Artículo de investigación

Comparison of the concentration of heavy metals in some vegetables (celery, broccoli and lettuce)

Comparación de la concentración de metales pesados en algunos vegetales (apio, brócoli y lechuga)

Comparação da concentração de metais pesados em alguns vegetais (aipo, brócolis e alface)

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Abstract

Heavy metal contamination is one of the main environmental and food safety concerns.
This study was conducted with the objective of determining the concentration of heavy metals such as cadmium, lead, copper, zinc and iron in stems and leaves in various vegetables (celery, broccoli and lettuce) in Shiraz. The metal concentrations in the vegetable samples were determined by atomic absorption spectroscopy (AAS). The results for the vegetable samples showed that the leaves contained much higher concentrations of heavy metals. The concentrations of Cd detected in the vegetable samples varied from a very low infection to 0.0025 mg / kg; very low infection at 0.51 mg / kg Pb; 0.93 to 2.91 mg / kg Cu. 1.44 to 9.69 mg / kg Zn and 2.54 to 11.05mg / kg Fe.
The findings of this study indicated that although most of the sampling plants were contaminated, except for lettuce, other crops have an EDI below the Tolerable Daily Intake (PTDI) recommended by the Institute of Standards and Industrial Research of Iran and the FAO / WHO.

Keywords: Accumulation, Heavy metals, Vegetables, FAO.

Resumen

La contaminación por metales pesados es uno de las principales preocupaciones ambientales y de seguridad alimentaria.
Este studio se realizó con el objetivo de determinar la concentración de metales pesados como cadmio, plomo, cobre, zinc y hierro en tallos y hojas en varios vegetales (apio, brócoli y lechuga) en Shiraz. Las concentraciones de metal en las muestras de vegetales se determinaron mediante espectroscopia de absorción atómica (AAS). Los resultados para muestras de vegetales mostraron que las hojas contenían concentraciones mucho más altas de metales pesados. Las concentraciones de Cd detectadas en las muestras de vegetales variaron desde una infección muy baja hasta 0,0025 mg / kg; infección muy baja a 0,51 mg / kg Pb; 0,93 a 2,91 mg / kg Cu. 1.44 a 9.69 mg / kg Zn y 2.54 a 11.05mg / kg Fe.
Los hallazgos de este estudio indicaron que aunque la mayoría de las plantas del muestreo estaban contaminadas, la ingesta diaria estimada de cada metal (EDI) mostró que, excepto la lechuga, otros cultivos tienen un EDI por debajo de la ingesta diaria tolerable (PTDI) recomendada por el Instituto de Normas e Investigación Industrial de Irán y FAO / OMS.

Palabras claves: Acumulación, Metales pesados, Verduras, FAO.

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Resumo

A contaminação por metais pesados é uma das principais preocupações ambientais e de segurança alimentar.
Este estúdio foi realizado a fim de determinar a concentração de metais pesados tais como cádmio, chumbo, cobre, zinco e ferro em caules e folhas em vários produtos hortícolas (aipo, brócolos e alface) em Shiraz. As concentrações de metais nas amostras vegetais foram determinadas por espectroscopia de absorção atômica (AAS). Os resultados par a as amostras vegetais mostraram que as folhas continham concentrações muito mais altas de metais pesados. As concentrações de Cd detectadas nas amostras vegetais variaram de uma infecção muito baixa a 0,0025 mg / kg; infecção muito baixa a 0,51 mg / kg Pb; 0,93 a 2,91 mg / kg Cu. 1,44 a 9,69 mg / kg Zn e 2,54 a 11,05 mg / kg Fe.
Os resultados deste estudo indicaram que, embora a maioria das plantas amostradas foram contaminados, exceto alface, outras culturas têm EDI abaixo da ingestão diária tolerável (PTDI) recomendado pelo Instituto de Padrões e Pesquisa Industrial de Irã e FAO / OMS.

Palavras-chave: Acumulação, Metais pesados, Vegetais, FAO.

1. Introduction

Vegetables are an important source of carbohydrates, proteins, vitamins, minerals, fiber and micronutrients, which are essential for maintaining health as well as treating various diseases. In addition to the benefits that the consumption of vegetables can have on a human diet, it may contain different amounts of heavy metals (Radwan, & Salama, 2006). These metals have a density of more than 5 grams per cubic centimeter and atomic weights of 63.5 and 200.6 (Srivastava & Majumder, 2008). These metals are among the natural factors of seawater, and many of them naturally enter the sea in a variety of ways, such as erosion of mines, winds, dust particles, volcanic activity, rivers, and groundwater. But what matters is the regional increase of these metals through human-induced industrial activities, such as increased industrial waste and oil pollution, poisons, pesticides, and pesticides (Amodio-Cocchieri, & Fiore, 1987).

