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A probabilistic health risk assessment of potentially toxic elements in edible vegetable oils consumed in Hamadan, Iran

Fereshteh Mehri[1], Ali Heshmati[1*], Elaheh Talebi Ghane[2], Mohammad Khazaei[3], Trias Mahmudiono[4] and Yadolah Fakhri[5]

Abstract

In this study, potential toxic element (PTEs) including lead (Pb), arsenic (As), cadmium(Cd), iron (Fe) and zinc (Zn) in traditional and industrial edible vegetable oils (peanut, sunflower, olive and sesame) collected from Hamadan, west of Iran were determined using Inductivity Coupled Plasma Optical Emission Spectrometry (ICP-OES). Besides, probabilistic health risk assessment (non-carcinogenic and carcinogenic risks) was identified via total target hazard quotient (TTHQ) and cancer risk (CR) by the Monte Carlo Simulation (MCS) model. The ranking of concentration PTEs in traditional and industrial edible vegetable oils was $Fe > Zn > As > Pb > Cd$. The in all samples, content of PTEs in industrial oils were upper than traditional oils ($p < 0.001$). The level of PTEs in most of vegetable oils was lower than permissible concentration regulated by Codex and national standard. In term of non-carcinogenic, consumers were at acceptable range (TTHQ < 1) due to ingestion both traditional and industrial vegetable oils content of PTEs. In term of carcinogenic, CR the both adults and children was higher than acceptable range (CR < 1E-6), Hence consumer are at unacceptable risk due to ingestion industrial vegetable oils content of inorganic As. Therefore, it is recommended to implement control plans for PTEs in vegetable oils consumed in Hamadan, Iran.

Keywords Food security, Potentially toxic element(s), Edible vegetable oils, Health risk, Monte Carlo simulation

*Correspondence:
Ali Heshmati
ali_heshmaati@yahoo.com
[1] Nutrition Health Research Center, Hamadan University of Medical Sciences, Hamadan, Iran
[2] Modeling of Noncommunicable Diseases Research Center, Hamadan University of Medical Sciences, Hamadan, Iran
[3] Department of Environmental Health Engineering, Research Center for Health Sciences, Hamadan University of Medical Sciences, Hamadan, Iran
[4] Department of Nutrition, Faculty of Public Health, Universitas Airlangga, Jl. Mulyorejo Kampus C, Surabaya 60115, Indonesia
[5] Food Health Research Center, Hormozgan University of Medical Sciences, Bandar Abbas, Iran

Introduction

Food security is one of the chief global worries in the last years [1–7]. Environmental pollution in soil [8, 9], air [10–13], water resources [14, 15], food such as dough, meat, wheat, rice and etc [1, 2, 16–30] has increased over decades [23, 24, 28, 31]. These pollutants includes microbial [32–34], mycotoxins [5, 35–38], heavy metals [6, 32, 39–47], pesticides, antibiotics [8, 48] and other contaminants [49–53] caused cancers [54–58] and other diseases [59–61]. The demand for the using of vegetable oils in different fields such as chemical science, medicinal, and cosmetic and active industries has increased in various counties of worldwide in recent decade [62].

The as reported during 2001–2011, mean per capita consumption of oils was stated to be 10.71 kg [63]. Vegetable oils are water insoluble constituents

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obtained from plants, which contain chiefly of long-chain fatty acid esters derived from the alcohol glycerol [64]. These compounds due to contain different components including linoleic, stearic, oleic, protein, carbohydrate, palmitic acid, antioxidant and vitamins play important role in human health as production energy source, use in structural component and help to absorption of the fat-soluble vitamins in body human [65, 66]. Moreover consumption of oils can result to cholesterol reduction effect, and prevention of cardiovascular pathologies [67].

However, many reports have documented the occurrence of potentially toxic elements in edible vegetable oils and soil in different regions of Iran and world [68–70] although there is a little information in Hamadan province, the western region of Iran.

The important objectives of the current study are 1) to determine the concentration of PTEs in the vegetable oils (sunflower, peanut, sesame and olive)available in the western Iran market using Inductivity Coupled Plasma Optical Emission Spectrometry (ICP-OES) detection, 2) to compare the occurrence levels compared to European Union and Iranian Standards maximum limits, 3) to assess the risks to the consumers exposure to PTEs in vegetable oils in Iran, 4) to draw the necessary consideration of the public health authorities towards conducting extensive monitoring and establish regulations for PTEs. The results of the current study will be beneficial for farmers, merchants, and consumers in the community.

Material and method
Collection of samples
The twenty of traditional vegetable oil including peanut ($n=5$), sunflower ($n=5$), olive ($n=5$) and sesame ($n=5$) were completely random bought from local shop and farmer's market in Hamadan, western Iran. Moreover, the twenty of vegetable oil samples peanut ($n=5$), sunflower ($n=5$), olive ($n=5$) and sesame ($n=5$) were obtained from the various cities of the province as industrial sample during 2022. All samples kept in closed polyethylene containers were stored in the temperature (4 °C) until the examination time.

Chemical materials, digestion samples and method validation
All solutions were purchased from Merck, (Darmstadt, Germany). Double de-ionized water was applied for all dilutions. Stock standard solutions of all elements (1000 mg/L) were prepared from Merck was used for calibration standards. HNO_3 (65%), de-ionized water, and H_2O_2 (30%) with a grade of spectroscopic, was taken by Merck (Darmstadt, Germany). All the Falcons pipe were washed by drenching in a nitric acid solution (10%) and formerly washed with de-ionized water prior to experimental to reduce the pollution of sample. For digestion 1 mL of each sample was poured in a glassware and were assimilated with 6 ml of HNO_3 (65%) and 2 ml of H_2O_2 (30%) and then the sample was stirred at room temperature for 11 h. The time and power of digestion was set in two stages—stage 1 (1 h at 80 °C) and stage 2 (3 h at 150 °C) [66]. In the continuation of the experiment, all samples were transferred to vials of ICP-OES for examination. Simultaneously, blank samples were organized with the same technique.

Method validation
The validation for PTEs in samples was done based on the procedure study [71]. The content of LOD and LOQ were considered using 3 and 5 times the standard deviation of the reply on the standard curve slope (SD/b), respectively. The linearity, recovery percentages, regression coefficient (R^2), LOQ and LOD, of metals in various samples are presented in Table 1.

Determination of PTEs
The measure of all vegetable oil samples was done by ICP-OES techniques. The operating factors were including: producer of RF was1400 W; the argon gas applied for plasma and nebulizer auxiliary was. Gas flow used for plasma, auxiliary, and nebulizer were 14.50, 0.90 and 0.85 $Lmin^{-1}$, respectively. Gas flow of 14.50, 0.90 and 0.85 $Lmin^{-1}$, were utilized for plasma, auxiliary, and nebulizer respectively.

Table 1 Method validation parameters reported by ICP-OES analysis in vegetable oils

Metals	Wavelength	R^2 Value	Calibration Range	Recovery %	LOD (µg/L)	LOQ (µg/L)
As	188.03	0.998	0.2–1400	99	0.16	0.50
Cd	227.80	0.997	0.3–1400	96	0.02	0.09
Pb	282.30	0.994	1.4–1400	99	0.12	0.41
Fe	328.2	0.996	0.4–1300	100	0.63	1.89
Zn	204.19	0.999	0.3–1300	95	0.43	1.30

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Moreover, period of uptake, rinse, and initial stabilization of samples was 240, 45 and 45 s, respectively. Also, period of replicate were zero. The frequency of the producer of RF was 27.12 MHz. Cyclonic and modified Lichte, was used as the types of detector solid state and spray chamber respectively. The delivery pump of sample was used four-channel, Furthermore the speed of pre-wash pump (rpm) was set as 60 (for 15 s), 30 (for 30 s), at the ultimately, the injection pump speed and time of pre-wash was 30 rpm and 45 s respectively.

