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Health risk assessment of As and Zn in canola and soybean oils consumed in Kermanshah, Iran

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Original Article

Abstract

Due to the limited number of researches conducted globally on heavy metals in edible oil, this study was carried out for analysis and health risk assessment of As and Zn in some brands of canola and soybean oils marketed in Kermanshah City, Iran, in 2015. In this research, 18 samples of three popular brands of edible oil (canola and soybean) in the Iranian market were analyzed for levels of As and Zn after digestion with acids using atomic absorption spectroscopy (AAS) in 3 replications and the health index was obtained. In addition, all statistical analyses were performed using the SPSS statistical package. The results showed that the mean concentrations of As and Zn in oil samples were 0.06 ± 0.05 and 100.17 ± 21.94 µg/kg, respectively. Moreover, the mean concentration of As and Zn in oil samples were lower than the World Health Organization's (WHO) maximum permissible limits (MPL). The health risk assessment showed no potential risk for children and adults by consumption of the studied vegetable oil samples. Although the results showed that the consumption of the analyzed vegetable oils did not have any adverse effects on the consumers' health, concerning increased use of agricultural inputs by farmers and industrial development, it is very important that the appropriate measures be taken by companies during the production process and products be treated before marketing.

KEYWORDS: Heavy Metals, Edible Oil, Health, Risk Assessment, Iran

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Introduction

Today, vegetable oils are widely used in cooking and alimentary, food processing, pharmaceutical and chemical industries, and cosmetics. Moreover, in recent years, their consumption has increased because of their cholesterol reduction effect, and prevention of cardiovascular pathologies. In addition, great importance has been placed on the monitoring of heavy and toxic metals contamination in alimentary products, mainly as a result of a requirement of the consumers who are, today, much more concerned about the safety, quality, and integrity of foodstuffs. The presence of inorganic metals in edible oils depends on many factors such as type of soil, fruit maturity, climatic condition, plant metabolism, use of agricultural inputs especially pesticides and chemical fertilizers, extraction and treatment procedures, packaging materials, and storage and technological factors.[1-3] Plants and animals depend on some metals as micronutrients. Iron, Cu, Zn, and Mn are essential nutrients for human growth. However, Cadmium, Pb, Cd, Co, and Cu can also be toxic, even in relatively small amounts, and therefore, have an adverse health effect on both humans and animals. The effects of chronic exposure to trace amounts of some toxic metals are not well understood. However, many events have demonstrated the

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seriousness of exposure to different amounts of some metals, including As and Zn.[4,5]

Arsenic is a widely distributed metalloid in the environment (lithosphere, hydrosphere, and atmosphere). The two significant industrial processes that lead to As contamination of the environment, especially atmospheric contamination, are smelting of non-ferrous metals and production of energy from fossil fuels. Other sources of contamination are the use of arsenical pesticides, manufacture of pesticides, and wood preservatives.[6] According to the World Health Organization (WHO), maximum permissible limit (MPL) of As in vegetable oils is 100 µg/kg.[7]

Zinc is an essential functional and structural element in biological systems often catalyzing reactions through binding to substrates by favoring various reactions, such as the mediation of redox or oxidation–reduction reactions via reversible changes in the oxidation state of the metal ions. However, Zn harms some physiological processes like breathing.[8,9] According to the WHO, the MPL of Zn in vegetable oils is 10000 µg/kg.[7]

Colza (canola) is a bright, yellow-flowering plant of the Brassicaceae family. In the past half century, this plant has become one of the most important oilseed crops worldwide. Today, canola oil accounts for 12% of the oil consumption in the world, and palm oil and soybean oil for 27%, and 24%, respectively.[10]

Soybean is a complete source of dietary protein, a variety of bioactive components including saponins, phytic acid, protease inhibitors, and isoflavones, and all the essential amino acids.[11]

Risk analysis is a process that combines risk assessment, risk management, and risk communication. Risk assessment includes scientific analyses, the results of which are quantitative or qualitative explanations of the likelihood of harm associated with exposure to a chemical compound. In this regard, the human health risk assessment requires identification, collection, and integration of information on the chemical's health hazards, exposure of humans to the chemical, and relationships between exposure, dose, and adverse effects.[12]

Due to the importance of the analysis of toxic metals in foodstuffs from the technological, nutritional, and toxicological points of view, this study was carried out for the analysis and health risk assessment of As and Zn in some of consumed brands of canola and soybean oils marketed in Kermanshah, Iran, in 2015 to provide some baseline information for further research in this field.

