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Assessment of Heavy Metals Residue in Edible Vegetables Distributed in Shiraz, Iran

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Abstract

Background: Given the importance of vegetables in the food pyramid, their safety is very important from view point of public health. Vegetable contamination by heavy metals can lead bioaccumulation of these toxic and disease-causing elements in the body of consumers. Therefore, in this study, the concentration of some heavy metals, including lead (Pb), cadmium (Cd), zinc (Zn) and copper (Cu) in edible vegetables distributed in Shiraz, Iran was investigated.
Methods: During spring 2014, a total of 184 vegetable samples, including basil, mint, parsley, torre, tarragon, purslane, and lettuce were randomly taken from markets of Shiraz, Iran. After sample preparation, atomic absorption spectroscopy (AAS) was used for determination of heavy metals concentrations. SPSS software version 16.0 with the significance level of 0.01 was used to analyze the data.
Results: The mean concentrations of Zn, Cu, Pb, and Cd in vegetables were 59, 51, 0.17 and 0.032 mg/kg, respectively. Mean values of heavy metals concentrations of different vegetable types were significantly ($p<0.01$) different.
Conclusion: The results of sample analysis and their comparison with standard values showed that the average concentration of all heavy metals in the studied vegetables was below the standard levels of the world health organization and food and agriculture organization and they had acceptable conditions for human consumption. However, considerable attention should also be paid to the potential health risk of heavy metals via other exposure pathways and other regions of this country.

Introduction

Vegetables are important components of a healthy and perfect diet of human beings (Shagal et al., 2012). Evidences from various studies in recent years have indicated that the consumption of various types of vegetables can significantly prevent chronic heart diseases and some types of cancers, especially cancers of the gastrointestinal

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tract such as colon cancer (Lawal and Audu, 2011; Temple et al., 2012).

Heavy metals are considered as one of the most significant environmental concerns because of their toxicity and accumulation in the tissues of living organisms which even at low levels can endanger human health (Arora et al., 2008; Heshmati, 2014; Khan et al., 2009; Sharma et al., 2006). The existence of heavy metals in the food chains and their critical concentration can have adverse metabolic and physiological effects on human body (Asadi et al., 1993; Rowland and McKinstry, 2006). The absorption of metals can be affected by several factors such as pH, ionic concentration of the solution, cationic concentration of metal, the presence of competitive metal cations, and organic and inorganic ligands (Gupta et al., 2012). Moreover, the shapes and different species of plants can create differences in their ability to absorb and accumulate heavy metals (Nazemi and Khosravi, 2011). Many studies have been conducted throughout the world in relation to plants and soil pollution with heavy metals through irrigation by urban and industrial effluent (Burchett, 2003; Khan et al., 2008; Lawal and Audu, 2011).

Lead (Pb) is one of the most known toxic heavy metal that can be great danger risks to human health because hematopoietic system, nervous system and kidneys are sensitive to it (Patrick, 2006a). The industrial use of Pb is the main cause of environmental pollution by this metal (Patrick, 2006b). The adverse effect of Pb is dose and exposure duration dependent, in other words more than the threshold of 0.3 mg/kg for food could be dangerous (Goyer, 1990; Grosell et al., 2006a; Pachathundikandi and Varghese, 2006; Patrick, 2006a; Rowland and McKinstry, 2006). Cadmium (Cd) is another toxic heavy metal that can lead to kidney damage, high blood pressure, nervous system disorders and carcinogenesis (Givianrad et al., 2009; Mohajer et al., 2012). Also, it has been stated that the weekly allowable amount of Cd uptake is 0.4-0.6 mg/person (Asadi et al., 1993). Furthermore, it has been known that another heavy metal named copper (Cu) naturally presented in vegetables can be contaminated after contact with and therefore, it accumulates in the tissues of plants. The most important sources of Cu for contamination of the vegetables are mining activities, agriculture, waste and sludge from wastewater treatment. The small amount of Cu is essential for humans, but if its value increases, it is dangerous to human health. In humans, the maximum allowed daily intake of Cu for adults is 0.9 mg/day (Trumbo et al., 2001). High intake of Cu can cause poisoning, hypotension, jaundice, liver problems, and death (Asadi et al., 1993). Zinc (Zn) is the other metal that is widely distributed in the environment so that it is available in most foods, water, and air. Due to its effect on the activity of enzymes and protein production, Zn is an essential element for human life (Nazemi and Khosravi, 2011). However, intake of this element more than needed could be harmful for health. The routine way for Zn to enter the body is foods which could in range of 5.2 to 16.2 mg/day. The recommended dietary allowance for Zn intake for men and women is 11 and 8 mg/day, respectively (Flores et al., 1997; Grosell et al., 2006b).

To the best of our knowledge, there is no published data about residues of Pb, Cd, Cu and Zn in vegetable marketed in Shiraz, Iran. Considering high importance role of these heavy metals in public health, their contents in edible vegetables distributed in this region was investigated in this study.