One of their important characteristics can be mentioned as they have a high biological life time, so they accumulate in different specimens of plants including stems, roots and leaves, and they are fed to humans by their use. From the nutritional point of view, metal elements in food composition can be classified into two essential groups (chromium, cobalt, zinc, copper, iron, etc.) and unnecessary (mainly lead, cadmium and mercury, etc.). The role of physiology of iron, copper, manganese and zinc is hemoglobin and cytochrome amine oxidase respectively, dopamine hydrozoas and collagen synthesis - superoxide dismutase - protein synthesis and DNA and RNA stabilization (Khanna, 2011). Cadmium is a carcinogenic substance and it affects the development of heart disease and blood pressure (Appleton, Fuge & McCall, 1996). It also appears to be a contributing factor in the development of heart disease and blood pressure. Lead also affects the blood and kidney system, causing metabolic abnormalities and physical-neurological deficits in children. It is also reported that if large amounts of heavy metals, such as lead, enter the body of pregnant mothers, the birth of premature infants and severe mental retardation of newborns will increase significantly (Zagrodzki, Zamorska & Borowski, 2003), (WHO, 2011). In recent years, a significant increase in contamination Vegetables have been reported in heavy metals, which is a serious threat to the health of the present day (Pan, Wu & Jiang, 2016), (Arora & et al. 2008). Several studies have been conducted in this regard. Radwan et al. examined the content of 4 elements of cadmium, lead, zinc and copper in a wide range of fruits and vegetables. The results showed that leafy vegetables such as lettuce and spinach had the highest levels of lead and cadmium (Radwan, & Salama, 2006). Torabian and Mahajori studied southern Tehran vegetable lands. The results showed that Basil vegetable had the highest mean zinc and copper concentration (Torabian & Mahjouri, 2002).

Samarghandi et al reviewed the amount of heavy metals in vegetable growing in the suburbs of Hamedan and reported that the lead metal content of the samples was higher than the standard (Samarghandi, Kari & Sadri, 2000). Due to the various problems that heavy metals have on human health, in addition to identifying these metals, it is necessary to determine the exact amount of their residues in different foods and to obtain sufficient information about their contamination. Therefore, the purpose of this study is to determine the amount of heavy metals cadmium, lead, copper, zinc and iron in leaves and stems of celery, broccoli and lettuce.

2. Materials and Methodologies

A sampling of ready-made vegetables in fruit and vegetable fields of Shiraz was done completely randomly. To collect the samples, four times and each time from three points of the field of fruit and vegetable, samples of celery, broccoli and lettuce were prepared and transferred to the laboratory in plastic bags. Then about one kilogram of each of them was isolated as a sample and immediately washed with water and finally rinsed with distilled water.

Measurements of heavy metals were performed according to standard AOAC 991.11 method (AOAC). 5 grams of each sample was weighted on a digital scale and burned it in a crucible and burn on heat to remove smoke from burning them. The samples were then placed in a 450 ° C electric furnace for 4 to 5 hours, resulting in a white ash showing the loss of organic matter. (Organic matter in the vegetable tissue interferes with the atomic absorption process).

After cooling the samples in a desiccator, 30 ml nitric concentrated nitrile was added to each crucible, and after complete dissolution, it was straightened with Wathman 42 filter paper and then dissolved in 2% nitric acid and distilled into volume. Then, dilution factor was written down. Finally, the concentrations of heavy lead, cadmium, copper, zinc and iron elements in the studied vegetables were determined by using the atomic absorption device (American Analyst 700 model) in the Shiraz Food and Drug Lab.