Materials and Methods

All reagents and standard stock solutions used were purchased from Merck & Co. (Germany). The concentrated HNO_3 was pure, specific for trace analysis, and was diluted to 10% (v/v) concentration with deionized water for blank solution.

In this study, 18 samples of three different brands of edible canola and soybean oils were obtained from food supply markets in Kermanshah for analysis of their As and Zn content.

First, 1 g of each sample was weighed into separate conical flasks. Then, 5 ml of concentrated HNO_3 was added and the contents heated at 70-80 °C on a hot plate for 2-3 hours. Heating was continued at about 150 °C overnight, and 3-5 ml of concentrated H_2SO_4 and 30% H_2O_2 (each) was added occasionally. The continuous heating further allowed the complete decomposition of the organic matter until obtaining clear solutions. All contents of the flasks evaporated and the semidried mass was dissolved in a small amount (approximately 5 ml) of deionized water, filtered through Whatman 42 paper (Sigma-Aldrich), and made up to a final volume of 25 ml in volumetric flasks with 2N HNO_3.[13,14] Finally, the concentrations of As and Zn were determined using an atomic absorption spectrophotometer (model Aa680, Shimadzu, Japan) with three replications.

Data were statistically analyzed using one sample t-test to compare the mean concentrations of As and Zn with the WHO's MPL in the SPSS software for Windows (version 20, SPSS Inc., Chicago, IL, USA).

Estimated average daily intake (EADI) of a metal in food and food consumption assumption were used to survey long-term health risks to consumers. For each type of exposure, the EADI was computed using equation 1:

$$EADI = \frac{C \ x \ F}{W \ x \ D} \quad (1)$$

where C is the concentration of metal in each commodity (mg/kg), F the mean annual intake of food per person, D the number of days in a year (365), and W the mean body weight (70 kg for adults and 15 kg for children).[15,16]

The WHO has set values for toxicity, termed acceptable daily intake (ADI), for a large number of chemicals, including some essential trace elements.[17] The health risk indices were obtained by dividing the EADI by ADI (mg/kg/day) established by the Food and Agriculture Organization (FAO)/WHO Codex Committee.[15-18] The hazard indices)HI) were computed using equation 2:

$$HI = \frac{EADI}{ADI} \quad (2)$$

When HI is more than 1, the food involved is considered a risk to the concerned consumers. When HI is less than 1, the food involved is considered as acceptable (no concern) for consumption by the concerned consumers.[16]

Results and Discussion

The concentrations of As and Zn in the analyzed oil samples are presented in table 1. Data presented in table 1 showed that the percentage of metal contamination of oil samples reached 100%. The As contents (mean and median levels) of samples were lower than the WHO's MPL (100 µg/kg). The highest and lowest As content were found in canola oil with 0.16 µg/kg and 0.015 µg/kg, respectively. Moreover, similar to As, the Zn contents (mean and median levels) of samples were low and did not exceed the WHO's MPL (10000 µg/kg). The highest and lowest Zn content were found in canola oil with 74.0 µg/kg and 134.30 µg/kg, respectively.

Table 1. Concentrations (mean concentration ± SD) of heavy metals in the oil samples (µg/kg)

Metal		Oil sample	
		As	Zn
Brand 1	Canola	0.015 ± 0.01	81.0 ± 8.0
	Soybean	0.024 ± 0.01	74.0 ± 5.0
Brand 2	Canola	0.160 ± 0.01	134.3 ± 9.5
	Soybean	0.026 ± 0.03	114.0 ± 11.0
Brand 3	Canola	0.043 ± 0.01	105.0 ± 7.0
	Soybean	0.087 ± 0.01	92.7 ± 2.5

SD: Standard deviation; As: Arsenic; Zn: Zink

The systemic health risk assessment of heavy metals found in oil samples is summarized in table 2. The results showed that the calculated EADIs of the analyzed metals ranged between 7.98 × 10^{-9} and 6.21 × 10^{-5} mg/kg/day. Moreover, the HI ranged from 3.80 × 10^{-6} to 2.07 × 10^{-4} for the analyzed metals. These results indicated no direct and serious hazard to human health by As and Zn, in spite of their presence in food.

A limited number of researches have been conducted around the world to assess the heavy metal content of edible oil and those available mainly refer to some metals such as As and Zn. Once heavy metals are ingested, they are not excreted, but are accumulated in the human body and in certain cases cause adverse health effects. Thus, it is necessary to pay great attention to the use of seeds and products, such as colza and soybean, grown in polluted regions as food.

