Evaluation of Mineral Elements in Berry Fruit Teas

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In recent years, berry teas based on dried fruit products have become a popular beverage due to their attractive flavours and their special taste. The aim of this study was to determine the mineral content in dry fruit teas and the infusions produced from them, using FAAS technique. The most abundant macro-element in all tea infusions was K, followed by Ca and Na, while the Fe content was predominant amount the micro-elements tested, followed by Zn, Mn and Cu. The percentage extraction of investigated elements ranged between 17.12 and 64.11%. According to the results obtained in this study, berry fruit teas are valuable sources of various minerals and could contribute to the daily intake of these nutrients.

Keywords: FAAS, minerals, berry fruits tea, tea infusions

Nowadays, berry fruits are considered a golden mine for human health. Due to their high content in vitamins, antioxidants and minerals, they are widely recommended in the dietary ratio for a healthy diet [1, 2]. Measurements of antioxidant activity using different methods in berry fruits lead to the conclusion that they have considerable high antioxidant capacity [3, 4].

It is considered that many health benefits associated with berry fruits dietary intake are linked to their high content in polyphenols, mainly anthocyanins. As a consequence, a growing number of scientific reports deal with that issue [5, 6].

Because it is relatively easy to process the dried berry fruits, food supplements containing dried berries are produced by many companies and are very appreciated by the customers. Among these supplements, berry fruit teas containing more or less dried berry fruits, are widespread in specialized markets. Due to their attractive flavours and their special taste, these berry fruit teas are more and more requested by the customers and have become a popular beverage [7]. Although the literature contains numerous reports on the chemical composition and biological activity of berries and their products, little research attention has been devoted to the berry fruit teas [8]. There are several studies regarding the amount of phenolic antioxidants in the berry fruit teas [9, 10]. On the contrary, there are fewer studies concerning the amount of minerals contained in these dietary supplements. The regular consumption of tea can contribute to the daily dietary requirements of some of these minerals [11, 12]. The aim of the present work is:

-to determine the mineral content of individual berry fruit teas;

-to evaluate the percentage transfer of the elements tested to the beverage prepared under recommended way;

-to determine the potential contribution to human nutrition;

Minerals selected for analysis were sodium, potassium, calcium, iron, manganese, zinc and copper.

Experimental part

Materials and methods

Reagents

All reagents used in this work were of analytical grade. The calibration curves were constructed in the range of 0.01-100 μg L^{-1} for trace metals while the curves for Na, K, Ca are in the range of 0.10-10 mg L^{-1}. The certified reference material (CRM) was used to check the accuracy of the applied method.

Apparatus

All measurements were carried out by the FAAS analytical technique (spectrometer SpectrAA 220). An acetylene-air or acetylene-nitrous oxide flame was used. The mean analytical parameters for the determination of metals in the studied samples were those recommended by the manufacturer (Varian, Australia).

Tea samples

Berry fruit teas are usually mixtures of dry berry fruit in varying amounts, available in bagged form. From our knowledge these is lack of information regarding the mineral profile of individual berry fruit teas and them infusions. Different brands of individual berry fruit teas available in health food store from Romania were purchased. The fruit tea samples were five blackberry-*Rubusfruticosus* L-(Bk), five bilberry tea-*Vacciniummyrtilus* S. (Bl) and five raspberry tea-*Rubusidaeus* L. (Rp). The infusion time and ratio sample/ water volume were selected based on the label indications (2 g of fruit material was added in 100 mL boiled water and steeped of 5 min).

Mineral analysis of dry fruit samples

Prior to analysis, the tea fruit samples were dried at 105^{0}C to constant weight, homogenized and grounded. Per sample, 1 g was weighted accurately in a dry, clean PTFE vessel and 6 mL of HNO_3 65% and 3 mL of H_2O_2 30% were added to each sample. The mixture was heated for 1 h (100^{0}C) until complete clarification. The sample was allowed to cool to room temperature, filtered and diluted to 50 mL with deionized water. Certified reference materials and blank, consisting of deionized water and reagents, were prepared in the same way as the samples. Three replicate measurements were made for each sample.

