Phenolic Compounds and Antioxidant Capacity of Dried and Candied Fruits Commonly Consumed in Serbia

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Abstract

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Dried fruits (plums, apricots, figs, grapes (amber light and amber dark), chokeberries, and bilberries), and candied fruits (cranberries, cherries, and dates), commercially available and commonly consumed in Serbia, were purchased on the same day in local groceries, and analysed for total phenolics and antioxidant capacity. Total phenolics contents of dried and candied fruits were as follows: dried chokeberries > dried bilberries > dried plums > candied cherries, dried apricot > dried grapes (amber light) > candied cranberries, dried figs, dried grapes (amber dark), candied dates. The order of antioxidant capacity showed a very similar trend as the total phenolics content. Significant correlation between total phenolics content and antioxidant capacity ($R = 0.9931$, $P < 0.001$) was observed. Using HPLC, the identification of selected phenolic compounds was carried out. Most of these compounds were the most abundant in dried chokeberries and dried bilberries, and consequently the highest antioxidant capacity was found in these dried fruit species.

Keywords: flavonols; hydroxycinnamic acids; HPLC; fruit processing; recommended daily intake

High consumption of fruits and vegetables has been considered to reduce the risk of a number of major diseases (Gillman *et al*. 1995; Joshipura *et al*. 2001). These effects are mainly associated with biologically active components that are naturally present in the fruits and vegetables, the most important of which being the phenolic compounds, carotenoids, vitamins, minerals, etc. (Vicente *et al*. 2009). The term "antioxidant" was defined as: "a substance in foods that significantly decreases the adverse effects of reactive species, such as reactive oxygen and nitrogen species, on normal physiologic functions in humans" (Seeram *et al*. 2008). Phenolics, as natural antioxidants, have come to the attention of nutritionists since the mid-1990s. Despite their wide distribution in plants and potential health benefits, phenolics have been neglected as antioxidants for a very long time due to the considerable diversity and complexity of their chemical structures (Scalbert *et al*. 2005a). Even though the data on the health effects of phenolic compounds cannot be considered comprehensive, since the mechanisms are not yet fully understood, the copious number of scientific publications strongly support the antioxidant, anticarcinogenic, antimicrobial, antiallergic, antimutagenic, and anti-inflammatory properties of phenolics (Juranic *et al*. 2005; Kaur *et al*. 2009; Krajka-Kuźniak *et al*. 2009; Alesiani *et al*. 2010; Bowen-Forbes *et al*. 2010; Baliga *et al*. 2011), and strongly suggest that phenolic compounds are associated with our health (Scalbert *et al*. 2005b).

Phenolic compounds are an integral part of the human diet (Wootton-Beard & Ryan 2011), and mainly determine the sensory qualities of the fruit (colour, taste, flavour) (Lesschaeve & Noble 2005; Labuda 2009; Schaefer 2011). Fruit phenolics include a wide range of compounds such as flavonols, flavan-3-ols, hydroxycinnamic acids, gallic acid de-

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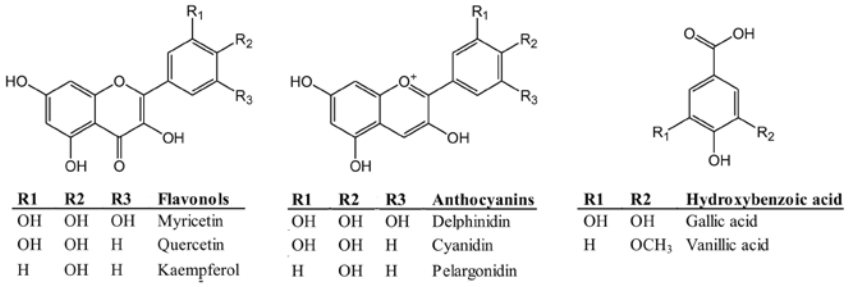
rivatives, and anthocyanins (Lachman *et al*. 2000). The functionality of these compounds is mainly expressed in their scavenging free oxygen radicals, which are involved in many pathological conditions (Briviba & Sies 1994; Tadić *et al*. 2008; Hasan *et al*. 2010). Antioxidants restrict the deleterious effects of these oxygen species either by eliminating them without generating more radical-induced damage or preventing radical formation (Fernandez-Orozco *et al*. 2011).

Since fresh fruits are rich in radical-scavenging compounds, dried fruits are also expected to be good sources of these compounds. However, these compounds may be decomposed during drying. Since dried fruits have been promoted in Serbia as functional food and a rich source of antioxidants, the aim of the current study was to analyse dried and candied fruits, commercially available on the national scasle, as a possible source of phenolics and antioxidants. Furthermore, it is of great interest to the general public to know the antioxidant capacity of the commonly consumed dried fruits, since the manufacturers base their marketing strategies on the antioxidant capacity. The phenolics analysed were: flavonols (myricetin, quercetin, kaempferol), anthocyanins (delphinidin, cyanidin, pelargonidin), and phenolic acids (gallic acid, chlorogenic acid, vanillic acid, caffeic acid, *p*-coumaric acid, ellagic acid, ferulic acid, rosmarinic acid) (Figure 1).

