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MINERAL COMPOSITION OF FRUIT IN BLACK AND RED CURRANT

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ABSTRACT. *Black currants (Ribes nigrum) and red currants (Ribes rubrum) are* highly appreciated for the food and therapeutic value of their fruits. *Mineral composition was determined in eight black currants cultivars ('Record', 'Bogatar', 'Deea', 'Abanos', 'Blackdown', 'Ronix', 'Tinker', 'Tenah') and three red currants cultivars ('Rosu timpuriu', 'Abundent', 'Houghton Castle'). For both species analyzed, the results indicated significant differences between cultivars (P < 0.05). The order of nutritive elements, depending on their content / 100 g of fruits, was: K > Ca > Mg > Fe > Al > Na > Mn > B > Cu. Mineral composition varies by cultivar and currant consumption can cover the required amount of mineral elements in a well-balanced diet.*

KEY WORDS*: currant, mineral, content, fruits, ICP-MS.*

INTRODUCTION

Black currants (*Ribes nigrum*) and red currants (*Ribes rubrum*) are highly appreciated for the food and therapeutic value of their fruits (Gopalan et al. 2012). Currant fruits constitute a good source of mineral and natural anti-oxidant substances (Borges et al. 2010, Lugasi et al. 2011, Wojdyło et al. 2013, Nour et al. 2014). Interest in consumption of currant (*Ribes* spp.) has increased in recent years as the fruits are rich in numerous health benefiting phyto-nutrients and anti-oxidants. Currant fruits are rich sources of compounds with high antioxidant properties. In terms of antioxidants capacity, Mikkonen et al. (2001) consider that flavonol content varies among black currant cultivars; and also the high variability in the levels of flavonols in different cultivars offers possible avenues for identifying and selecting cultivars rich in certain flavonols for the special production of berries for industrial use. Main minerals and essential trace elements are very important in biological processes, and play a vital role in normal growth and development and have also been involved in prevention of some chronic diseases (Gorinstein et al. 2001). In terms of phyto-nutrients, red and black currants make an excellent source of minerals. Black and red currants have rich mineral composition, especially potassium, calcium and magnesium (Nour et al. 2011). In dried fruits, Bennett and et al. (2011) found that Australian dried sultanas, Carina currant, Zante currant, apricots, and prunes contained Cu, Fe, K, and Mn at levels of >20% of daily Required Dietary Intake. Tahvonen et al. (1993) found significant amounts of calcium, magnesium, iron, manganese and zinc in black currant berries (0.4±0.6 g/kg Ca, 0.2±0.3 g/kg Mg, 3.2±3.9 g/kg K, 6.4±13.1 mg/kg Fe, 2.4±8.4 mg/kg Mn and 2.1±2.4 mg/kg Zn). Press residue from black currant juice production was used for development of a nutritious breakfast cereal manufactured using an extrusion process at high temperatures by Tahvonen et al. (1998). Content in phenols and minerals are varying by genotype, location and year. Vagiri et al. (2013) show that selection of cultivars and production sites are important for cultivation of high-quality black currant raw material for health-promoting products.

The aim of the study was to determine the contents of mineral elements in fruits of eight black currants cultivars and three red currants cultivars that are cultivated in the same climate and farming condition.

MATERIAL AND METHODS

Plant material. The study was conducted using fruits of black currant and red currant collected in Craiova (44°20′N, 23°49′E), at the commercial maturity stage. The climate is temperate continental, the average temperature range from 10°C to 11.5°C and precipitation level is 580 nm - 600 mm. Currant fruits were harvested from 10 bushes of each cultivar. Approximately 500 g of fruits were collected from each genotype. Fruits were placed directly on ice in the field and frozen at -10°C, and taking care to avoid unripe, damaged, or overripe fruits.

