Detecting of some heavy metals in greenhouse cucumber in Egypt

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Abstract: The presence of high levels of trace metals in foods poses a significant risk to human health. Metals can accumulate in vegetables grown in metal-contaminated soil or irrigated with wastewater, and bioaccumulation in the food chain can affect animals and humans. The current study aimed to measure the levels of Cadmium (Cd), Lead (Pb), Manganese (Mn), Zinc (Zn), and Chromium (Cr) in greenhouse cucumber samples collected from Kafr El-Zayat district in El-Gharbia Governorate and Bader district in El-Beheira Governorate, Egypt, and to determine their potential health risks. Cucumber samples were subjected to heavy metals analysis. The metal concentration was determined using an atomic absorption spectrophotometer (Mp–AES using Agilent technologies optical emission spectrometer). The obtained results revealed that the concentration levels of Cd and Pb valu es ranged between (Below detection limit BDL-0.15 mg/kg) and (BDL -1.21mg/kg) in Kafr El-Zayat cucumber samples and (BDL -0.16 mg/kg) and (BDL-0.66 mg/kg) in Bader cucumber samples respectively. In addition, data showed that in some greenhouse cucumber samples, the concentration levels of Cd and Pb were higher than the Maximum Permissible limits values established for each element. The concentration values of Mn, Zn, and Cr in all greenhouse cucumber samples ranged between (BDL -1.54 mg/kg), (BDL -23.32 mg /kg) and (BDL -0.02 mg /kg) in Kafr El-Zayat cucumber samples and (0.06 -1.57 mg/kg), (BDL – 37.13 mg/kg) and (BDL – 0.05 mg/kg) in Bader cucumber samples, respectively. Results showed that no exceeding of the concentration levels of Mn, Zn, and Cr in all greenhouse cucumber samples in Kafr El-Zayat and Bader above the Maximum Permissible limits values established for each element.

The Food and Nutrition Board recommendations were used to evaluate the health risk assessment for estimated weekly intake. The weekly intakes of all elements were found to be significantly lower than the recommended tolerable weekly intakes (APTWI), indicating that there were no adverse effects on humans.

Keywords: Detecting, Heavy metals, Risk assessment, Greenhouse, Cucumber.

1.INTRODUCTION

Fresh vegetable consumption is one of the most health-promoting practices. Vegetables are an important component of human nutrition. Protein, carbs, vitamins, fiber, and minerals are the key functional ingredients of vegetables, and phytochemicals, such as antioxidants, which found in most vegetables. People all around the world have recently begun to substitute fresh vegetables for their meals in order to prevent the occurrence of chronic diseases such as diabetes, cancer, cardiovascular disease, and other age-related ailments. (**Nassar *et al.*, 2018 and Abdel-Rahman *et al.*, 2018**), (**Nisa *et al.*, 2020**).

Contamination in vegetables cannot be neglected, as these foodstuffs are important components of the human diet. Vegetables are contaminated with heavy metals due to Contaminated soil, polluted air, pesticides and chemicals sprays, preservatives, industrialization, mining activities, fertilizers, and use of wastewater irrigation (**Abdel-Rahman *et al.*, 2018); (Hellen and Othman, 2014) and (Khan *et al.*, 2019).** The toxicity of heavy metals is one of the main fears to health with numerous health risks related to it. Heavy metals are not biodegradable; So they accumulate in different body organs due to their long half-life with the potential for leading to unwanted side effects (**Ezeilo *et al.*, 2020**). Heavy metals are obviously occurring metallic elements with a high atomic weight and at least five times the density of water. They are toxic or poisonous at low concentrations and have metallic properties, atomic numbers greater than 20, and a relatively high density. They enter the environment through both natural and anthropogenic sources such as industrial discharge, automobile exhaust, and mining. (**Tchounwou *et al.*, 2012, Tangahu *et al.*, 2011)**

Heavy metals uptake by plants and subsequent buildup in edible plant parts may constitute a health risk to humans. Cadmium (Cd), chromium (Cr), lead (Pb), and nickel (Ni) are among the heavy metals that have the potential to harm human health even in small concentrations (**Jaishankar *et al.*, 2014**).

Determination of heavy metals in foodstuff is a significant aspect of food quality. Therefore, the aim of the present investigation was to monitor the levels of Cd, Pb, Mn, Zn, and Cr in the greenhouse cucumber samples, collected from the local markets located in Kafr El-Zayat district, El-Gharbia Governorate, and Bader district, El-Beheira Governorate, Egypt. In addition, to assess the potential risk to human health from daily exposure to these metals through consumption of the tested vegetables.

