ASSESSMENT AND EXAMINATION OF MINERAL ELEMENTS IN APRICOT (*PRUNUS ARMENIACA* L.) CULTIVARS: A SPECIAL ATTENTION TO SELENIUM AND OTHER ESSENTIAL ELEMENTS

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The climatic conditions of some regions of Hungary provide great opportunity for apricot cultivation. A majority of apricot fruit is harvested in the northern part of the country. The most important traditional cultivars include 'Gönci magyar kajszi', 'Ceglédi óriás' and 'Bergeron'. The element content of six different apricot cultivars ('Goldrich', 'Ceglédi óriás', 'Aurora', 'Gönci Magyar kajszi', 'Magyar kajszi C.235' and 'Orange Red') was examined in this study. The total element content was measured by Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES). Selenium content was determined by polarography. From geographical point of view there is a wide variation in the selenium content of fruits. Apricot cultivars show great variations in element contents. It was determined that apricot contains a low quantity from most elements and daily requirements may not be covered by consumption of 300 g fresh apricot. Although they might be good sources of some essential elements. On the basis of RDA and DRI each examined apricot cultivar proved to be a good source of potassium; 'Gönci Magyar kajszi' and 'Ceglédi óriás' for manganese, 'Aurora' for manganese, potassium and copper. 'Aurora' fruits contain the most appreciable element concentrations (Ca, Fe, K, Mg, Na and S). An excellent content of potassium (ranged from 2127 to 4175 mg kg^{-1} fresh weight) was observed in fruits of all tested cultivars. Although non-essential elements such as B and Al were also present in multiple DRI quantities in samples.

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Introduction

A sum of 3 900 828 Mt apricot (*Prunus armeniaca* L.) fruit production was noticed all over the world in 2011.[1] In Hungary alone, it was 24 766 t in 2011, although this value was reduced to only 10 800 t in 2012[2]. Most apricot varieties are harvested in the region of Northern Hungary.[3] Because of large cultivation and production of apricot, Gönc city has a special attention in northern region of the country.[4] In Hungary, 'Gönci magyar kajszi' cultivar was produced in the 20 % of orchards and it was followed by 'Ceglédi óriás' and 'Bergeron' each with 11 % share respectively in 2012.[5]

Like other fruits apricot has a beneficial effect on human health and constitutes a rich source of minerals including potassium, iron, zinc, magnesium, manganese and selenium. Iron is a trace element and it has an important role as a core ion in haemoglobin while zinc is reported as a coenzyme for over 200 enzymes involved in body immunity systems.[6] Magnesium has an important role in the nervous system stability, muscle contraction and as an activator of alkaline phosphatase.[7] Manganese is a component of arginase and superoxide dismutase and plays a role as co-factor of certain enzymes.[7] Selenium has an important role as a part of glutathione peroxidase, which was the first described seleno`enzyme, which has also been identified as a cellular antioxidant.[8,9] Because of the increased applications of fertilizers and other chemicals the heavy metal pollution may cause problems in the human body. However, according to previous reports hazardous element (As, Cd, Hg, Pb) contents of nine apricot cultivars in Hungary were found to be lower than in apricots of other countries, and hence the daily intake of fresh and dry apricot may not cause serious health problems.[10]

Apricot is rich in polyphenols, carotenoids and vitamins, such as vitamin C.[8, 11] Half of the carotenoids (about 50 % of total available carotenoids) is β-carotene, which is followed by β-cryptoxanthin and γ-carotene.[12, 13] It is well known fact that the protective effects of natural antioxidants in fruits and vegetables are associated with vitamins, phenolics and carotenoids.[14]

Apricot is one of the most widely processed fruits in Hungary too. End users and consumers can have the benefit of the fresh fruit in a short period of the year with various forms of processed apricot like canned, frozen, jam, dried, juice or puree.[15] Almost the half of the world's total dried apricots is produced in Turkey. These fruits are pre-treated with SO_2 and then sun-dried to have moisture content of 23-28 %.[15] Apricot kernel is used in the production of cosmetics, oil, activated carbon, benzaldehyde and aroma perfume.[16]

The main aim of the present research article was to evaluate and assessment of the element content, especially the selenium content, which is one of the least studied elements, in fruits of six apricot cultivars.

Materials and methods

Fruits of six different apricot (*Prunus armeniaca* L.) cultivars ('Goldrich', 'Ceglédi óriás', 'Aurora', 'Gönci Magyar kajszi', 'Magyar kajszi C.235' and 'Orange Red') were collected in the germplasm collection of Department of Genetics and Plant Breeding, Corvinus University of Budapest.