Mineral analysis. A commercial system of inductively coupled plasma mass spectrometry (ICP-MS; Perkin-Elmer Elan 9000), a flame atomic absorption spectrometer (Flame AAS; Avanta PM), and a Milestone digestion microwave system were used. Etalon standards were obtained from multi-element stock solutions ICP–MS calibration STD 3, etalon solutions mono-element 1000 ppm K, 65% nitric acid puriss p.a (Fluka, Germany), 33% oxygenated water reactive p.a and ultrapure water, of 1st degree, according to ISO 3696:1987. Samples of approximately 1.5 g fruit were weighed in Teflon vessels, over which 6 ml 65% nitric acid and 2 ml 30% hydrogen peroxide were added. The vessels were put under thermic treatment programme under pressure: heating them up to 180°C by a rate of 4.5°C/min and keeping them for 20 minutes at 180°C. After cooling down, the liquid samples were transferred into 50 ml volumetric flasks, made up to the mark with ultrapure water, and they were analyzed according to specific procedures in the two spectrometer instruments. Reagent blanks were included in each series of digestions. Mineral elements Ca, Mg, Fe, Al, Na, Mn, B, Cu (method 985.35, 999.10, 986.24) and K (method 985.35) were determined according to the official methods of the Association of Official Analytical Chemists (A.O.A.C., 2000). Three independent samples were performed for each determination and the resulting data were used to obtain average values and standard deviations for all tests. The method was previously described by Cosmulescu et al. (2009, 2010, 2013).

Statistical analysis. Data were subjected to analysis of variance (ANOVA) and Principal component analysis (PCA) using Statgraphics Centurion XVI software (StatPoint Technologies, Warrenton, VA, USA). Differences were estimated with a multiple range test using the least significant difference (LSD) at $P < 0.05$.

RESULTS AND DISCUSSION

Currants are considered a good source of dietary minerals. The fruits of black currant cultivars contained the highest levels of macro minerals such as Ca, K, Mg, and P (Hegedűs et al., 2008). They also contain significant amounts of essential minerals that are associated with an improved health status. The composition of mineral elements in black and red currant cultivars was analyzed. Nine essential minerals were determined and the results are given in Table 1 and 2. For both species analyzed (*R. nigrum* and *R. rubrum*) the results indicated significant differences between cultivars ($P < 0.05$). Considering the fact that all varieties were grown in the same climate and farming condition, it is believed that such differences in mineral contents are related to the characteristics that are intrinsic to each cultivar. The order of nutritive elements, depending on their content/100 g of fruits, was: K > Ca > Mg > Fe > Al > Na > Mn > B > Cu. The highest amount was obtained in potassium. In black currant the content ranged between 178.90 mg / 100g ('Record') and 299.26 mg/100g ('Tinker'). In red currant the potassium content ranged from 188.25 mg/100g ('Houghton Castle') to 204.05mg/100g ('Rosu timpuriu'). Potassium concentrations in the present study were similar to those reported by the USDA Nutrient Database (275 mg/100g for red currant and 322mg/100g for black currant). The average potassium content (249.69mg/100g for black currant and 197.32mg/100g for red currant) determined here was closer to those reported by Hegedűs et al. (2008) for currant cultivars grown at Nagyrede, Hungary (277.45mg/100g and 190.64mg/100g). Many fruits contain good amounts of calcium, and berries are on top of this list. In the present study the calcium content ranged from 22.82mg/100g ('Rosu timpuriu') to 72.97mg/100g ('Tinker'), values that are close to those reported by the USDA Nutrient Database (33mg/100g for red currant and 55mg/100g for black currant). In this study, the average calcium content in black currant is 36.14mg/100g and 25.76mg/100g in red currant. Higher values (63.51mg/100g and 51.1mg/100g, respectively) were reported by Hegedűs et al. (2008). Magnesium plays an essential role in reducing the risk of cardio-vascular diseases. The fruits analyzed have a good content of magnesium; the values were between 21.39mg/100g in 'Houghton Castle' cultivar and 58.79mg/100g in 'Tinker' cultivar. Magnesium content is higher than the one reported by USDA Nutrient Database (13mg/100g for red currant and 24mg/100g for black currant). It follows that black currant fruits were superior to red currants and other small fruits with regard to

Table 1. Mineral content* of fruits in black currant (*Ribes nigrum*)cultivars (mg/100 g fruits).

