Available online at http://journal-of-agroalimentary.ro

Journal of Agroalimentary Processes and Technologies 2011, *17*(1), 36-41

Journal of Agroalimentary Processes and Technologies

An Evaluation of Heavy Metals Concentration in Edible Vegetables Grown Around Arad Area

M.F. Munteanu[1], D. Ionescu[2], C. Peev[2], M. Butnariu[3], C. A. Dehelean[2*]

[1]*University of Medicine and Pharmacy "Victor Babes" Timisoara, E Murgu 2, 300041, Timisoara Romania*
[2]*University of Medicine and Pharmacy "Victor Babes" Timisoara, E Murgu 2, 300041, Timisoara Romania*
[3] *Banat's University of Agricultural Sciences and Veterinary Medicine, 300645-Timişoara, C. Aradului 119, Romania*

Received: 12 December 2010; Accepted: 11 February 2011

Abstract

The objective of our study was to assess the concentrations of heavy metals in selected edible vegetables grown in the farmlands around Pancota City from Arad Area. The levels of four heavy metals [cadmium (Cd), lead (Pb), chromium (Cr) and copper (Cu)] were determined in various vegetables [leek (*Allium ampeloprasum* L.), sweet basil (*Ocimum basilicum* L.), parsley (*Petroselinum crispum*), and tarragon (*Artemisia dracunculus*)]. 75 samples (15 samples per month) were collected for five months during the cultivation season (May–September) during the year 2009. Heavy metals concentration was determinate by atomic absorption spectrometry. It was used an atomic absorption spectrophotometer, controlled by PC (AAS, Analytik Jena AG). The average concentrations of each heavy metal regardless of the kind of vegetable for Pb, Cu, Cr and Cd were 13.90±3.17, 12.40±1.43, 5.40±1.21 and 0.28±0.06 mg/kg, respectively. The main conclusion is that the edible vegetables that are growing in Arad region are not dangerous for human consumption because of the low detected concentrations of heavy metals. Our study revealed the heavy metals concentrations within acceptable limits after the FDA and WHO standards

Keywords: Heavy metals contamination, *Allium ampeloprasum, Ocimum basilicum, Petroselinum crispum, Artemisia dracunculus*

1. Introduction

Food safety represents an important public health problem concern worldwide. An increasing demand of food safety has stimulated research regarding the risk associated with consumption of foodstuffs contaminated by pesticides, heavy metals and/or toxins [1].

A great quantity of heavy metals and other chemicals, especially produced by industries, agriculture, mining, combustion of fossil fuels and traffic are often released to the atmosphere, soil and water. They aggressively manifested on terrestrial and aquatic flora and fauna [2, 3, 4, 5].

Heavy metals are among the major contaminants of food supply and may considered the most important problem to our environment [6]. They are not biodegradable, have long biological half–lives and have the potential for accumulation in the different body organs leading to unwanted side effects [7, 8]. Heavy metals easily accumulate in large quantities in plant tissues with no visible phytotoxicity, but exceed human and animal tolerance [9, 10]. Both tolerable and lethal dose of toxic compounds for different plants have been established and in some cases, the modification of chemical composition of the plants under the action of pollutants has been observed [11, 12, 13].

Corresponding author: *e-mail:* cadehelean@umft.ro

Lead and cadmium are among the most abundant heavy metals and are particularly toxic. The excessive content of these metals in food is associated with etiology of a number of diseases, especially with cardiovascular, kidney, nervous as well as bone diseases [14, 15, 16, 17].

In addition, they are also implicated in causing carcinogenesis, mutagenesis and teratogenesis [18, 19]. Other metals such as copper and zinc are essential for important biochemical and physiological functions and necessary for maintaining health throughout life [20, 21, 22].

Heavy metal contamination may be occurred due to irrigation with contaminated water, the addition of fertilizers and metal–based pesticides, industrial emissions, transportation, harvesting process, storage and/or sale [23].

Human beings are encouraged to consume more vegetables and fruits, which are a good source of vitamins, minerals, fibbers, carbohydrates, low in fats and also beneficial to their health. However, these plants contain both essential and toxic metals over a wide range of concentrations. It is well known that plants take up metals by absorbing them from contaminated soils as well as from deposits on parts of the plants exposed to the air from polluted environments [24, 25].

