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LEVELS OF POTENTIALLY TOXIC HEAVY METALS IN BULBS OF DIFFERENT VARIETIES OF ONION

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Abstract

The presence of toxic heavy metals in food is regulated by legal acts and limited to the permissible contents because the consumption of contaminated food over a long period of time is dangerous for health.
Tests for the presence of heavy metals in bulbs of onion variety Stuttgarter (standard) and new varieties Konjicki and Zenicki were conducted in 2012 and 2013 by performing experiments on the site of Butmir, Sarajevo. Even though none of the test samples contained heavy metals above the prescribed amount, as per detected presence of lead, arsenic and cadmium, there are indications of present differences related to the examined varieties of onions or even year of breeding. In 2013 detected content of lead increased by 0.0090 mg/kg, 0.0074 mg/kg of arsenic and 0.0033 mg /kg of cadmium, comparing to 2012. Among the examined varieties of onion, a variety Stuttgarter in 2012 had the highest contents of all studied toxic heavy metals, while such properties in 2013 had variety Zenicki. The results indicate that only the amount of the bulb yield that is significantly higher for the variety Konjicki (34%) in 2012, and 30% for the variety Konjicki and 27% for Zenicki in 2013, comparing to standard, is not enough to accept a new line of onion as fit for human consumption.

Key words: *heavy metals, onion, varieties, bulbs.*

Introduction

Some heavy metals are in the form of elements in trace necessary – essential for a number of functions in the human body, and its deficiency results in the appearance of symptoms of diseases and serious defects in the metabolism. Increased concentration in the body is undesirable and dangerous. Most often it is a question of toxicity of quantity, and this range varies with each individual element.
Heavy metals can be in the form of fine particles of dust released into the atmosphere, where they deposit in the water and soil. In waters, they quickly dilute and deposit on the bottom as insoluble carbonates, sulfates or sulfides.
Circulation of heavy metals in the nature highly depends of the changes which these metals are subject to. The concentration of these compounds in adverse conditions (out of mineral soil) is of anthropological origin and is the result of industrial pollution. Mentioned concentrations occur in industrial products (detergents, batteries, food additives, etc.) or as a result of technological processes (combustion, smelting, electroplating, etc.).
Contamination of soil, surface and groundwater with nitrates, heavy metals and remains of active ingredients of pesticides occurs occasionally in environmental conditions of uncontrolled extensive and intensive agricultural production. In the soil-water-plant system the more actual is problem of heavy metals that do not belong to the biogenic elements, but

act solely toxically as e.g. cadmium and lead. However, the sources of contamination of soil and water are not always nor exclusively from agriculture (Vidaček et al., 1999).
The content of available forms of inorganic and organic pollutants in soil is variable and depends primarily on the parent material, pH (greater mobility in acidic soils), the content of organic matter in the soil, $CaCO_3$, textural and others. (Teodorović et al., 2009). The acidic environment causes the appearance of ionic forms of metals in the soil, which are mobile and available to plants.
Adoption of heavy metals in plants is primarily carried out by the roots from the soil solvate, and to a lesser extent through above ground organs from the atmosphere. Because of its durability, heavy metals accumulate in the soil where plants can adopt them through the roots. Part of the heavy metals, which is deposited on the leaves, is absorbed, and other part can be washed by precipitation. Rinsing depends on the degree of dissolubility.
The occurrence of possible contamination of food by heavy metals in primary agricultural production is very significant problem that creates confusion among consumers, so the researches related to the presence of potentially toxic heavy metals in bulbs of different varieties of onion in the framework of this paper, the contribution of the production of safe food.