Mineral analysis of tea infusion

The infusion time and ratio sample/ water volume were selected based on the label indications and using the method described by Gallaher et al, [13]. Brewing was

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performed with 2 g of fruit sample in 100 mL boiled deionized water into a standardized flask. The resulting infusion was stirred with a glass rod for 30s to ensure proper wetting, covered and steeped for 5.5 more minutes (total 6 minutes), which is the tea industry's indicated brew time; the solubility of elements is higher in the first 5 min of infusion [14,15]. The steeped infusion was filtered and evaporated to dryness and the residue was prepared as above for the dry material.

Quality parameters

The accuracy and precision of the method used for determination of the elements were confirmed by analysis of certified standard reference materials. No berry fruit teas certified materials were available and, thus one CRM, similar to the analysed samples, was chosen: NCS DC 73351 Tea (National Analysis Centre for Iron and Steel, Beinjing, China). The mineral contents of the reference material were evaluated on a dry weight basis, as recommended in the certificate.

Limits of detection (LOD) of every studied element were experimentally calculated as three times the standard deviation of ten measurements of independent reagent blank solutions (mg kg^{-1}). These values were Na (0.2), K (0.3), Ca (1.0), Fe (0.4), Zn (0.1), Mn (0.02) and Cu (0.003).

In order to obtain good quality data, several aspects such as: chemical composition of tea material and tea preparation conditions, it must be considered. In order to avoid the influence of these factors, the samples were purchased from specialized market and tea infusions were prepared at the same conditions using label indications.

Data analysis

Data were reported as mean values ± standard deviations for triplicate determinations. A one-way ANOVA was applied to assess the variability of individual mineral concentrations between of berry fruit teas. Least significant differences test was applied to compare means, and significance was accepted at $p = 0.05$.

Results and discussions

Results of mean elemental concentrations with standard deviations obtained in the analyses of certified reference material are listed in table 1. Recoveries of the elements analysed varied between 92.9 and 107.5%. Most of the results agree with certified values presenting relative errors lower than 6.9 %. They also presented good precision with relative standard deviations varying from 0.6 to 6.1%.

The mean values of the individual mineral contents of berry fruit teas and tea infusions are presented in table 2 and 3, respectively. The analysis of variance (ANOVA) indicated that in the berry fruit teas, there is a higher difference in the K, Ca and Fe content between the three types of berry fruits, while the Zn quantity is not significant. On the other hand, the amount of metals changes in the berry tea infusion: the difference between blackberry, bilberry and raspberry tea infusions is strongly significant for K, Fe and Mn. In contrast, when measuring the level of Na, no variation can be distinguished.

Sodium is required by body to regulate blood pressure and also it in the proper functioning of the muscles and nerves [16]. The mean concentrations of Na in berry fruit tea ranged from 4.82 mg/100g (raspberry) to 7.27 mg/100g (blackberry), respectively. The percentage transfer

Element	NCS-DC 73351 Certified value	Found value	Recovery %	RDS (%)
K	16,600	16,466±611	99.2	3.7
Na	44	43±2.64	97.7	6.1
Fe	264	252±13	95.4	5.1
Mn	1240	1184.3±15.5	95.5	1.3
Zn	26.3	24.6±1.54	93.5	0.6
Cu	17.3	16.4±0.41	95.2	2.4

Table 1
MEASUREMENTS OF ELEMENTS CONCENTRATIONS IN REFERENCE MATERIAL (mg/kg)

Berry fruit type	N	Statistics	Na	K	Ca	Fe	Mn	Zn	Cu
Blackberry(Bk)	4	Mean	7.27	985.57	187.97	5.21	2.12	3.62	0.93
		SD	1.21	135.57	16.79	0.54	0.65	0.39	0.10
Bilberry (Bl)	4	Mean	6.34	1357.1	141.68	4.45	1.22	2.54	0.65
		SD	1.02	83.42	4.20	1.98	0.28	0.72	0.37
Raspberry (Rp)	4	Mean	4.82	1105.0	201.28	8.66	1.81	3.08	0.72
		SD	1.61	126.22	15.62	0.52	0.11	0.38	0.10
All samples	12	Mean	6.14	1149.27	176.97	6.10	1.72	3.08	0.76
		SD	0.30	49.39	6.95	0.83	0.27	0.19	0.16
		p value	0.0218	0.000367	0.000367	3.9×10^{-5}	0.0357	0.052	0.00903

Table 2
STATISTICS OF THE MINERAL ELEMENTS CONTENTS IN BERRY FRUIT TEAS (mg/100g)