The measurements of cadmium, lead, copper, zinc and iron were measured at wavelengths of 228.8, 217, 328.8, 213.3, and 248 nm, respectively, and width of cadmium, lead, copper and zinc (0.7) Nm) and iron 0.2 nm. In order to determine the concentration of the elements from stoic cadmium, lead, copper, zinc and iron solutions, standards were prepared with 6 concentrations and the standard curves were drawn for each one and the criterion was to determine the final concentration of the elements. After determining the concentration of heavy metals, the amount of their entry into the human body can be measured. For this purpose, the estimated absorbed value of each EDI element for each product should be calculated according to the amount of consumption of that product (Table 1). EDI is obtained from the following equation.

$$EDI = \frac{C \times Cons}{Bw}$$

In this regard, C is the concentration of each heavy metal in products in mg/kg (average heavy metal content in stems and leaves), Cons Consumption of this product per person in grams in Iran and Bw in the average body weight of an adult (kg). Finally, the obtained number was compared to the PTDI declared in the National Iranian Standard (Institute of Standards and Industrial Research of Iran, 2010).

Table 1. The amount of vegetables used in the food basket of Iranian households (Institute of Standards and Industrial Research of Iran, 2010)

Lettuce	Broccoli	Celery	Variety of Vegetables
58	12	5	Amount of intake (g/day)

The data were analyzed by SPSS18 (version 24) and analyzed by ANOVA. Comparison of the mean of three replications was performed using Tukey test and at 5% confidence level. LSD test was used to compare the mean concentration of the elements evaluated in the samples.

3. Result

The results of this study showed that in the samples, the cadmium content was varied to a small and unmeasured extent to 0.00254 mg/kg. Lettuce leaf showed the highest amount of cadmium, which had a significant difference with other samples (P<0.05). Figure 2 shows that maximum and minimum lead concentrations are related to celery leaf (0.51 mg/kg) and broccoli leaf (insignificant and indeterminate). Two samples of stems of celery and lettuce were ranked next. The statistical test showed that there was a significant difference between the samples (P<0.05). As shown in Fig. 3, among the selected samples, the highest copper content was obtained from celery (2.91 mg/kg). There was a significant difference between the sample and the rest of the samples (P<0.05).

