Lentil halim, Kaleh pache, and Chicken stew.

Table 3 also contains the HI values of toxic metals found in traditional foods for the two age groups studied (adults and children). None of the food items in this survey received an HI value below 1; they all have HI values higher than the critical limit proposed by USEPA. The highest and lowest HI values were found for Chicken stew and kubideh kebab, respectively. As can be seen in Table 3, the HI value for children is almost 3 times that for adults, indicating that the potential risk of non-cancerous diseases is higher for children than adults.

Table 2. Mean and standard deviation of heavy metals concentrations (m m^{-1}) in traditional foods prepared in Isfahan restuarants

Samples	Cr	Ni	Pb	Cu	Fe
Kashk and eggplant	0.17±0.14	0.05±0.00	0.05±0.00	0.05±0.00	10.78±2.03
Eggplant halim	0.07±0.02	0.05±0.00	0.05±0.00	0.05±0.00	13.40±1.62
Halim	0.05±0.00	0.05±0.00	0.05±0.00	0.63±0.82	15.71±5.23
Adasi	0.14±0.02	0.11±0.02	0.13±0.11	5.25±5.73	99.88±0.49
Lentil halim	0.34±0.41	0.19±0.19	0.33±0.40	6.34±1.44	146.17±8.56
Abgosht	0.20±0.06	0.23±0.34	0.79±0.96	0.58±0.32	25.46±1.20
Kaleh pache	0.23±0.05	0.20±0.21	0.70±0.92	4.08±0.87	36.41±5.83
Barbecue chicken	0.65±0.35	0.05±0.00	0.05±0.00	0.73±0.96	14.82±3.69
Kubideh kebab	0.75±0.43	0.05±0.00	0.05±0.00	0.29±0.34	28.63±0.95
Beriani	0.77±0.89	0.09±0.05	0.16±0.16	3.29±0.52	67.44±5.39
Kofteh Tabrizi	0.33±0.31	0.17±0.59	0.05±0.00	0.05±0.00	31.01±2.57
Chicken tah-chin	0.62±0.80	0.21±0.23	0.16±0.16	0.58±0.74	21.21±2.46
Chicken stew	0.41±0.50	0.14±0.13	0.19±0.19	2.37±1.23	52.17±11.52
Fesenjan stew	0.13±0.12	0.43±0.54	0.44±0.55	2.52±1.18	17.74±0.95
Gheymeh stew	0.12±0.09	0.08±0.04	0.32±0.38	1.63±1.47	23.08±1.73

Table 2. Continued.

Ghormeh sabzi stew	0.15±0.07	0.29±0.33	0.27±0.31	0.84±0.96	30.95±7.95
Sholeghalamkar ash	0.12±0.02	0.08±0.04	0.05±0.00	0.88±0.12	31.47±2.17
Ashe reshteh	0.08±0.04	0.18±0.19	0.29±0.34	0.18±0.03	15.64±2.95
Barley soup	0.09±0.01	0.18±0.18	0.31±0.37	0.06±0.02	40.55±4.22
Milk soup	0.23±0.05	0.24±0.26	0.23±0.25	0.09±0.05	40.22±1.40
Maximum allowable concentration	0.050	0.5	0.025	10	48
References	(15)	(15)	(15)	(15)	(15)
P-value	0.003	0.001	0.001	0.007	0.001

*P-value less than 0.5 was observed in all food samples, which is statistically significant.

Table 3. Target Hazard Quotient (THQ) and Hazard Index (HI) for adults and children exposed to heavy metals in contaminated traditional foods.