Keeping in view of the potential toxicity, persistent nature and cumulative behavior as well as the consumption of vegetables and fruits, there is necessary to test and analyze these food items to ensure that the levels of these contaminants meet the agreed international requirements.

Regular survey and monitoring programme of heavy metal contents in foodstuffs have been carried out for decades in most developed countries. Heavy metals are of special importance from the ecotoxicological point of view, both because of the high toxicity of compounds containing in these metals and because of their accumulation in various organisms. Information on their content in plants and animals is of great botanical, nutritional and environmental interest. Some of the heavy metals are toxic when their concentrations exceed certain values [26, 27, 28, 29, 30, 31, 32, 33, 34]. The objective of our study was to assess the concentrations of heavy metals in selected edible vegetables grown in the farmlands around Pancota City, Arad area and to estimate their contribution to the daily intake of the metals.

2. Materials and Method

Sampling is a major part of the program. Inadequate or inconsistent sampling procedures produce data of questionable quality which may lead to erroneous interpretation and conclusions.

Most analytical testing constitutes three steps, namely sample preparation, decomposition and determination.

The levels of four heavy metals [cadmium (Cd II), lead (Pb II), chromium (Cr III) and copper (Cu II)] were determined in various vegetables [leek (*Allium ampeloprasum* L.), sweet basil (*Ocimum basilicum* L.), parsley (*Petroselinum crispum*), and tarragon (*Artemisia dracunculus*)] cultivated around Pancota City.

The contributions of the vegetables to the daily intake of heavy metals from vegetables were investigated. 75 samples (15 samples per month) were collected for five months during the cultivation season (May–September) during the year 2009. All samples were collected and stored in polythene bags according to their type and brought to the laboratory for preparation and treatment.

For lead, cadmium, chromium and copper analyses, vegetable samples were washed with distilled water to eliminate suspended particles. The leafy stalks were removed from all samples and these were sliced and dried on a sheet of paper to eliminate excess moisture.

In porcelain capsules, previously brought at constant weight by drying at 105°C, was weighing a 1.000g sample. The capsules with samples were introduced into drying stove at 50–60°C for almost 8 hours. Then the temperature was increased at 105° C for 5–6 hours.

After this time, the sample capsules were took out from drying stove and introduced into calcinations oven, at cold. It was increased progressively the temperature at 200–250°C and it was maintained to complete calcinations of the samples.

Then the temperature was increased to 500°C and the samples were calcined for 6–8 hours to a white ash was obtained. The samples that were incompletely calcined were treated with 1ml concentrated HNO_3, drying on the sand bath and then calcined at 500°C for others 2 hours. After cooling, the ash was treated with 0.5 ml bidistilled water and 1ml hydrochloric acid 6N and was evaporated to dry, on the sand bath; the operation was repeated for two times.

The residue was dissolved in small portions of 5 ml HCl 0.5N, passed quantitatively into a 50 ml glass flask and completed to exactly 50 ml with HCl 0.5N solution. The glass flask content was finally filtered in a perfectly dry flask. For each sample set was achieved a control sample.

Heavy metals concentration was determinate by atomic absorption spectrometry. The heavy metals were measured from the obtained hydrochloric solution by pulverization in the air–acetylene flame and measurement of the absorbance, respectively emission at the characteristic wavelength for each analyzed element. It was used an atomic absorption spectrophotometer, controlled by PC (AAS, Analytik Jena AG).

For the spectrophotometer calibration were prepared sets of etalons of different concentrations in HCl 0.5N solution for each analyzed element, starting to the concentrated standard solutions.

The concentration (C) for each determined element was calculated with the following formula:

C *(mg/kg or ppm)* $= a \times f / m$,

where:
f = dilution factor;
a = element content indicated by apparatus (mg/l);
m = sample initial weight.