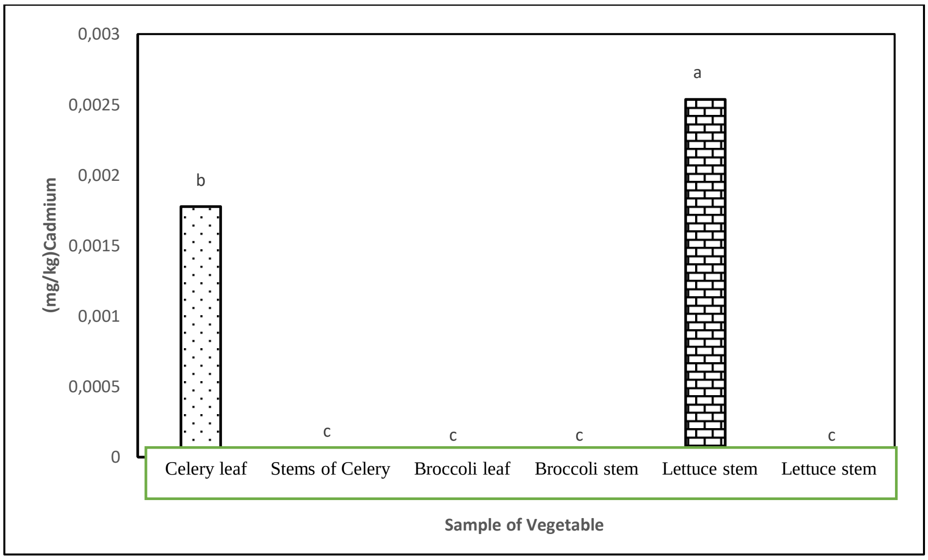

Figure 1. Cadmium heavy metal concentration in vegetable samples

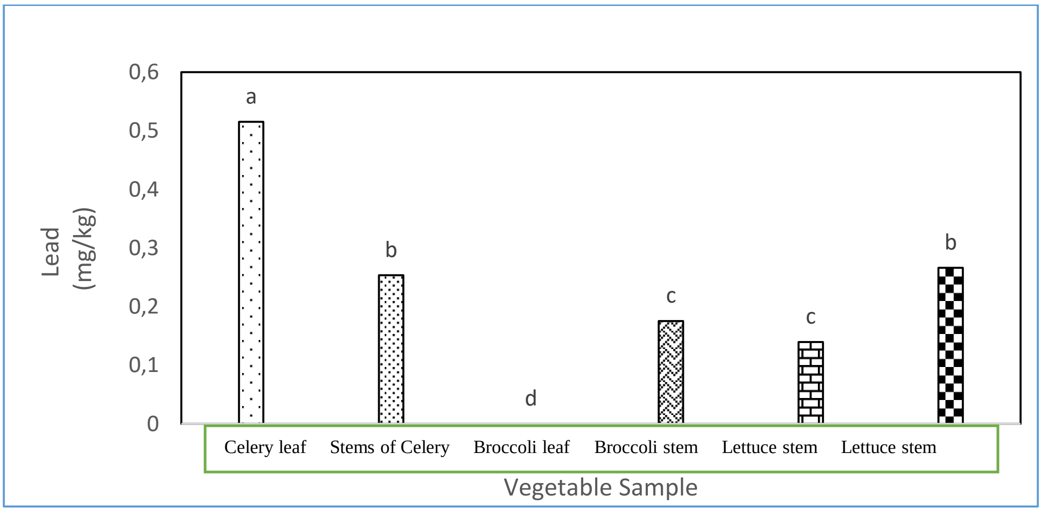

Figure 2. Heavy metal concentration of lead in vegetable samples

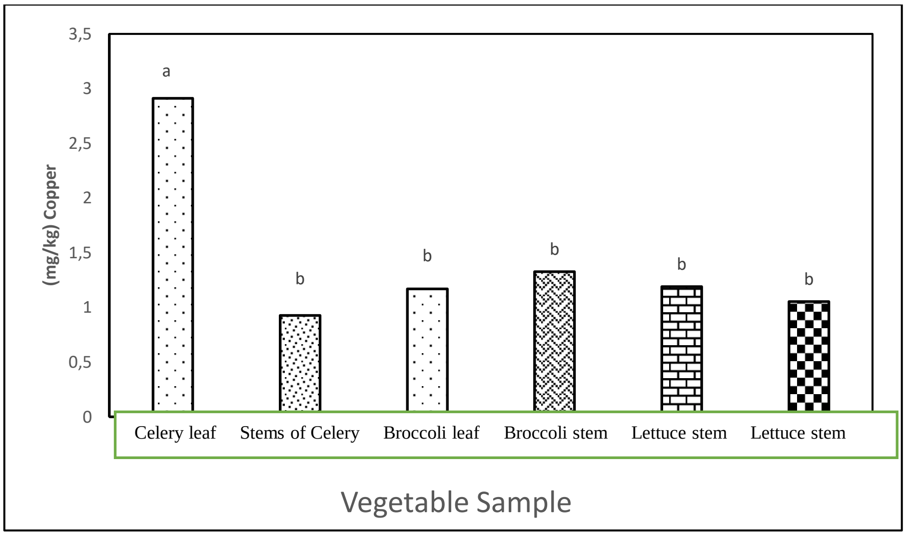

Figure 3. Copper heavy metal concentration in vegetable samples

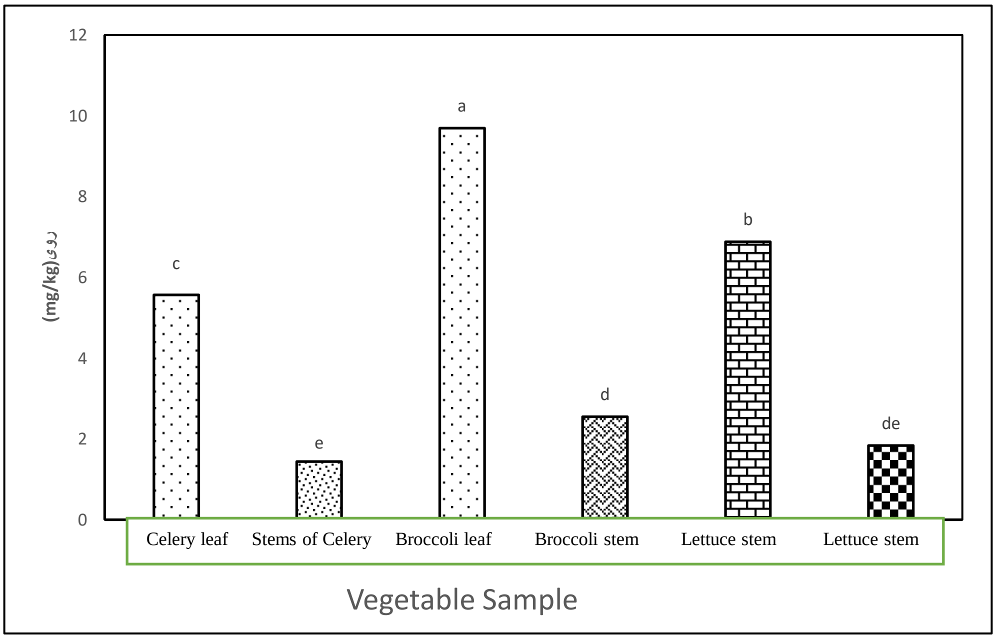

Figure 4. Zinc heavy metal concentrations in vegetable simples

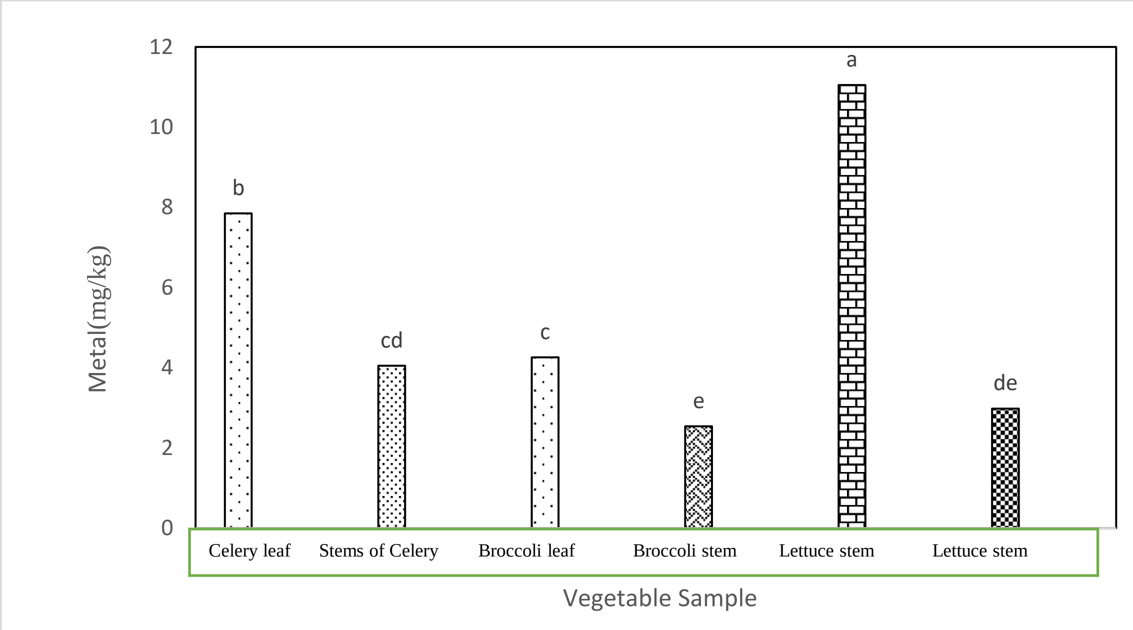

Figure 5. Heavy Metal Concentration in Vegetable Samples

Discussion

The ability of plants to absorb, accumulate and tolerate cadmium is different. As shown in Fig. 1, lettuce leaves had the highest concentration of cadmium. The absorption of cadmium by the plant and its entry into the food chain depends on factors such as salinity, pH, and the ability to absorb the element in soil and organic matter (McLaughlin & et al, 1999). Cadmium among heavy metals has a small combinational desire for bonding with soil stabilizing phases such as oxides and calculates. Therefore, the ability of this element to absorb the plant and transfer it to the shoots of the plant is high. Cadmium also has high ability to cross the cell membrane of the root. All of these factors have increased the risk of cadmium in the food chain (Sharifi, Afyuni & Khoshgoftarmanesh, 2010). In all samples, the concentration of cadmium in the leaf of vegetables was higher than that of the stalks, as reported by Ramos et al. They announced that cadmium is a movable metal that is easily absorbed from the root surface of the plants and moves to their tissue and accumulate in the upper parts of the plant. So that the accumulation of cadmium in the aerial part of the plant will be greater than the ground (tuber or root) (Ramos & et al, 2002). Torabian and his colleague also said that some plants, such as alfalfa, spread cadmium in the root, and others distribute it like lettuce in leaves (Torabian & Mahjouri, 2002).