Samples	**Adult 70 kg**						**Children 24 kg**					
	Cr	**Ni**	**Pb**	**Cu**	**Fe**	**HI**	**Cr**	**Ni**	**Pb**	**Cu**	**Fe**	**HI**
Kashk and eggplant	0.02	0.48	2.34	0.23	5.16	8.23	0.06	1.28	6.84	0.68	14.74	23.6
Eggplant halim	0.006	0.36	1.80	0.18	4.83	7.17	0.02	1.06	5.26	0.52	14.11	20.97
Halim	0.006	0.51	2.52	3.17	7.93	14.13	0.02	1.49	7.36	9.26	23.14	41.57
Adasi	0.02	1.04	6.10	25.87	46.85	79.88	0.05	2.98	16.84	75.47	136.67	232.01
Lentil halim	0.03	1.39	11.90	22.88	52.75	88.95	0.10	4.05	34.73	66.73	153.86	259.47
Abgosht	0.02	1.68	28.51	2.19	9.18	41.58	0.06	4.90	83.15	6.10	26.79	121
Kaleh pache	0.02	1.46	25.26	14.72	13.14	54.6	0.07	4.26	73.68	42.94	38.32	159.27
Barbecue chicken	0.06	0.36	1.80	2.63	5.34	10.19	0.18	1.06	5.26	7.68	15.59	29.77
Kubideh kebab	0.04	0.18	0.90	0.52	5.16	6.8	0.11	0.42	2.63	1.47	15.06	19.69
Beriani	0.07	0.65	5.77	11.87	24.33	42.69	0.21	1.92	16.84	34.63	70.98	126.58
Kofteh Tabrizi	0.08	3.11	4.51	0.45	27.97	36.12	0.23	9.25	13.15	1.31	81.59	105.53
Chicken tah-chin	0.06	1.53	5.77	2.19	7.65	17.2	0.17	2.56	16.84	6.10	22.32	47.99
Chicken stew	0.04	2.91	19.66	24.36	53.65	100.62	0.11	8.32	57.36	71.05	156.50	293.34
Fesenjan stew	0.01	3.46	17.46	9.88	6.90	37.71	0.03	10	50.94	29.15	20.14	110.26
Gheymeh stew	0.02	0.83	16.24	8.37	11.86	37.32	0.04	2.34	47.36	24.42	34.61	108.77
Ghormeh sabzi stew	0.02	3.01	13.71	3.75	15.85	36.34	0.05	8.75	39	10.94	46.26	105
Sholeghalamkar ash	0.01	0.72	2.16	3.89	14.01	20.79	0.04	1.92	6.84	11.36	40.87	61.03
Ashe reshteh	0.008	1.51	11.90	3.64	6.48	23.53	0.02	4.26	34.73	10.63	18.92	68.56
Barley soup	0.005	0.89	7.57	0.14	9.59	18.19	0.01	2.56	22.10	0.42	29.02	54.11
Milk soup	0.01	1.07	5.15	0.18	8.85	15.26	0.03	3.12	14.73	0.52	25.82	44.22

*P-value less than 0.5 was observed in all food samples, which is statistically significant.

DISCUSSION

Concentrations of heavy metals

Chromium (Cr)

In the current survey, the highest amount of Cr was found in Beriani (0.77 m m^{-1}) and the lowest in Halim (0.05 m m^{-1}). The mean levels of Cr in 95% of the examined foods were considerably higher than the allowable limits set by FAO/WHO [15]. The meat-based foods in the present investigation showed the highest levels of Cr; which may be due to the high absorption rates of Cr in meat products [16].

This element can be useful or toxic for humans and animals, depending on its oxidation state and concentration. In general, meat, shellfish, fish, eggs, whole grain cereals, nuts, and some fruits and vegetables are good sources of Cr. Trivalent Cr (Cr(III)) is an important component in balanced human and animal diets, and its deficiency can disrupt the metabolism of glucose and lipids, and thereby cause symptoms of diabetes and cardiovascular diseases. But, hexavalent Cr (Cr(VI)) is highly toxic and carcinogenic and it can cause death in humans, animals, and plants if ingested in high amounts. The short-term adverse effects of Cr on humans include the inflammation and irritation of the mouth, nose, and lungs, skin inflammation, problems with digestion, and damage to the kidneys and liver [17]. Therefore, the average values of Cr(VI) were measured in this study.

In an investigation in 2015, the levels of Cr in street foods (pork, beef, goat, and chicken meat) were above those set by public health regulations [18]. In a study conducted in Irbid, the average concentrations of Cr in a large number of canned fruits and vegetables (tomato sauce, green beans, pineapple juice, and carrots) were found to be above the permissible limit set by FAO/WHO [19]. Furthermore, the results of another study on vegetables revealed much higher Cr concentrations than the safe limit proposed by FAO/ WHO [20].

The Cr levels found in the current study were lower than those determined by Bamuwamye et al., Massadeh and Al-Massaedh, and latif et al.

Nickel (Ni)

The levels of Ni in the examined food samples were between 0.05 and 0.43 m m^{-1}; which is below the maximum limit set by FAO/WHO.