Each apricot fruit (peel and flesh together) was lyophilized (ScanVac lyophilizer, Denmark). The freeze-dried fruit samples (0.5 g) were digested in a mixture of 5 mL HNO_3 (65 %) and 2 mL H_2O_2 (30 %) in Thermoreactor (VELP-ECO 6). The digested samples were diluted with double-distilled water to 25 mL. Element concentrations (Al, B, Ba, Ca, Cu, Fe, K, Li, Mg, Mn, Na, P, S, Si, Sr, Ti and Zn) in apricot fruit samples were determined by inductively coupled plasma optical emission spectrometry (ICP-OES). Type of instrument is Spectro Genesis ICP-OES (Kleve, Germany).[17,18] In the study, lyophilized samples were used and each quantity was expressed in fresh weight.

Selenium measurement was carried out with polarographic method (MDE 150 polarograph) using lyophilized fruite samples (0.5 g) which were digested in a mixture of 3 mL HNO_3 (65 %), 3 mL HCl (37%) and 2 mL H_2O_2 (30 %) and diluted with bidistilled water to 10 mL.[19]

Statistical analysis

In order to determine the statistical analysis, the SPSS 13.0 (SPSS Inc., Chicago, USA) program was used. In each case the evaluation was preceded by normality and homogenity tests. One way analysis of variance (ANOVA) was used for identifying the deviation within groups for equal variances or Welch test was used for unequal variances. The significance level was determined at 5 %.

Results

The element concentration in fresh fruit of six apricot cultivars are shown in Table 1. The concentrations of As, Co, Cd, Cr, Mo, Ni, Sn, Pb and V were under the detection limit; therefore, these elements are not shown in the table. Potassium was the most abundant mineral in apricot. In our study, the range of potassium content varied between 2127 ('Orange Red') and 4175 mg kg^{-1} ('Aurora'), further, it is followed by phosphorus, calcium and magnesium. 'Aurora' has the highest content of Ca (187.10 mg kg^{-1}) and Mg (160.74 mg kg^{-1}), which was approximately the double of the content found to be in 'Gönci Magyar kajszi' and 'Ceglédi óriás'. The content of Fe and Zn varied from 1.95-3.40 and 0.72-2.12 mg kg^{-1}. The concentrations of these two essential elements were the highest in 'Aurora' (3.40 and 2.12 mg kg^{-1}). The concentration of Mg and Mn varied from 88.79 to 160.74 and from 0.77 to 1.44 mg kg^{-1} in fresh weight, respectively. 'Gönci Magyar kajszi' had the highest content of manganese.

Fruits of the six apricot cultivars contained a low amount of selenium ranging from 0.003 to 0.005 mg kg^{-1} fresh weight. The highest content of selenium was measured in 'Orange Red', 'Ceglédi óriás' and 'Magyar kajszi C.235'. According to previous studies on different Turkish apricot cultivars, selenium content ranged between 0.1 and 0.2 mg kg^{-1} in fresh weight so this fruit can be considered as a rich source of selenium.[8] Although in our study the selenium content of six cultivars remained below the range compared to Turkish apricots. This may be explained by the general poor selenium content of the Carpathian basin soils.[20]

According to these results significant variations were observed among all tested cultivars except in the cases of boron and iron. It is also to be mentioned here that the lowest iron content was found in 'Gönci Magyar kajszi'. In respect of boron and iron contents the cultivars were similar.

Discussion

Fruits of the 'Aurora' apricot cultivar had the highest average element content. Even than by consuming 300 g apricot per day (this amount is equivalent to about seven pieces of medium-sized apricot), the daily requirement will not be covered for some metal ions. Although apricot can be a good source of some elements, which reach at least 15 % of the Recommended Dietary Allowances (RDA) or Dietary Reference Intake (DRI).[21, 22]

Based on the RDA values and taking into consideration consumption of 300 g apricot, 'Goldrich', 'Orange Red', 'Gönci Magyar kajszi', 'Aurora', 'Ceglédi óriás' and 'Magyar kajszi C.235' may be considered as good sources (33.1 %, 32 %, 43.1 %, 62.6 %, 43.7 % and 36.0 % of the daily need) of <u>potassium</u> (RDA value: 2000 mg day^{-1}/ adult of 70 kg). Our study shows that 'Gönci Magyar kajszi', 'Aurora' and 'Ceglédi óriás' apricot cultivars also seem to be good sources (21.6 %, 20.1 % and 18.0 % of the daily need) of <u>manganese</u> (RDA value: 2 mg day^{-1}/ adult of 70 kg). It should be also mentioned that <u>'Aurora'</u> contains sufficient quantities of <u>copper</u> (31.8 % of the daily need, RDA value: 1 mg day^{-1}).

