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THE MINERAL PROFILE OF SOME PLUM (*PRUNUS DOMESTICA)* VARIETIES

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Abstract

This study aims to determine the concentration of some essential and toxic mineral elements from four plum varieties harvested from the orchard of the Lugoj area. The metallic elements were determined by the atomic absorption spectrometry method in flame. Phosphorus was determined in the form of molybdenum blue by spectrophotometric method. The obtained results show that the analysed plum varieties ('Record', 'Vinete românești', 'Čačanska lepotica' and 'Stanley') contain important quantities of essential elements unevenly distributed: 898 - 1.897 mg/kg K, 165 - 429 mg/kg Ca, 119 - 315 mg/kg Mg, 216 - 497 mg/kg P, 3.353 - 4.233 mg/kg Fe, 0.306- 0.726 mg/kg Mn, 0.306 - 1.488 mg/kg Zn, 0.780 - 2.088 mg/kg Cu, 0.032 - 0.198 mg/kg Cr and very small amounts below the lead limits. No significant amounts of Ni and Cd were detected. The results obtained following evaluation of the mineral intake show that, in the present conditions, the degree of coverage of the daily mineral requirement varies in wide limits, depending on the variety of fruit, consumer and the nature of the mineral element.

Key words*: mineral intake, minerals, Prunus domestica, varieties.*

INTRODUCTION

Prunus domestica is one of the most cultivated fruit trees in Romania, Serbia, France, Germany, Turkey and Italy (Konarska, 2015). The interest for the cultivation of this fruit tree is determined by the popularity of these fruits, which are particularly beneficial for human nutrition due to their low energy value and their increased content of nutrients and dietetics (Milošević & Milošević, 2012; Birwal et al., 2017**)**.

Plum fruits have been known and used as food by people since ancient times, either as fresh or dried fruit, or processed in the form of jams, compotes, jellies, candied fruits, as well as in the preparation of pastry etc. (Milošević & Milošević, 2012; Bozhkova, 2014).

The nutritional and dietary qualities of plums are determined by their nature and the concentration of compounds in their composition: carbohydrates (mono and disaccharides, pectin, dietary fiber), proteins, organic acids (citric acid, malic acid), phenolic compounds, flavonoids, carotenoids, vitamins, minerals, etc. (Milošević & Milošević, 2012; Birwal et al., 2017; Maglakelidze et al., 2017).

In addition to ensuring the nutritional level, eating plums helps prevent heart disease, lung and oral cancer, lowers blood sugar and blood pressure, helps with Alzheimer's disease, muscle degeneration, improves memory capacity, stimulates bone health, regulates the functioning of the digestive system, etc. (Heghedus et al., 2014; Maglakelidze et al, 2017**)**.

Plums are rich sources of macro and micro-elements: K, Ca, Mg, P, Na, Fe, Mn, Zn, Cu, Cr, etc., essential for important biochemical and physiological functions and are necessary for maintaining the body health (Grembecka & Szefer, 2013). The concentrations of plum mineral elements are influenced by a number of factors such as, varieties, pedo-climatic conditions, cultivation techniques and harvest period, the presence of pollution factors, etc. (Milošević et al., 2011; Miloševici & Miloševici, 2012; Grembecka & Szefer, 2013).

The fact that plums contain significant amounts of essential minerals and very small amounts of toxic metals is mentioned, not only by international databases. USDA Food Composition Databases (https://fdc.nal.usda.gov/fdc-app.html#/food-details/169949/nutrients) and Frida fooddata.dk. (https://frida.fooddata.dk/food/15?lang=en) (Table 1), but also a consistent number of studies by researchers in the field.

Table 1. Mineral profile of plum, after Frida fooddata.dk, and USDA Food Composition Databases

Mineral	Frida fooddata.dk		USDA Food Databases	
	Mean	Limits	Mean	Limits
Na, mg/100g	3.00	2.7 – 4	0	0 - 2
K, mg/100g	140	113 – 169	157	111-207
Ca, mg/100g	8.57	5.88 – 16	6.0	4.0-26
Mg, mg/100g	5.00	3.9 - 7.1	7	5- 9
P, mg/100g	19.6	14.3 - 25.6	16	9-25
Fe, mg/100g	0.140	0.05 - 0.2	0.17	0.07-0.59
Cu, mg/100g	0.0630	0.044 - 0.103	0.057	0.015- 0.151
Zn, mg/100g	0.0910	0.066 - 0.114	0.100	0.04- 0.3
I, µg/100g	0.400	0.15 - 0.6		-
Mn, mg/100g	0.1000	0.077 - 0.12	0.052	0.018-0.094
Cr, µg/100g	0.300	0 - 1.2	-	-
Se, µg/100g	0.114	0 - 0.7	0	0
Mo, µg/100g	0	0	-	-
Ni, µg/100g	6.67	0 - 22.3	-	-
Hg, µg/100g	0.0400	0 - 0.2	-	-
As, µg/100g	0.0200	0 - 0.1	-	-
Cd, µg/100g	0.0700	0 - 0.39	-	-
Pb, µg/100g	0.500	0.1 - 5	-	-

Particularly important information on the distribution of mineral elements in fresh fruit was reported by Grembecka and Szefer (2013), who analyzed 12 mineral elements from 98 fruits grown in different geographical areas of the world. The results show that plums (*Prunus domestica*) grown in Poland contain significant amounts of essential mineral elements.