Probabilistic health risk assessment
Non-carcinogenic risk
The chronic daily intake (CDI), target hazard quotient (THQ) and total target hazard quotient (TTHQ) due to ingestion vegetable oils content of PTEs were calculated based on the following equations [72–75].

$$CDI = \frac{C \times IR \times ED \times EF}{BW \times AT} \quad (1)$$

$$THQ = \frac{CDI}{RfD \text{ or } TDI} \quad (2)$$

Where, CDI is chronic daily intake; C, concentration of PTEs (mg/kg); IR, ingestion rate; EF, exposure frequency (350 days/year); ED, exposure duration that for children and adults was set 6 and 70 years, respectively; BW, body weight that for children and adults was set 15 and 70 kg, respectively; and AT for non-carcinogenic risk is the mean time life span for children and adults is equal to 2190 and 25550 days, respectively and for carcinogenic risk for both children and adults is equal to 25550 days. IR for vegetable oil by Iranian consumers which was set at (adults (100 g/d-n) and children (20 g/d-n)), respectively [76]. Oral RfD indication oral reference dose of set for Cd, Zn, Fe and As was 0.001, 0.3, 0.7 and 0.0003 mg/kg-d, respectively. While, TDI for Pb was 0.0036 mg/kg-d [62].

$$TTHQ = \sum_{J}^{j} THQ \quad (3)$$

Where, TTHQ is sum of individual THQ. When THQ and/or TTHQ is lower than 1 value consumers are at safe non-carcinogenic risk [62].

Carcinogenic risk
The carcinogenic risk (CR) of the inorganic As in vegetable oils was calculated using this equation

$$CR = CDI \times CSF \quad (4)$$

Where, CSF is cancer slope factor that is for inorganic As 1.5 (mg/kg-d)$^{-1}$. When CR is lower than 1.00E-6 value, consumers are at safe carcinogenic risk [62].

Uncertainty analysis
Then single-point values were employed for evaluation of risk, high uncertainty can occur in the analysis of the results, therefore for raise precise of risk Monte Carlo simulated (MCS) technique was utilized for estimate health risk. The type of distribution of PTEs concentration data was obtained as log-normal through fit-distribution command and according to similar studies distribution of ingestion rate was selected log-normal [77–79]. In this way cut point of risk was considered as median of THQ and CR with 50,000 repetitions [80].

Statistical analysis of study
The measurement of all data was conducted by the SPSS 11.5.1 software. A finding was indicated in three repetitions and was indicated as mean ± standard deviation (M ± SD). The difference among the PTEs was stated by one-way ANOVA, and the Duncan's new multiple was used as post-doc test. The significance was set at 0.05.

Results and discussion
PTEs concentration in traditional edible vegetables oils and comparison with published studies
In this study, mean content of PTEs (As, Cd, Pb, Fe, and Zn) in 40 samples of traditional and industrial edible vegetables oils were shown in Table 2. As seen of results, there were suitable linear associations between the answers of instrumental and the PTEs level in edible oils with correlation coefficients of 0.997 or upper. The optimized method indicated to have the high sensitive and selective, so that LOD, LOQ and recover was ranged from (0.02 to 0.63 µg/L), (0.09 to 1.89µg/L) and (95% to 100%), respectively Table 1. According to results, as seen from Table 2, A mean concentration of 0.60 ± 0.22 (As), 0.005 ± 0.02 (Cd), 8.92 ± 0.91 (Fe), 0.14 ± 0.004 (Pb), and 3.74 ± 0.53 (Zn) mg/kg was reported for olive oil samples. With regards to sunflower oil samples, mean concentration of As, Cd, Fe, Pb, and Zn was 0.05, 0.011, 2.19, 0.011, and 2.10 mg/kg, respectively (Table 2). Moreover, mean concentration of As, Cd, Fe, Pb, and Zn in sesame oil samples was 0.06, 0.009, 15.09, 0.009 and 3.19mg/kg, respectively. These values in peanut oil samples were 0.005, 0.006, 5.65.0.25 and 2.86 mg/kg respectively.

Compared to our results, Heidary et al. indicated mean content of Cd, Pb, and Zn, in olive oil of Iran country was 0.071, 0.22 and 41.38 mg/kg, respectively [81]. In conducted study by Luka et al. on olive oil samples from the Cyprus country mean level of Cd, Pb and As was 0.08, 0.45 and 0.19 mg/kg than were upper than our study [82]. Ieggli et al. concluded mean concentration of Fe, Pb, As and Cd in sunflower oil samples of Saudi Arabia country was 99.3, 0.09, 0.08 and 0.09 mg/kg [83]. Consistent with

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Table 2 Mean concentration of PTEs (mg/kg) in traditional and industrial vegetable oils samples ($n = 40$)

Oil		As	Cd	Fe	Pb	Zn
Olive	**Traditional**	0.060 ± 0.022	0.005 ± 0.002	8.928 ± 0.913	0.014 ± 0.004	3.756 ± 0.538
	Industrial	0.113 ± 0.028	.007 ± 0.002	11.739 ± 2.147	0.016 ± 0.002	3.644 ± 0.458
	P-value	< 0.001	0.045	< 0.001	0.119	0.544
Sunflower	**Traditional**	0.052 ± 0.032	0.011 ± 0.006	2.195 ± 1.226	0.011 ± 0.003	2.102 ± 0.654
	Industrial	0.053 ± 0.021	0.010 ± 0.004	0.097 ± 0.028	0.016 ± 0.003	3.551 ± 0.542
	P-value	0.946	0.827	< 0.001	< 0.001	< 0.001
Sesame	**Traditional**	0.064 ± 0.037	0.009 ± 0.004	15.091 ± 1.182	0.009 ± 0.004	3.192 ± 2.143
	Industrial	0.091 ± 0.033	0.009 ± 0.003	23.664 ± 2.698	0.013 ± 0.002	6.299 ± 0.974
	P-value	0.043	0.603	< 0.001	< 0.001	< 0.001
Peanut	**Traditional**	0.005 ± .003	0.006 ± .002	5.655 ± 1.477	0.025 ± 0.035	2.863 ± 1.977
	Industrial	0.089 ± .038	0.009 ± .002	11.323 ± 1.726	0.027 ± .045	8.835 ± 1.346
	P-value	< 0.001	< 0.001	< 0.001	0.889	< 0.001
Total	**Traditional**	0.046 ± .035	0.008 ± 0.004	7.967 ± 4.937	0.015 ± 0.018	2.978 ± 1.598
	Industrial	0.086 ± .037	0.009 ± 0.003	11.706 ± 8.613	0.018 ± 0.023	5.582 ± 2.366
	P-value	< 0.001	0.172	0.004	0.370	< 0.001
P-value	Type	< 0.001	0.124	< 0.001	0.356	< 0.001
	Oil	< 0.001	< 0.001	< 0.001	0.019	< 0.001
	Type × Source	0.201	0.078	0.389	0.985	0.113

this study, in research conducted by Zhu et al., mean concentration of Fe and Pb obtained 29.2 and 0.010 mg/kg [84] that was above our results. Acar et al. reported level contamination of Pb, Fe and Zn in Sunflower oil samples of Turkey country was 0.08, 1.51and 1.23 mg/kg that than our results was lower [85]. Yao et al. expressed mean concentration of Pb and Cd in peanut oil samples of China country was 0.093 and 3.47 µg kg-1 [86]. Asemave et al. indicated mean concentration of Fe, Cd and Pb in peanut oil samples of Nigeria country was 8.51, 0.16 and 0.02 µg kg-1[87]. Zhu et al. reported mean concentration of As, Pb, Cd, Fe, and Zn in sesame oil samples of China country was 0.015, 0.014, 0.005, 37.9 and 0.07 µg kg-1, respectively [84]. Razzaghi et al. indicated mean concentration of As, Pb, Cd, Fe, and Zn in sesame oil samples of Iran country was 0.011, 0.016, 0.001, 3.49 and 1.70 µg kg-1, respectively [88].