Materials and methods

Samples

This work was a descriptive and cross-sectional study conducted at the time interval of the beginning and the end of spring in 2014. Samples were included basil (*Cocimum basillicum*), mint (*Mentha piperita*), parsley (*Petroselinum crispum*), torre (*Allium ampeloprasum persicum*), tarragon (*Artemisia dracunculus*), purslane (*Portulaca oleracea*) and lettuce (*Lactuca sativa*). Totally, 23 samples of each type of vegetable were randomly selected from the markets of Shiraz, Iran, put in polyethylene bags, and transferred immediately to the laboratory. Then, samples were washed separately with tap water to remove contaminants resulting from the soil and then they were washed with distilled water.

Atomic absorption spectroscopy assay

The samples were crushed and were placed on an aluminum sheet in the oven at 105 $^{\circ}$C for 24 h. After complete drying, 0.25 g of each vegetable was weighed with accurate scale; and acid digestion for each sample was done according to the standard methods of B3113 and F3030 (APHA, 1981) for examination of water and wastewater. To measure heavy metals in all the mentioned vegetables, atomic absorption spectroscopy with the detection limit of micrograms per liter was used.

Statistical analysis

In order to analyze the data, SPSS, Inc, Chicago, IL software version 16.0 was used and the results were expressed as mean, standard deviation (SD) and range of changes. To compare the average concentration of heavy metals in the vegetables samples, parametric tests of one way analysis of variance (ANOVA) by confidence level of 95% and significance level of 0.01 was considered.

Results

Range of concentration (mg/kg) of Pb, Cd, Cu, and Zn in different kinds of vegetables are indicated in Table 1. The mean concentrations of Zn, Cu, Pb, and Cd in vegetables were 59, 51, 0.17 and 0.032 mg/kg, respectively. As illustrated in Fig. 1 to Fig. 4, all vegetable samples had less mean contents of Pb, Cd, Zn and Cu than maximum acceptable standard levels. The highest mean levels of Pb, Cd, Zn and Cu were found in basil, Varamin lettuce, purslane and tarragon, respectively. Their lowest mean levels of Pb was detected in Jahrom lettuce; whereas mint samples had significantly (p<0.01) less mean content of Cd, Zn and Cu compared to other kinds of vegetables.

Table 1: Range concentration (mg/kg) of Pb, Cd, Cu, and Zn in vegetables marketed in Shiraz, Iran

Scientific name	Folk name	Pb	Cd	Cu	Zn
Cocimum basillicum	basil	0.002-0.202	0.001-0.098	20.182-47.720	7.124-87.270
Artemisia dracunculus	tarragon	0.01-0.142	0.003-0.046	5.801-65.219	12.413-61.992
Allium ampeloprasum persicum	torre	0.001-0.100	0.000-0.062	8.570-67.185	14.615-91.912
Petroselinum crispum	parsley	0.013-0.197	0.028-0.094	1.925-52.281	21.931-81.100
Mentha piperita	mint	0.000-0.284	0.000-0.078	0.687-41.072	18.247-51.994
Portulaca oleracea	purslane	0.014-0.295	0.013-0.095	9.211-51.558	24.257-82.431
Lactuca sativa	Jahrom lettuce	0.016-0.206	0.000-0.076	18.756-65.781	16.160-71. 947
	Varamin lettuce	0.012-0.217	0.021-0.051	3.835-63.138	14.110-83.592
acceptable level by world health organization (WHO)		0.3	0.1	73	100

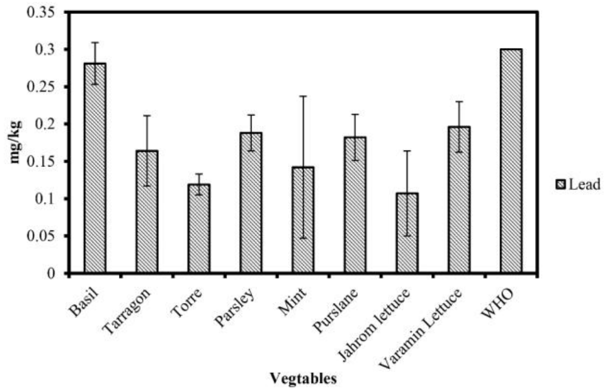

Fig. 1: Mean concentration of Pb in different vegetables with comparison by WHO acceptable level

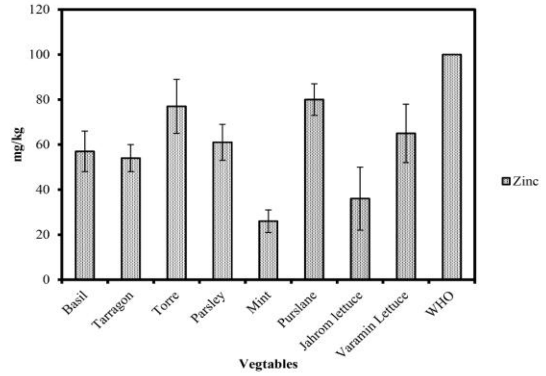

Fig. 3: Mean concentration of Zn in different vegetables with comparison by WHO acceptable level