Analyzing the influence of factors on the concentration of mineral elements in plums grown in Serbia, Milošević and Milošević (2012), found that the levels of ash and mineral elements in the analyzed plums, excepting nitrogen, differs significantly between the treatments performed. Similar values were obtained by Milošević et al. (2011), who analyzed plums grown in an area close to Čačak, which is a typical area for plum cultivation in Western Serbia. The results obtained from the analysis of fresh plums from seven promising F1 plum hybrids and their parents as a control cultivar shows that they contain significant amounts of minerals: 0.36-0.89% N, 0.04-0.09% P, 1.42-1.71% K, 0.05-0.09% Ca, 0.15-0.26% Mg, 0.42-0.49% Na, 19.25-23.65 mg/kg Fe of dry matter. The study authors report significant differences among hybrids, and among hybrids and control cultivars.

Analyzing several physical, pomological and nutritional properties of two plum (*Prunus domestica* L.) cultivars ('Stanley' and 'Frenze 90') grown in the Antalya region, (Ertekin et al., 2006) found that these fruits contain high amounts of essential minerals (of dry mater): 0.45% N, 870 ppm P, 1.200 ppm K, 230 ppm Mg, 160 ppm Na, 21.0 ppm Fe, 2.6 ppm Mn, 11.2 ppm Zn, 13 ppm Cu - in 'Stanley' plums and 0.62% N, 1.260 ppm P, 1.500 ppm K, 360 ppm Mg, 160 ppm Na, 20.0 ppm Fe, 3.6 ppm Mn, 14.7 ppm Zn, 46 ppm Cu - in 'Frenze' plums.

Data on the distribution of essential and toxic mineral elements in plums are presented in two papers by Heghedűş-Mîndru et al. (2014), who analysed some mineral in plum fruits purchased in supermarkets and food markets in Timisoara (Romania), as well as the concentration of some macro elements from plums grown in Rachita locality, Timis county (Romania) (Heghedűş-Mîndru et al., 2015). The results obtained from the analysis of plum samples purchased in supermarkets and food markets in Timisoara (Romania) show that the analysed plums contain significant quantities of essential elements and very low contents of toxic elements. It was observed that mineral elements with pronounced toxic potential Pb and Cd, have been identified in extremely small quantities, below the toxicity limits allowed by the European legislation (0.10 mg/kg, respectively 0.05 mg/kg) (https://eur-lex.europa.eu/legal-content/EN/TXT /PDF/?uri =CELEX:32015R 1005; http://extwprlegs1.fao. Org /docs/pdf /eur133613.pdf). Regarding the mineral concentration of plums grown in Rachita, the authors of the study determined important concentrations of macro elements (Heghedűş-Mîndru et al., 2015).

Data on the mineral composition of some plum varieties grown in Romania are presented by Bobis et al. (2017) which determined the chemical composition of 'HoneySweet' transgenic plum and two conventional ones: 'Reine Claude d'Althan' and 'Stanley'.

Preliminary results obtained in determining the mineral elements of plum varieties: 0.107-0.126 mg/kg Mg, 1.919-18.019 mg/kg Fe, 5.7.4-5.709 mg/kg Ca, 0.542-0.714 mg/kg Na and 1.936-3.364 mg/kg K, reveals high concentrations of Ca, K and Fe and lower concentrations of Na and Mg. 'Stanley' cultivar presented a very high amount of iron, but the highest amount of identified minerals from the three studied varieties.

In a study of the qualities of 'HoneySweet' cv., Ravelonandro et al. (2013) found that these fruits have nutritional qualities comparable to those of conventional plums.

The nutritional quality of plums is determined by a series of factors, like cultivated varieties and varieties, pedo-climatic conditions, but also cultivation techniques, etc. (Dimkova et al, 2018). Lombardi-Boccia et al. (2004) assessed aspects regarding the nutritional qualities of yellow plums (*Prunus domestica* L., var. 'Shiro'), conventionally and organically grown. The results obtained in determining some essential mineral elements in 'Shiro' cv. grown conventionally (chemical fertilizers were applied) and organic fertilizers (organic fertilizers were used): 11.9 mg/100 g P, 1.459 mg/100 g Na, 1.749 mg/100 g K, 4.909 mg/100 g Mg, 4.169 mg/100 g Ca, 0.299 mg/100 g Fe, 609 mg/100 g Zn, 609 mg/100 g Cu, 509 mg/100 g Mn - in conventionally grown plums and 14.6-15.1 mg/100 g P, 1.0-1.3 mg/100 g Na, 201-218 mg/100 g K, 5.40-5.80 mg/100 g Mg, 4.26-4.85 mg/100 g Ca, 0.26-0.27 mg/100 g Fe, 40-90 mg/100 g Zn, 50-60 mg/100 g Cu and 40-50 mg/100 g Mn - in organically grown plums, does not reveal major differences between the mode of culture. However, organic plums had slightly higher ash content (0.37%) than conventional ones (0.33%). Also, organically grown plums are richer in K, Mg and Zn compared to conventionally grown ones; Na and Cu were determined in higher concentrations in conventional cultivation.

Regarding the distribution of mineral elements in the edible part of plums, it was shown that there is a difference between mineral content in the skin and in the pulp (Cosmulescu et al., 2017; Motyleva et al., 2017). When analyzing the evaluation of the mineral profile in the skin and pulp of twelve varieties of plums grown in Romania, by the technique of spectrometry (ICP-MS), the study authors found significant differences between the concentrations in the two edible parts of fresh plums. Therefore, the peel of the plums has a higher mineral content compared to the pulp. Removing the skin from the fruit can lead to significant loss of mineral nutrients. This fact was also demonstrated by Motyleva et al., 2017 which when analyzing some macro and microelements from 6 cultivar of 3 plum species found that the values of Ca, Cu, Fe, Ni, Zn and Pb concentrations in plum skin is 2-10 times higher than in the pulp. The same is not true for potassium, which accumulates 7-20% more pulp.