PTEs concentration in industrial edible vegetables oil and comparison with published studies

In our study, 40 samples from various edible vegetable oils were investigated; of which 20 samples were industrial products. Mean concentration of As, Cd, Fe, Pb, and Zn, in industrial olive oil samples were 0.11 ± 0.02, 0.007 ± 0.002, 11.73 ± 2.14, 0.16 ± 0.002, and 3.64 ± 0.45 mg/kg, respectively (Table 2). With regards to results, mean concentration of 0.053 ± 0.02 (As), 0.010 ± 0.004 (Cd), 2.97 ± 0.28 (Fe), 0.16 ± 0.003 (Pb), and 3.51 ± 0.54 (Zn) mg/kg was detected for sunflower oil samples, respectively. Mean concentration of As, Cd, Fe, Pb, and

Zn in sesame oil samples was 0.091, 0.009, 23.66, 0.013 and 6.29mg/kg, respectively. These values in industrial peanut oil samples were 0.86, 0.009, 11.32, 0.0.027 and 8.83 mg/kg respectively.

Aligned with our findings, Mendil et al. indicated concentration of PTEs such as Cd, Pb, Zn and Fe in industrial olive oils samples of Turkey country was 0.15, 0.03, 1.03 and 139.0 respectively that in comparison with our study amount of Cd and Zn was lower and Pb and Fe was higher [89]. Farzin et al. showed level of Cd and Pb in industrial olive oils samples of Iran country was 0.045 and 0.046 mg/kg respectively that was lower than this study [66]. In a similar study, Zhu et al. showed level of PTEs such as Cd, Pb, Zn and Fe in industrial olive oils samples of China country was 0.002, 0.009, 32.8 and 1.24 respectively [66]. Compared to our findings, Dugo et al., reported concentration range of Pb and Zn in industrial sunflower oil of Italy country was 0.005–0.016 and 0.08–0.33 mg/kg, respectively. Ashraf et al. showed mean concentration of As, Cd, Fe and Zn in industrial sunflower oil samples of Saudi Arabia country was 0.013, 0.002, 33.4, 0.011 and 1.54 mg/kg [90]. The results of these two studies were lower than our findings. Furthermore, Pehlivan et al. concluded mean concentration of Fe, Pb, As and Cd in industrial sunflower oil samples of Turkey country was 0,01, 0.002, 0.001 and 0.02 mg/kg [91]. Consistent with this study, Nunes et al., reported mean concentration of Fe and Pb in industrial sunflower oil samples of Brazil country obtained 2.99 and 0.3 mg/kg [92], that was higher compared to the results

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of this study. Zhu et al. reported mean concentration of As, Cd, Fe, Pb, and Zn in industrial sesame oil samples of China country was 0.019, 0.018, 0.005, 37.9 and 0.78 mg/kg, respectively. These values in industrial peanut oil samples were 0.013, 0.007, 0.003, 44.7 and 1.18 mg/kg, respectively [84]. Asemave et al. indicated mean concentration of As, Fe, Pb, and Cd in industrial peanut oil samples of Nigeria country was 8.51, 0.16, and 0.002 mg/kg, respectively [87]. In other study conducted by Ashraf et al., they reported concentration of As, Cd, Fe, Pb and Zn for industrial peanut oil samples was 0.017, 0.003, 37.8, 0.13 and 1.71 mg/kg, respectively. While, these values in industrial sesame oil was 0.018, 0.005, 43.8, 0.17 and 0.95 mg/kg, respectively [90].

Comparison of PTEs in traditional and industrial edible vegetables oils with standard level

According to (Table 2), the PTEs such as Fe, Cd, As, Zn and Pb were identified in all traditional and industrial edible vegetables oils. PTEs content was obtained in order of $Fe > Zn > As > Pb > Cd$ in traditional and industrial vegetables oils, respectively. The level of all PTEs in industrial oils were higher compared traditional oils ($p < < 0.001$). The findings of statistical analysis indicated the oil varieties have significant effect the on concentration of PTEs except Cd and Pb. Though, sources (brands) and interaction of Type×Source did not express any effect on the amount PTEs. In our study, the content of PTEs from various edible oils was compared with international organizations code. In this study, concentration of PTEs in all samples was lesser relative to maximum concentration permissible of As (0.1 mg/kg), Cd (0.05 mg/kg), Pb (0.1 mg/kg) regulated by Codex and national standards [66]. All traditional and industrial oils samples concentration of Fe was higher than maximum permissible concentration of Fe (1.5 mg/kg) except industrial sunflower oil [66]. As seen from Table 1, level Zn in all samples was higher than Provisional Tolerable Daily Intakes PTDI (mg/kg-bw) Considered by Institute of Standards and Industrial Research of Iran (ISIRI) standards [81].

As mentioned in current study and in those of previous investigations, there is significant change between metal content in traditional and industrial oils samples. Based on studies, species and breed of the cultivated plant, difference in the bioavailability each of PTEs, improper use of fertilizers, near to roads with heavy traffic, industrial factories, active mines, highways, as well as, storage situation and processing equipment can be mentioned as influential factors [62]. In line with these differences, Nayek et al. reported high mobility of PTEs such as Fe and Cd than Pb can lead to transfer them from polluted soil to plant stems [93]. Ansari et al. concluded that the using of appropriate seeds and irrigation system, could decrease the metal value in sunflower oil [94]. In traditional oils samples, apply of various fertilizers in farming environment can alters the pH, organic level, and biodegradation of PTEs in the soil [95]. Similarly to this study, Ab Manan et al. indicated rise the absorption of PTEs can occur due to decrease of pH and formation of metal–carbonate complexes in oil producing plants [96]. In industrial oils samples, technologies utilized in the manufacture of oil by different processing (bleaching, hardening, refining, and deodorization) can effectively rise the amount of PTEs in raw compounds of seed plants [97]. Finster et al., reported concentration of Pb in the soils of parts near to tetraethyl emissions originated from exhausted car, was upper compared to the soil of other parts [76]. The weather conditions, pollution of the region the like (air pollution from industries, sewage from factories near cultivation) can be mentioned as other sources of contamination from PTEs in oils [65].

