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Factors affecting apricot fruit antioxidant capacity and mineral element contents

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Summary: Several epidemiological studies revealed that the consumption of antioxidant compounds and the risk of atherosclerosis, increased blood pressure or cancer are inversely proportional. The individual amounts and relative proportions of macro- and micro elements present in food is also of great consideration since these are involved in a wide range of physiological processes including the influence of the redox homeostasis. The antioxidant power and mineral nutrient content of fruits might be affected by several factors including genotype, ripening stage, year-effects or a wide range of environmental conditions. This study was carried out to survey the antioxidant power and mineral element content in fresh fruits of apricot and analyse some genetic and environmental factors that may have important contribution to the inner content of apricot fruits. In addition, the influencing effect of the extraction procedure used for antioxidant analyses was also tested. Our analyses indicate that a considerable fraction of antioxidant capacity is attributable to the hydrophilic antioxidants. The genetic background has crucial importance in determining apricot fruit antioxidant capacity and mineral nutrient content; however, the growing season and the ripening time of fruits may have also important effects.

Key words: antioxidant, apricot, mineral elements, *Prunus armeniaca*, total phenolics

Introduction

Recently, Hungary has witnessed a slight increase in the production of main stone fruit crops (eg. cherries, apricot, peaches and nectarines and plums) (*Faostat*, 2007). Probably the consumption of stone fruits will also rise, because people pay more and more attention for their health. Therefore, natural foods having enhanced functional properties may be very popular in the future. The increased consumption of fresh fruits has several health-promoting effects. Because of their high antioxidant capacity, they inhibit the harmful oxidative processes, and reduce the risk of several degenerative diseases (i.a. cancer, stroke, cardiovascular diseases) (*Liu*, 2003; *Scalzo* et al., 2005; *Dauchet & Dallongeville*, 2008).

Apricot (*Prunus armeniaca* L.) fruit contains three major types of antioxidant molecules: water-soluble vitamin C, lipid-soluble carotenoids as well as polyphenolics comprising both hydro- and lipophilic components. In several Spanish apricot genotypes, a five-fold difference was obtained between the highest and lowest polyphenolic contents (*Ruiz* et al., 2005) as calculated by summing the quantities of several individually determined components using HPLC-DAD. *Betul Akin* et al. (2008) measured phenolic content using Folin reagent and revealed an almost two-fold variation among 11 sampled cultivars. Ferric reducing ability of plasma (FRAP) and trolox equivalent antioxidant capacity (TEAC) assays were used for comparing the antioxidant capacities in fresh fruits of several Mediterranean apricot cultivars (*Bartolini* et al., 2006; *Leccese* et al., 2008).

As with other stone fruits (*Prior* et al., 1998; *Serrano* et al., 2005), several factors were shown to modify the antioxidant capacity of fruits or the quantity of individual antioxidant compounds. These factors include geographic region, maturity stage and fruit ripening calendar (*Bartolini* et al., 2006; *Dragovic-Uzelac* et al., 2007; *Leccese* et al., 2008). The FRAP values increased in parallel with the fruit ripening process, with highest values corresponding to both consumption ripeness and maximum organoleptic quality (*Bartolini* et al., 2006). *Leccese* et al. (2008) showed increasing TEAC and total phenolic content (TPC) values in the late ripening cultivars among several Mediterranean cultivars. For many fruit species, genotype proved to be one of the most important factors influencing the fruits' antioxidant power and contents (*Hegedűs* et al., 2008; *Papp* et al., 2008; *Prior* et al., 1998; *Scalzo* et al., 2005; *Yilmaz* et al., 2009). *Drogoudi* et al. (2008) determined much higher 2,2'-diphenyl-1-picrylhydrazyl (DPPH) scavenging capacity and TPC values for North American apricot genotypes compared with Greek accessions.

In addition, minerals have also considerable health-effects (*Stefanovits-Bányai* et al., 2006; *Hegedűs* et al., 2008). Stone fruits are rich sources of the most important macro- (Na, K, Ca, Mg) and microelements (Fe, Cu, Zn, Mn)

that have a considerable contribution to the human redox homeostasis through several mechanisms, e.g. they are indispensable cofactors of antioxidant enzymes. The transient metals, Fe and Cu ions may induce oxidative hazard because they can easily donate electrons to other molecules (*Toyokuni*, 2002; *Valko* et al., 2005). The zinc ions help to build biomembranes, in absence of this metal element biomembranes may be easily disorganized. Knowledge on the Na/K ratio is indicative, and because of the high Na levels in human diet fruits rich in potassium may be beneficial. Calcium and magnesium are required for the healthy bones and teeth, normal blood circulation, as well as for the efficient working of nerves and muscles.