A low amount of Ni is needed for the production of red blood cells in the body; although it can be rather toxic in high quantities. The lowest levels of Ni are generally found in dairy products and milk. The high concentration of this metal in food products is usually caused by food processing and preparation. Ni intake does not seem to cause any problems in the short term, but it can reduce body weight, damage the heart and liver, and lead to allergies and various types of cancers in the long run [21].

Meanwhile, the Ni concentrations found in the present work are greater than those observed by Zhu et al. That study reported Ni concentrations of 0.026–0.075 m m^{-1} in edible vegetable oils; which are below the permissible limit. In another study on vegetables (potato, cabbage, carrot, tomato, and spinach), found Ni concentrations of 0.1–0.84 m m^{-1}; which are at the safe limit [9]. In addition, Ni concentrations in the chicken meat consumed in southern China were not above the food safety limit [22]. The findings of the present study are in line with those of this latter study in southern China.

Lead (Pb)

Pb was detected in all the examined food samples in the present study; and this should be a call for concern. The maximum amount of this element (0.79 m m^{-1}) was found in Abgosht. As can be seen in Table 2, Pb is the heavy metal with the highest concentration in the examined food samples. Therefore, for safeguarding human health, it is important to monitor Pb concentrations in various foods.

Different factors affect the way Pb is absorbed from food by the body. For instance, Fe and calcium deficiencies in a diet with high carbohydrate and low protein contents can lead to increased ingestion of Pb. Foods, in general, have low levels of Pb; however, relatively high amounts of Pb can be found in sea foods and animal organs such as liver and kidneys. Pb adversely affects human health by disrupting the development of nervous system and causing hypertension [5].

Abgosht is a traditional Iranian food, with meat, potatoes and legumes as its main ingredients [23]. Potato is the third most widely used agricultural product in Iran after rice and wheat. Potatoes are likely to be contaminated with heavy metals either at the cultivation stage or the processing stage [22].

Bamuwamye et al. found the Pb levels in grilled pork, beef and chicken to be greater than the maximum permitted level specified by public health regulations. According to the findings in Malaysia, the Pb level in shrimp (consumed in

large amounts in Malaysia) was higher than the FAO/WHO limit [25]. Another study in China reported high levels of Pb, exceeding the safe limit, in 35.9% of vegetables studied [26].

Copper (Cu)

The Cu levels in the examined traditional foods were in the range of 0.05–6.34 m m^{-1}. In the present study, in all the tested food samples, the concentrations of both Cu and Ni were found to be lower than the regulation levels proposed by FAO/WHO. Thus the Cu levels in the traditional foods examined in this study do not pose a health risk to consumers.

Cu is one of the most important metals in food and an essential element for the body. However, it can be harmful to health in high doses. This element is useful for making red blood cells. It also helps the thyroid gland to balance the hormones. Cu has an effective role in the activities of intestinal enzymes. It increases the level of adrenaline, norepinephrine, and dopamine [27].

Bamuwamye et al. reported an average Cu level of 1.22 m m^{-1} in grilled pork, beef, goat and chicken meat; which is below the standard level. Latif et al. found a Cu concentration of 65 m m^{-1} in vegetables; which is within the permissible limit, and much greater than the levels found in this study. In a study conducted on rice, lentils, vegetables, snacks, fish, and chicken meat in India, Das and Das found Cu contents of 1.04–17.05 m m^{-1}; which are below the standard permissible levels.

Iron (Fe)

The Fe levels in the food samples were in the range of 10.78-146.17 m m^{-1}. Also, the concentration of Fe in 20% of the examined traditional foods was much higher than the limit determined by FAO/WHO. The highest amount of Fe was observed in Lentil halim and the lowest in Kashk and eggplant.

Fe is an essential mineral for body's proper functioning. Therefore, it is crucial to receive enough Fe through daily diet. People eating large quantities of red meat, chicken, fish, lentil, spinach and plums have a higher Fe content in their blood than others. Although Fe is an essential element in human nutrition and is present in a number of important biochemical proteins such as hemoglobin, cytochromes, and many reducing oxidizing enzymes, its intake in large amounts causes hemochromatosis, kidney failure, hypertension, joint pain, Alzheimer, arthritis, dyspnea, heart attacks, and cancer [28].

A study conducted by Zhu et al. on vegetable oils in China reported high Fe levels in the range of 16.2–45.3 m m^{-1} which are above the level recommended by the Institute of Medicine of the National Academies. A study by Bamuwamye et al. on grilled meats found Fe contents in the range of 5.58–24.55 m m^{-1}; which are lower than those found in the present study. Moreover, in a study by Latif et al. the concentration of Fe was higher than the standard level in two of the samples tested; but even the highest amount of this element in our samples is much smaller than what was reported by Latif et al.