Cultivars**	K	Na	Ca	Mg	Fe	Mn	Cu	Al	B
'Record'	178.9 ± 7.77^{a}	1.8 ± 0.15^{f}	28.66 ± 0.88^{b}	25.26 ± 0.42^{a}	1.17 ± 0.10^{a}	0.18 ± 0.03^{a}	0.17 ± 0.02^{c}	0.42 ± 0.06^{a}	0.13 ± 0.02^{a}
'Bogatar'	277.99 ± 13.95^{de}	1.15 ± 0.07^{e}	23.70 ± 0.76^{a}	25.30 ± 0.97^{a}	1.09 ± 0.13^{a}	0.24 ± 0.04^{ab}	0.10 ± 0.01^{a}	0.68 ± 0.08^{bc}	0.21 ± 0.03^{b}
'Deea'	248.25 ± 12.15^{bc}	0.56 ± 0.08^{d}	32.8 ± 1.09^{c}	27.85 ± 1.01^{b}	2.15 ± 0.23^{c}	0.32 ± 0.05^{c}	0.10 ± 0.01^{a}	2.06 ± 0.16^{f}	0.33 ± 0.03^{d}
'Abanos'	228.67 ± 14.12^{b}	0.27 ± 0.05^{ab}	28.32 ± 1.21^{b}	33.55 ± 0.88^{c}	1.14 ± 0.18^{a}	0.30 ± 0.04^{bc}	0.13 ± 0.01^{b}	0.52 ± 0.05^{ab}	0.33 ± 0.03^{d}
'Blackdown'	252.69 ± 12.88^{bc}	0.40 ± 0.06^{c}	33.41 ± 0.66^{c}	34.10 ± 0.68^{cd}	1.28 ± 0.18^{a}	0.27 ± 0.03^{bc}	0.15 ± 0.02^{bc}	0.56 ± 0.06^{abc}	0.27 ± 0.02^{c}
'Ronix'	264.49 ± 16.66^{cd}	0.17 ± 0.02^{a}	41.32 ± 1.32^{d}	35.57 ± 0.95^{d}	1.40 ± 0.20^{ab}	0.29 ± 0.04^{bc}	0.09 ± 0.01^{a}	0.72 ± 0.09^{c}	0.32 ± 0.04^{cd}
'Tinker'	299.26 ± 18.99^{e}	0.31 ± 0.02^{bc}	72.97 ± 1.88^{e}	58.79 ± 0.87^{e}	2.47 ± 0.28^{c}	0.49 ± 0.05^{d}	0.16 ± 0.01^{c}	1.61 ± 0.14^{e}	0.43 ± 0.03^{e}
'Tenah'	247.25 ± 15.15^{bc}	0.27 ± 0.03^{ab}	27.93 ± 0.98^{b}	34.58 ± 1.12^{cd}	1.71 ± 0.26^{b}	0.31 ± 0.04^{bc}	0.16 ± 0.02^{c}	1.37 ± 0.19^{d}	0.37 ± 0.04^{d}
Mean±SD	249.69±36.18	0.62±0.56	36.14±15.10	34.38±10.28	1.55±0.52	0.30±0.09	0.13±0.03	0.99±0.59	0.30±0.09

*Average value±standard deviation.

**Different subscript letters within the same column indicate significant differences ($P < 0.05$) among cultivars.

Table 2. Mineral content* of fruits in red currant (*Ribes rubrum)* cultivars (mg/100 g fruits).

Cultivars**	K	Na	Ca	Mg	Fe	Mn	Cu	Al	B
'Rosu timpuriu'	204.05 ± 9.98^{a}	0.25 ± 0.04^{b}	22.82 ± 0.77^{a}	23.23 ± 0.42^{b}	3.29 ± 0.29^{b}	0.37 ± 0.05^{b}	0.10 ± 0.01^{a}	2.61 ± 0.23^{b}	0.19 ± 0.02^{a}
'Abundent'	199.65 ± 12.12^{a}	0.16 ± 0.03^{a}	31.61 ± 1.12^{b}	24.47 ± 0.66^{c}	1.32 ± 0.17^{a}	0.30 ± 0.04^{ab}	0.12 ± 0.01^{b}	0.79 ± 0.11^{a}	0.38 ± 0.03^{b}
'Houghton Castle'	188.25 ± 10.66^{a}	0.26 ± 0.05^{b}	22.84 ± 0.66^{a}	21.39 ± 0.58^{a}	1.36 ± 0.15^{a}	0.28 ± 0.03^{a}	0.10 ± 0.01^{a}	0.76 ± 0.09^{a}	0.37 ± 0.03^{b}
Mean±SD	197.32±11.83	0.23±0.06	25.76±4.46	23.03±1.43	1.99±0.99	0.32±0.05	0.11±0.02	1.39±0.93	0.31±0.10

*Average value±standard deviation.

**Different subscript letters within the same column indicate significant differences ($P < 0.05$) among cultivars.

Table 3. Correlation matrix between the analyzed variables.