Materials and methods

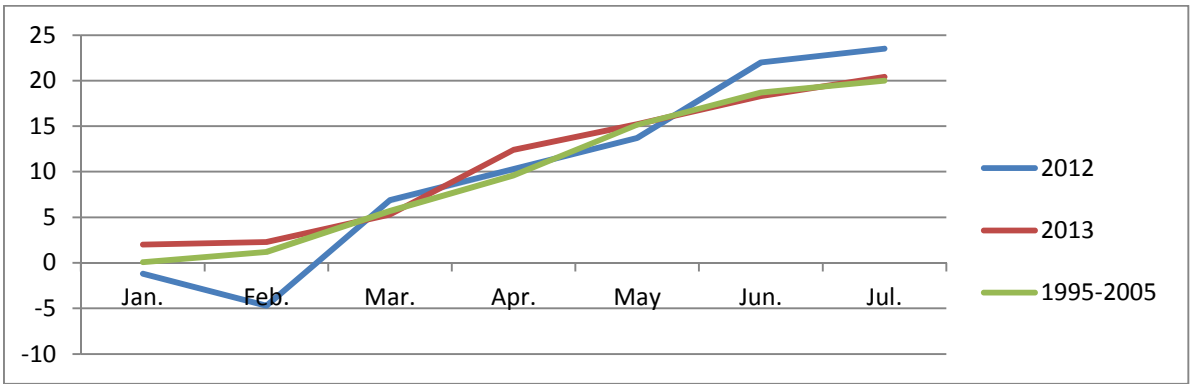
The experiments were carried out at the site Butmir (Sarajevo) during two years (2012, 2013) with new varieties of onions, variety Zenicki and Konjicki. For standard is used Stuttgarter variety, which is widespread in production in Bosnia and Herzegovina. Experiments have been conducted on a randomized block design with five replications. The main parcel size was 4.5 m^2 (5x 0.9 m), with three rows of the parcel (30 x 10 cm), or 150 plants per parcel (330 thousand plants / ha).
Planting of onion was done manually, on 18th of March 2012 and 6th of March 2013. During the growing season were administered all necessary measures of care in the production of onion. During fertilization it was taken into account the preceding crop and soil type. It was sought to provide plants with such conditions which will allow expression of the maximum capacity of yielding of variety. In the soil were added fertilizers in the following quantities of pure nutrients: 56 kg / ha N, 112 kg/ha P_2O_5 and 294 kg/ha K_2O. In early spring NPK fertilizers were added. Fertilization was carried out before the first hoeing.
The content of heavy metals were detected: EN 13805:2002, 15763:2009 ITD and EN, by ITD method on the instrument Inductively coupled plasma with mass spectrometry, with the previous preparation of plant material in a microwave for digestion. Samples of plant material (bulbs at the stage of full maturity without outer sheath, only edible part) were destroyed with nitric acid HNO_3 and 65% hydrogen peroxide.
All analyzes were performed in the laboratory of the Federal Institute for Agriculture, Sarajevo.

Environmental conditions in the course of performing experiments:

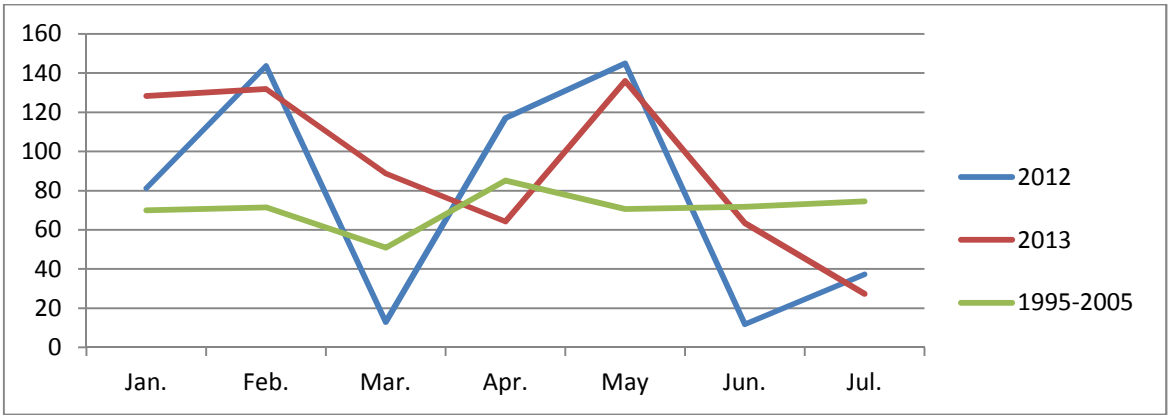
On the site Butmir where experiments were carried out, the soil is brown valley, and the composition of the feed is moderately supplied with phosphorus and potassium (Table 1).
For view of the climatic conditions during the vegetation period, data from meteorological stations Sarajevo (Site Butmir) was used. The average monthly temperatures and rainfall for the growing season onion were showed (Graph 1 and 2).
Climatic conditions vary from year to year. Butmir has harsh winters and moderately warm summers. In the years of testing temperature ranged within the multi-year average.