It should be noted that the distribution of mineral elements in plums changes during their processing. This was reported by Yagmur and Taskin (2011), who analyzed the changes in the concentrations of some plum and strawberry mineral trace elements during their preservation: before washing, after washing treatment and the product final after heat treatment (canned fruit and syrup). The Fe, Cu, Zn and Mn concentrations determined in unprocessed plums were found to be, on average, 5.8389, 0.4510, 0.8630 and 0.5374 ppm, respectively. After washing, the concentrations of the mineral elements decreased to: 4.7032 ppm Fe, 0.4080 ppm Cu, 0.8119 ppm Zn and 0.4593 ppm Mn. The concentrations of the elements in canned plums decreased again to: 2.6112 ppm Fe, 0.3076 ppm Cu, 0.6780 ppm Zn and 0.4033 ppm Mn. It can be seen that the mineral values of plums have decreased during the preservation process. However, it was found that there was no significant difference between the mineral content of the fruit after washing and the combined total mineral values of the fruit and syrup after canning. From presented data, it can be seen that plums are important sources of essential minerals: K, Ca, Mg, Fe, Mn, Zn, etc. However, these fruits may also accidentally contain appreciable amounts of toxic elements (Pb, Cd et al.), or microelements that in certain concentrations present a risk of toxicity (Cr, Ni, Cu, etc.) (Papa et al., 2009). Analyzing the distribution of some minerals, separately from the pulp and skin, from five varieties of fruits and vegetables, Papa al. (2009), reported that the analyzed plums contain different amounts of toxic or potentially toxic elements (mg/kg dry weight): 0.31 (Pb), 0.12 (Cd), 5.49 (Cu), 0.11 (Cr), 1.30 (Ni) - in skin and 0.49 (Pb), 0.67(Cd), 6.48 (Cu), 0.46 (Cr), 1.10 (Ni) - in pulp (Papa et al., 2009). These values show higher mineral concentrates in the pulp than the skin. In addition, considering the fact that the concentrations of the analyzed elements are related to the dry mass, the concentrations of lead and cadmium in the plum pulp exceed the maximum limits provided by the legislation (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:320151005; http://extwprlegs1.fao.org/docs/pdf/eur133613.pdf). For this reason, we consider that to evaluate the nutritional qualities of these fruits, it is necessary to know, in equal measure, both the essential and toxicogenic elements.

This study aims to determine the concentrations of some essential elements (Na, K, Ca, Mg, Fe, Mn, Zn, Cu, Ni, Cr) and toxic (Pb and Cd) from four plum cultivars: Romanian cvs. ('Record' and 'Vinete româneşti'), an American cv. ('Stanley') and a Serbian cv. ('Čačanska lepotica').

MATERIALS AND METHODS

Plant material

The plum samples were taken from the orchard Farm 3 located in the Lugoj area (Timis County, Romania), which belongs to the University of Life Sciences "King Mihai I" from Timisoara. The fruits come from four plum cultivars: 'Stanley', 'Vinete româneşti', 'Record' and 'Čačanska lepotica' and were harvested in the optimal ripening period (August, 2018). For each plum variety, 15 fruits were taken from different parts of the tree, which formed the basis for the analysis. After harvesting, the samples were immediately transported to the laboratory and stored (in polyethylene bags) cold at 2-4ºC until analysis. Before being analyzed, the fruits were washed with double-distilled water and dried by dabbing with filter paper. After removing the seeds, the fruit pulps were homogenized using a kitchen blender. Homogenized samples were immediately used for analysis.

Measurements

The determination of K, Ca, Mg, Fe, Mn, Zn, Cu, Cr, Ni, Pb and Cd was performed by flame atomic absorption spectrometry, using the method recommended and verified by Iordanescu et al. (2018). Basically, 3 g of plum sample was calcined at 550ºC in an oven for 8 hours (Nabertherm B150, Lilienthal, Germany). The ash resulting from calcination was solubilized in 20% HCl and made up to 20 ml in a volumetric flask. The mineral elements concerned were determined by atomic absorption spectroscopy (AAS; Varian 220 FAAS). Mix standard solutions (ICP Multi Element Standard solution IV CertiPUR) were purchased from Merck. Phosphorus was determined from the ash resulting from calcination, previously solubilized in 20% HCl and brought to a level of 100 ml, in the form of molybdenum blue by spectrophotometric method (Cintra 101 - UV-Visible Spectrometer, variant AA240 FS, at 715 nm) (Soceanu et al., 2009).

All chemicals and solvents used in this study were of analytical grade. The results were expressed on the basis of fresh weight (FW). Each value was the mean of three (n = 3) independent determinations.

Statistical analysis

The mean values and standard deviations of the concentrations of the mineral elements were calculated, and then they were statistically tested to find significant differences. The t-test was used: Two-Sample Assuming Unequal Variances for p=0.05 (IBM SPSS Statistics for Windows, Version 21.0 (IBM Corp., Armonk, NY, USA).

RESULTS AND DISCUSSIONS

The results obtained in determining the total concentrations of micro and macro elements in the plum varieties tested are presented in Tables 2 and 3.

As can be seen from Tables 2, 3, the distribution of the analyzed mineral elements shows obvious nonhomogeneous, depending on the nature of the elements and the analyzed plum cultivar. The best represented are the macro elements: K, P, Ca and Mg, which represent over 99.00% of the total elements analyzed. The microelements: Fe, Mn, Zn, Cu, were determined in much lower and very small concentrations: Pb, Cr. Nickel, cadmium and chromium (in the Stanley and Record varieties) were not detected, their concentrations being below the limits of detection of the application. diminish much of their essentiality because the body functions require small amounts of such elements (small table of such elements.