Probabilistic health risk assessment

The exposure to little concentrations of PTEs can induce health complications for consumers. The loss of appetite, vomiting, diarrhea, and immune system disease, memory disorder, and damage the various tissue are one of the common complications of metal toxicity [98]. The rank order of PTEs based on their THQ in adults consumers due to ingestion traditional vegetable was As (0.1627) > Fe (0.0132) > Zn (0.0117) > Cd (0.0097) > Pb (0.0036) and in children, As (0.1128) > Fe (0.0092) > Zn (0.0082) > Cd (0.0068) > Pb (0.0025) (Appendix 1 and 2). TTHQ in adults and children due to ingestion traditional vegetable oils content of PTEs was equal to 0.201 and 0.133, respectively (Fig. 1). TTHQ in the both adults and children was lower than 1 value, hence consumer are at acceptable range due to ingestion traditional vegetable oils content of PTEs. The rank order of PTEs based on their THQ in adults consumers due to ingestion industrial vegetable was As (0.3510) Zn (0.0228) > Fe (0.0179) > Cd (0.0121) > Pb (0.0041) and in children, As (0.2450) > Zn (0.0159) > Fe (0.0125) > Cd (0.0084) > Pb (0.0029) (Appendix 3 and 4). TTHQ in adults and children due to ingestion industrial vegetable oils content of PTEs was equal to 0.408 and 0.285, respectively (Fig. 2). TTHQ in the both adults and children was lower than 1 value, hence consumer are at acceptable range (TTHQ < 1) due to ingestion industrial vegetable oils content of PTEs. In term of carcinogenic risk, as stated from investigations, median of CR in the adults and children due to ingestion traditional vegetable oils content of inorganic As was equal to 7.54E-5 and 5.28E-5, respectively (Fig. 3). CR the both adults and children was higher than safe
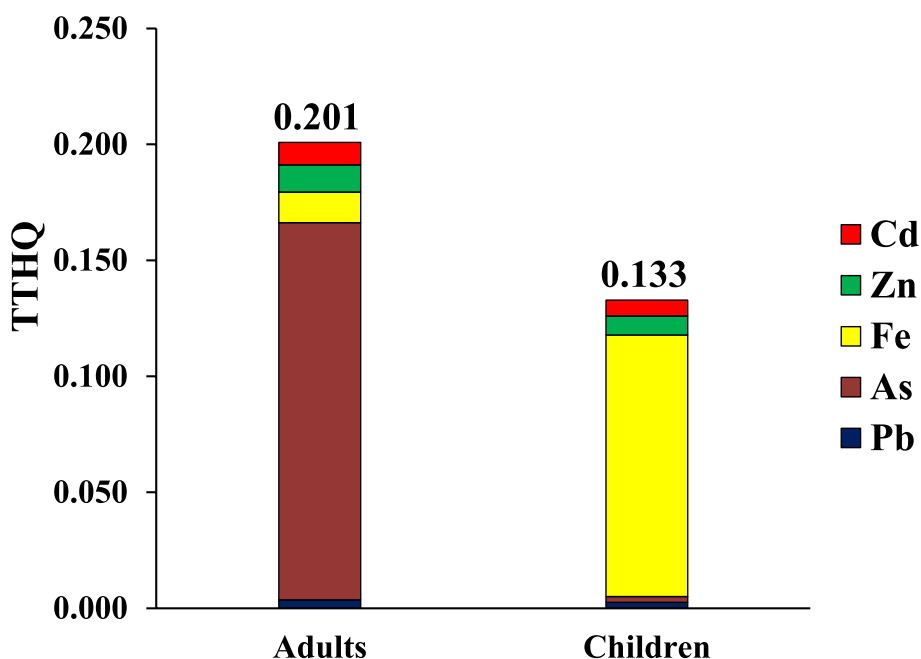
Fig. 1 TTHQ in adults and children due to ingestion traditional vegetable oils content of PTEs
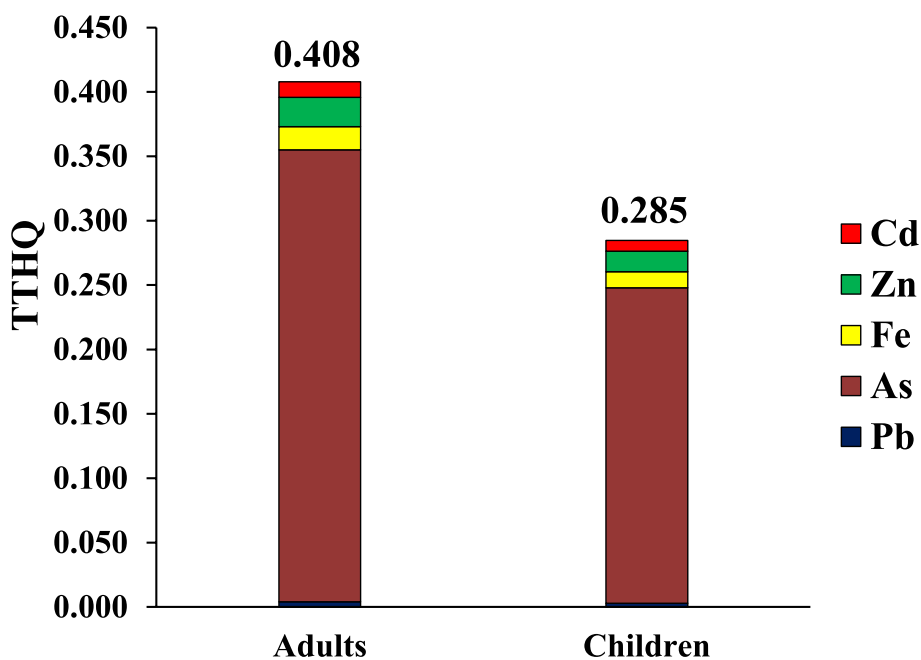

Fig. 2 TTHQ in adults and children due to ingestion industrial vegetable oils content of PTEs

range (CR < 1E-6), Hence consumer are at unacceptable risk due to ingestion traditional vegetable oils content of inorganic As. Median of CR in the adults and children due to ingestion industrial vegetable oils content of inorganic As was equal to 1.61E-4 and 1.15E-4, respectively (Fig. 4). CR the both adults and children was higher than safe range (CR < 1E-6), Hence consumer are at unacceptable risk due to ingestion industrial vegetable oils content of inorganic As. The risk pattern is different in countries and it can be related
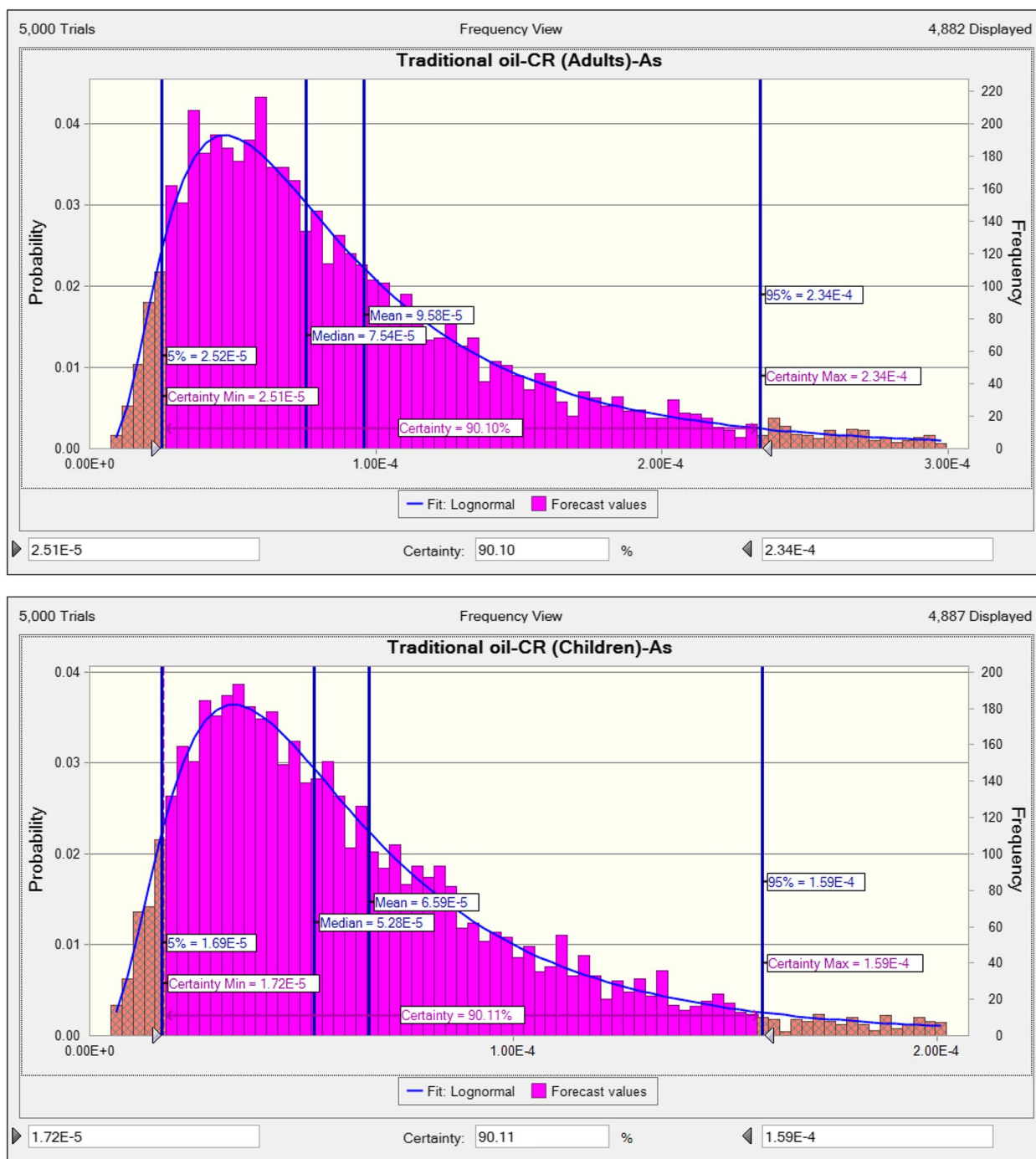
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Fig. 3 CR in adults and children due to ingestion traditional vegetable oils content of inorganic As

