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VARIATION IN HEAVY METAL CONCENTRATIONS OF POTATO (*Solanum tuberosum* L.) CULTIVARS

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ABSTRACT

Heavy metals composition of foods is of immense interest because of its essential or toxic nature. This study examines concentrations of some heavy metals (Fe, Cu, Zn, Mn, Pb, Ni and Cd) from sixteen potato cultivars grown at Erzurum, Turkey. The present study revealed that the potato cultivars studied showed a considerable variation in heavy metal concentrations. The contents of heavy metals in the potato cultivars were found in the ranges: 48.87-72.64 mg kg^{-1} for iron, 3.07-5.43 mg kg^{-1} for copper, 13.80-18.89 mg kg^{-1} for zinc, 6.93-13.06 mg kg^{-1} for manganese, 0.51-0.77 mg kg^{-1} for lead, 2.02-3.55 mg kg^{-1} for nickel and 0.08-0.32 mg kg^{-1} for cadmium. The accumulation pattern for the metals in the potato tubers was in the order; Fe>Zn>Mn>Cu>Ni>Pb>Cd.

Keywords: *Solanum tuberosum* L., potato tuber, heavy metals, concentration.

INTRODUCTION

The potato is the world's fourth largest food crop and is a staple in many diets around the world. In addition to being a source of highly digestible carbohydrate and nutritionally complete protein, the potato is also an excellent source of other essential nutrients (Suttle, 2008).

In recent years, increasing attention has focused on heavy metal concentrations of vegetables all over the world. Heavy metals have important positive and negative roles in human life (Adriano, 1984; Slaveska *et al*., 1998; Divrikli *et al*., 2003; Dundar and Saglam, 2004; Colak *et al*., 2005; Oktem *et al*., 2005). Metals such as lead, mercury, cadmium, and copper are cumulative poisons, which cause environmental hazards and are reported to be exceptionally toxic (Ellen *et al*., 1990). Metals like iron, copper, zinc and manganese are essential metals for humans, since they play an important role in biological systems, but the essential heavy metals can produce toxic effects when their intake is excessively elevated (Schroeder, 1973; Mendil *et al*., 2005; Narin *et al*., 2005). Hence, the trace heavy metal content in potato is an important consideration.

Heavy metal concentrations of plants is directly associated with their concentrations in soils, but their levels significantly differ with plant species, and even can also affected by genotypes within the same species (Kabata-Pendias and Pendias, 2001). From this point of view, it can be concluded that potato genotypes also will differ in heavy metal concentrations. This information may be useful for designing future breeding efforts to improve potato quality management. Little information on the magnitude of variation in heavy metal content of potato genotypes is currently available in literature and more data would benefit future nutritional studies.

In the current study, the levels of iron, copper, zinc, manganese lead, nickel and cadmium were determined in selected potato varieties.

MATERIALS AND METHODS

This study was conducted in 2006 at the Agricultural Research and Extension Center of Ataturk University located at Erzurum, Turkey. Previous crop at this site was wheat (*Triticum aestivum* L.). Surface soil samples (0–0.30 m) were taken at experimental site before planting. The soil was a clay-loamy, pH 7.5, low in organic matter (1.24%), rich in available phosphorus and potassium (16.6 kg da^{-1} ve 175.9 kg da^{-1}). Mean temperatures dring the growing season ranged from 11.4 to 22.6 and the relative moisture varied from 50.9 to 67.3%. The highest temperature was recorded in August and the highest relative moisture recorded in May. The total rainfall for the growing season was 114.2 mm. The highest rainfall (41.6 mm) fell in May.

The experimental design was the randomized complete block design with three replicates. Sixteen potato cultivars. Marabel (early), Fianna (intermediate), Cosmos (intermediate), L.Nigetta, Ardenta (early to intermediate), Arinda (early), Santa (intermediate to late, intermediate, early to intermediate, early), Agria (late, intermediate to late, intermediate), Famosa (late, intermediate), Quinta (intermediate), Binella (intermediate, very early to early), Marfona (intermediate, early to intermediate), Morene (late, intermediate), Granola (intermediate to late, intermediate), Monaliza (early to intermediate), Vangogh (intermediate to late) were used in the present study. Plot size was 2.8 by 7.0 m with four rows per plots. Row spacing was 70 x 35cm. Nitrogen (ammonium sulphate), phosphorus (triple super phosphate) and potassium (potassium sulphate) fertilizers were applied broadcast at a rate of 100 kg N $ha^{-}1$, 100 kg P ha^{-1}, and 50 kg K_2O ha^{-1}, respectively, and incorporated into soil before planting. Planting was done by hand on May 10. Weeds were controlled by hand weeding. Plots were irrigated as and when needed. Tubers were harvested on September 28, 2006. At harvest, two samples of five consecutive plants each were collected from an area of 4.9 m^2 from the middle two rows.