Analyzing the total concentrations of the mineral elements analyzed in the four plum cultivars, it can be stated that the plums from the 'Čačanska lepotica' cv. have the highest content of mineral elements (3.146 mg/kg). The 'Vinete românești' (2.065 mg/kg) and 'Record' The lower concentrations of the essential microelements (Fe, Mn, Zn, Cu, Cr) do not (1.995 mg/kg) cultivars have lower contents compared to the 'Čačanska lepotica' cv., but are statistically close to each other (p>0.05). The lowest mineral content was determined by the 'Stanley' cv. (1.417 mg/kg), which shows obvious differences, especially in comparison with the 'Čačanska lepotica' cv., but also compared to the 'Vinete românești' and 'Record' cvs.

Table 2. The concentration of Na, K, Ca and Mg in some plum varieties (*Prunus domestica*)

Variety	Mineral element, mg/kg fresh fruit*			
	K	Ca	Mg	P
Stanley	898±11.52d	165±7.34c	119±4.97d	230±6.98c
Vinete românești	1.385±14.70b	174±6.16c	167±7.04b	331±9.42b
Record	1.332±11.67c	301±8.04b	134±5.35c	216±3.74c
Čačanska lepotica	1.897±13.37a	429±6.37a	315±5.72a	497±8.29a

*Different letters in same column show statistically significant differences between mean values at p<0.05

Table 3. The concentration of Fe, Mn, Zn, Cu, Cr, Ni, Pb and Cd in some plum varieties (*Prunus domestica*)

Variety	Mineral element, mg/kg fresh fruit							
	Fe	Mn	Zn	Cu	Cr	Ni	Pb	Cd
Stanley	3.432±0.38a	0.306 ±0.04b	0.750±0.09b	0.780±0.90b	SLD	SLD	0.027±0.01a	SLD
Vinete românești	3.353±0.21a	0.502±0.06a	1.488±0.09a	2.088±0.17a	0.198 ± 0.04a	SLD	0.042±0.01a	SLD
Record	4.215±0.31a	0.700±0.08a	1.173±0.15a	1.872±0.19a	SLD	SLD	0.019±0.01a	SLD
Čačanska lepotica	4.233±0.39a	0.726±0.08a	1.195±0.10a	1.943±0.35a	0.032 ± 0.01b	SLD	0.013±0.01a	SLD

*Different letters in same column show statistically significant differences between mean values at p<0.05

Potassium, an essential macro element that counteracts the effects of sodium, contributes to maintaining normal blood pressure and maintaining acid-base balance in the body (Pohl et al., 2013), was determined in the highest concentrations of all elements analyzed. The highest potassium concentrations were determined in the 'Čačanska lepotica' cv. (1.897 mg/kg). In lower but statistically different concentrations (p>0.05) it was identified in the 'Vinete românești' and 'Record' cvs.: 1.385, respectively 1.332 mg/kg. The poorest in potassium are the 'Stanley' cv. (898 mg/kg). It is difficult to compare the experimental results with the results obtained by other authors, because, as shown above, the distribution of mineral elements in plums varies widely depending on several factors: varieties, pedo-climatic conditions, techniques crop and harvest period, the presence of pollution factors, etc. In addition, the literature consulted contains too little data on the mineral profile of the plum varieties tested. However, if we consider the dry matter (DM) contents in the four plum cultivars (15.13% - 'Čačanska lepotica', 25.63% - 'Vinete românești', 12.09% - 'Stanley' and 22.20% - 'Record') determined by Scedei et al. (2019) and the values determined to be reported by other authors could be noticed possible differences. Thus the concentration of potassium in the 'Čačanska lepotica' cv. (12.538 mg/kg DM) is of the same order of magnitude as the potassium concentrations reported by Milošević & Milošević (2012), (15.500 mg/kg DM) and Milošević et al. (2011) (14.200-17.100 mg/kg DM) and relatively close to the concentration reported by Ertekin et al. (2006), (11.515 mg/kg DM) (Ertekin et al., 2006; Milošević et al., 2011; Milošević & Milošević, 2012). Potassium concentrations in the Romanian cultivars 'Stanley', 'Record' and 'Vinete românești' are below the levels reported by Milošević & Milošević (2012), Milošević et al. (2011) and Ertekin et al. (2006). Potassium concentration in the 'Čačanska lepotiča' cv. (1.897 mg/kg FM) is also reported in the concentration ranges reported by the USDA database (1.110-2.070 mg/kg FM) and of the same order of magnitude as the concentrations obtained by Cosmulescu et al. (2017) (1.5417 mg/kg FM), Božović et al. (2017) (1.893-2.199 mg/kg FM) and Lombardi-Boccia et al. (2004) (1.740 mg/kg FM). The concentration of potassium determined in the 'Stanley' cv. (898 mg/kg FM) is lower than that determined by Papa et al. (2009) (1.270 mg/kg FM).

Calcium, which functions as a component of bones and teeth, participates in the regulation of nerve and muscle function and plays a vital role in activating enzymes (Soetan et al., 2010) was determined in concentrations between 165-429 mg/kg. The distribution of calcium in the analyzed plum varieties is uneven. The highest concentrations of Ca, which differ statistically significantly ($P<0.05$) were determined in the varieties 'Čačanska lepotica' (429 mg/kg) and 'Record' (301 mg/kg). In much lower concentrations, which do not differ from each other from a statistical point of view, for $P<0.05$, they were determined in the 'Vinete românești' and 'Stanley' cvs.: 174, respectively 165 mg/kg. The concentration of calcium in 'Vinete românești' plums (679 mg/kg DM) shows values close to those of Milošević & Milošević (2012) (760 mg/kg DM) and Milošević et al. (2011) (780 mg/kg DM). Also, the 'Stanley' cv. contains almost identical amounts of Ca, compared to the Ca concentration determined by Ertekin et al. (2006) (1.202, compared to 1.200 mg/kg DM). The concentration of calcium in the varieties 'Stanley' (165 mg/kg FM) and 'Vinete românești' (174 mg/kg FM) falls within the limits reported in the USDA databases (40-260 mg/kg FM) and at the upper limit in Frida food database (58.8-160 mg/kg). In the varieties Record (1.356) and 'Čačanska lepotica' (2.835 mg/kg DM) higher amounts of Ca were determined than those determined by Milošević and Milošević (2012) (760 mg/kg DM) and Milošević et al. (2011) (780 mg/kg DM).