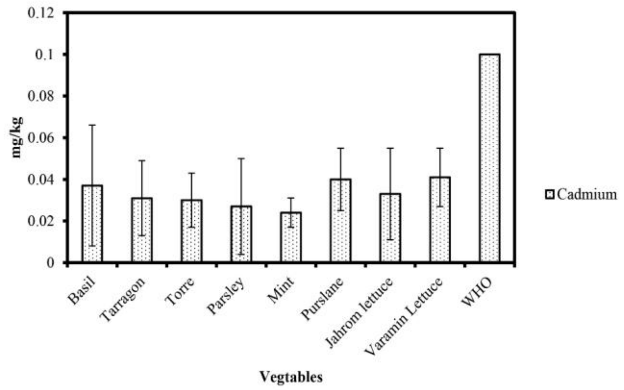

Fig. 2: Mean concentration of Cd in different vegetables with comparison by WHO acceptable level

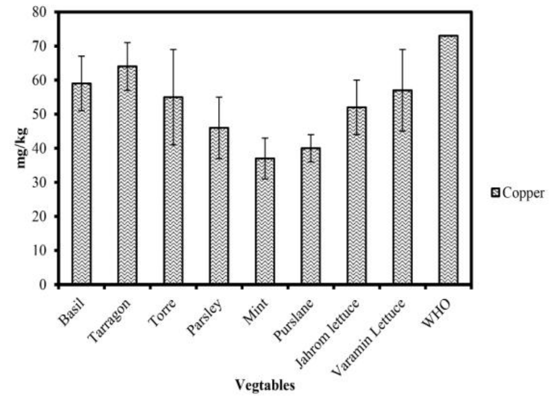

Fig. 4: Mean concentration of Cu in different vegetables with comparison by WHO acceptable level

Discussion

One of the basic problems of the health is the entrance of heavy metals into the human food chain that could have destructive and harmful effects on the environment and living creatures (Lawal and Audu, 2011; Temple et al., 2012). However, in the present work, the levels of Pb, Cd, Zn, and Cu in mentioned vegetable samples were below the maximum acceptable standard levels. In contrast, Mohajer et al. (2012) reported that Pb concentration in 75% of the vegetables marketed in Isfahan, Iran exceeded the acceptable level (0.3 mg/kg). Also, Givian et al. (2009) reported that Cd content in fresh vegetables of Tehran, Iran, was as high as 0.14 mg/kg which was more than the maximum acceptable level (0.1 mg/kg). According to a survey by Nazemi and Khosravi (2011), concentration of Pb, Cd, and Zn in vegetable samples of Shahroud, Iran was stated as 23.99, 2.09, and 168.4 mg/kg, respectively which indicated that the concentration of Cd and Pb was higher than the standard level. In the study conducted by Sharma et al. (2009) the mean concentration of heavy metals of Zn, Cu, Cd, and Pb was reported to be 29.6-45.5, 9.5-25.6, 0.5-1.5, 0.3-1.4 mg/kg in vegetable. Although the mean concentration of Zn and Cu declared by them was less than the results of this study, but the mean concentration of Cd and Pb were more than the results of the present work. Lacatusu and Lacatusu (2008) found that concentration of Cd and Pb in vegetables and fruits samples of Romania was 2.5 and 11 times higher than standard limit, respectively. Moreover, Lawal and Audu (2011) analyzed heavy metals in vegetables cultivated in Niagara suburb and reported that the concentrations of Cu, Zn, Pb were less than the suggested standard limits which is in agreement with our findings. Comparison of some previous researches published in this regard, it seems that irrigation of vegetables with heavy metals-contaminated water is the most important pathway of pollution. However, the results of this research suggested that the consumption of vegetables has negligible health risk of these heavy metals in the local population. This may be due to the fact that most of vegetable products of this area of Iran are cultivated out of urban regions where the lands are too far from current industrial environmental contaminants. Meanwhile, the differences of heavy metals residues in various kinds of vegetables could initially be attributed to differences exist in plant's needs to various minerals, soil components, as well as abilities of the plants to bioaccumulation of the elements (Nazemi and Khosravi, 2011).

Conclusion

The results of sample analysis and their comparison with standard values showed that the average concentration of all heavy metals in the studied vegetables was below than the standard levels of the WHO and therefore, they had acceptable conditions for human consumption. However, considerable attention should also be paid to the potential health risk of heavy metals via other various exposure pathways and other regions of this country.

Conflicts of interest

All the authors declare that they have no conflicts of interest.

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