Table1.Chemical habits of soil

Year	Reaction pH		Content %			mg of soil contains phisiologially	
	H_2O	KCl	Total N	$CaCO_3$	Humus	P_2O_5	K_2O
2012.	5,89	-	0,09	-	1,80	12,50	10,9
2013.	6,02	-	0,08	-	1,80	8,45	14,20



Graph 1.Middle average air temperatures (°C)



Graph 2.Monthly precipitation (l/m^2)

If we analyze the temperature data, it can be seen that the temperatures in the period of performing experiment with varieties of onion (2012, 2013) were satisfactory comparing to the perennial average. Higher mean monthly temperatures were in the III, IV, VI and VIII month (2012), and II, IV and VII month (2013) in relation to a multi-year average. Maximum temperatures were higher in the sixth month (2012) and IV and VI month (2013), while minimum temperatures were slightly higher except in V month (2012) in relation to a multi-year average. The lack of rainfall during the growing season was in III, VI and VII month (2012) and IV, VI and VII month (2013), which did not significantly affect the germination of onion because the land had sufficient accumulated moisture. In this paper, data on the climate conditions in the years of testing should be an indication of the possible impacts on the mobility of heavy metals.

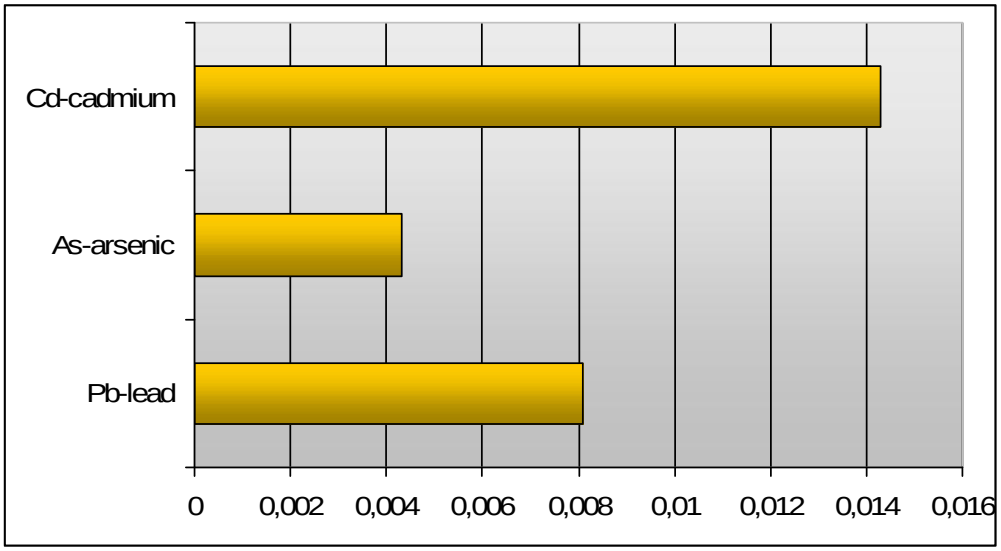
Results and discussion

It is known that plants acquire large amounts of metals in their vegetative parts (root, stem, leaf) rather than in fruit and seed. In particular, the attention should be paid to the cultivation of green leafy vegetables such as cabbage, which adopt a significant amount of pollutants in their edible parts. Also, growing forage crops and by pasture, heavy metals can enter the food chain via cattles consuming contaminated forage, and then by using the meat, milk, or other products to the man. Therefore, it is important to dynamically observe and monitor the occurrence of not only the soil but also the plant material, whereby a relatively small amount of pollutants in the soil of the plants may accumulate in large quantities in their organs (Masih and Bhadauria, 2010).

Starting from these statements, the results of examination of potentially toxic heavy metals in onion, are represented by the varieties and years of study.

Results of heavy metals detected in samples of onion on average for all three varieties (Graph 3) indicate that this is not about amounts that exceed the threshold amount. Regulations on maximum permitted amounts for certain contaminants in food (Official Gazette of BiH, No. 37/09) restricts the presence of lead and cadmium on 0.10 mg/kg, and arsenic at 0.3 mg/kg) as contaminants in food. Onion bulbs contained the highest amount of cadmium (0.0143 mg/kg), and lead (0.0081 mg/kg), and minimum of arsenic (0.0043 mg/kg).

Heavy metals in plants affect many physiological and biochemical processes such as photosynthesis, nitrogen assimilation, adoption and metabolism of essential elements, enzyme activity, respiration and water regime, and in addition they affect the growth and development of plants. In the period of performance of experiment no symptoms were reflected of influence of heavy metals such as necrosis and chlorosis on the oldest, and later on other leaves, and especially what was not observed is phenomenon of extinction of old leaves and stunted growth. Could detectable amounts of heavy metals in conditions of performing experiments cause such disorders, a more detailed examination are necessary that could provide answers about the effect of heavy metals depending on the type of plants, the way in which are adopted by the plants, and the effects of the adoption and distribution of the elements that are necessary for the plant and the water regime of plants.