The tuber samples were dried at 105 ^{0}C for 24 hour, ground to pass 1 mm, and stored until analysis for heavy metals (Fe, Cu, Zn, Mn, Pb, Ni and Cd). A Perkin–Elmer Analyst 700 atomic absorption spectrometer with deuterium background corrector was used in this study. The operating parameters for working elements were set as recommended by the manufacturer. Pb, Ni, Cd, Cu in potato tubers were determined by HGA graphite furnace using argon as inert gas. The other elements were determined by using air-acetylene flame. Berghof Speedwave microwave digestion (MWS-3+) system was used. All reagents used in the present work were of analytical reagent grade unless otherwise stated. Deionised water (Millipore-Q Gradient) was used for all dilutions. All the plastic and glassware were cleaned by soaking in dilute HNO_3 (1 + 9) and were rinsed with distilled water prior to use. The standard solutions of analytes used for calibration were produced by diluting a stock solution of 1000 mg/l of the given element supplied by Sigma–Aldrich (St Louis, MO, USA). 300-500 mg of sample was digested with 8 ml of concentrated HNO_3 (65%) (Suprapure, Merck) and 2 ml of concentrated H_2O_2 (30%) (Suprapure, Merck) in microwave digestion system and diluted to 30 ml with double deionized water (Millipore-Q Gradient).

Statistical analysis was done using PROC ANOVA (SAS Inst., 1998) with mean separation by Fisher's protected LSD.

RESULTS AND DISCUSSION

Fe Concentration: Of all the micronutrients, iron is required by plants in the largest amount. Fe concentrations of the cultivars investigated significantly differed (p<0.01) (Table 1). The iron contents of the potato cultivars ranged from 48.87 to 72.64 mg kg^{-1}. Quinta was the least Fe containing cultivar, while Binella was the most Fe containing cultivar (Fig. 1).

Cu Concentration: Copper is one of the essential micronutrients, and its adequate supply for growing plants should be ensured through artificial or organic fertilizers (Itanna, 2002). Cu occurs in the compounds with no known functions as well as enzymes having vital function in plant metabolism (Kabata-Pendıas and Pendias, 2001)

As can be seen in the Table 1, the average Cu concentrations signifiantly differed among the potato cultivars (P<0.01). Fianna had the highest Cu concentration (5.43 mg kg^{-1}), followed by Morene (4.97 mg kg^{-1}). The lowest Cu value was obtained from Marabel (3.07 mg kg^{-1}) (Fig. 2).

Zn Concentration: Analysis of variance revealed that, the cultivars studied significantly differed in terms of Zn concentration (p<0.01) (Table 1). The highest Zn concentration (18.88 mg kg^{-1})was determined in the cultivar Fianna,. Among the cultivars, Cosmos had the lowest Zn concentration (13.80 mg kg^{-1}) (Fig. 3).

Zinc is one of the important metals for normal growth and development in human beings. Deficiency of zinc can result from inadequate dietary intake, impaired absorption, excessive excretion or inherited defects in zinc metabolism (Colak *et al*., 2005; Narin *et al*., 2005).

Mn Concentration: Manganese activates numerous essential enzymes. Food contains trace amounts of manganese (Colak *et al.,* 2005). In this study there were differences with regard to Mn concentration among the potato cultivars (p<0.01) (Table 1). The cultivars Vangogh and Monaliza, (13.06 and 12.19 mg kg^{-1}, respectively), were the cultivars having the highest Mn concentrations. In contrast, the lowest Mn values were detected in the cultivars Fianna'da (6.93 mg kg^{-1}), Cosmos (7.20 mg kg^{-1}) and Ardenta (7.44 mg kg^{-1}), respectively (Fig. 4).

Pb Concentration: Significant differences were observed among the potato cultivars for Pb (Table-1). The mean Pb concentrations varied between 0.77 mg kg^{-1}, obtained for the cultivar Binella, to 0.51 mg kg^{-1}, found for the cultivar Agria (Fig. 5).

Ni Concentration: Nickel plays some roles in body functions including enzyme functions. In very trace amounts it may be beneficial to activate some systems, but its toxicity at higher levels is more enzyme prominent (Onianwa *et al*., 2000).

Significant differences (p<0.05) were found among the mean concentrations of the sixteen cultivars for Ni (Table 1). The Ni concentrations of the potato cultivars ranged from 2.02 to 3.55 mg kg^{-1}. The highest Ni containing cultivars were Santa, Marabel and Binella, respectively (Fig. 6).