2.MATERIAL AND METHODS

2.1. Chemicals:

Stock standard solutions of Zn, Pb, Cr, Mn, and Cd were obtained from Merck at a concentration of 1000 mg/L (Merck, Darmstadt, Germany. Nitric acid (HNO_3) (density at 20ºC: 1.4 g/mL) (95% purity) was obtained from SDS, Peypin, France.

2.1.Sample preparation:

Sixty fresh cucumber samples were randomly gathered from each local markets in Kafr El-Zayat district, El-Gharbia Governorate, and Badr district, El-Beheira Governorate, Egypt. Cucumber samples were collected and cleaned with distilled water to eliminate dust particles before being chopped into small pieces and oven dried at 105°C. Dried samples were ground to a fine particle size with a porcelain mortar and piston and stored in plastic containers for analysis.

2.2.Quality control:

Quality control was assumed from the use of analytical blank and spike. The blank was prepared in same procedure as the samples. All instrument readings were corrected with the blank. A recovery test of the entire procedure was carried out by spiking and analysis with known standard concentration of the metal of interest. An acceptable percentage recovery (R) of tested heavy metals in cucumber samples was obtained 86.25±2.12 for Cd, 82.25±4.24 for Pb, 90.30±5.43 for Zn, 91.88±1.2458 % for Mn, and 76.03±4.55 for Cr, was achieved for cucumber sample.

$$R = \frac{Concentration\ of\ spiked\ sample - Concentration\ of\ unspiked\ sample}{Concentration\ of\ spike}\ X\ \frac{100}{1}$$

2.3.Digestion of cucumber Samples for heavy metal determination:

One gram of dried sample was placed in a conical flask and digested to a constant volume with perchloric: nitric acid (1:4 v/v). After cooling, the digested samples were filtered and deionized water was used to make up the final volume of 25 ml (**Issa *et al.,* 2018**). All the chemicals were of analytical grade. Before usage, all plastics and glassware were soaked in nitric acid for 15 minutes and then cleaned with deionized water. For the best results, instrument calibrations with standard solutions were carried out.

2.4.Microwave Plasma Atomic Emission spectrophotometry:

Metal determination was carried out using Agilent technologies microwave plasma atomic emission spectrometer (Mp–AES). The instrument is equipped with a nebulizer and spray chamber and coupled with an SPS3 auto sample and controlled with MP Expert software version 1.3.0.3510. The instrumental conditions are as follows the pump speed from 15 rpm reached to 80 rpm in rinse with stabilization time 15 sec., sample uptake 25 sec. and rinse time 20 sec.

2.4.1.Calibration and certified reference materials:

Mp–AES calibration was carried out using standard solutions ranging from 0.01 ppm to 5ppm from a multi-element standard solution with 5 elements of 1000 ppm in 5% nitric acid (chem-lab reference material).

2.5. Health risk estimation:

Many researchers have studied the exposure pathway of potentially toxic elements to humans via ingestion of contaminated food. Assumptions are used in health risk assessments. The health risk associated with the dietary exposure effect was estimated in this study.

2.5.1. Estimation of daily and weekly intake:

The survey results were combined with food consumption data to determine whether the estimated provisional tolerable daily intake (EPTDI) and estimated provisional tolerable weekly intake (EPTWI) of detected metals through greenhouse cucumber samples consumed by Egyptian consumers were a cause of toxicological concern according to the Food Agriculture Organization (FAO)/World Health Organization recommended dose (WHO). The calculated (EPTDI) was obtained by multiplying the highest metal concentrations detected by the highest consumption diets of the WHO/Global Environment Monitoring System- Food Contamination Monitoring and Assessment Programme (WHO/GEMS/FOODS) (**Gems/Foods (2012)** was 5.9 g/day. According to the Food and Nutrition Board, the ideal body weight of an Egyptian adult is 70 kg. The long-term risk assessments of the intakes were performed by dividing the (EPTWI) by the relevant acceptable provisional tolerable weekly intake (APTWI) set by the metals toxicological data (Food and Nutrition Board and JECFA). The following equation was used to calculate the estimated provisional tolerable daily intake (EPTDI). **Gems/Foods (2012)**

EPTDI = FC* MC/ BW *10-3

EPTDI: Estimated provisional tolerable daily intake (mg/kg.BW/day)

FC: Food consumption (mg /day)

MC: Metal concentration (mg/kg)

BW: Average body weight kg

10^{-3}: The unit conversion factor

3.RESULTS and DISCUSSION

The values of Cd, Pb, Mn, Zn, and Cr were detected in different green house cucumber samples collected from the two sites locate in two large Egyptian Governorates (Kafr El-Zayat district at El-Gharbia Governorate and Bader district at El-Beheria Governorate) were given in table (1) and fig (1).