to agents including the content of PTEs, ingestion rate of vegetables oils, body weight and exposure time [99]. Consistent with our study, in study inducted by Haj Heidary et al. indicated the concentration of Pb, Cd, Zn and Fe in vegetables oils in Iran was safe and did not pose any health risks [81]. Zhu et al. reported that the concentration of PTEs (Cu, Zn, Fe, Cd, Pb and As) in vegetable oils was lesser than 1, therefore pose no risk to human health [84].
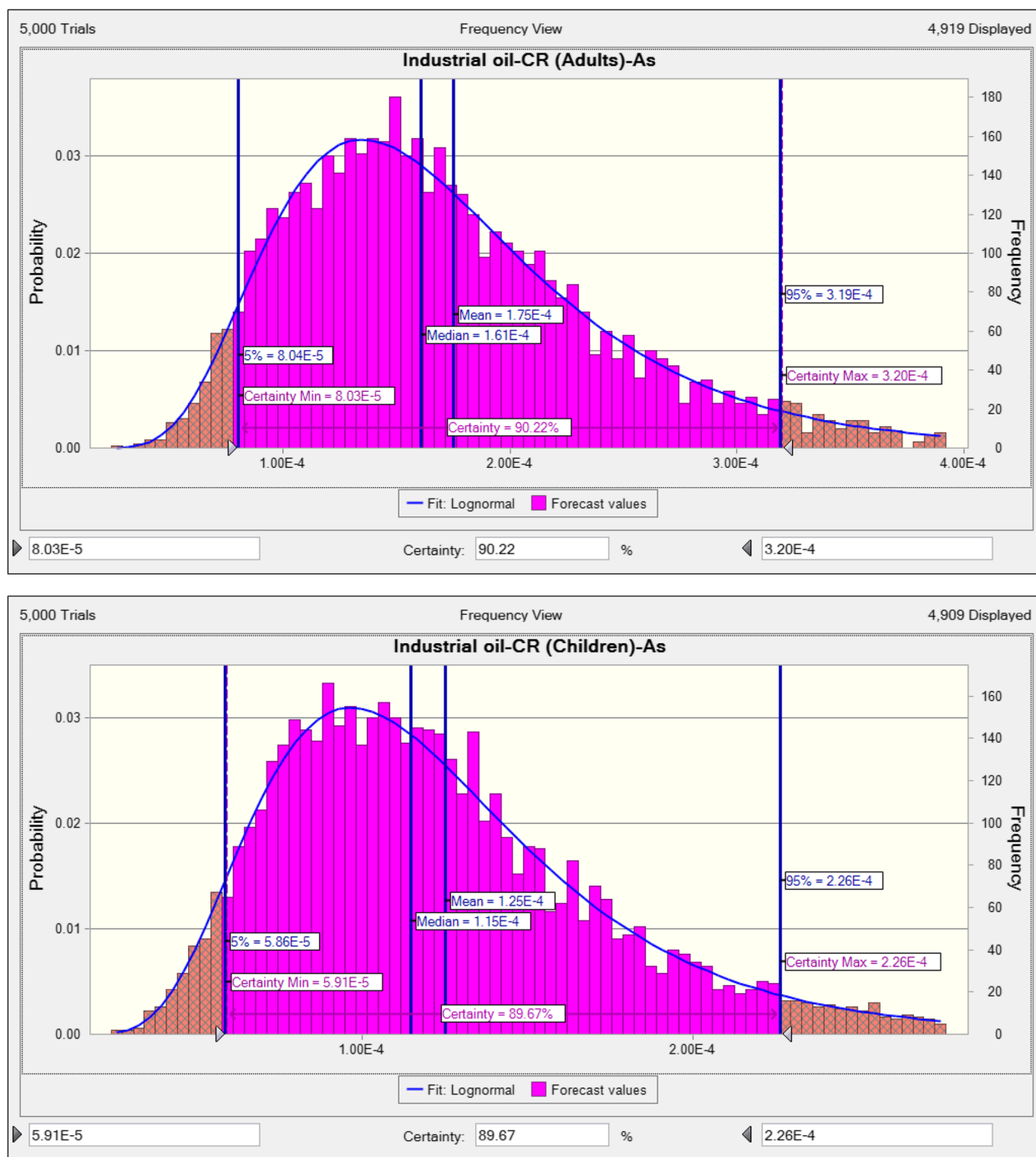
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Fig. 4 CR in adults and children due to ingestion industrial vegetable oils content of inorganic As

Conclusion

This study was carried out to provide information on of PTEs (Cd, Pb, As, Fe, and Zn) content in traditional and industrial vegetable oils in Hamadan, West of Iran. According to the results, the highest and lowest level of PTEs found was related to Fe and Cd respectively. In samples investigated concentrations of PTEs in industrial vegetable oils were higher than traditional fruit juices $p < 0.001$. The content of Pb, Cd, As, Zn and Fe in all samples were detected to be lower compared the suggested legal limits. In term of non-carcinogenic, consumer were at acceptable range (TTHQ < 1) due to ingestion

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traditional and industrial vegetable oils content of PTEs. In term of carcinogenic, CR the both adults and children was higher than safe range (CR < 1.00E-6), Hence consumer are at unacceptable risk due to ingestion industrial vegetable oils content of inorganic As. Because of discharge of pollutants into the environment from some resources, including, industrial and agricultural activities, stricter inspection and control on vegetable oils should be enforced. Moreover, evaluating of the effect of different production processes on the content of metals in vegetable oils is recommended.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-023-17624-1.

Additional file 1: Appendix 1. THQ in the adults consumers due to ingestion traditional vegetable oils content of PTEs. **Appendix 2.** THQ in the children consumers due to ingestion traditional vegetable oils content of PTEs. **Appendix 3.** THQ in the adults consumers due to ingestion industrial vegetable oils content of PTEs. **Appendix4.** THQ in the children consumers due to ingestion industrial vegetable oils content of PTEs.

Authors' contributions
Samples collection and detection of heavy metals in samples were conducted by ET. G, M. K; Analysis of data by F. M, A. H and Y. F; Writing paper by F. M, A.H, T.M and Y.F. All authors reviewed the manuscript.

Availability of data and materials
The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