Materials and methods

Cultivars tested

Altogether, 27 apricot cultivars and hybrids were used for the analyses. All cultivars and hybrids were cultivated at the same germplasm collection of the Department of Genetics and Plant Breeding, CUB (Szigetcsép, Central Hungary) and fruits were harvested during the season of 2006 and 2007.

Sample preparation

For antioxidant assays, 100 g fruit were homogenized (peel and flesh together) and centrifuged with a Hettich Zentrifugen (Mikro 22 R; Tuttlingen, Germany) device (4 °C, 35 min, 18 750 *g*), after which supernatants were used for most of the redox assays (exceptions are indicated). Samples for further analyses were kept at –80 °C until use. For extraction analyses, the apricot fruit pulp was first mixed with known volumes of 80% (v/v) ethanol. After centrifugation, the supernatant was used for measurements and the precipitate was suspended in acetone. The suspension in acetone as detergent was carried out three times.

Antioxidant and total phenolic assays

Antioxidant capacity was determined by the FRAP method (*Benzie, & Strain*, 1996) and expressed as mmol ascorbic acid (AA)/L fruit juice or µmol AA/100 g fresh weight. Total phenolic content (TPC) was measured using Folin-Ciocalteu's reagent according to the method of *Singleton & Rossi* (1965). The content of soluble phenols was calculated from a standard curve based on gallic acid concentration.

Determination of element content

0.2 g of the freeze-dried fruit samples was delivered into a teflon bomb (PTFE). 2.0 cm^3 nitric acid and 2.0 cm^3 hydrogen-peroxide were added to the samples and they were left standing for a night. Next day the closed teflons were boiled in hot water for half an hour. The digested samples were transfused in volumetric flask and supplemented to the volume of 10 ml with Milli-Q water. This solution was filtered through filter-paper into test tubes. The following elements were determined by ICP-OES (Thermo Jarrell Ash Co, ICAP 61): Al, As, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Na, P, Pb, and Zn.

Statistical analysis

Correlation analyses of redox parameters and one-way analysis of variance (ANOVA) were carried out in Microsoft Excel 2003. Significant differences were calculated according to Duncan's multiple range tests. Differences at $P0.05$ were considered statistically significant.

Results and discussion

The antioxidant capacity (FRAP value) of several cultivars belonging to different eco-geographical groups apricot was studied during two consecutive seasons (*Figure 1*). Within each season, the cultivars characterized by relatively early ripening time ('Harmat', 'Orange red', 'Goldrich' etc) had lower antioxidant capacity than those ripening later in the season (e.g. 'Bergeron', 'Pisana', 'Zard'). The highest antioxidant capacity was found in case of the hybrid 'Preventa' resulting from breeding program of the Department of Genetics and Plant Breeding, CUB. This extremely high FRAP value proved to be a stable character free from considerable variations according to the growing seasons since both 2006 and 2007 it reached a value over 10 mmol AA/L. For some cultivars (e.g. 'Toyesi', 'Pannónia' and 'Gönci magyarkajszi'), higher variations in the antioxidant capacity occurred when compared the seasons of

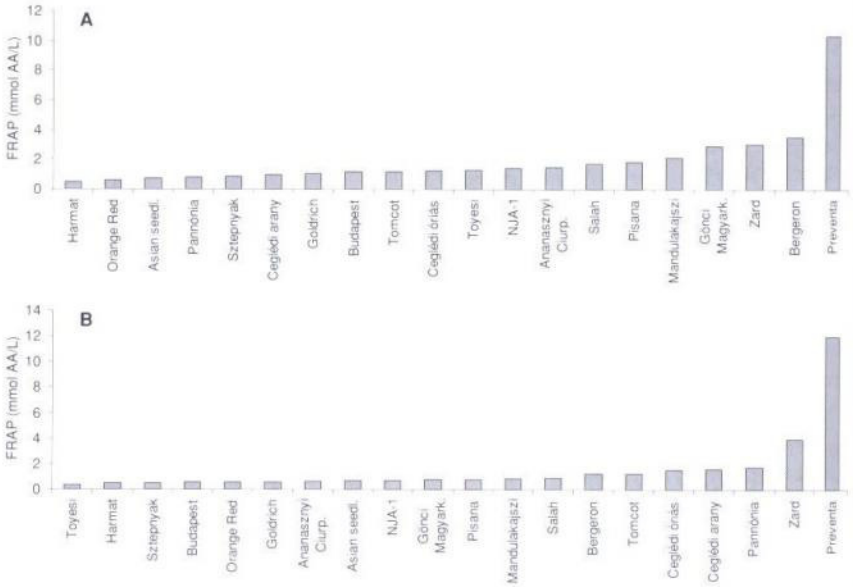

Figure 1: Antioxidant capacity of apricot cultivars in 2006 (A) and 2007 (B)