Berry fruit type	N	Statistics	Na	K	Ca	Fe	Mn	Zn	Cu
Blackberry(Bk)	4	Mean	4.20	623.10	55.83	1.13	0.62	0.65	0.32
		SD	1.12	19.08	7.42	0.21	0.43	0.43	0.05
Bilberry (Bl)	4	Mean	3.41	879.15	41.18	1.37	0.24	1.22	0.17
		SD	0.64	28.53	3.17	0.34	0.05	0.26	0.02
Raspberry (Rp)	4	Mean	2.75	624.17	44.15	2.20	0.31	1.04	0.21
		SD	0.34	38.40	2.86	0.27	0.04	0.30	0.05
All samples	12	Mean	3.45	708.80	47.05	1.56	0.39	0.97	0.23
		SD	0.79	9.66	2.54	0.20	0.22	0.12	0.02
		p value	0.0734	1.58×10^{-6}	0.00548	0.000825	3.9×10^{-6}	0.00832	0.00235

Table 3
STATISTICS OF THE MINERAL ELEMENTS CONTENTS IN TEA INFUSIONS (mg/100mL)

from fruit teas to infusions, varied from 51.82% in bilberry infusion to 55.77 % in blackberry one (fig. 1). The concentrations of Na in these fruit tea types varied considerably ($p < 0.05$), but no variation can be distinguished in tea infusion ($p > 0.05$).

Potassium is one of the most important intracellular ions and is essential for the homeostatic balance of body fluids [16]. Available literature data have shown that potassium is the element present in higher level in berry fresh fruits [17]. The concentrations of K ranged between 985.20-1357.30 mg/100g in berry fruits sample, and the percentage transfer of the total K content to the infusion was ranged between 61.08% and 64.11%, which shows that K is highly extractible metal (fig. 1).

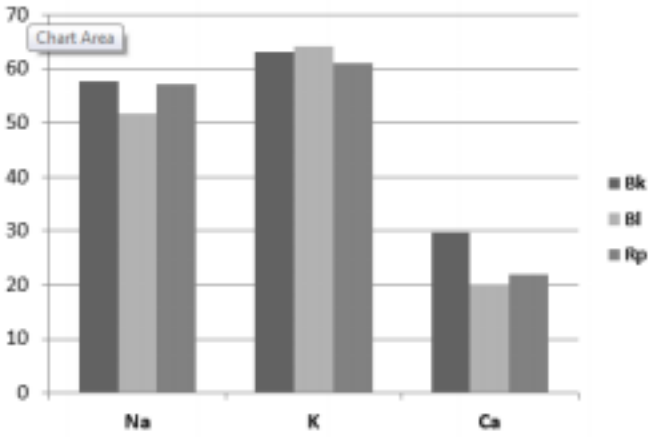

Fig. 1 Percent extraction (%) of macro-elements from dry fruits to infusions (mean value)

In the tissue of many fruits, calcium is a mineral considered to be an important factor governing fruit storage quality. It has been reported to delay ripening and to reduce storage disorder [18]. Significant differences were found in the Ca content between the fruit teas, (141.68 to 211.29 mg/100g), having the highest content in raspberry tea. In tea infusions, the mean concentrations of Ca found between 41.18 and 55.83 mg/100g, and the percentage transfer of the mineral, ranged from 20.06% in bilberry infusion to 29.70 % blackberry one.

Iron is an essential element for plant growth, and the uptake in plants depends on species and specific accumulation mechanism, based on Fe reduction or chelation in the rhizosphere [16].

The concentrations of Fe in these fruit teas and them infusions varied considerably ($p < 0.5$), raspberry tea containing higher concentrations of this mineral. It should be also noted that the percentage transfer of this metal from tea fruits to infusions had an average of 30% (fig. 2).

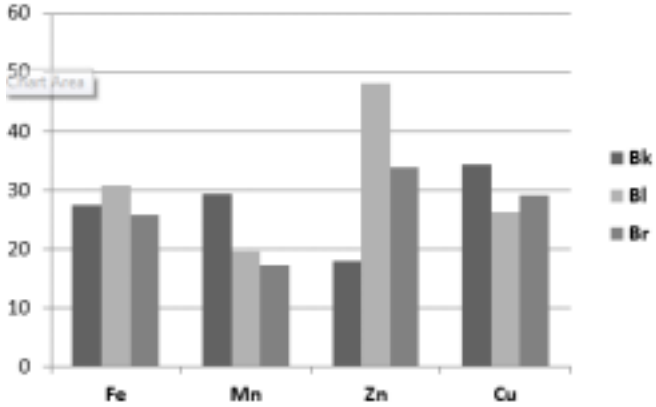

Fig. 2 Percent extraction (%) of micro-elements from dry fruits to infusions (mean value)