Samples were prepared for quantitative determination by mineralization using the microwave (MW)–assisted digestion with nitric acid, nitric and hydrochloric acids without or with the addition of hydrogen peroxide is a widely used technique for the dissolution of vegetables samples. (SR EN 13804: 2003, Determination of microelements).

Spectrophotocolorimetric determination is a physical–chemical method whose principle is based on comparing the intensity of staining intensity color sample for analysis of known concentrations and different solutions.

Metals were determined by atomic absorption spectrophotometer AAS, Analytik Jena AG, (SR EN ISO 6869:2002, Determination of metals and ISO 78–4:1998, standard plans). Since the trace level analysis of transition metals is limited by the purity of water and the reagents, precautions must be taken at every step of sample and standard preparation to minimize contamination.

All reagents were of analytical–reagent grade. Eluents were filtered and degassed before use. All mobile phase components and PAR monosodium salt (post-column derivatization reagent) were obtained from Sigma–Aldrich, Germany. Double distilled water was purified (deionized) with an Easypure system (18 MΩcm). Analysis were done in duplicates. In all determinations, blanks were included.

3. Results and Discussion

The determination of trace elements in vegetables samples is of interest because of nutritional and toxicological reasons.

The average concentrations of heavy metals found in the vegetables samples are showed in the following figures (figure 1; figure 2; figure 3; figure 4). The average concentrations of each heavy metal regardless of the kind of vegetable for Pb, Cu, Cr and Cd were 13.90±3.17, 12.40±1.43, 5.40±1.21 and 0.28±0.06 mg/kg, respectively.

The highest concentrations of heavy metal were observed in tarragon while leek and sweet basil had the lowest concentration. Our study revealed heavy metal concentrations within acceptable limits after the FDA and WHO standards. Based on the above concentrations and the information of Institute of Food.

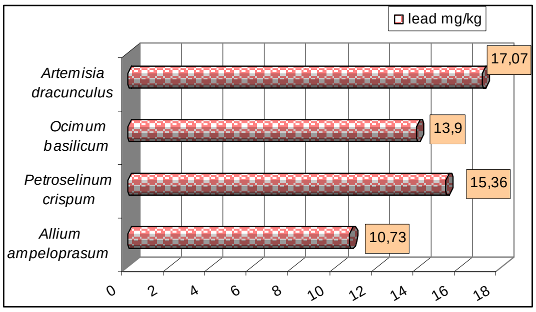

Figure 1. Comparative evaluation of the average concentration of lead in vegetable samples analyzed

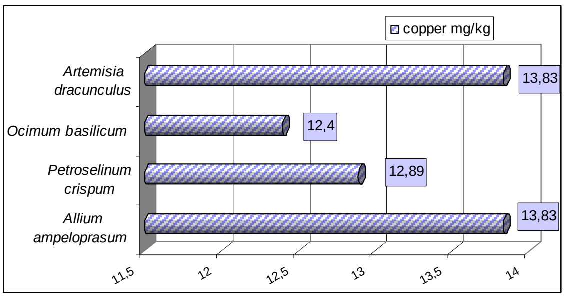

Figure 2. Comparative evaluation of the average concentration of copper in vegetable samples analyzed

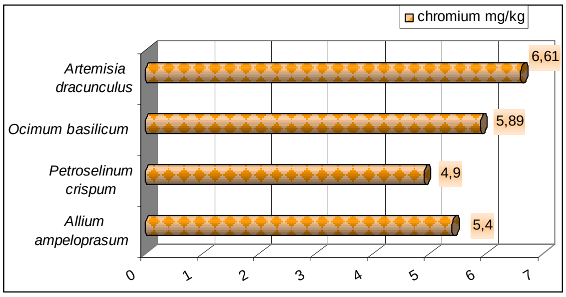

Figure 3. Comparative evaluation of the average concentration of chromium in vegetable samples analyzed

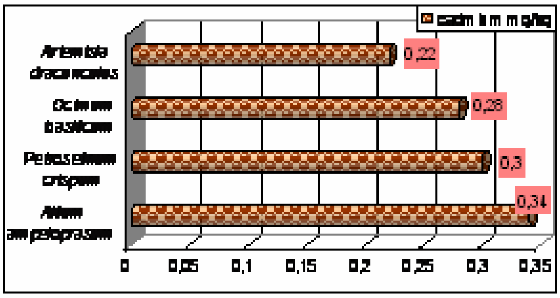

Figure 4. Comparative evaluation of the average concentration of cadmium in vegetable samples analyzed