Table 2. Acceptable and estimated daily intakes and health index for metals found in oil Samples

Metal	ADI (mg/kg/day)[7,19]	Mean concentrations	EADI (mg/kg/day) (Children)	HI (Children)	HI (Chi EADI (mg/kg/day) (Adults)	HI (Adults)
As	0.002	6.0 × 10^{-5}	3.73 × 10^{-8}	1.77 × 10^{-5}	7.98 × 10^{-9}	3.80 × 10^{-6}
Zn	0.300	1.0 × 10^{-1}	6.21 × 10^{-5}	2.07 × 10^{-4}	1.33 × 10^{-5}	4.44 × 10^{-5}

Means, within each column, followed by the same letter are not significantly different at the 0.01 probability level.
ADI: Acceptable daily intake; EADI: Estimated average daily intake; HI: Hazard indices

Literature has reported few data on the presence of heavy metals in edible oils. In this regard, Farzin and Moassesi determined the Zn content of edible vegetable oils produced in Iran.[20] They reported that the concentration of Zn in canola and soybean oil samples were 4870.0 ± 160.0 µg/kg and 3580.0 ± 100.0 µg/kg, respectively, and were lower than the maximum values recommended by the FAO/WHO Expert Committee.[20] Acar reported that the average concentration of Zn in soybean oil samples marketed in Turkey was 1210.0 ± 110.0 µg/kg.[21] Zhu et al. determined the concentrations of As and Zn in some varieties of edible vegetable oils consumed in China and reported that As and Zn were observed in the range of 9-19 and 742-2560 µg/kg, respectively.[22] Mendil et al. determined the heavy metal content of edible oils (olive oil, hazelnut oil, sunflower oil, margarine, butter, and corn oil) in Turkey and reported that the concentration of Zn (µg/g) in the oil samples were found to be 3.08-1.03.[23] Pehlivan et al. reported that the average Zn content (µg/kg oil) of soybean oil samples were 34.80 ± 2.0.[5] Cindric et al. studied selected metals in various oil samples and reported that the mean concentration of Zn (µg/g) in olive, pumpkin seed, sunflower, sesame seed, hazelnut, grape, soya, and rice oil were 3.40, 13.50, 3.20, 3.10, 3.40, 3.20, 4.30, and 2.90, respectively.[24] Anwar et al. reported that the average Zn content of some cooking oils were 87.25 ± 27.72 µg/kg.[13]

Dugo et al. reported that the Zn content (µg/g) of sunflower and soybean oils consumed in Italy were in the range of 0.175-0.31 and 0.03-0.04, respectively.[25] Garrido et al. reported that the Zn content (µg/g) of olive, sunflower, and soybean oil samples were in the range of 0.06-0.43, 0.08-0.33, and 0.08-0.27, respectively.[26] Furthermore, comparison with intake levels recommended by the United States Environmental Protection Agency (USEPA) and FAO/WHO Expert Committee showed that the dietary intake of As and Zn from weekly consumption of 175 g of edible vegetable oils for a 70 kg individual should pose no risk to health.[22]

The EADI of heavy metals was compared with the oral reference dose (RfD) or provisional tolerable weekly intake (PTWI) to survey the potential health risks. In accordance with the standard methods (USEPA), the risk of chronic-toxic effects (HI or HQ) is explained as the ratio of the dose resulting from exposure to site media at the dose that is believed to be safe, even in sensitive individuals such as children and the elderly. If the HI is less than 1, no significant risk of chronic-toxic effects exists. If the HI is greater than 1, chronic-toxic effects may occur. The chronic-toxic effects tend to increase with increased HI. On the other hand, the HI expresses the combined chronic-toxic effects of multiple metals.[27,28] As shown in table 2, HI values of As and Zn for children and adults are less than 1. Here, the average HI value was 0.00002 for adults and 0.0001 for children. Therefore, it can be concluded that the target population might have no potential significant health risk through only consuming canola and soybean oils from the study area. However, the non-carcinogenic risks were greater for children than for adults.

Conclusion

This study was carried out for the first time in Iran with the aim of health risk assessment of As and Zn in some consumed brands of canola and soybean oils marketed in Kermanshah to provide some baseline information for further research in this field. The results showed that the metal contamination in oil samples reached 100%. Nevertheless, the average concentrations of As and Zn were lower than the MPL reported by the WHO. Although all these metals have toxic potential, the detrimental impact becomes observable only after several years of exposure. Therefore, monitoring of toxic metals in oil is essential in order to prevent excessive build-up of these pollutants in the human food chain. Finally, it is recommended that the appropriate measures be taken by companies during the production process and products be treated before marketing.

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