Magnesium is an essential macro element with many biological functions, where it functions as a cofactor in over 300 enzyme systems that regulate various biochemical reactions in the body, including protein synthesis, muscle and nerve function, blood glucose control and blood pressure regulation (Falah et al., 2017). This element was determined in much lower concentrations than potassium and lower than phosphorus and calcium, the concentration limits being between 119 and 315 mg/kg. The richest in magnesium are the plums from the 'Čačanska lepotica' and 'Vinete românești' cvs. that contain statistically different amounts ($P<0.05$) of Mg: 315, respectively 167 ± 7.04 mg/kg. Lower, statistically different magnesium contents ($P<0.05$) were identified in the 'Record' (134 mg/kg) and 'Stanley' (119 mg/kg) cvs. The magnesium concentration determined in 'Stanley' plums (857 mg/kg DK) is lower than the concentrations determined by Milošević and Milošević (2012) (1.500 mg/kg DM) and Milošević et al. (2011) (1.500-2.600 mg/kg DM), but higher compared to the concentration reported by Ertekin et al. (2006) (230 mg/kg DM). The concentration of magnesium determined in plums of the 'Čačanska lepotica' cv. (2.835 mg/kg DM) is higher than the concentration determined by Milošević and Milošević (2012) (1.690 mg/kg DM), but it falls within the range of values determined by Milošević et al. (2011) (1.500-2.600 mg/kg DM). 'Record' (604 mg/kg DM) and 'Vinete românești' (652 mg/kg FM) cvs. have lower concentrations, compared to those determined by Milošević and Milošević (2012) (1.690 mg/kg DM) and Milošević N. et al. (2011) (1.500-2.600 mg/kg DM), but higher compared to the concentration reported by Ertekin et al. (2006) (230 mg/kg DM). Regarding the concentrations of magnesium, calculated from fresh substance, determined in the plums taken in the analysis, they are above the concentration levels reported by USDA databases (50-90 mg/kg FM), Frida food database (39-71) and Grembecka and Zviad (2013) (66.7-90.5 mg/kg FM).

Phosphorus, a macro element that functions as a component of bones, teeth, adenosine triphosphate, phosphorylated metabolic intermediates, and nucleic acids (Soetan et al., 2010), has been identified in concentrations ranging from 216 ± 3.74 to 497 mg/kg. The highest concentrations of phosphorus, statistically different (P<0.05), were determined in the plums of the 'Čačanska lepotica' and 'Vinete românești' (497, respectively 331 mg/kg) cvs.. Much lower concentrations of phosphorus, statistically without differences between them (P<0.05) were identified in the cultivars 'Stanley' and 'Record': 230 ± 6.98, respectively 216 mg/kg.

Comparing the phosphorus concentrations determined in the analyzed plum cultivars (1.673-3.285 mg/kg DM, respectively 216-640 mg/kg FM) with those reported by Milošević and Milošević (2012) (520-640 mg/kg DM), Milošević et al. (2011) (400-900 mg/kg DM) and Ertekin et al. (2006) (870 mg/kg DM), respectively with USDA databases (90-250 mg/kg FM) and Frida food database (520-640 mg/kg FM) can be seen to have higher values.

Iron is an essential trace element, which is an important component of hemoglobin, an erythrocyte protein that transfers oxygen from the lungs to tissues (Falah et al., 2017) in the highest concentrations of the analyzed trace elements. The concentration of iron in the four plum cultivars was 3.432 ('Stanley'), 3.53 ('Vinete românești'), 4.215 ('Record'), respectively 4.233 mg/kg ('Čačanska lepotica'), shows very close values and statistically equal for P<0.05. Iron concentrations in the varieties determined in 'Čačanska lepotica' (27.978 mg/kg DM) and 'Stanley' (24.996 mg/kg DM) are higher than those obtained by Milošević and Milošević (2012) (19.25 mg/kg DM - in 'Čačanska lepotica' and 18.25 mg/kg DM - in 'Stanley'), Milošević N. et al. (2011) (19.25 - 23.25 mg/kg DM, in hybrid 'Čačanska lepotica/Stanley') and Ertekin et al. (2006) (21.0 mg/kg DM - in 'Stanley'). The concentration of iron in the cultivars 'Record' (18.98625 mg/kg DM) and 'Vinete românești' (13.982 mg/kg DM) is below the concentration reports reported by those obtained by Milošević and Milošević (2012) (18.0 - 21.62 mg/kg DM). Comparing the concentrations of iron, reported from fresh substance (3.353-4.233 mg/kg FM) with the values recorded in the consulted databases, the experimental values are lower than those recorded in Frida food database (0.5-2.0 mg/kg FM), but falls within the limits of the USDA database (0.7-5.9 mg/kg FM). The iron concentrations of the analyzed plum varieties are higher than those determined by Djina Božović et al. (2013) (1.2-1.95 mg/kg FM) and Lombardi-Boccia G. et al. (2004) (2.9 mg/kg FM), but lower than those reported by Yagmur and Taskın (2011) (5.8389 mg/kg FM) and Grembecka and Szefer (2013) (4.4-7.7 mg/kg FM).