The highest concentration of this metal was found in Lentil halim, a popular traditional food in Iran, which is consumed as breakfast, lunch, or dinner. Among the legumes, lentils have the highest Fe content (73–90 m m^{-1}) [23].

THQ and HI of heavy metals from restaurant traditional foods for adults and children

According to experimental data, the THQ values of heavy metals in the examined traditional foods, for adults and children, are in the following order: Fe > Pb > Cu > Ni > Cr. The results show that the THQs of Ni, Cu, Pb and Fe elements found in most of the traditional foods consumed by children and adults in Isfahan province are higher than the USEPA guideline values. This indicates that both adults and children will experience adverse health effects in their lifetime. Also, regarding the levels of Fe and Cr in the tested foods, it is concluded that Fe is a much more dangerous element.

One of the reasons the tested food samples in this survey had such high levels of Pb, Ni, Cu and Fe, compared to Cr, could be the contamination of foods in this study with these metals. The low RFD values of Pb (0.004), Ni (0.02), Fe (0.7) and Cu (0.04), in comparison to Cr (1.5), could be

another major reason [29]. Therefore, based on the results of this study, it can be concluded that children are much more prone to non-cancerous diseases than adults through the consumption of these kinds of foods.

The HI values of greater than 1 (HI > 1) for food samples in Table 3 indicate the adverse health effects of these foods on consumers and for both age groups, the highest value of HI belongs to Chicken stew. This reveals that this traditional food is the main source of heavy metals intake, followed by Lentil halim, Adasi, Kale pache, and Beriani. Accordingly, younger individuals like children, who may consume these contaminated foods for a longer period, are more susceptible to heavy metal toxicities and should exercise more precautions.

Therefore, it can be concluded that the traditional foods consumed in Isfahan do not generally meet the food health and safety guidelines.

Since the highest values of THQ and HI belonged to chicken meat, we can think of several sources of heavy metals contamination in poultry, including the contamination of the drinking water used in poultry farms, contaminated poultry feed, and infected chicks used for breeding. Another possible source of heavy metals contamination could be the pesticides used on agricultural lands [22].

A study by Islam et al. on consumed foods in Bangladesh found THQ values of more than 1 for fish, vegetables, cereals and fruits. Also, a risk assessment of heavy metals in foods consumed in Greece and revealed that the THQ values of these elements are higher than the stipulated healthy limits [30]. A health risk assessment of vegetables in 2019 year found THQ values of 1.59–6.4 (above the standard levels) for all the examined vegetables [31]. Furthermore, a survey conducted in Nigeria by Ezemonye et al. on drinking water, fish and shrimp intake showed THQ values of higher than 1 for drinking water and fish.

In contrast, in the study by Bamuwamye et al. on barbecued pork, beef, goat, and chicken, the highest HI value belonged to beef, with a higher HI (risk) for children than for adults. A study conducted by Janadeleh and Kardani in Iran showed HI values of greater than 1 for two types of fish. Also in another study out of 21 kinds of street foods in Nigeria, the HI values were higher than 1 in 4 samples for children and 3 samples for adults [32]. Islam carried out a study on meat products and showed the highest HI value for Pb, with a higher risk for children than adults. The findings of our study are consistent with Islam's research.

Based on the findings of the current survey, the THQ and HI values for non-cancerous diseases are much higher than those found in other studies.

CONCLUSIONS

The amounts of heavy metals measured in all the traditional food samples in this study (except Ni and Cu) were above the maximum limits defined by FAO/WHO standards. Considering the high levels of Pb found in traditional foods, it is crucial to examine the contamination of various foods with this heavy metal in different parts of Iran. The accumulation of Pb in restaurant foods poses a health risk to consumers, especially to children, who will be consuming these foods for a longer period. The THQ and HI values of heavy metals ingested through Chicken stew were much greater than the USEPA guideline values, indicating that the residents of Isfahan face a significant potential health risk by consuming Chicken stew. The THQ and HI values of heavy metals as related to non-cancerous diseases were higher for children than adults. Therefore, it can be concluded that the traditional foods examined in this study are rather unsafe and unhealthy in terms of heavy metals contamination, and that the general public in Iran should be careful about the overconsumption of these kinds of foods.

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Conflict of interests

The authors have declared that there is no conflict of interest.

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