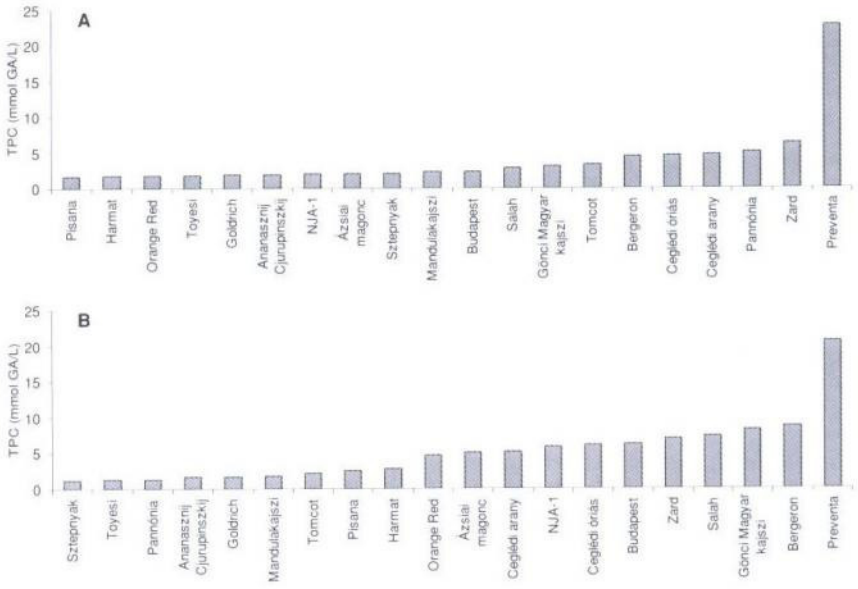

Figure 2: Total phenolics content of apricot cultivars in 2006 (A) and 2007 (B).

2006 and 2007. However, this was always due to a difference of only 0.5–1.0 mmol AA/L and did not affect the ranking order of most of the cultivars only those having very similar FRAP values.

Polyphenolics are a major group of antioxidants in apricot fruits (*Ruiz* et al., 2005; *Betul Akin* et al., 2008). Total polyphenolic contents (TPC) showed a very similar tendency as observed for the FRAP values (*Figure 2*). Again, cultivars with early ripening time had the lowest TPC values, while most late ripening cultivars had higher polyphenolic contents. This tendency was also observed for several Italian apricot cultivars (*Leccese* et al., 2008). In general, TPC values were higher in 2007 (*Figure 2B*) than 2006. 'Orange red', 'NJA-1' and 'Pannónia' were among the genotypes characterized by considerably different ranking orders in two different seasons.

Since the antioxidant capacity of apricot fruits derives from several compounds comprising both hydro- and lipophilic components, the effect of different extraction methods on the antioxidant capacity determined for fruits was also tested (*Table 1*). The ethanolic extraction represented a remarkable fraction (60-80%) of the total antioxidant capacity. This relative percentage was somewhat influenced by the genotype-dependent differences in fruit inner contents. The first round of acetonic (lipophilic) extraction still represented a considerable fraction of the total antioxidant capacity (approx. 20%). Approximately 5%, 1.2% and 0.4% of the total antioxidant capacity was recovered by the second, third and fourth rounds of acetonic extraction, respectively. The differences in the relative percentage of antioxidant capacity extractable with acetone may indicate the quantity of lipophilic polyphenolics, carotenoids and other compounds with antioxidant capacity.

Considerable differences in element contents occurred between cultivars (*Table 2*). The French cultivar 'Bayoto' has considerable B, Ba, Ca and Mn contents while the North American 'Tomcot' accumulated outstanding levels of Mg,

Table 1: Total antioxidant capacity (FRAP) of apricot fruits after ethanolic and acetonic extractions