Manganese microelement that functions both as an activator and as a constituent of several enzymes in the body (Mehri, 2020) was determined in concentrations between 0.303-0.7026 mg/kg. In higher concentrations, statistically equal (P<0.05), it was determined in the varieties 'Čačanska lepotica' (0.726 mg/kg), 'Record' (0.700 mg/kg) and 'Vinete românești' (0.502 mg/kg). Statistically lower concentrations of Mn (P <0.05) compared to other varieties were determined in the 'Stanley' cv. (0.306 mg/kg). The manganese concentrations determined in the plum varieties 'Čačanska lepotica' (4.798 mg/kg DM) and 'Stanley' (2.227 mg/kg DM) are lower than those obtained by Milošević and Milošević (2012) (12.50, respectively 10.62 mg/kg DM), but close to the concentration determined by Ertekin et al. (2006) (2.6 mg/kg DM) in 'Stanley' plums. It can also be seen that the fresh plum varieties analyzed contain more manganese (0.306-0.700 mg/kg FM) compared to the limits contained in the Frida food database (0.77-1.20 mg/kg FM) and USDA databases (0.18-0.94 mg/kg FM) and close to the manganese content determined by Yagmur and Taskın (2012) (0.5374 mg/kg FM).

Zinc is a microelement involved in many enzymes or as a stabilizer of the molecular structure of constituents and subcellular membranes (Falah et al., 2017). This element that participates in the synthesis and degradation of carbohydrates, lipids, proteins and nucleic acids and that plays an essential role in the transcription and translation of polynucleotides and therefore in the processes of genetic expression (Mehri, 2020) was determined in different concentrations between 0.750 mg/kg and 1.488 mg/kg. The poorest in zinc is the 'Stanley' cv., where it was identified in the lowest concentration and statistically different (P<0.05) from the other three analyzed varieties. Richer in zinc are the cultivars 'Vinete românești', 'Čačanska lepotica' and 'Record', where it was identified in close and statistically equal concentrations (P<0.05): 1.488, 1.195, respectively 1.173 mg/kg. As with manganese, the concentrations of zinc in the cultivars 'Čačanska lepotica' (7.980 mg/kg DM) and 'Stanley' (5.462 mg/kg DM) are lower than those obtained by Milošević and Milošević (2012) (20.25, respectively 19.66 mg/kg DM) and Ertekin et al. (2006) (11.2 mg/kg DM - in 'Stanley' plums). Comparing the Mn concentrations of the analyzed fresh plum varieties (0.750-1.488 mg/kg FM) with the limits contained in the databases, it can be seen that they are very close to the values recorded in Frida food database (0.66-1.14 mg/kg FM) and falls within the limits of the USDA databases (0.4-3.0 mg/kg FM). Comparing the concentrations of 'Čačanska lepotica' (1.195 mg/kg FM) and 'Stanley' analyzed (0.750 mg/kg FM) varieties with the concentrations determined by Djina Božović et al. (2017) (0.410 mg/kg FM - in 'Čačanska lepotica' and 0.550 mg/kg FM - in 'Stanle'y) there are differences in the 'Čačanska lepotica' cv. and similar values in the 'Stanley' cv.

Copper an essential micronutrient that plays an important role as a cofactor for several cellular processes, the deficiency of which leads to anemia and bone marrow suppression, followed by a neurological syndrome called myelopathy (Davarynejad et al., 2012), was determined in concentrations lower than iron and relatively close to the concentration of zinc. The lowest amount of copper (0.780 mg/kg), different statistically (P<0.05) compared to other varieties is recorded in the case of the 'Stanley' cv. Close, statistically equal values (P<0.05) of Cu content were determined in the 'Vinete românești' cv. (2.088 mg/kg), 'Čačanska lepotica' (1.943 mg/kg) and 'Record' (1.872 mg/kg). Comparing the copper concentrations obtained experimentally (5.687-12.842 mg/kg DM) with those recorded in the consulted studies can be shown as higher than those obtained by Milošević and Milošević (2012) (2.750-3.775 mg/kg DM), but lower than those reported by Ertekin et al. (2006) (13.80 in 'Stanley' mg/kg DM) and Hegedus-Mandru et al. (2014) (15.0 mg/kg FM). With the exception of 'Stanley' plums (in which the Cu concentration is 0.780 mg/kg FM), the experimentally determined copper concentrations are higher than those determined by Grembecka and Szefer (2013) (0.30-0.70 mg/kg FM), Lombardi-Boccia et al. (2004) (0.600 mg/kg FM), Yagmur and Taskın (2012) (0.451 mg/kg FM) and those recorded in Frida food database (0.74-1.03 mg/kg FM) and USDA databases (0.15-1.51 mg/kg FM).

Nickel is considered an essential microelement, although its biological function in the human body is still somewhat unclear. Since nickel is found in the body in higher concentrations of nucleic acids, especially RNA, it is believed to be involved in some way in the structure or function of proteins (Mehri, 2020). The concentrations of this element in the analyzed plum varieties are below the detection limits, under the conditions of the present experiment.

Chromium, an essential microelement that potentiates insulin, thus influencing the metabolism of carbohydrates, lipids and proteins (Mehri, 2020), was determined in significant concentrations, only in the 'Vinete românești' and 'Čačanska lepotica' cvs.: 0.198 and 0.032 mg/kg, respectively. These concentrations show values close to the value reported by Grembecka and Szefer (2013) (0.04 - 0.1 mg/kg FM) and compared to those recorded in Frida databases (0-0.12 mg/kg FM).

Lead is an extremely toxic metal that affects almost every organ in the body, the most affected being the nervous system which may contribute to behavioral problems, learning deficits, and lowered IQ (Mehri, 2020). The concentrations of this heavy metal in all four plum cultivars show very low and statistically equal values, for P<0.050, below the allowed toxicity limits (0.1 mg/kg) (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri =CELEX:32015R1005).