The mean concentrations of Cd, Pb, Mn, Zn and Cr were 0.048, 0.67, 0.81, 11.42, 0.012 and 0.062, 0.29, 0.77, 19.81, 0.025 mg/kg for samples of Kafr El-Zayat and Bader districts, respectively. However, Cd concentrations ranged from (below the detection limits) BDL to 0.15 mg/kg in samples of Kafr El-Zayat and from BDL to 0.16 mg/kg in samples of Bader district. The concentration of cadmium (Cd) observed in some cucumber samples varied; some samples were lower than the maximum permissible values (0.1 mg/kg) **(FAO/WHO., 2011**), others exceeded, the rest of samples contaminated by Cd metals below the detection limits. Cd concentrations ranged from BDL to 0.15 mg/kg in samples of Kafr El-Zayat and from BDL to 0.16 mg/kg in samples of Bader district. While, Pb ranged from BDL to 1.21 mg/kg in samples of Kafr El-Zayat and from BDL to 0.66 mg/kg in samples of Bader district. The concentration of Pb present in cucumber samples also varied in some samples the values were lower than the maximum permissible values (0.1 mg/kg) **(FAO/WHO., 2014**), some others exceeded the maximum permissible values and the rest were contaminated by pb metals below the detection limits. The lead (pb) concentration ranged from BDL to 1.21 mg/kg in sample of kafr El-Zayat and from BDL to 0.066 mg/kg in samples of Bader district. Concentration of Mn ranged from BDL to 1.54 mg/kg in samples of Kafr El-Zayat and from 0.06 to 1.57 mg/kg in samples of Bader district. The concentration of Mn observed in cucumber samples were lower than the maximum permissible values (500 mg/kg) **(FAO/WHO., 2011).** As Zn and Cr the concentration of ranged from BDL to 23.32 and from BDL to 0.02 mg/kg, respectively in samples of Kafr El-Zayat, while the concentrations of Zn and Cr in samples of Bader district ranged from BDL to 37.13 and from BDL to 0.05 mg/kg, respectively. The concentration of Zn and Cr in cucumber samples were lower than the permissible values (50 and 0.05 mg/kg), respectively **(EU, 2013 and (FAO/WHO., 2011).**

Table 1: The Concentration in (mg/kg) of some heavy metals in greenhouse cucumber from Kafr El-Zayat district and Bader district

Element	Kafr El-Zayat		Bader		MRL (mg/kg)
	range	mean ± SE	range	mean ± SE	
Cd	BDL-0.15	0.048±0.22	BDL-0.16	0.062±0.54	0.1 (FAO/WHO. 2011)
Pb	BDL-1.21	0.67±0.56	BDL-0.66	0.29±0.31	0.1 (FAO/WHO. 2014)
Mn	BDL-1.54	0.81±1.39	0.06-1.57	0.77±0.55	500 (FAO/WHO. 2011
Zn	BDL-23.32	11.42±0.64	BDL-37.13	19.81±0.59	50 (EU 20١٣)
Cr	BDL-0.02	0.012±0.51	BDL-0.05	0.025±0.02	0.05 (FAO/WHO. 2011)