MATERIAL AND METHODS

Fruit collections. Dried and candied fruits, commonly consumed in Serbia, were bought on the same day in a local grocery and an open-air street market. After purchasing fruits were stored in a freezer (–20°C) for no longer than one week, before analyses were performed. The following dried fruits were obtained: plums, apricots, figs, grapes (amber light), grapes (amber dark), chokeberries, while bilberries involved; and candied fruits: cranberries, cherries, and dates were obtained. Since the dried and candied fruits were bought in a local grocery and an open-air market, the detailed drying procedures remain completely unknown, as well as the fruit cultivars used. Especially noteworthy is the fact that the candied fruits were completely dry, not immersed in some sugar syrup, and had the same appearance as any other dried fruits.

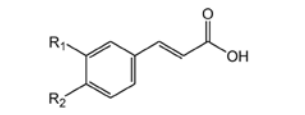
Chemicals and reagents. HPLC grade solvents were purchased from J.T. Baker (Center Valley, USA), and HPLC-grade water was obtained with a Crystal E HPLC water purifying system from Adrona (Riga, Latvia). Trolox (6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid) was purchased from Acros Organics (Geel, Belgium). Folin-Ciocalteu's phenol reagent, ABTS [2,2'-azino-bis(3-ethylbenzthiazoline-6-sulphonic acid) diammonium salt] were purchased from Sigma-Aldrich (St. Louis, USA). Pure standards



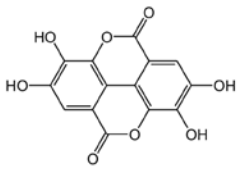
R1	R2	R3	Flavonols
OH	OH	OH	Myricetin
OH	OH	H	Quercetin
H	OH	H	Kaempferol

R1	R2	R3	Anthocyanins
OH	OH	OH	Delphinidin
OH	OH	H	Cyanidin
H	OH	H	Pelargonidin

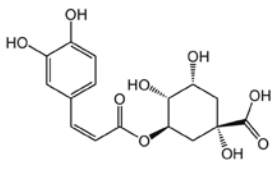
R1	R2	Hydroxybenzoic acid
OH	OH	Gallic acid
H	OCH_3	Vanillic acid



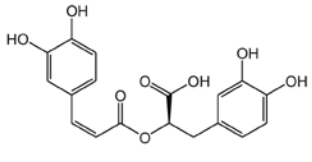
R1	R2	Hydroxycinnamic acid
OH	OH	Caffeic acid
H	OH	*p*-coumaric acid
OCH_3	OH	Ferulic acid



Ellagic acid



Chlorogenic acid



Rosmarinic acid

Figure 1. Structural formulae of analyte used, including flavonols, anthocyanins, and phenolic acids

were obtained from LGC Standards (Teddington, UK) and Dr. Ehrenstorfer GmbH (Augsburg, Germany). The standards were dissolved in methanol, and the working solutions were prepared each day by appropriate dilution with methanol. Sodium carbonate, potassium persulfate, and tert-butylhydroquinone (TBHQ) were obtained from Merck KGaA (Darmstadt, Germany).

Determination of dry matter content and total phenolics content. The dry matter content was determined by drying the whole fruit at 105°C to constant mass, and the results were expressed as percentage of the fresh weight

Total phenolics content and antioxidant activity. Prior to analysis, whole edible parts of fruits were frozen by placing them into liquid nitrogen after which they were homogenised together, using a stainless steel blender, for subsequent extraction and compounds analysis. The total phenolics content was determined using a modified Folin-Ciocalteu colorimetric method (Singleton *et al*. 1999) and the results were expressed as milligrams of gallic acid equivalents per 100 g dry matter (mg GAE/100 g DM). Antioxidant activity was determined by the ABTS and DPPH assays. $ABTS^{\bullet}+$ radical cation scavenging activity was determined according to the method described by Re *et al*. (1999). Antioxidant activity was determined using the DPPH method reported by Brand-Williams *et al*. (1995) with modifications (Sanchez-Moreno *et al*. 1998). The results were expressed as Trolox equivalent antioxidant capacity (mmol TE/100 g DM for ABTS assay; μmol TE/100 g DM for DPPH assay).