Cadmium is considered a toxic and hazardous metal to both humans and animals, which acts as a mitogen and promotes cancer in several tissues (Sharma et al., 2015). This heavy metal with pronounced toxicity, the concentration of which in fresh fruit (http://extwprlegs1.fao.org /docs/pdf/eur133613.pdf), has not been determined under the experimental conditions described. The experimental results obtained in determining the essential elements from the fresh plums taken in the experiment allowed the evaluation of the mineral intake of these fruits. To evaluate the mineral intake, the recommended mineral requirement in the daily diet was taken into account (Table 4), and the mineral content from the mineral canteen in the mass of consumed fruit (Table 5).

Table 4. Dietary reference intakes (DRIs): Recommended dietary allowances
and elements tolerable upper intake levels elements for the man and women 19-50 ages

Values	Gender	Mineral element, mg/day								
		K	Ca	Mg	P	Mn	Fe	Zn	Cu	Cr**
Recommended	Man	3.400	1.000	420	700	2.3	8	11	0.9	0.035
	Women	2.600	1.000	310	700	1.8	18	8	0.9	0.025
Tolerable	Man	ND*	2500	350	4.000	11	45	40	10	ND*
	Women	ND*	2500	350	3.000	11	45	40	10	ND*

*ND: Not determinable owing to a lack of a specific toxicological effect. WHO considered that chromium supplementation should not exceed 250 µg/day (Opinion of the Scientific Committee on Food on the Tolerable Upper Intake Level of Trivalent Chromium (expressed April 4, 2003), https://ec.europa.eu/food/sites/food/files/safety/docs/sci-com_scf_out197_en.pdf).
(Dietary reference intakes (DRIs): Recommended dietary allowances and adequate intakes, elements, http://nationalacademies.org/hmd/~/media/Files/Report%20Files/2019/ DRI-Tables-2019/2_RDAAIVVE.pdf?la=en; Dietary Reference Intakes (DRIs): Tolerable Upper Intake Levels, Elements, https://www.ncbi.nlm.nih.gov/books/NBK545442/table/appJ_tab9/?report=objectonly)

The correlation analysis (Table 5) shows very good correlations (r>0.9) between the pairs: Mg/K (r = 0.92), Fe/Ca (0.91), P/Mg (0.98) and Cu/Zn (0.92). Good correlations (r> 0.8) can also be observed between the pairs: Ca/K (0.86), P/Ca (0.88), Mn/K (0.84), Mg/Ca (0.83), Mn/Ca (0.86) and Mn/Fe (0.88).

Table 5. Matrix of correlations between macro and microelements

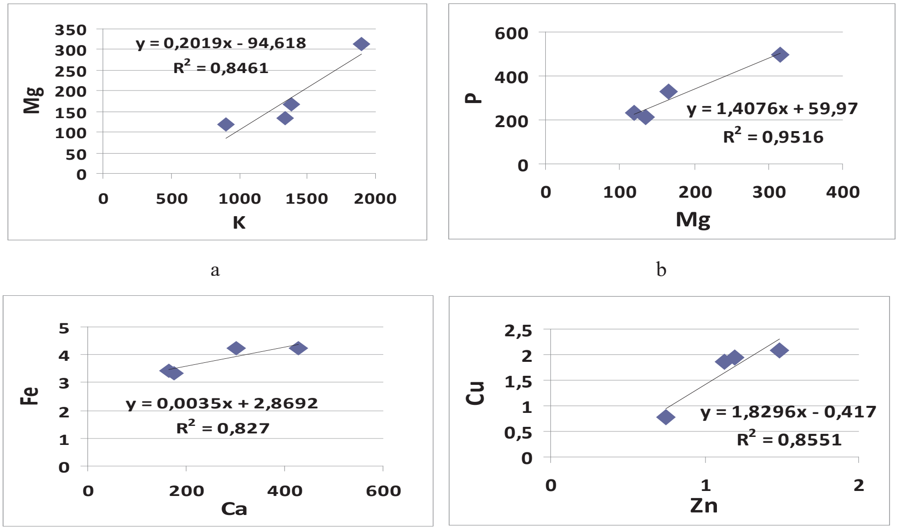
	K	Ca	Mg	P	Fe	Mn	Zn	Cu
K	1							
Ca	**0.856651**	1						
Mg	***0.919843***	0.828323	1					
P	**0.879955**	0.688435	***0.975513***	1				
Fe	0.642216	***0.909385***	0.521993	0.330156	1			
Mn	**0.841769**	**0.863104**	0.617297	0.493218	**0.881082**	1		
Zn	0.587299	0.141395	0.329969	0.420533	0.018527	0.489148	1	
Cu	0.763752	0.459788	0.471624	0.479935	0.395917	0.782478	***0.924732***	1

Thus, for strong correlations, the regression curves can make a forecast of the evolution of the content of an element in relation to the concentration of the other analyzed elements (Figure 1: a, b, c, d).

The experimental results obtained for the determination of the essential elements in the fresh plums taken in the experiment allowed the evaluation of the mineral intake of these fruits. For the evaluation of the mineral intake, the recommended mineral requirement in the daily diet (Table 5) and the mineral content of the mineral canteen in the consumed fruit mass (Table 6) were considered.

From those presented in Table 7 it can be seen that the degree of coverage of the daily requirement of mineral elements, at a consumption of 400 g of fresh plum pulp is uneven, depending on the consumer, the nature of the mineral element and the variety of and presents values included in the following limitation: 4.68-22.32% K, 6.60-17.16% Ca, 8.45-30.00% Mg, 12.34-28.40% P, 16.77-21.17% Fe, 5.32-12.63% Mn, 2.73-5.41% Zn, 34.67-92.80% Cu and 36.57-226% Cr - for men's 6.12-21.31% K, 6.60-17.16% Ca, 11.45-40.65% Mg, 12.34-28.40% P, 7.45-9.41% Fe, 6.80-16.13% Mn, 3.75-7.44% Zn, 34.67-92.80% Cu and 51.20-317% Cr - for women.