BLD=below detection limits, values refer to Maximum Limit

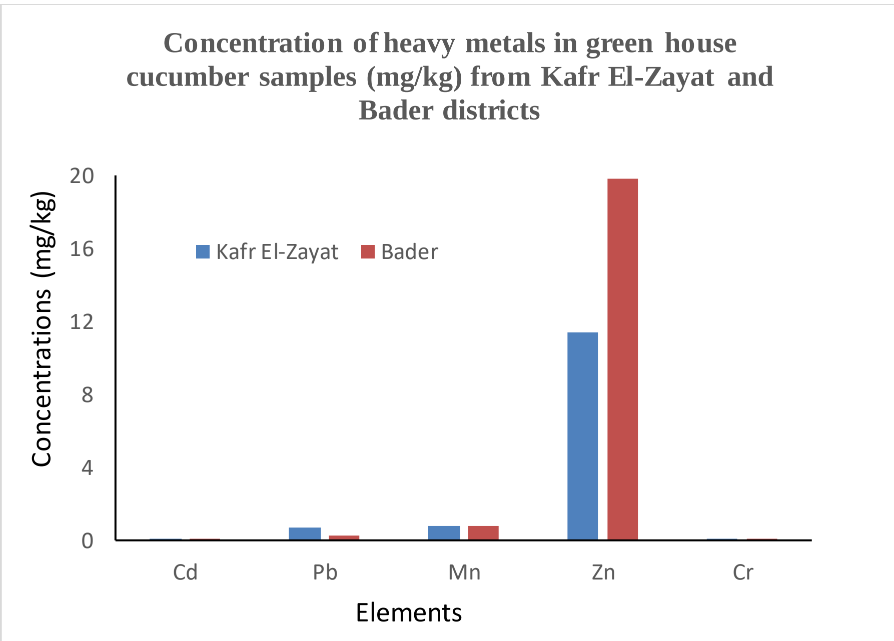

Fig 1: Concentration of some heavy metals in green house cucumber samples (mg/kg) from Kafr El-Zayat district and Bader district.

Contamination of food substances by heavy Metals is one of the greatest significant considerations in food quality assurance (**Mashall, 2004; Wang *et al.*, 2005; Ali and Al-Qahtani, 2012**). Contaminated vegetables with heavy Metals cannot be disregarded because these food substances are highly nutritious, largely consumed, and form essential to food quality has decreased the maximum acceptable levels of toxic metals in food substances due to an increased cognizance of the danger of heavy metals contamination in food chain contamination. Based on the heavy metal persistent and cumulative behavior and the possibility of their potential toxicity effects as a result of intake vegetables and fruits, analysis of food substances is needed to confirm that the levels of these trace elements are in accordance with international requirements.

The results of **(Sobukola, *et al*., 2010) are in** agreement with our results, where the levels of Lead, Cadmium, Copper, and Zinc ranged from 0.072±0.06 to 0.128±0.03; 0.003±0.01 to 0.005±0.01; 0.002±0.00 to 0.015±0.02 and 0.039±0.01 to 0.082±0.01 mg/kg, respectively, for the fruits. The levels of Lead, Cadmium, Copper and Zinc for the leafy vegetables respectively ranged from 0.09±0.01 to 0.21±0.06; 0.03±0.01 to 0.09±0.00; 0.02±0.00 to 0.07±0.00 and 0.01±0.00 to 0.10±0.00 mg/kg. **Basha *et al.* (2014)** reported that the concentrations of trace metals in vegetables and fruits are found in the range of 75.5-13.9 mg/kg for Fe, 2.3-0.8 mg/kg for Cu, 9.2-3.1 mg/kg for Zn, 0.2-1.4 mg/kg for Pb, 46.5-2.3 mg/kg for Cd.

Table 2: Estimated weekly intakes (mg/kg b.w/day) at Maximum concentrations of some heavy metals in greenhouse cucumber samples from collected from Kafr El-Zayat district and Bader district

Tested elements	Kafr El-Zayat district				Bader district			
	Maximum Concentrations (mg/kg)	**EPTWI (mg/kg bw/week)**	**APTWI (mg/kg bw/wee)**	**EPTWI As % of APTWI**	**Maximum Concentrations (mg/kg)**	**EPTWI (mg/kg bw/week)**	**APTWI (mg/kg bw/week)**	**EPTWI As % of APTWI**
Cd	0.150	8.85E-05	0.007	1.2643%	0.160	9.44E-05	0.007	1.35%
Cr	0.020	1.18E-05	0.029	0.0407%	0.050	2.95E-05	0.029	0.10%
Mn	1.540	9.09E-04	1.28	0.0710%	1.570	9.26E-04	1.28	0.07%
Pb	1.210	7.14E-04	0.025	2.8556%	0.660	3.89E-04	0.025	1.56%
Zn	23.320	1.38E-02	4.65	0.2959%	37.130	2.19E-02	4.65	0.47%

Food consumption (g/day) of cucumber = 5.9
EPTWI: Estimated provisional tolerable weekly intake
APTWI: Acceptable provisional tolerable weekly intake

3.1.Health risk estimation:

For this health, risk estimation estimated weekly intake (EPTWI)

For the daily and weekly intake estimation, five elements (Cd, Cr, Mn, Pb, and Zn) with concentration levels in greenhouse cucumber samples collected from Kafr El-Zayat and Bader districts were chosen. The results in (table 2) showed that even at maximum concentrations, the intake of all elements detected in the samples collected from each Kafr El-Zayat district and Bader district did not exceed the APTWI in all analysed cucumber samples. The estimated provisional tolerable weekly intakes for Cd, Cr, Mn, Pb, and Zn in the Kafr El-Zayat district were (8.85x 10-5, 1.18x 10-5, 9.09x 10-4, 7.14x 10-4, and 1.38x 10 -2 mg/kg BW/day), respectively. This amounts to roughly 1.2643%, 0.0407%, 0.071%, 2.8556%, and 0.2959% of the provisional total tolerable weekly intake Cd, Cr, Mn, Pb, and Zn, respectively.