The intake of non-essential elements is relatively low, although <u>aluminium</u> intake in case of 'Aurora' and 'Magyar kajszi C.235', which contains 38.5-50.9 % and 28.4-37.6 % of DRI (DRI value between: 3.1-4.1 mg day^{-1}/adult of 70 kg), is relatively high but it has to be mentioned that other cultivars may also accumulate high quantity of aluminium. 'Gönci Magyar kajszi', which contains the least aluminium, is also abundant in aspect of this non-essential element (17.6-23.2 % of the daily need). <u>Boron</u> contents in fruits of each apricot cultivar may result in the consumption of multiple amounts of the recommended intake. In the case of 'Aurora' containing the least boron, the intake is 204.4 % (DRI value: 0.96 mg day^{-1}/adult of 70 kg). According to previous reports the major minerals of the apricot fruit are Al, Ca, Fe, K, Mg, Na and P and in the present study we determined that K and P were the most abundant minerals in apricot. The content of minerals was found to vary widely depending on the different cultivars of apricot.[23]

During the examination and assessment we found significant variations among the element contents of six apricot cultivars; however, in case of elements like boron and iron there were no significant variation between the cultivars under examination.

Table 1. Element concentrations (mg kg $^{-1}$ fresh weight ± standard deviation, *n*=3) in fruits of apricot cultivars (**n*=1).

	Goldrich	**Orange Red**	**Gönci Magyar kajszi**	**Aurora**	**Ceglédi óriás**	**M. kajszi C.235**	**ANOVA (*P*<0,05)**
Al	3.70±0.47	3.60±0.22	2.40±0.41	5.26±0.08	2.63±0.46	3.88±0.52	< 0.001
B	7.36±1.71	7.74±1.28	7.11±1.19	6.54±0.51	6.63±0.24	8.13±1.47	0.689
Ba	0.11±0.01	0.09±0.01	0.09±0.01	0.14±0.01	0.09±0.01	0.12±0.01	< 0.001
Ca	164.11±5.69	108.22±0.26	81.70±0.79	187.10±2.26	92.71±6.50	116.36±1.71	< 0.001
Cu	0.42±0.01	0.65±0.03	0.75±0.02	1.06±0.04	0.40±0.02	0.28±0.02	< 0.001
Fe	3.06±0.37	2.73±0.29	1.95±0.2	3.40±0.63	2.92±0.47	2.85±0.14	0.064
K	2205±22	2127±56	2871±22	4175±50	2910±88	2400±17	< 0.001
Li	0.004±0.001	0.010±0.002	0.007±0.002	0.01±0.002	0.002±0.002	0.003±0.001	0.008
Mg	104.80±17.91	98.10±16.30	88.79±6.03	160.74±13.13	92.84±14.36	100.60±15.92	< 0.001
Mn	0.77±0.06	0.75±0.03	1.44±0.01	1.34±0.02	1.12±0.05	0.98±0.01	< 0.001
Na	4.85±0.87	5.27±0.85	8.25±1.16	10.21±1.04	6.66±0.9	5.35±0.20	< 0.001
P	277.8±22.3	278.1±22.4	251.9±18.8	296.7±22.2	317.0±25.0	260.0±20.7	< 0.001
S	64.91±0.86	52.94±1.76	64.51±0.93	92.07±1.71	72.14±1.15	51.84±0.26	< 0.001
Se*	0.004	0.005	0.003	0.004	0.005	0.005	
Si	19.60±1.54	18.38±1.59	17.35±1.00	16.87±1.97	24.35±0.60	14.62±1.55	0.003
Sr	0.66±0.03	0.50±0.01	0.37±0.01	1.10±0.02	0.39±0.03	0.46±0.01	< 0.001
Ti	0.07±0.01	0.15±0.01	0.13±0.02	0.17±0.01	0.07±0.01	0.08±0.01	< 0.001
Zn	1.29±0.02	0.90±0.09	1.25±0.06	2.12±0.06	1.01±0.09	0.72±0.08	< 0.001

Results of the present investigation show that each apricot cultivar contains significant quantity of potassium, which is followed by phosphorus, calcium and magnesium. It may also be significant that apricot may prove to be a good source of manganese too. Among the major cultivars ‘Aurora’ has the greatest mineral content. Our study indicates that fruits of the six apricot cultivars contain a low amount of selenium.

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