Cd Concentration: Cadmium is a nonessential element in foods and natural waters, and it accumulates principally in the kidneys and liver. Cadmium in foods is mostly derived from various sources of environmental contamination (Adriano, 1984). Among the cultivars, Santa presented the highest mean concentration (0.32 mg kg^{-1}) for Cd. In contrast, Morene had the lowest Cd concentration, with 0.08 mg kg^{-1} (Fig. 7). The differences among the cultivars tested were significant ($p<0.01$) (Table 1).

Potato cultivars have been shown to differ in their ability to accumulate Cd, although the differences between cultivars are not consistent. Harris *et al*. (1981), found no differences in tuber Cd concentration of cultivars. Mclaughlin *et al.* (1997), however, found that cultivars grown commercially exhibited significant differences in tuber Cd concentration.

Averaged over the sixteen potato genotypes, the metal accumulation pattern for the potato tubers was in following order; Fe>Zn>Mn>Cu>Ni>Pb>Cd. Similar accumulation trend was also observed by Mendil *et al.* (2005).

Table 1. The results of analysis of variance for some heavy metal concentrations in potato genotypes grown in Erzurum, Turkey.

Source of variation	df	Mean square						
		Fe	Cu	Zn	Mn	Pb	Ni	Cd
Genotype	15	179.378**	1.069*	4.956 **	9.905**	0.010**	0.593*	0.010**
Error	32	27.107	0.477	2.937	0.461	0.002	0.222	0.001
LSD		8.681	1.151	2.858	1.132	0.090	0.786	0.038
CV (%)		8.199	16.969	10.208	6.823	9.178	18.041	15.388

*,** significant at P < 0.05 and P < 0.01; *CV* = coefficient of variations, NS = not significant

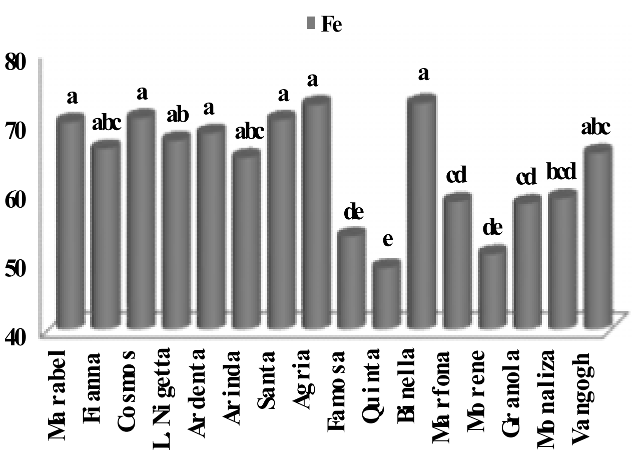

Fig. 1. Fe concentrations in the tubers of potato genotypes.

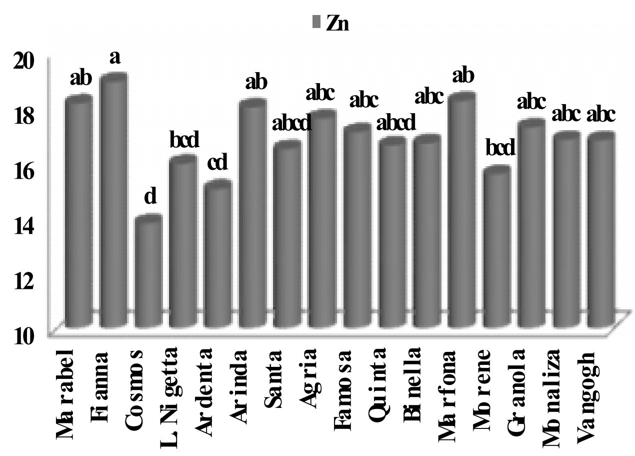

Fig. 3. Zn concentrations in the tubers of potato genotypes.

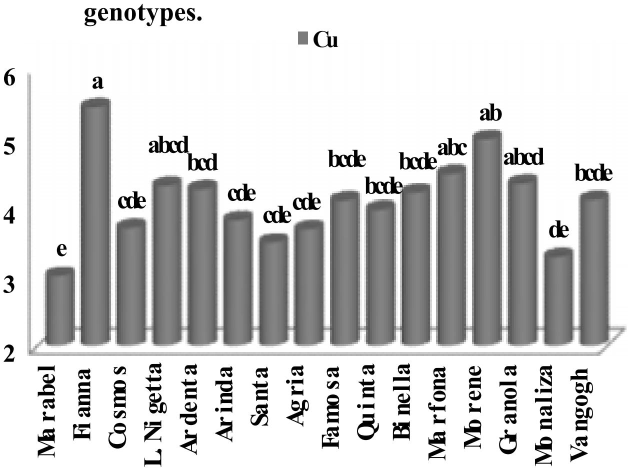

Fig. 2. Cu concentrations in the tubers of potato genotypes.