However, in the Bader district, the estimated provisional tolerable weekly intakes for Cd, Cr, Mn, Pb, and Zn were (9.44x 10-5, 2.95x 10-5, 9.26x 10-4, 3.89x 10-4, and 2.19x 10 -2 mg/kg BW/day), respectively. This amounts to about 1.35%, 0.1%, 0.07%, 1.56%, and 0.47% of the provisional tolerable weekly intakes of Cd, Cr, Mn, Pb, and Zn, respectively.Results revealed that both Cd and Pb in all analyzed cucumber samples collected from Kafr El-Zayat district and Bader district recorded the highest constitution of the provisional tolerable weekly intake. Overall, the estimated average weekly intakes of tested elements were discovered to be significantly lower than the acceptable provisional tolerable weekly intakes (APTWI).

CONCLUSION

Determination of elements of Cd, Pb and Zn in green house cucumber some samples from Kafr El-Zayat district in El-Gharbia Governorate and Bader district in El-Beheira Governorate were higher and the rest were less than the Maximum acceptable values in all greenhouse cucumber samples. Concentration of Mn and Cr were lower than the Maximum acceptable values in all cucumber samples. Considering the possible health outcomes due to consumption of contaminating vegetables, it is required to take proper action for avoiding the presence of any samples exceeding the maximum acceptable values to avoid people chronic exposure.

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الكشف عن بعض العناصر الثقيلة في الخيار المنزرع في البيوت المحمية– مصر

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الملخص العربي:

الهدف من البحث هو تقدير مستويات بعض العناصر الثقيلة في بعض عينات خيار الصوب الزجاجية في مركز كفر الزيات-محافظة الغربية و مركز بدر في محافظة البحيرة -مصر .وتم التقدير باستخدام جهاز الامتصاص الطيفي-كانت النتائج المتحصل عليها كالآتي :-تركيزات عنصري الكادميوم و الرصاص في بعض عينات خيار الصوب الزجاجية المأخوذة كانت أعلى من الحدود المسموح بها و في بعض عينات الخيار الأخرى كانت القيم أقل من الحدود المسموح بها وفقا لمنظمة الصحة العالمية. كانت متوسط قيم التقدير تتراوح ما بين (اقل من حدود التقدير-٠.١٥ مليجرام لكل كيلوجرام)و (اقل من حدود التقدير -١.٢١ مليجرام لكل كيلوجرام) في عينات خيار كفر الزيات و (اقل من حدود التقدير -٠.١٦ مليجرام لكل كيلوجرام)و (اقل من حدود التقدير -٠.٦٦ مليجرام لكل كيلوجرام) لعنصري الكادميوم و الرصاص في عينات خيار مركز بدر على الترتيب.بينما كانت مستويات عنصري المنجنيز و الزنك والكروم في جميع عينات خيار الصوب الزجاجية المأخوذة في مركزي كفر الزيات و بدر كانت أقل من الحدود المسموح بها وفقا لمنظمة الصحة العالمية وكانت تتراوح بين (اقل من حدود التقدير -١.٥٤ مليجرام لكل كيلوجرام) و (اقل من حدود التقدير -٢٣.٣٢ مليجرام لكل كيلوجرام) و (اقل من حدود التقدير - ٠.٠٢ مليجرام لكل كيلوجرام) في عينات خيار مركز كفر الزيات و (٠.٠٦-١.٥٧ مليجرام لكل كيلوجرام)و (اقل من حدود التقدير -٣٧.١٣ مليجرام لكل كيلوجرام) و و (اقل من حدود التقدير -٠.٠٢٥ مليجرام لكل كيلوجرام) لعنصر المنجنيز و الزنك والكروم على الترتيب في عينات خيار مركز بدر و تم تقييم المخاطر الصحية لتقدير المتناول الأسبوعي باستخدام توصيات مجلس الغذاء والتغذية. تم العثور على المتناولات الأسبوعية لجميع العناصر لتكون أقل بكثير من المتناولات الأسبوعية المسموح بها (APTWI)، مما يشير إلى عدم وجود أي آثار خطر على الإنسان.

الكلمات المفتاحية: الكشف – المعادن الثقيلة – تقييم المخاطر – البيوت المحمية - الخيار