It is known that manganese is present in small amounts in many common foods. The mean concentrations of this element in the studied tea samples ranged from 1.22 mg/100g to 2.12 mg/100g and from 0.24 to 0.62 mg/100g in tea infusions. The highest mean value of Mn was observed in blackberry tea, while the lowest mean value was observed in the bilberry sample. Transfer of Mn from tea samples to infusions was between 17.12 % and 29.24 %. Regarding the Mn profile of individual berry fruit infusions, one can consider it as a poorly extractible element in case of bilberry and raspberry teas, and as moderately extractible in blackberry one (fig. 2).

Zinc and copper are essential components of enzymatic and redox reactions in human [16]. The concentration of zinc in fruit teas varied from 2.54 mg/100g in bilberry to 3.62 mg/100g in blackberry. In the tea infusions, the lowest concentrations of water-extracted Zn were found in blackberry tea and the highest in bilberry one. These data show that this metal may present low and moderately solubility in brew extracts, percentage transfer ranging between 17.95 and 48.03%.

The mean concentrations of Cu in examined samples ranged from 0.65 bilberry tea to 0.93 mg/100g in blackberry one. Percentage transfer of Cu in infusions ranged between 26.5 to 34.4%, which represents about 30% of the total concentration, and this metal can be considered as moderately extractable element.

The observed variations in the elements content of tea materials were probably due to the fruit species, its preferential absorbability of the element, mineral composition of the soil in which the plant was grown as well as and its surrounding climatic conditions [19]. Other

possible explanation for the observed differences of mineral constituents is the technology of the tea processing.

The drop of metals concentration in tea infusion compared to fruit teas could be due to fact that in the berry fruits most of the metals are present in complex form. Brewing may cause partial dissolution of such complexes and the nature of the metal complexes determines the rate to transfer of metal into infusion.

In their study, Natesan et al., [20], classified elements into three groups, highly extractable (>55%) moderately extractable (22-55%) and poorly extractable (<22%). According to these data, the extraction grade for each metal is calculated and in our study Na, K appear to be the most extractible elements in all the samples, while Ca, Mn, Zn and Cu appear as moderately extractible elements and Mn as poorly extractible element.

The contribution of berry tea consumption to the daily mineral intake

The percentages of recommended daily intakes (RDIs) based on average consumption of 250mL of berry fruits tea per day were calculated for Na, K, Ca, Fe, Mn, Zn and Cu, in regard to adult person. In these calculations, we considered the average mineral contents in the tea infusions and the current recommended daily allowance (RDA) values, as follows (mg/day): 1,300-1,500 Na, 3,100 K, 900-1,000 Ca, 9-18 Fe, 1.8-2.3 Mn, 7-9.5 Zn 1.1Cu [21].

The percentages of RDIs were: 0.79-1.12% for K, 0.20-0.28 % for Ca, 0.011-0,017 % for Na, 0.45-0.74 % for Fe, 0.61-1.62 % for Mn, 0.35-0.66 % for Zn and 1.13-2.13 % for Cu.

In the present study, the obtained values can be considered as orientation values, based on the assumption of total absorptions of individual elements. The tea infusions were prepared using deionized water, but tea infusions are generally prepared with tape water, which may contains different mineral concentration, having the potential to increase the mineral content in tea infusions. On the other hand the absorptions of some minerals can be reduced due to presence of various antinutrients like phytic acid, fibres, certain tannins, or due to some competition between minerals as the absorption of Mn can be inhibited by the presence of excessive amounts of Ca and P in the diet [22].

Conclusions

The mineral profile of the individual berry fruit teas have been analyzed in order to be used as dietary supplements. Generally speaking, the most abundant macro-element in all tea infusions was K, followed by Ca, Na. Evaluating micro-elements content, raspberry had the highest value of Fe, with possible benefit interactions in the prevention of anaemia. On the other hand, bilberry was the richest source in Zn, while blackberry had the highest values of Mn and Cu. The results concerning the mineral content in berry fruit teas, presented in our study, provide useful data for further use of berry teas, as part of the diet, in health promotion.

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