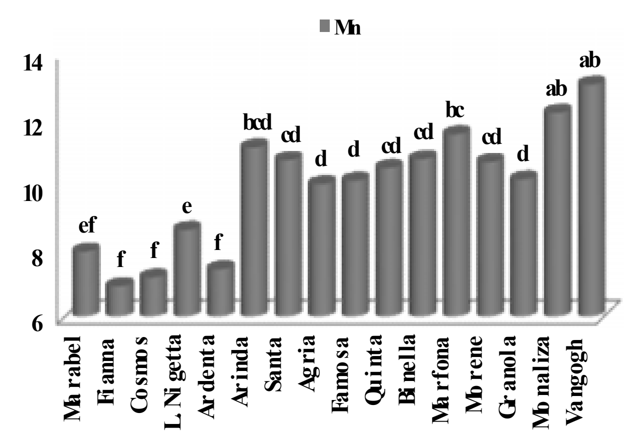

Fig. 4. Mn concentrations in the tubers of potato genotypes.

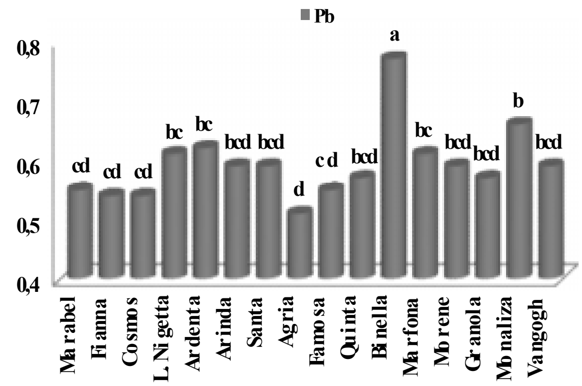

Fig. 5. Pb concentrations in the tubers of potato genotypes.

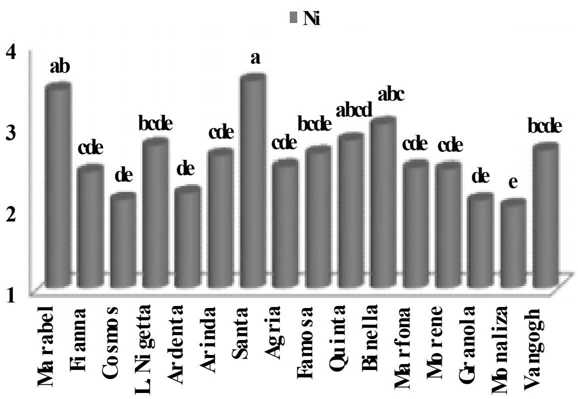

Fig. 6. Ni concentrations in the tubers of potato genotypes.

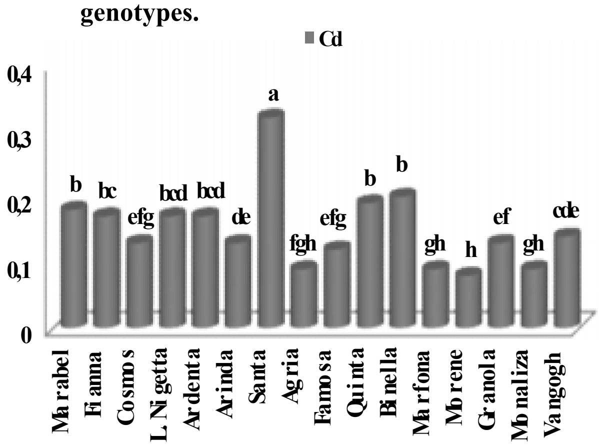

Fig. 7. Cd concentrations in the tubers of potato genotypes.

The present study revealed that the potato cultivars studied showed considerable variation in heavy metal concentrations. In particular, the uptake of Cd, Cu, Pb and Mb and their concentrations are mostly affected by genotypic differences (Prosba-Bialczyk and Mydlarski, 2000). Moreover, heavy metal content could also be influenced by localation, soil and climate properties, and other factors (Caussy *et al*., 2003; Tok, 1997; White and Zasoski, 1999). In this study, it is also important to note that of the cultivars studied, Marfona, the most preferred cultivar by the local producers in this region, usually contained more heavy metal concentrations. We believe that such information can be beneficial for understanding the importance of cultivar selection in healthy nutrition and improving consumer awareness.