Cultivar (maturity)	Dimension	ethanolic	aceton 1	aceton 2	aceton 3	aceton 4	Σ
T8 (ripe)	µmolAA/100g FW	76.93	16.86	7.62	1.62	0.20	103.23
	Percent of total (%)	74.52	16.33	7.38	1.57	0.19	100.00
Salah (ripe)	µmolAA/100g FW	156.05	50.61	12.72	2.62	0.96	222.96
	Percent of total (%)	69.99	22.70	5.70	1.18	0.43	100.00
Gönci mk. (half matured)	µmolAA/100g FW	209.22	51.98	12.24	2.67	1.05	277.15
	Percent of total (%)	75.49	18.75	4.41	0.96	0.38	100.00
M604 (unripe)	µmolAA/100g FW	321.31	70.58	12.75	5.04	0.76	410.43
	Percent of total (%)	78.29	17.20	3.11	1.23	0.19	100.00
Gönci (unripe)	µmolAA/100g FW	139.86	29.45	8.51	1.85	0.52	180.18
	Percent of total (%)	77.62	16.35	4.72	1.03	0.29	100.00
Ceglédi arany (ripe)	µmolAA/100g FW	105.71	23.77	3.55	1.56	0.61	135.20
	Percent of total (%)	78.19	17.58	2.62	1.16	0.45	100.00
Ceglédi óriás (ripe)	µmolAA/100g FW	115.19	46.37	6.87	1.90	0.68	171.01
	Percent of total (%)	67.36	27.12	4.02	1.11	0.40	100.00
Goldrich (ripe)	µmolAA/100g FW	120.96	29.26	0.01	1.84	0.39	152.45
	Percent of total (%)	79.34	19.20	0.00	1.20	0.25	100.00
Jumbocot (ripe)	µmolAA/100g FW	152.05	47.89	9.82	1.96	1.10	212.81
	Percent of total (%)	71.45	22.50	4.61	0.92	0.52	100.00
Ceglédi Piroska (ripe)	µmolAA/100g FW	171.99	106.64	17.50	4.39	1.15	301.67
	Percent of total (%)	57.01	35.35	5.80	1.46	0.38	100.00
Baneasa (ripe)	µmolAA/100g FW	110.28	29.63	5.06	2.10	0.66	147.73
	Percent of total (%)	74.65	20.05	3.42	1.42	0.45	100.00
Σ	Percent of total (%)	73.08	21.19	4.16	1.20	0.36	

Table 2: Mineral element composition in fruits of apricot cultivars. Black and gray background colours show the highest and lowest values respectively for each element among all tested cultivars

	Al*	B*	Ba*	Ca*	Cu**	Fe*	K*	Mg*	Mn**	Na*	P*	Zn*
Auróra	0.23	**0.31**	**0.02**	**12.90**	100.39	0.28	240.20	10.80	80.93	**0.37**	20.95	0.17
Bayoto	0.17	**0.68**	**0.08**	**33.50**	154.97	0.25	258.30	13.18	**163.98**	3.56	22.14	0.14
Bergeron	0.19	0.43	0.07	18.70	100.54	**0.15**	247.10	9.28	**77.93**	3.09	**15.30**	**0.06**
Gönci mk.	**0.48**	0.39	0.07	21.63	**239.02**	0.26	275.68	9.58	94.91	3.56	20.85	0.11
Harcot	0.20	0.35	0.06	22.28	166.77	0.23	211.68	9.18	86.22	2.90	16.69	0.13
Tomcot	0.26	0.52	0.07	30.80	213.70	0.30	275.79	**14.21**	115.97	**3.66**	**31.45**	**0.18**
Toyesi	0.14	0.47	0.07	22.66	156.57	0.27	213.34	10.68	95.41	2.97	16.98	0.11
Toyiba	**0.10**	0.61	0.05	14.85	147.82	0.25	178.82	**8.61**	113.91	2.36	20.18	0.13
Toyuda	0.15	0.34	0.06	19.36	**84.75**	0.20	**178.66**	9.53	114.75	2.75	18.83	0.12
Zard	0.32	0.41	0.07	22.55	128.19	**0.33**	**310.17**	14.02	104.09	3.38	17.09	0.09

*mg/100 g fresh weight; **µg/100g fresh weight

Na, P and Zn. Interestingly, the Hungarian cultivar 'Gönci magyarkajszi' showed relatively larger quantities from the metals Al and Cu, while the Central Asian 'Zard' had the highest Fe and K contents. The lowest Al content was measured in fruits of the 'Toyiba' cultivar, which can be regarded as a positive character; however, its Mg content reached also the lowest value among all tested genotypes. 'Toyuda' proved to be a poor source of copper and potassium. The North American cultivar 'Aurora' showed the lowest B, Ba, Ca and Na contents. Its Na content was especially low, which along with a medium K content resulted in an extremely high K/Na ratio of approx. 650 compared with the range 65–90 for the rest of the cultivars. The fruits of this cultivar may be useful to compensate for high Na levels in a typical human diet (*John* et al., 2002). Since all trees were grown under identical climatic and soil conditions, such differences among cultivars within each species may be attributed to their different origins and genetic constitutions (*Halász*, 2007a,b; *Szabó*, 2007; *Szilvássy* et al., 2008). It might offer the possibility to construct individual diets in response to the varied requirements arising from specific health conditions or demographic aspects and promote the medical treatment and help the patients to get better in a natural way.

Stone fruits are characterized by seasonal availability in the markets. The food processing industry should find alternative ways to process these fruits while preserving their beneficial coumpounds, antioxidants, vitamins and mineral elements. Vegetable and fruit consumptions are very important factors of a health-promoting diet, and statistic data show that Hungarian people do not eat enough from these foods. New products, which are rich in health protecting components, together with the required marketing strategy may help to alleviate this problem.

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