A hierarchy of fruit varieties according to their mineral intake is quite difficult, as the distribution of mineral elements in the analyzed fruit varieties is different. However, considering the sum of the total contents of each fruit variety, which shows the following decreasing trend: 3146 mg/kg 'Čačanska lepotica' plums; >2065 mg/kg 'Vinete românești' plums; >995 mg/kg 'Record' plums; >1417 mg/kg 'Stanley' plums, it can be stated that in this order also decreases the mineral intake of these fruits. The average inputs with mineral elements, for which the average of the individual values of the four fruit varieties were taken into account, show the following decreasing trend (%): Cu>Fe>P>Mg>K>Ca>Mn>Zn – men's Cu>Mg>K>P>Mn>Ca>Fe>Zn - women.



a b c d

Figure 1. Regression lines for pairs of elements: Mg/K (a), P/Mg (b), Fe/Ca (c) and Cu/Zn (d)

Table 6. Dietary reference intakes (DRIs): Recommended dietary allowances and elements tolerable upper intake levels elements for the man and women 19-50 ages

Values	People range	Mineral element, mg/day								
		K	Ca	Mg	P	Mn	Fe	Zn	Cu	Cr**
Recommended	Man	3.400	1.000	420	700	2.3	8	11	0.9	0.035
	Women	2.600	1.000	310	700	1.8	18	8	0.9	0.025
Tolerable	Man	ND*	2.500	350	4.000	11	45	40	10	ND*
	Women	ND*	2.500	350	3.000	11	45	40	10	ND*

*ND: Not determinable owing to a lack of a specific toxicological effect. WHO considered that chromium supplementation should not exceed 250 µg/day (https://www.ncbi.nlm.nih.gov/books/NBK545442/table/appJ_tab9/?report=objectonly; https://ec.europa.eu/food/sites/food/files/safety/docs/ sci -com_scf_out197en.pdf)

Table 7. Mineral intake in the recommended daily diet (men and women aged between 19 and 50 years)

Variety		K	Ca	Mg	P	Fe	Mn	Zn	Cu	Cr
Stanley	M	4.68	6.60	8.45	13.14	17.16	5.32	2.73	34.67	-
	W	6.12	6.60	11.45	13.14	7.63	6.80	3.75	34.67	-
Vinete românești	M	16.29	6.96	15.90	18.91	16.77	8.73	5.41	92.80	226
	W	21.31	6.96	21.55	18.91	7.45	11.16	7.44	92.80	317
Record	M	15.72	12.04	12.76	12.34	21.08	12.17	4.27	83.20	-
	W	20.55	12.04	17.29	12.34	9.37	15.56	5.87	83.20	-
Čačanska lepotica	M	22.32	17.16	30.00	28.40	21.17	12.63	4.35	86.36	36.57
	W	29.18	17.16	40.65	28.40	9.41	16.13	5.98	86.36	51.20
Mean values	**M**	***14.75***	***10.69***	***16.78***	***18.20***	***19.04***	***9.71***	***4.19***	***74.26***	**-**
	W	***19.57***	***10.07***	***22.73***	***18.20***	***8.46***	***12.41***	***5.76***	***74.26***	**-**

A possible supplement of plum consumption, to increase the mineral intake may be possible but with caution respecting the tolerable quantities for each element (Table 7). In addition, it should be borne in mind that an increase brings with it other compounds, which in too large quantities can have undesirable side effects.

CONCLUSIONS

The cultivars of *Prunus domestica*: 'Stanley', 'Vinete românești', 'Record' and 'Čačanska lepotica' taken in the experiment contain significant quantities of essential mineral elements unevenly distributed depending on the variety and the nature of the element analyzed: 898-1.897 mg/kg K, 165-429 mg/kg Ca, 119-315 mg/kg Mg, 216-497 mg/kg P, 3.353-4.233 mg/kg Fe, 0.306-0.726 mg/kg Mn, 0.306-1.488 mg/kg Zn, 0.780-2.088 mg/kg Cu, 0.032-0.198 mg/kg Cr and low amounts, below the toxicity limits of Pb toxic elements (0.013-0.042 mg/kg). No significant amounts of Ni and Cd were detected.

The highest mineral content (sum of mineral elements) was determined in the 'Čačanska lepotica' cv. (3.146 mg/kg), followed by the 'Vinete românești' (2.065 mg/kg) and 'Record' (1.995 mg/kg) cvs., which have higher contents, small compared to the 'Čačanska lepotica' cv., but close to each other, but statistically different ($p<0.05$). The lowest mineral content was determined by the 'Stanley' cv. (1.417 mg/kg), which shows obvious differences, especially in comparison with the 'Čačanska lepotica' cv., but also compared to the 'Vinete românești' and 'Record' cvs. Mutual correlations were determined between mineral elements, which can prove dependence between macro and microelements. The highest correlation coefficient values were determined for the elemental pairs: Mg/K, Ca/Fe, Mg/P and Zn/Cu ($r> 0.9$) and K/Ca, K/P, K/Mn, Ca/Mg, Ca/Mn and Fe/Mn ($r> 0.8$).

Under the conditions of the present experiment to evaluate the mineral intake, the degree of coverage of the daily requirement of mineral elements presents different values depending on the consumer gender (male or female), the variety and the nature of the mineral element. The average inputs with mineral elements, for which the average of the individual values of the four fruit varieties were considered, show the following decreasing trend. (%): Cu> Fe> P> Mg> K> Ca> Mn> Zn - man and Cu> Mg> K> P> Mn> Ca> Fe> Zn - woman.

As a conclusion it can be stated that the plums taken in the experiment contain important quantities of essential mineral elements and can be considered in respect of mineral intake. In addition, these fruits are not contaminated with lead or cadmium.

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