The maximum tolerance of cadmium metal is given in accordance with the National Iranian Standard No. 12968 and the Joint Committee of the United Nations Food and Drug Administration and the World Health Organization, FAO / WHO, in Table 2. The maximum heavy metal tolerance is the highest amount of heavy metal in human feed and livestock, which, in the short or long term, does not cause harmful effects on human health. The control of the maximum tolerance of heavy metals is essential. The concentration of cadmium in all studied vegetables was lower than the national standard of Iran and FAO / WHO. This study is consistent with the report of Tabander and his colleague regarding the lower level of cadmium in vegetables grown in Zanjan province, in comparison with Iran's national standard (WHO, 2011), (Institute of Standards and Industrial Research of Iran, 2010).

Table 2: Maximum tolerance for cadmium and lead by product type

Lettuce	Broccoli	Celery	
0.1	0.05	0.1	Maximum Cadmium Tolerance National Standard of) Iran)
0.1	0.1	0.1	Maximum Cadmium Permit
0.2	0.3	-	Maximum Lead National Iranian)Tolerance (Standard
0.3	0.3	0.3	Maximum allowed lead (FAO/WHO)

Davis and Smith in a study titled Products, as indicators of the importance of heavy metals contamination, showed that lettuce, spinach, celery and cabbage tend to accumulate large amounts of cadmium, while potatoes, corn, beans and peas they store a small amount of cadmium, which is consistent with this research. In fact, the absorption of cadmium in leafy vegetables is far higher than root vegetables and glands (Davis, & Carlton-Smith, 1980). Various researches in this field have suggested that irrigation of vegetables with urban sewage, the use of urban sewage sludge as fertilizer and the introduction of phosphate fertilizers into crops are the main cause of contamination of vegetables with cadmium (Samarghandi, Kari & Sadri, 2000), (Bigdeli & Seilsepour, 2008). Lead is a toxic metal, which usually has the ability to absorb and accumulate this element without changing their apparent performance. So, in many plants, the accumulation of lead is hundreds of times greater than acceptable and acceptable (Marais & Blackhurst, 2009). Celery leaves and lettuce stems had higher concentrations of heavy metals than the maximum lead tolerance. Maximum amount of lead in agricultural products is 0.3 according to FAO / WHO recommendation (Table 2). Accordingly, the concentration of Celery leaf lead (0.51 mg / kg) is higher than the limit of both standards. Some soil factors such as low pH, low soil phosphorus concentration and the frequency of organic ligands are known to increase lead absorption by plant and lead transfer to plant aerial parts (Nazari & et al, 2006).

Samarghandi et al. investigated the amount of heavy metals in vegetable growing in the suburbs of Hamedan and reported that the amount of lead metal in the samples was higher than the limit (Samarghandi, Kari & Sadri, 2000). The absorption and accumulation of heavy metals in plants is influenced by factors such as climate, atmospheric sediments, heavy metal concentrations in the soil, the nature of the soil and their growth (Sharma, Agrawal & Marshall, 2009). Atmospheric pressure is considered as the main route of lead entry for well-known leafy vegetables (Onder, & Dursun, 2006). Gyvian Rad et al. (2011) measured the amount of heavy metals cadmium and lead in cultivars of lettuce, mint and turbot in different lands of southern Tehran and concluded that the difference in lead between different samples was statistically significant Darry has not been seen (Givianrad & et al, 2011). The results were not consistent with the results of this study, but this is probably due to the similarity of all the studied vegetables to the present study. In their study, Zheng et al. concluded that heavy metal transfer factors from soil to vegetables were reduced, respectively, by cadmium> zinc> copper> lead> mercury, heavy metal transfer factors in leaves were more than other tissues compared to the results This study was (Zheng, Wang & Zheng, 2007). Rarely, the toxic effects of zinc have been reported on the human body, and the most important is the onset of the element of copper in the metabolic processes. The toxicity of this element is nausea, indigestion, vomiting, diarrhea and damage to the liver parenchyma (Salgueiro & et al, 2000).