Bioresources, the dietary intake of Pb, Cu, Cr and Cd through vegetable consumption was estimated at 1.96, 1.50, 0.72 and 0.02 mg/day, respectively. Thus, the consumption of average amounts of these foodstuffs does not pose a health risk for the consumer [35,36]. Heavy metals, such as cadmium, copper, lead, and chromium are important environmental pollutants, particularly in areas with high anthropogenic actions. Their presence in the atmosphere, soil and water, even in traces, can cause serious problems to all organisms. Heavy metal accumulation in soils is of concern in agricultural production due to the adverse effects on food quality (safety and marketability), crop growth (due to phytotoxicity) [37,38,39] and environmental health (soil flora/fauna and terrestrial animals).The mobilization of heavy metals into the biosphere by human activity has become an important process in the geochemical cycling of these metals. Heavy metal bioaccumulation in the food chain can be especially highly dangerous to human health. These metals enter the human body mainly through two routes namely: inhalation and ingestion, and with ingestion being the main route of exposure to these elements in human population. Heavy metals intake by human populations through the food chain has been reported in many countries with this problem receiving increasing attention from the public as well as governmental agencies, particularly in developing countries [40]. Since the dietary intake of food may constitute a major source of long–term low–level body accumulation of heavy metals, the detrimental impact becomes apparent only after several years of exposure. Regular monitoring of these metals from effluents, sewage, in vegetables and in other food materials is essential for preventing excessive buildup of the metals in the food chain [41]. Uncontrolled mining activities and mining has left a lot of environmental hazards and enormous amount of wastes and different types of pollutants are generated. Adverse environmental and ecological changes as a result of anthropogenic input have become more tangible and menacing. There exist concerns and question on the state of the soil and quality of food crops, fruits and vegetables cultivated.

4. Conclusion

The main conclusion is that the edible vegetables products that are growing in Arad region are not dangerous for human consumption because of the low detected concentrations of heavy metals. Our study revealed the heavy metals concentrations within acceptable limits after the FDA and WHO standards. The analytical results obtained for heavy metals in plant sample show that they have lower concentrations than those recommended by the World Health Organization.

Factors affecting the thresholds of dietary toxicity of heavy metal in soil–crop system include: soil type involving soil pH, organic matter content, clay mineral and other soil chemical and biochemical properties; and crop species or cultivars regulated by genetic basis for heavy metal transport and accumulation in plants.

Further research is needed to find out the variations in metal uptake by different vegetable species, and the site–specific risk assessment guidelines to highlight and to minimize the potential health risks of ingesting vegetables containing high levels of heavy metals.

It is therefore suggested that regular survey of heavy metals should be done on all food commodities in order to evaluate whether any health risks from heavy metal exposure do exist, to assure food safety and to protect the end user from food that might injure their health.