Excessive fertilization and irrigation water pollution may cause hevay metal pollution in potato production areas. In such case, a useful approach may be to use the potato genotypes that accumulate less heavy metal.

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REFERENCES

Adriano, D. C. (1984). Trace Metals in The Terrestrial Environment. Verlag Spiegler, New York.

Colak, H., M. Soylak and O. Turkoglu, (2005). Determination of trace metal content of various herbal and fruit teas produced and marketed from Turkey. *Trace. Elem. Electrolytes,* 22, 192-195.

Caussy, A., M. Gochfeld, E. Gurzau, C. Neagu and H. Ruedel (2003). Lessons from case studies of metals: Investigating exposure, bioavailability, and risk. *Ecotox Environ Safe*, 56, 45–51.

Divrikli, U., S. Saracoglu, M. Soylak and L. Elci (2003). Determination of trace heavy metal contents of green vegetable samples from Kayseri-Turkey by flame atomic absorption spectrometry. *Fresenius Environmental Bulletin (FEB)*, 12, 1123–1125.

Dundar, M. S. and H. B. Saglam (2004). Determination of cadmium and vanadium in tea varieties and their infusions in comparison with 2 infusion processes. *Trace. Elem. Electrolytes*, 21, 60-63.

Ellen, G., J.W. Loon and K. Tolsma (1990). Heavy metals in vegetables grown in the Netherlands and in domestic and imported fruits. *Z. Lebensm. Unters. Forsch.,* 190, 34-39.

Harris, M. R., S. J. Harrison, N. J. Wilson and N. W. Lepp (1981). Varietal differences in trace metal partitioning by six potato cultivars grown on contaminated soil. In: Proceedings of the international conference on heavy metals in the environment. *Edinburgh: CEP Consultants,* pp. 399-402.

Itanna, F. (2002). Metals in leafy vegetables grown in Addis Ababa and toxicology implications. *Ethiopia J. of Health Dev.*, 16, 295-302.

Kabata-Pendias, A. and H. Pendias (2001). Trace Elements in Soils and Plants. 3rd ed. CRC Press Boca Raton FL, p.114.

Mendil, D., M. Tuzen, K. Yazici and M. Soylak (2005). Heavy metals in lichens from roadsides and an industrial zone in Trabzon, Turkey. *Bull. Environ. Contam. Toxicol*., 74, 190-194.

Mclaughlin, M. J., K. G. Tiller and M. K. Smart (1997). Speciation of cadmium in soil solutions of saline/sodic soils and relationship with cadmium concentrations in potato tubers (*Solanum tuberosum* L.). *Aust. J. Soil. Res.*, 35, 183-198.

Narin, I., M. Tuzen, H. Sari and M. Soylak (2005). Heavy metal content of potato and corn chips from Turkey. *Bull. Environ. Contam. Toxicol*., 74, 1072-1077.

Oktem, F., H. Yavrucuoglu, A. Turedi and B. Tunc (2005). The effect of nutritional habits on hematological parameters and trace elements in children. *Suleyman Demirel Univ. Tip Fak. Der.*, 12, 6-10. (In Turkısh)

Onianwa, P. C., J. A. Lawal, A. A. Ogunkeye and B. M. Orejimi (2000). Cadmium and Nickel composition of Nigerian foods. *J. Food. Compos. Anal*., 13, 961-969.

Prosba-Bialczyk, U. and M. Mydlarski (2000). Changes in the content of trace elements in potato tubers caused by organic and mineral fertilization. Biulteyn Instytutu Hodowlii Aklimatyzacji Roslin, (No:213), pp. 55-60.

SAS Institute, (1998). SAS/STAT User's Guide, Version 6.4. SAS Institute, Cary.

Schroeder, H. A. (1973). Pollution by Industrial Metals. In: Trace Elements and Nutrition Some positive and Negative Aspects Faber and Faber Lonson, pp. 119-128.

Slaveska, R., I. Spirevska, T. Stafilov and T. Ristov (1998). The content of trace metals in some herbal teas and their aqueous extracts. *Acta Pharm*., 48, 201-209.

Suttle, J. (2008). Symposium Introduction: Enhancing the Nutritional Value of Potato Tubers. *Am. J. Potato. Res.*, 85, 266.

Tok, H. H. (1997). Çevre Kirliliği. Trakya Universitesi Ziraat Fakültesi Toprak Bölümü Yayın No: 185, Ders Kitabı No:20, Tekirdağ. (In Turkısh)

White, J. G. and R. J. Zasoski (1999). Mapping soil micronutrients. *Field Crop Res*, 60, 11-26.