Since the limit amount for copper, zinc and iron elements is not defined in the national standard of Iran, therefore, in order to compare these elements, the Standards Committee of the United Nations Food and Agriculture Organization and the World Health Organization (FAO / WHO) have been used (WHO, 2011). Allowed values for these three metals are 0.1, 0.1 and 0.3 mg/kg, respectively. The reference number 21 of these heavy metals was set at the above samples. Rouniasi and colleagues conducted a study on the amount of heavy metals in Karaj farms and stated that in all plants spinach, onion and lettuce, iron content was higher than the FAO / WHO standard (Rokni, 1999), which is consistent with the present study. In all samples, the amount of these elements in the leaf was greater than the stem. Uwah et al. Conducted a study to study the amount of heavy metals on vegetables. They stated that the amount of metals in different parts of the plant was different and expressed the amount of metals in different organs of the plant. The vine> root> root> Button> Onion> Fruit> Grain (Uwah & et al, 2009). The result of this study shows that different herbs have a different absorption rate, which is consistent with the results of Yadav et al. 2013 research, which showed that different vegetable varieties can be contaminated with different amounts of heavy metals (Yadav, Yadav, & Shukla, 2013). From the heavy metals measured, the iron content was the highest and the zinc was second only. In 2009, Hao et al. measured the concentration of heavy metals (cadmium, lead, copper and zinc) in several vegetable samples in China, and reported that the amount of zinc in the vegetable samples was higher than the rest of the metals (Xiu-Zhen & et al, 2009) Comes with the current study. Sharma et al. surveyed some of the heavy metals in vegetables in a store in Orban, India in 2009 (Sharma, Agrawal & Marshall, 2009). In their study, Nayek et al. concluded that iron, manganese, copper, zinc and chromium were the most commonly transmitted to the aerial parts of the plant (Nayek, Gupta & Saha, 2010), which was consistent with the results of this study. Farmers, using fertilizers and fungicides containing copper, lead to increased concentrations of these elements in plants. High levels of copper can cause diseases such as anemia, changes in bones, increased cholesterol and greenness, hair loss in the body, and sometimes death (Fuentes & et al, 2004). In Table 3, the EDI is calculated in mg/kg for each product.

Table 3. EDI amount in mg / kg in vegetable simples

Metal	Zinc	Copper	Lead	Cadmium	Product
0.495	0.291	0.160	0.00318	0.00148	Celery
0.68	1.224	0.250	0.00350	nd	Broccoli
6.781	4.214	1.082	0.0195	0.0245	Lettuce
0.930	1	0.5	0.0036	0.001	PTDI

As noted earlier, according to the results obtained (Table 3), the amount of heavy metals entering can be calculated by consuming the vegetables and for an adult (60 kg). The results showed that in all of the vegetables in view of the high concentration of iron in comparison with other heavy elements, the amount of daily iron intake was higher than other elements, and then zinc element was placed on the next rank. Meanwhile, among the different vegetables, the highest daily intake of heavy elements related to lettuce was observed. In the case of the risk of these vegetables, human health should be taken into account in the estimated EDI value in Table 3. The results showed that the EDI value of lettuce is higher than that of PTDI, and for broccoli this value is within the risk boundary. It's also in PTDI> EDI celery, so it's not a threat to the consumers of this product. Cadmium absorption in lettuce and broccoli was higher than the limit. Plants can collect and store large amounts of cadmium without being harmed. The accumulation of cadmium in plants can increase the potential for this element to be absorbed by humans. This is due to the fact that these plants are part of human diet. Rokni has a much higher level of lead absorption in lettuce, and also the amount of lead in two samples It was no longer at risk. The amount of copper, zinc and iron was very high in lettuce (Rokni, 1999). In a study conducted in China on soils and vegetables that were irrigated with sewage water, it was found that the ratio of absorption to the acceptable daily intake rate for cadmium and nickel was less than one. In another study, which was grown in Spain on vegetables, it was irrigated with catholic water. The results showed that the ratio of absorption to the acceptable daily intake for cadmium and nickel metals was less than one (Wang, Qiao, Liu, & Zh, 2010), which corresponds to the results of this study. There are some differences in some of the samples due to differences in the type of samples examined. In a study by Harmansko et al., On vegetables grown in mineral areas, the rate of absorption was estimated to be as high as the daily allowance for Cadmium, Nickel, Lead and Zinc, and it was found that in contaminated areas, the risk index and for health, for lead metal it is higher than 1, and also for cadmium, nickel and zinc, less than one that is consistent with this research (Harmanescu & et al, 2011). Hence, if celery is balanced, no harmful effects on human health will occur because PTDI> EDI. Otherwise, over time and with more consumption of such contaminated vegetables can threaten human health and have irreparable consequences on the human food chain. Therefore, several efforts have to be made to remove heavy elements from the human food chain in various ways in order to control pollution and prevent the spread of it. Environmental studies on soil and other crops are recommended annually. Also, careful monitoring of the amount of fertilizers and chemical pesticides used in the fields.

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