Variables	K	Na	Ca	Mg	Fe	Mn	Cu	Al	B
K	1.000								
Na	-0.582	1.000							
Ca	0.573	-0.362	1.000						
Mg	0.611	-0.538	0.940*	1.000					
Fe	0.496	-0.390	0.745	0.685	1.000				
Mn	0.714	-0.636	0.866	0.918*	0.845	1.000			
Cu	-0.345	0.212	0.219	0.328	0.118	0.110	1.000		
Al	0.425	-0.350	0.414	0.361	0.908*	0.649	-0.099	1.000	
B	0.330	0.369	-0.312	-0.334	-0.355	-0.262	-0.413	-0.201	1.000

*correlation coefficient is significant at $p \leq 0.05$

Table 4. Explained Variance (Eigenvalues).

Value	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7	PC 8	PC 9
Eigenvalue	4.891	1.793	1.007	0.916	0.333	0.057	0.003	0.000	0.000
% of Var.	54.344	19.921	11.189	10.176	3.705	0.628	0.036	0.000	0.000
Cum. %	54.344	74.265	85.454	95.630	99.336	99.964	100.000	100.000	100.000

Table 5. Comparison of black and red currants (*Ribes sp.*) mineral content (mg/100g) with published data for some common berry fruit.

Common name	K	Na	Ca	Mg	Fe	Mn	Cu	Al	B
Blak currants	249.69	0.62	36.14	34.38	1.55	0.30	0.13	0.99	0.30
Red currants	197.32	0.23	25.76	23.03	1.99	0.32	0.11	1.39	0.31
Lowbush blueberry*	68.4	0.14	21.3	8.2	0.31	2.6	0.04	0.3	0.10
Strawberry**	153	1	16	13	0.41	0.386	0.048	-	-
Blackberry**	162	1	29	20	0.62	0.646	0.165	-	-
Blueberry**	77	1	6	6	0.28	0.336	0.057	-	-
Raspberry**	151	1	25	22	0.69	0.670	0.090		

* Bushway et al. 1983; **US Department of Agriculture, 2008; - no data reported.

potassium, calcium and magnesium content (Table 5). Similar results were reported by Nour et al. (2013).

Iron content was higher than the one reported by USDA Nutrient Database with variation within 1.09mg/100g ('Bogatar') and 3.29mg/100g ('Rosu timpuriu'). Aluminum, sodium, manganese, boron and copper were found in lower amounts, fewer than 1mg/100g. Aluminum content varied within 2.61 and 0.42mg/100g, manganese within 0.49 and 0.18mg/100g, boron within 0.43 and 0.13mg/100g and copper within 0.17 and 0.09mg/100g. Manganese assists with bone formation and metabolic functions. Sodium and chloride are the fifth most abundant minerals in the body, and are both electrolytes that help maintaining fluid and electrolyte balance. In humans, copper is essential to proper functioning of organs and metabolic processes. Compared to other small fruits, currants are important sources of micronutrients (Table 5).

Correlations of elements analyzed were calculated ad the data are given in Table 3. Few significant relations between the set of variables evaluated were obtained. The Mg are significantly correlated with the Ca (0.94) and Mn (0.918) and Fe with the Al (0.908). Correlations between the other variables were not significant. More than 85% of variability obtained in this study was explained by the first three variables (Table 4). PC1, PC2 and PC3 accounted for 54.34%, 19.92% and 11.8% of the variability, respectively. Table 5 compares the results obtained for mineral content of black and red currants with published data that were obtained for some common berry fruit. In general the mineral contents are comparable to the values observed in the common berry fruit. However for the elements K, Ca, Mg, Fe, Cu, black and red currants fruit appears to be a better source of these elements.

In conclusion, the data obtained in this study do confirm that black and red currant represent a valuable source of different nutrients. Mineral composition varies by cultivar and currant consumption can cover the required amount of mineral elements in a well-balanced diet. The positive mineral profile of currant grown in Romania may be due to good growing conditions for the currant. These results are important in the choice of cultivars with superior properties for consumption and recommending more widespread consumption of currant fruit.

REFERENCES

A.O.A.C. (2000): Official methods of analysis of AOAC international (17th ed.). Gaithersburg, MD: AOAC International.