Graph 3.Average values of heavy metals detected in bulbs of onion

Regardless of the detected average amounts of heavy metals in onion bulbs, the fact of the presence of potentially toxic elements, impose a need for better understanding of results and from aspect of impact of variety and year of examination (Table 2). Even more there are

results of such researches in other production conditions. Particularly are interesting impacts of soil and water contamination by heavy metals, and contamination of soil, surface water and groundwater with nitrates, heavy metals and residues of pesticide active substances occur occasionally in uncontrolled environmental conditions of extensive and intensive agricultural production (Vidaček et al., 1999). Without going into such considerations of possible impacts of soil and water at the site of the experimental field Butmir (we leave this to experts of that field) we point out that the pH is from 5.89 to 6.02, and the humus content is 1.80% (Table1).
Research results in this paper indicate that the highest content of lead (0.0060 mg / kg), arsenic (0.0010 mg / kg) and cadmium (0.0300 mg / kg) were detected in the variety Stuttgarter in 2012, and in 2013 that were bulbs of variety Zenicki with 0.0180 mg/kg of lead, 0.0090 mg/kg of arsenic and 0.0220 mg/kg of cadmium.
As indicators of possible increases in the accumulation of potentially toxic heavy metals in onion bulbs, can be used results shown through the differences of their presence in the 2013 as compared to 2012. All the studied species of bulbs of onion on average, in 2013 there is more all investigated heavy metals: lead 0.0090 mg/kg, arsenic 0.0074 mg/kg and cadmium 0.0033 mg/kg. Only the bulb Stuttgarter had a lower content of cadmium in 2013 for 0.0140 mg/kg, while the lead content was increased for 0.0010 and arsenic for 0.0070 mg/kg.
Varieties Konjicki and Zenicki, increased detected amounts of lead were much higher than the standard variety: Konjicki for 0.0100 mg/kg, and Zenicki for 0.0160 mg/kg. Variety Zenicki had greater increase in arsenic (up to 0.0086 mg/kg in 2013), and cadmium in bulbs (to 0.0150 mg/kg) compared to the Konjicki onion and variety Stutgartner.

Table 2. Detected amounts of heavy metals in bulbs of onion (mg/kg) by variety and year of examination

Year	Heavy metals	Sort/variety			Average
		Stuttgarter	Konjicki	Zenicki	
2012.	Pb-lead	0.0060	0.0030	0.0020	0.0055
	As-Arsenic	0,.0010	0.0004	0.0004	0.0006
	Cd-Cadmium	0,.0300	0,.0070	0,.0070	0.0105.
2013.	Pb-lead	0.0070	0.0130	0.0180	0.0127
	As-Arsenic	0.0080	0.0070	0.0090	0.0080
	Cd- Cadmium	0.0160	0.0160	0.0220	0.0180
Differences in 2013 in compare to 2012	Pb-Lead	+ 0.0010	+ 0.0100	+ 0.0160	+ 0.0090
	As-Arsenic	+ 0.0070	+ 0.0066	+ 0.0086	+ 0.0074
	Cd-Cadmium	- 0.0140	+ 0.0090	+ 0.0150	+ 0.0033

The results indicate that only the level of the bulb yield that is significantly higher (for 34%) for variety Konjicki in 2012, and 30% for variety Konjicki in 2013 and 27% for variety Zenicki comparing to the standard, is not the only parameter to a accept a new sort of onion as fit for human consumption (Ćota et al., 2014). Farming area in relation to soil habits,

expressed mobility of heavy metals (Teodorović et al., 2009), possibility of larger accumulation in parts of cultivated plants which are used as food (Maksimović et al., 2012), should be and remain the main indicator of successful production of safe food.

Conclusion

Tests for the presence of heavy metals in bulbs of onion variety Stuttgarter (standard) and new varieties Konjicki and Zenicki were conducted in the period of 2012 and 2013 by performing experiments on the site of Butmir, Sarajevo. The results indicate that:

the quantity of heavy metals detected in the samples of onions on the average for all three are not in amounts that exceed the threshold amounts

that the highest contents of lead (0.0060 mg/kg), arsenic (0.0010 mg/kg) and cadmium (0.0300 mg/kg) were detected in the variety Stuttgarter in 2012, and in 2013 that were bulbs of variety Zenicki with 0.0180 mg/kg of lead, 0.0090 mg/kg of arsenic and 0.0220 mg/kg of cadmium.

Varieties Konjicki and Zenicki onion, increase of the detected amount of lead (in 2013) was significantly higher than those of the standard variety: Konjicki for 0.0100 mg/kg, and Zenicki for 0.0160 mg/kg.

Line of Zenicki onion had greater increase in arsenic (in 2013 for 0.0086 mg/kg), and cadmium in bulbs (for 0.0150 mg/kg) compared to Konjicki onion and variety Stuttgarter.

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