References

1. D'Mello, J.P.F., *Food safety: Contaminants and Toxins.* CABI Publishing, Wallingford, Oxon, UK, Cambridge, MA, p. 480. 2003.
2. Celik A., Kartal A., Akdogan A., Kaska Y. Determining the heavy metal pollution in Denizli (Turkey) by using *Robinia pseudoacacia L. Environ. Int.* **2005**, *31*(1), 105–112, doi:10.1016/j.envint.2004.07.004
3. Okafor E. Ch., Opuene K. Preliminary assessment of trace metals and polycyclic aromatic hydrocarbons in the sediments. *Int. J. Environ. Sci. Tech.,* **2007***, 4*(2), 233–240
4. Mahvi A. H., Application of agricultural fibers in pollution removal from aqueous solution. *Int. J. Environ. Sci. Tech*., **2008**, *5*(2), 275–285
5. Yasar U., Ozyigit I. I., Serin, M., Judas tree (*Cercis siliquastrum* L. subsp. *siliquastrum*) as a possible biomonitor for Cr, Fe and Ni in Istanbul (Turkey). *Rom. Biotech. Lett.,* **2010**, *15*(1), 4983–4992
6. Zaidi M.I., Asrar A., Mansoor A., Farooqui M..A.,. The heavy metal concentrations along roadside trees of Quetta and its effects on public health. *J. Appl. Sci.* **2005**, 5(4), 708–711, doi: 10.3923/jas.2005.708.711
7. Jarup L., Hazards of heavy metal contamination. *Br. Med. Bull.* **2003**, *68*(1), 167–182
8. Sathawara N.G., Parikh D.J., Agarwal, Y.K., Essential heavy metals in environmental samples from western India. *Bull. Environ. Contam. Toxicol*., **2004**, *73*(4), 756–761, doi: 10.1007/s00128-004-0490-1
9. Kovalchuk, I.; Kovalchuk, O., Hohn, B., Biomonitoring the genotoxicity of environmental factors with transgenic plants. *Trends. Plant. Sci.* **2001**, *6*(7), 306–310, doi:10.1016/S1360-1385(01)01985-9
10. Prasad, N.M.V., Freitas, H.M.O., Metal hyperaccumulation in plants–biodiversity prospecting for phytoremediation technology. *Electron. J. Biotech.* **2003**, *6*(3), 285–321
11. Kabata-Pendias, A.; Pendias, H., *Trace elements in soils and plants*. 3rd. Ed., Crc Press Inc., Boca Raton, Florida, U.S.A. 2001
12. Nameni, M., Alavi Moghadam, M. R., Arami, M., Adsorption of hexavalent chromium from aqueous solutions by wheat bran. *Int. J. Environ. Sci. Tech.* **2008**, *5*(2), 161–168
13. Akguc N., Ozyigit I.I. et al Use of *Pyracantha coccinea* Roem. as a possible biomonitor for the selected heavy metals *Int. J. Environ. Sci. Tech.* **2010**, *7*(3), 427–434
14. WHO, Cadmium. Environmental Health Criteria, Geneva. Switzerland, Vol. 134. 1992.
15. WHO, Lead. Environmental Health Criteria, Geneva. Switzerland Vol. 165. 1995.
16. Steenland K., Boffetta P., Lead and cancer in humans: where are we now? *Am. J. Ind. Med.* **2000**, *38*(3), 295–299, doi: 10.1002/1097-0274(200009)
17. Jarup, L., Hazards of heavy metal contamination. *Br. Med. Bull.* **2003**, *68*(1), 167–182, doi: 10.1093/bmb/ldg032
18. IARC, Cadmium and cadmium compounds. In: Beryllium, Cadmium, Mercury and Exposure in the Glass Manufacturing Industry IARC Monographs on the evaluation of carcinogenic risks to humans, Vol. 58. *International Agency for Research on Cancer,* Lyon, 1993, pp. 119–237
19. Pitot C.H., Dragan, P.Y., *Chemical carcinogenesis,* fifth Ed. In: Casarett, Doulls (Eds.), Toxicology International Edition, McGraw Hill, New York, 1996, pp. 201–260
20. Prentice, A., Does mild zinc deficiency contribute to poor growth performance? *Nutr. Rev.,* **1993**, *5*(9), 268-270, doi: 10.1111/j.1753-4887.1993.tb03118.x
21. ATSDR, Agency for toxic substance and disease registry. *Toxicological profile for zinc.* US Department of Health and Human Services, Public Health Services, Division of Toxicology Information Branch, Atlanta, Georgia, 1994
22. Linder, C., Azam, M.H. Copper, biochemistry and molecular biology. *Am. J. Clin. Nutr.* **1996**, 63 (Suppl.), 797S–811S
23. Radwan M.A., Salama A.K., Market basket survey for some heavy metals in Egyptian fruits and vegetables, *Food and Chemical Toxicology* **2006**, *44*(8), 1273–1278, doi:10.1016/j.fct.2006.02.004
24. Khairiah T., Zalifah M.K., Yin Y.H., Aminah, A., The uptake of heavy metals by fruit type vegetables grown in selected agricultural areas. *Pak. J. Biol. Sci*. **2004**, *7*(8), 1438–1442, doi: 10.3923/pjbs.2004.1438.1442
25. Chojnacha K., Chojnacki, A., Gorecka H., Gorecki H., Bioavailability of heavy metals from polluted soils to plants. *Sci. Total Environ.* **2005**, *337*(1–3), 175–182
26. Jorhem L., Sundstroem B., Levels of lead, cadmium, zinc, copper, nickel, chromium, manganese and cobalt in foods on the Swedish market, 1983–1990. *J. Food Compos. Anal,*. **1993**, *6*(3), 223–241
27. Pennington J., Schoen S., Salmon G., Young B., John R., Mart R., Composition of core foods of the USA food supply 1982–1991. II. Calcium, magnesium, iron and zinc. *J. Food Compos. Anal.*, **1995a**., *8*(2), 129–169, doi:10.1006/jfca.1995.1013
28. Pennington, J., Schoen, S., Salmon, G., Young, B., John, R., Mart, R., Composition of core foods of the USA food supply 1982–1991. III. Copper, manganese, selenium and iodine. *J. Food Compos. Anal.,* **1995b**. 8, 171–217.
29. Milacic R., Kralj B., Determination of Zn, Cu, Cd, Pb, Ni and Cr in some Slovenian foodstuffs. *Eur. Food Res. Technol*, **2003**, *217*(3), 211–214, doi: 10.1007/s00217-003-0755-7