References

1. Dou X, Lv M, Ren X, He Y, Liu L, Zhang G, Sun Y, Zhang N, Chen F, hua Yang C. Test conditions of texture profile analysis for frozen dough. Ital J Food Sci. 2023;35(4):58–68.
2. Bautista-Martinez Y, Granados-Rivera LD, Maldonado-Jáquez JA, Arenas-Baéz P. Effect of the addition of palmitic acid on fattening performance, carcass and meat quality of sheep. Ital J Food Sci. 2023;35(4):79–87.
3. Siripongvutikorn S, Banphot P, Rampoei N, Thantrirat J. Quality of Thai Furikake dried seasoning powder fortified with natural calcium and phosphorus. Ital J Food Sci. 2023;35(4):88–101.
4. Kaya GK, Çoban ÖE, Bilici R. Effects of rosehip sauce on chemical, oxidative and sensorial quality of marinated anchovy (Engraulis Encrasicolus Linnaeus, 1758). Ital J Food Sci. 2023;35(4):102–10.
5. Meng W, et al. Triboelectric-electromagnetic hybrid generator based self-powered flexible wireless sensing for food monitoring. J Chem Eng. 2023;473:145465.
6. Kan Y, Li J, Zhang S, Gao Z. Novel bridge assistance strategy for tailoring crosslinking networks within soybean-meal-based biocomposites to balance mechanical and biodegradation properties. J Chem Eng. 2023;472:144858.
7. Zhang S, Dongye Z, Wang L, Li Z, Kang M, Qian Y, Cheng X, Ren Y, Chen C. Influence of environmental pH on the interaction properties of WP-EGCG non-covalent nanocomplexes. J Sci Food Agric. 2023;103(11):5364–75.
8. Zhang G, et al. Changes in abiotic dissipation rates and bound fractions of antibiotics in biochar-amended soil. J Clean Prod. 2020;256:120314. https://doi.org/10.1016/j.jclepro.2020.120314.
9. Raimi MO, Iyingiala A-A, Sawyerr OH, Saliu AO, Ebuete AW, Emberru RE, Sanchez ND, Osungbemiro WB: Leaving no one behind: impact of soil pollution on biodiversity in the global south: a global call for action. In: Biodiversity in Africa: Potentials, Threats and Conservation. edn.: Springer; 2022: 205–237.
10. Wen Z, Wang Q, Ma Y, Jacinthe PA, Liu G, Li S, Shang Y, Tao H, Fang C, Lyu L. Remote estimates of suspended particulate matter in global lakes using machine learning models. Int Soil Water Conserv Res. 2024;12(1):200–16.
11. Wei N, Yin L, Yin C, Liu J, Wang S, Qiao W, Zeng F. Pseudo-correlation problem and its solution for the transfer forecasting of short-term natural gas loads. Gas Sci Eng. 2023;119:205133.
12. Feng X, Wang B, Gao G, Gao S, Xie C, Shi J-W. MnyCo3− yOx bimetallic oxide prepared by ultrasonic technology for significantly improved catalytic performance in the reduction of NOx with NH3. Fuel. 2023;352:129159.
13. Aguilar-Gomez S, Dwyer H, Graff Zivin J, Neidell M. This is air: the "non-health" effects of air pollution. Annual Rev Res Econ. 2022;14:403–25.
14. Tang T, et al. Sensitive and selective electrochemical determination of uric acid in urine based on ultrasmall iron oxide nanoparticles decorated urchin-like nitrogen-doped carbon. Colloids and Surfaces B: Biointerfaces. 2022;216:112538.
15. Morin-Crini N, Lichtfouse E, Liu G, Balaram V, Ribeiro ARL, Lu Z, Stock F, Carmona E, Teixeira MR, Picos-Corrales LA. Worldwide cases of water pollution by emerging contaminants: a review. Environ Chem Lett. 2022;20(4):2311–38.
16. Sahni P, Sharma S. Quality characteristics, amino acid composition, and bioactive potential of wheat cookies protein-enriched with unconventional legume protein isolates. Qual Assur Saf Crops Foods. 2023;15(2):1–10.
17. Li X, Jing R, Wang L, Wu N, Guo Z. Role of arbuscular mycorrhizal fungi in cadmium tolerance in rice (Oryza sativa L): a meta-analysis. Qual Assur Saf Crops Foods. 2023;15(2):59–70.
18. She X, Gao Y, Shi Y. Determination of glufosinate-ammonium residue in wheat and soil by ultra-performance liquid chromatography-tandem mass spectrometry. Qual Assur Saf Crops Foods. 2023;15(2):244–51.
19. Özlü H, Çevik B, Atasever M, Sarıalioğlu MF, Polat BA. Investigation of meat species adulteration in beef-based meat products via real-time PCR in Türkiye. Qual Assur Saf Crops Foods. 2023;15(4):42–8.
20. Zhu J, Fan S, He M, Wang N, Xu X, Pang J, Yan Y, Li L, Yang J, Chang W-T. Quality-grade analysis of velvet antler materials using ultra-weak delayed luminescence combined with chemometrics. Qual Assur Saf Crops Foods. 2023;15(4):1–10.
21. Chaari M, Elhadef K, Akermi S, Hlima HB, Fourati M, Mtibaa AC, D'Amore T, Ali DS, Mellouli L, Ennouri M. Potentials of beetroot (Beta vulgaris L.) peel extract for quality enhancement of refrigerated beef meat. Qual Assur Saf Crops Foods. 2023;15(4):99–115.

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22. Chen D, Lv J, Han T, Kan J, Jin C-H, Liu J. Hepatic antioxidant and gut ecological modulation properties of long-term intake of tea (Camellia sinensis L.) flower extract in vivo. Qual Assur Saf Crops Foods. 2023;15(3):11–21.

23. Gao P, Liang W, Zhao Q, Li H, Guan L, Li D. Effects of vitamins A, C, and D and zinc on urinary tract infections: a systematic review and meta-analysis. Qual Assur Saf Crops Foods. 2023;15(3):88–95.

24. Assad A, Bhat MR, Bhat Z, Ahanger AN, Kundroo M, Dar RA, Ahanger AB, Dar B. Apple diseases: detection and classification using transfer learning. Qual Assur Saf Crops Foods. 2023;15(SP1):27–37.

25. Kaya GK, Çoban ÖE, Bilici R. Effects of rosehip sauce on chemical, oxidative and sensorial quality of marinated anchovy (Engraulis Encrasicolus Linnaeus, 1758). Ital J Food Sci. 2023;35(4):20–5.

26. Hwang I, Kwon H. Acrylamide formation in carbohydrate-rich food powders consumed in Korea. Qual Assur Saf Crops Foods. 2022;14(3):43–54.

27. Liao S, Hu K, Xu S, Tao G, Zhang Q: Establishment of dairy product risk rank model based on the perspective of time, space, and potential contaminants. quality assurance and safety of crops & foods 2023, 15(4):1–15.

28. Sarkar T, Mukherjee A, Chatterjee K, Smaoui S, Pati S, Shariati MA. Progressive quality estimation of oyster mushrooms using neural network–based image analysis. Qual Assur Saf Crops Foods. 2023;15(SP1):16–26.

29. Tao R, Liu H, Guo C, Zou J, Zhu Q, Yang Y, Yang B, Chen L. Vintage identification of sauce-flavor liquor based on fluorescence spectroscopy. Qual Assur Saf Crops Foods. 2023;15(4):125–32.

30. Liao S, Hu K, Xu S, Tao G, Zhang Q. Establishment of dairy product risk rank model based on the perspective of time, space, and potential contaminants. Qual Assur Safet Crops Foods. 2023;15(4):143–55.

31. Bangar SP, Sharma N, Bhardwaj A, Phimolsiripol Y. Lactic acid bacteria: a bio-green preservative against mycotoxins for food safety and shelf-life extension. Qual Assur Saf Crops Foods. 2022;14(2):13–31.

32. Mukhametov A, Chulenyov A, Kazak A, Semenycheva I. Physicochemical and microbiological analysis of goose meat. Qual Assur Saf Crops Foods. 2023;15(2):49–58.

33. Yi Y, Shan Y, Lou Y, Ning Z, Zhang Q, Yang Y, Liang Y, Shi J, Hou Z. Antifungal strains M1-8 and M6-4 as biocontrol agents against Aspergillus flavus on peanut kernels. Qual Assur Saf Crops Foods. 2023;15(4):116–24.

34. Yi Y, Hou Z, Yang Q, Cui L, Lu H, Li R, Liu Y, Zhang Y, Chen Y. Antimicrobial mechanism and biocontrol effect of Bacillus cereus XZ30-2 on Aspergillus niger. Qual Assur Saf Crops Foods. 2023;15(4):77–88.

35. Pires RC, Portinari MR, Moraes GZ, Khaneghah AM, Gonçalves BL, Rosim RE, Oliveira CA, Corassin CH. Evaluation of anti-aflatoxin M1 effects of heat-killed cells of saccharomyces cerevisiae in Brazilian commercial yogurts. Qual Assur Saf Crops Foods. 2022;14(1):75–81.

36. Tenge BN, Muiru WM, Kimenju JW, Schwake-Anduschus C, Kimaru SL, Nkonge C. Verification of the Accuscan gold reader and RIDA smart phone application rapid test kits in detection and quantification of aflatoxin levels in maize from selected regions in Kenya. Qual Assur Saf Crops Foods. 2022;14(4):125–35.

37. Basso ABG, Ali S, Corassin CH, Rosim RE, de Oliveria CAF. Individual and combined decontamination effect of fermentation and ultrasound on aflatoxin B1 in wheat-based doughs: A preliminary study. Qual Assur Saf Crops Foods. 2023;15(3):96–103.

38. Onyeaka H, Anumudu CK, Okolo CA, Anyogu A, Odeyemi O, Bassey AP. A review of the top 100 most cited papers on food safety. Qual Assur Saf Crops Foods. 2022;14(4):91–104.

39. Gavahian M. Valorized pineapple waste by conventional and energy-saving ohmic extraction: potentially toxic elements and mycotoxin contamination. Quality Assurance and Safety of Crops & Foods. 2023;15(4):11–20.