Bennett, L.E., Singh, D.P., Clingeleffer, P.R. (2011): Micronutrient mineral and folate content of Australian and imported dried fruit products. Critical Reviews in Food Science and Nutrition 51**:** 38-49.

Borges, G., Degeneve, A., Mullen, W., Crozier, A. (2010): Identification of flavonoid and phenolic antioxidants in black currants, blueberries, raspberries, red currants, and cranberries. Journal of Agricultural and Food Chemistry 58**:** 3901-3909.

Bushway, R.J., Gann, D., Cook, W.P., Bushway, A.A. (1983): Mineral and vitamin content of lowbush blueberries (*Vaccinium angustifolium* Ait.). Journal of Food Science 48*:* 1878-1878.

Cosmulescu, S., Baciu, A., Achim, G., Botu, M., Trandafir, I. (2009): Mineral composition of fruits in different walnut (*Juglans regia* L.) cultivars. Notulae Botanicae Horti Agrobotanici 37: 156-160.

Cosmulescu, S., Botu, M., Trandafir, I. (2010): Mineral composition and physical characteristics of walnut (*Juglans regia* L.) cultivars originating in Romania. Selçuk Journal of Agriculture and Food Sciences (Selçuk Tarım ve Gıda Bilimleri Dergisi) 24*:* 33-37.

Cosmulescu, S., Botu, M., Trandafir, I. (2013): The mineral source for human nutrition of nuts in different hazelnut (*Corylus avellana* L.) cultivars. Notulae Botanicae Horti Agrobotanici 4: 1-6.

Gopalan, A., Reuben, S.C., Ahmed, S., Darvesh, A.S., Hohmann, J., Bishayee, A. (2012): The health benefits of blackcurrants. Food & Function 3: 795-809.

Gorinstein, S., Zachwieja, Z., Folta, M., Barton, H., Piotrowicz, J., Zemser, M., Weisz, M., Trakhtenberg, S., Màrtín-Belloso O. (2001): Comparative contents of dietary fiber, total phenolics, and minerals in persimmons and apples. Journal of Agricultural and Food Chemistry 49*:* 952-957.

Hegedűs, A., Balogh, E., Engel, R., Sipos, B.Z., Papp, J., Blázovics, A., Stefanovits-Bányai, É. (2008): Comparative nutrient element and antioxidant characterization of berry fruit species and cultivars grown in Hungary. Horticultural Science 43*:* 1711-1715.

Lugasi, A., Hovari, J., Kadar, G., Denes, F. (2011): Phenolics in raspberry, blackberry and currant cultivars grown in Hungary. Acta Alimentaria 40*:* 52-64.

Mikkonen, T. P., Määttä, K.R., Hukkanen, A.T., Kokko, H.I., Törrönen, A.R, Kärenlampi, S.O., Karjalainen, R.O. (2001): Flavonol content varies among black currant cultivars. Journal of Agricultural and Food Chemistry 49*:* 3274-3277.

Nour, V., Trandafir, I., Ionica, M.E. (2011): Ascorbic acid, anthocyanins, organic acids and mineral content of some black and red currant cultivars. Fruits 66: 353-362.

Nour, V., Trandafir, I., Cosmulescu, S. (2014): Antioxidant capacity, phenolic compounds and minerals content of blackcurrant (*Ribes nigrum* L.) leaves as influenced by harvesting date and extraction method. Industrial Crops and Products 53: 133–139.

Tahvonen, R. (1993): Contents of selected elements in some fruits, berries, and vegetables on the finnish market in 1987-1989. Journal of Food Composition and Analysis 6: 75-86.

Tahvonen, R, Hietanen, A., Sankelo, T., Korteniemi, V.M., Laakso, P., Kallio, H. (1998): Black currant seeds as a nutrient source in breakfast cereals produced by extrusion cooking. Z Lebensm Unters Forsch A. 206: 360-363.

Vagiri, M., Ekholm, A., Öberg, E., Johansson, E., Andersson, S.C., Rumpunen, K. (2013): Phenols and ascorbic acid in black currants (*Ribes nigrum* L.): Variation due to genotype, location, and year. Journal of Agricultural and Food Chemistry 61: 9298-9306.

Wojdyło, A., Oszmiański, J., Milczarek, M., Wietrzyk J. (2013): Phenolic profile, antioxidant and antiproliferative activity of black and red currants *(Ribes spp.)* from organic and conventional cultivation. International Journal of Food Science & Technology 48: 673-892.