30. Saracoglu S., Tuzen M., Mendil D., Soylak M., Elci, L., Dogan, M., Heavy metal content of hard biscuits produced in *Turkey. Bull. Environ. Contam. Toxicol.* **2004**, *73*(2), 264–269
31. Dogheim S.M., El-Ashraf, M.M., Gad Alla S.A., Khorshid M.A., Fahmy S.M., Pesticides and heavy metals levels in Egyptian leafy vegetables and some aromatic medicinal plants. *Food Addit. Contam.* **2004**, *21*(4), 323–330
32. Butnariu M., Goian M. *Metalele grele din solurile Banatului şi biomonitorizarea lor,* Ed. Orizonturi Universitare, Timisoara, 2005 p. 125
33. Butnariu M. *Chimie generală*, Ed. Mirton, Timişoara, Colecția Paideia, 2006, p.225
34. Butnariu M. *Notiuni teoretice şi practice de biochimie vegetală*, Ed. Mirton, Timisoara, 2007 p. 95.
35. FAO/WHO. *Food additives and contaminants.* Joint Codex Alimentarius Commission, FAO/WHO Food standards Programme, ALINORM 01/ 12A. 2001
36. Joint FAO/WHO *Expert Committee on Food Additives, Expert Committee on Food Additives.* Summary and conclusions, 53rd meeting. Rome: Joint FAO/WHO, 1–10 June, 1999
37. Ma Q.Y., Traina S.J., Logan T.J., Effect of aqueous Al, Cd, Fe(II), Ni and Zn on Pb immobilization by hydroxyapatite. *Environ. Sci. Technol.*, **1994,** *28*(7), 1219–1228, doi: 10.1021/es00056a007
38. Msaky J.J., Calvert R., Adsorption behavior of copper and zinc in soils: influence of pH on adsorption characteristics. *Soil Sci*., **1990,** *150*(2), 513–522
39. Fergusson J.E., *The Heavy Elements: Chemistry, Environmental Impact and Health Effects.* Pergamin Press, Oxford, 1990, p.382–399.
40. Ejazul E, Xiaoe Y, Zhenli HE, Qaisar M, Assessing potential dietary toxicity of heavy metals in selected vegetables and food crops *J Zhejiang Univ Sci B,* **2007**, *8*(1), 1–13, doi: 10.1631/jzus.2007.B0001
41. Bahemuka T.E., Mubofu E.B., Heavy metals in edible green vegetables grown along the sites of the Sinza and Msimbazi rivers in Dar es Salaam, Tanzania. *Food Chem.*, **1999**, *66*(1), 63–66, doi:10.1016/S0308-8146(98)00213-1