40. Bai B, Xu T, Nie Q, Li P. Temperature-driven migration of heavy metal Pb2+ along with moisture movement in unsaturated soils. Int J Heat Mass Transf. 2020;153:119573.

41. Bai B, Jiang S, Liu L, Li X, Wu H. The transport of silica powders and lead ions under unsteady flow and variable injection concentrations. Powder Technol. 2021;387:22–30.

42. Chen X, Liao Y, Long D, Yu T, Shen F, Lin X. The Cdc2/Cdk1 inhibitor, purvalanol A, enhances the cytotoxic effects of taxol through Op18/stathmin in non-small cell lung cancer cells in vitro. Int J Mol Med. 2017;40(1):235–42.

43. Gao L, Huang X, Wang P, Chen Z, Hao Q, Bai S, Tang S, Li C, Qin D. Concentrations and health risk assessment of 24 residual heavy metals in Chinese mitten crab (Eriocheir sinensis). Qual Assur Saf Crops Foods. 2022;14(1):82–91.

44. Hu L, Wang X, Zou Y, Wu D, Gao G, Zhong Z, Liu Y, Hu S, Fan H, Zhang B. Effects of inorganic and organic selenium intervention on resistance of radish to arsenic stress. Ital J Food Sci. 2022;34(1):44–58.

45. Zoghi A, Salimi M, Mirmahdi RS, Massoud R, Khosravi-Darani K, Mohammadi R, Rouhi M, Tripathy AD. Effect of pretreatments on bioremoval of metals and subsequent exposure to simulated gastrointestinal conditions. Qual Assur Saf Crops Foods. 2022;14(3):145–55.

46. Cai S, Zeng B, Li C. Potential health risk assessment of metals in the muscle of seven wild fish species from the Wujiangdu reservoir, China. Qual Assur Saf Crops Foods. 2023;15(1):73–83.

47. Luo C, Sun J, Tan Y, Xiong L, Peng B, Peng G, Bai X. Comparison of the health risks associated with exposure to toxic metals and metalloids following consumption of freshwater catches in China. Qual Assur Saf Crops Foods. 2022;14(4):1–12.

48. Alnour TM, Ahmed-Abakur EH, Elssaig EH, Abuduhier FM, Ullah MF. Antimicrobial synergistic effects of dietary flavonoids rutin and quercetin in combination with antibiotics gentamicin and ceftriaxone against E. coli (MDR) and P. mirabilis (XDR) strains isolated from human infections: Implications for food–medicine interactions. Italian J Food Sci. 2022;34(2):34–42.

49. Liu W, Huang F, Liao Y, Zhang J, Ren G, Zhuang Z, Zhen J, Lin Z, Wang C. Treatment of CrVI-containing Mg (OH) 2 nanowaste. Angew Chem. 2008;120(30):5701–4.

50. Huang W, Xia J, Wang X, Zhao Q, Zhang M, Zhang X. Improvement of non-destructive detection of lamb freshness based on dual-parameter flexible temperature-impedance sensor. Food Control. 2023;153:109963.

51. Jin P, Fu Y, Niu R, Zhang Q, Zhang M, Li Z, Zhang X. Non-destructive detection of the freshness of air-modified mutton based on near-infrared spectroscopy. Foods. 2023;12(14):2756.

52. Tang Y, Yang G, Liu X, Qin L, Zhai W, Fodjo EK, Shen X, Wang Y, Lou X, Kong C: Rapid Sample Enrichment, Novel Derivatization, and High Sensitivity for Determination of 3-Chloropropane-1, 2-diol in Soy Sauce via High-Performance Liquid Chromatography–Tandem Mass Spectrometry. Journal of Agricultural and Food Chemistry 2023.

53. Kan Y, Kan H, Bai Y, Zhang S, Gao Z. Effective and environmentally safe self-antimildew strategy to simultaneously improve the mildew and water resistances of soybean flour-based adhesives. J Clean Prod. 2023;392:136319.

54. Song W, Lv W, Bi N, Wang G. Tectorigenin suppresses the viability of gastric cancer cells in vivo and in vitro. Qual Assur Saf Crops Foods. 2023;15(3):117–25.

55. Jiang M, Zheng S. Geniposide inhibits non-small cell lung cancer cell migration and angiogenesis by regulating PPARγ/VEGF-A pathway. Qual Assur Saf Crops Foods. 2022;14(1):46–54.

56. Geyik ÖG, Tekin-Cakmak ZH, Shamanin VP, Karasu S, Pototskaya IV, Shepelev SS, Chursin AS, Morgounov AI, Yaman M, Sagdic O. Effects of phenolic compounds of colored wheats on colorectal cancer cell lines. Quality Assurance and Safety of Crops & Foods. 2023;15(4):21–31.

57. Wang M, Dai L, Yan W, Chen Y, Wang Y. Brusatol inhibits the growth of prostate cancer cells and reduces HIF-1α/VEGF expression and glycolysis under hypoxia. Qual Assur Saf Crops Foods. 2022;14(4):13–22.

58. Ullah MF, Ahmad A, Bhat SH, Abuduhier FM, Mustafa SK, Al-Qirim T. Functional profiling of Achillea fragrantissima (a perennial edible herb) against human cancer cells and potential nutraceutical impact in neutralizing cell proliferation by interfering with VEGF and NF-κB signaling pathways. Ital J Food Sci. 2022;34(3):35–47.

59. Zhao Y, Chen S, Shen F, Long D, Yu T, Wu M, Lin X. In vitro neutralization of autocrine IL-10 affects Op18/stathmin signaling in non-small cell lung cancer cells. Oncol Rep. 2019;41(1):501–11.

60. Chen S, Zhao Y, Shen F, Long D, Yu T, Lin X. Introduction of exogenous wild-type p53 mediates the regulation of oncoprotein 18/stathmin signaling via nuclear factor-κB in non-small cell lung cancer NCI-H1299 cells. Oncol Rep. 2019;41(3):2051–9.

61. Abbas MM, Almasri M, Abu-Zant A, Sharef S, Mahajne S, Kananbi K. Prevalence of anterior nares colonization of Palestinian diabetic patients with staphylococcus aureus or methicillin-resistant staphylococcus aureus. Qual Assur Saf Crops Foods. 2023;15(4):32–41.

62. Ghane ET, Poormohammadi A, Khazaei S, Mehri F. Concentration of potentially toxic elements in vegetable oils and health risk

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assessment: a systematic review and meta-analysis. Biol Trace Elem Res. 2022;200(1):437–46.

63. Einolghozati M, Talebi-Ghane E, Ranjbar A, Mehri F. Concentration of aflatoxins in edible vegetable oils: a systematic meta-analysis review. Eur Food Res Technol. 2021;247(12):2887–97.

64. Mukhametov A, Yerbulekova M, Dautkanova D, Tuyakova G, Aitkhozhayeva G. Heavy metal contents in vegetable oils of Kazakhstan origin and life risk assessment. Int J Agricultural Biosystems Eng. 2020;14(11):163–7.

65. Poormohammadi A, Bashirian S, Mir Moeini ES, Reza Faryabi M, Mehri F. Monitoring of aflatoxins in edible vegetable oils consumed in Western Iran in Iran: a risk assessment study. Int J Environ Anal Chemistry. 2021;103:1–11.

66. Farzin L, Moassesi ME. Determination of metal contents in edible vegetable oils produced in Iran using microwave-assisted acid digestion. J Appl Chemical Res. 2014;8(3):35–43.

67. Sobhan Ardakani S. Health risk assessment of As and Zn in canola and soybean oils consumed in Kermanshah Iran. J Adv Environ Health Res. 2016;4(2):62–7.

68. Li J, Zhang G, Ned JP, Sui L. How does digital finance affect green technology innovation in the polluting industry? Based on the serial two-mediator model of financing constraints and research and development (R&D) investments. Environ Sci Pollut Res. 2023;1–12.

69. Askarpour SA, Molaee-Aghaee E, Ghaderi-Ghahfarokhi M, Shariatifar N, Mahmudiono T, Sadighara P, Fakhri Y. Potentially Toxic Elements (PTEs) in refined and cold-pressed vegetable oils distributed in Ahvaz, Iran: a probabilistic health risk assessment. Biol Trace Elem Res. 2023;201(9):4567–75.

70. Taghizadeh SF, Rezaee R, Boskabady M, Mashayekhi Sardoo H, Karimi G. Exploring the carcinogenic and non-carcinogenic risk of chemicals present in vegetable oils. Int J Environ Anal Chem. 2022;102(17):5756–84.

71. Heshmati A, Mehri F, Karami-Momtaz J, Khaneghah AM. The concentration and health risk of potentially toxic elements in black and green tea—both bagged and loose-leaf. Qual Assur Saf Crops Foods. 2020;12(3):140–50.

72. Qin Y, et al. Relative bioavailability of selenium in rice using a rat model and its application to human health risk assessment. Environ Pollut. 2023;338:122675.

73. Xiong J, Chen F, Zhang J, Ao W, Zhou X, Yang H, Wu Z, Wu L, Wang C, Qiu Y. Occurrence of Aflatoxin M1 in Three Types of Milk from Xinjiang, China, and the Risk of Exposure for Milk Consumers in Different Age-Sex Groups. Foods. 2022;11(23):3922.

74. Xiong J, Wen D, Zhou H, Chen R, Wang H, Wang C, Wu Z, Qiu Y, Wu L. Occurrence of aflatoxin M1 in yogurt and milk in central-eastern China and the risk of exposure in milk consumers. Food Control. 2022;137:108928.

75. Einolghozati M, Talebi-Ghane E, Khazaei M, Mehri F. The level of heavy metal in fresh and processed fruits: a study meta-analysis, systematic review, and health risk assessment. BiolTrace Element Res. 2022;201:1–15.

76. Khazaei S, Talebi Ghane E, Bashirian S, Mehri F. The concentration of potentially toxic elements (PTEs) in fruit juices: a global systematic review, meta-analysis and probabilistic health risk assessment. Int J Environmental Analytical Chemistry. 2021;103:1–13.

77. Askarpour SA, Molaee-Aghaee E, Ghaderi-Ghahfarokhi M, Shariatifar N, Mahmudiono T, Sadighara P, Fakhri Y. Potentially Toxic Elements (PTEs) in refined and cold-pressed vegetable oils distributed in ahvaz, iran: a probabilistic health risk assessment. Biol Trace Element Res. 2022;201:1–9.

78. Mahdavi V, Omar SS, Zeinali T, Sadighara P, Fakhri Y. Carcinogenic and non-carcinogenic risk assessment induced by pesticide residues in fresh pistachio in Iran based on Monte Carlo simulation. Environ Sci Pollution Res. 2023;30:1–10.

79. Mohamadi S, Mahmudiono T, Zienali T, Sadighara P, Omidi B, Limam I, Fakhri Y: Probabilistic health risk assessment of heavy metals (Cd, Pb, and As) in Cocoa powder (Theobroma cacao) in Tehran, Iran market. International Journal of Environmental Health Research 2022:1–16.

80. Fakhri Y, Daraei H, Hoseinvandtabar S, Mehri F, Mahmudiono T, Mousavi Khaneghah A: The concentration of the potentially toxic element (PTEs) in black tea (Camellia sinensis) consumed in Iran: a systematic review, meta-analysis, and probabilistic risk assessment study. International Journal of Environmental Analytical Chemistry 2022:1–10.

81. Haj Heidary R, Golzan SA, Mirza Alizadeh A, Hamedi H, Ataee M. Probabilistic health risk assessment of potentially toxic elements in the traditional and industrial olive products. Environ Sci Poll Res. 2022;30:1–13.

82. Luka MF, Akun E. Investigation of trace metals in different varieties of olive oils from northern Cyprus and their variation in accumulation using ICP-MS and multivariate techniques. Environmental Earth Sci. 2019;78(19):1–10.

83. Ieggli C, Bohrer D, Do Nascimento P, De Carvalho L. Flame and graphite furnace atomic absorption spectrometry for trace element determination in vegetable oils, margarine and butter after sample emulsification. Food Addit Contam. 2011;28(5):640–8.

84. Zhu F, Fan W, Wang X, Qu L, Yao S. Health risk assessment of eight heavy metals in nine varieties of edible vegetable oils consumed in China. Food Chem Toxicol. 2011;49(12):3081–5.

85. Acar O. Evaluation of cadmium, lead, copper, iron and zinc in Turkish dietary vegetable oils and olives using electrothermal and flame atomic absorption spectrometry. Grasas Y Aceite. 2012;63(4):383–93.

86. Yao L, Liu H, Wang X, Xu W, Zhu Y, Wang H, Pang L, Lin C. Ultrasound-assisted surfactant-enhanced emulsification microextraction using a magnetic ionic liquid coupled with micro-solid phase extraction for the determination of cadmium and lead in edible vegetable oils. Food Chem. 2018;256:212–8.

87. Asemave K, Ubwa S, Anhwange B, Gbaamende A. Comparative evaluation of some metals in palm oil, groundnut oil and soybean oil from Nigeria. Int J Modern Chemistry. 2012;1(1):28–35.

88. Razzaghi N, Ziarati P, Rastegar H, Shoeibi S, Amirahmadi M, Conti GO, Ferrante M, Fakhri Y, Khaneghah AM. The concentration and probabilistic health risk assessment of pesticide residues in commercially available olive oils in Iran. Food Chem Toxicol. 2018;120:32–40.

89. Mendil D, Uluözlü ÖD, Tuezen M, Soylak M. Investigation of the levels of some element in edible oil samples produced in Turkey by atomic absorption spectrometry. J Hazard Mater. 2009;165(1–3):724–8.

90. Ashraf MW, Khobar A. Levels of selected heavy metals in verities of vegetable oils consumed in kingdom of Saudi Arabia and health risk assessment of local population. J Chem Soc Pak. 2014;36(4):691–8.

91. Pehlivan E, Arslan G, Gode F, Altun T, Özcan MM. Determination of some inorganic metals in edible vegetable oils by inductively coupled plasma atomic emission spectroscopy (ICP-AES). Grasas Aceites. 2008;59(3):239–44.

92. Nunes LS, Barbosa JT, Fernandes AP, Lemos VA, Dos Santos WN, Korn MGA, Teixeira LS. Multi-element determination of Cu, Fe, Ni and Zn content in vegetable oils samples by high-resolution continuum source atomic absorption spectrometry and microemulsion sample preparation. Food Chem. 2011;127(2):780–3.

93. Nayek S, Gupta S, Saha R. Metal accumulation and its effects in relation to biochemical response of vegetables irrigated with metal contaminated water and wastewater. J Hazard Mater. 2010;178(1–3):588–95.

94. Ansari R, Kazi TG, Jamali MK, Arain MB, Sherazi ST, Jalbani N, Afridi HI. Improved extraction method for the determination of iron, copper, and nickel in new varieties of sunflower oil by atomic absorption spectroscopy. J AOAC Int. 2008;91(2):400–7.

95. Li Z, Ma Z, van der Kuijp TJ, Yuan Z, Huang L. A review of soil heavy metal pollution from mines in China: pollution and health risk assessment. Sci Total Environ. 2014;468:843–53.

96. Ab Manan WNA, Sulaiman FR, Alias R, Laiman R. Determination of selected heavy metal concentrations in an oil palm plantation soil. J Physical Sci. 2018;29:63–70.

97. Cabrera-Vique C, Bouzas PR, Oliveras-López MJ. Determination of trace elements in extra virgin olive oils: A pilot study on the geographical characterisation. Food Chem. 2012;134(1):434–9.

98. Rahimi A, Talebi Ghane E, Mehri F. Concentration of potentially toxic elements (PTEs) in milk and its product: a systematic review and meta-analysis and health risk assessment study. Int J Environ Analytical Chemistry. 2021;103:1–15.

99. Ghane ET, Khanverdiluo S, Mehri F: The concentration and health risk of potentially toxic elements (PTEs) in the breast milk of mothers: a systematic review and meta-analysis. Journal of Trace Elements in Medicine and Biology 2022:126998.

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