Extraction and HPLC-DAD analyses. The samples were prepared according to the method of Hertog *et al*. (1992). Briefly, 15 g of ground fruit was dispersed in 20 ml of 62.5% aqueous methanol containing 2 g/l of TBHQ. To this extract 5 ml of 6M HCl was added. Hydrolysis was carried out in a shaking water bath at 85°C for 2 hours. After hydrolysis, the sample was allowed to cool, then it was filtered, made up to 50 ml with methanol, and was ultrasonicated for 5 minutes. Before quantification by HPLC, the sample was filtered through a 0.45 μm membrane filter. The samples were analysed using an Agilent 1260 series HPLC (Agilent Technologies, Santa Clara, USA) linked to a ChemStation data handling system, using a ZORBAX Eclipse Plus C18 column (4.6 × 150 mm, 3.5 μm particles). The injection volume was 5 μl and the column temperature was set at 30°C. Solvent A was 1% formic acid and solvent B was acetonitrile. The gradient used was as follows: 0–10 min, 10% of B in A; 10–25 min, 15–50% of B in A; 25–30 min, 50–80% of B in A; 30–32 min, 10% of B in A (flow rate 0.5 ml/min). The HPLC equipment was used with a diode array detector (DAD). In order to determine chlorogenic acid and caffeic acid contents, samples were also prepared according to the method of Escarpa and González (2000), and were further analysed using the same HPLC system. Phenolic compounds were detected at 260 nm (vanillic and ellagic acids), 280 nm (gallic and *p*-coumaric acids), 329 nm (chlorogenic, caffeic, ferulic, and rosmarinic acids), 360 nm (myricetin, quercetin, kaempferol), and 520 nm (delphinidin, cyanidin, pelargonidin). Phenolic compounds were identified by comparing the retention times (RT) and spectral data (UV/Vis spectra) with those of authentic standards. Quantitative determinations were carried out using the calibration curves of the standards based on the peak areas, and expressed as mg/100 g DM. The recovery was measured of each fruit species by spiking pure standards into the samples before extraction at the level of 50–100% of the measured content, and it was found to be 85–95%.

Statistical analysis. In all the experiments, three samples were analysed and all the assays were carried out in triplicate. The data were analysed by one-way analysis of variance (ANOVA) to examine the differences between the fruits, using Statistica vers. 7 (StatSoft, Inc., Tulsa, USA). The pairwise comparisons between different parameters were carried out using Duncan's test ($P < 0.05$). An overall antioxidant potency composite index was calculated by assigning all assays an equal weight, assigning the index value of 100 to the best score for each test, and then calculating an index score for all other samples within the test as follows: antioxidant index score = [(sample score/best score) × 100]; the average of both tests (ABTS and DPPH) for each fruit species was then taken for the antioxidant potency composite index (Seeram *et al*. 2008).

RESULTS AND DISCUSSION

Total phenolic content and antioxidant activity. The dry matter content of fruit species tested ranged from 70.1% (dried plums) to 88.6% (dried amber dark grapes). The average amount of total phenolics of dried and candied fruits mostly consumed in Serbia was as follows: dried chokeberries > dried bilberries > dried plums > candied cherries, dried apricot > dried grapes (amber light) > candied cranberries, dried figs, dried grapes (amber dark), candied dates (Table 1).

Table 1. Dry matter, total phenolic contents (mg/100 g DM), free radical scavenging parameters (ABTS and DPPH assays), and the antioxidant potency of dried and candied fruit species

Fruit	Dry matter (%)	Total phenolics (mg/100 g DM)	ABTS (mmol/100 g DM)	DPPH (μmol/100 g DM)	ABTS index	DPPH index	Antioxidant potency composite index
Dried							
Plums	70.11 ± 0.88	564.72 ± 8.19^{c}	2.913 ± 0.139^{c}	503.65 ± 9.52^{c}	13.6	23.6	18.35 ± 0.11^{b}
Apricots	76.70 ± 0.22	467.43 ± 8.62^{d}	1.377 ± 0.101^{e}	317.56 ± 25.39^{e}	6.4	14.9	10.49 ± 0.47^{d}
Figs	81.57 ± 0.17	195.33 ± 1.07^{f}	0.388 ± 0.042 g	129.55 ± 11.26^{g}	1.8	6.1	3.76 ± 0.35^{f}
Grapes (amber light)	85.76 ± 0.12	400.37 ± 26.17^{e}	2.188 ± 0.074 d	264.56 ± 8.77^{ef}	10.2	12.4	11.17 ± 0.30^{d}
Grapes (amber dark)	88.60 ± 0.30	174.70 ± 8.09^{f}	0.648 ± 0.074^{fg}	152.53 ± 5.75^{g}	3.0	7.2	5.00 ± 0.19^{ef}
Chokeberries	79.35 ± 0.20	2995.20 ± 42.28^{a}	21.378 ± 0.032^{a}	1815.08 ± 91.63^{b}	100.0	85.2	91.52 ± 2.16^{a}
Bilberries	85.60 ± 0.03	2592.24 ± 64.14^{b}	17.996 ± 0.524^{b}	2130.23 ± 45.91^{a}	84.2	100.0	90.84 ± 0.25^{a}
Candied							
Cranberries	84.34 ± 0.13	197.30 ± 3.74^{f}	0.835 ± 0.119^{f}	139.80 ± 20.93^{g}	3.9	6.6	5.15 ± 0.75^{e}
Cherries	82.55 ± 0.16	497.37 ± 18.40^{d}	3.038 ± 0.145^{c}	254.64 ± 7.10^{f}	14.2	12.0	12.93 ± 0.25^{c}
Dates	80.63 ± 0.01	167.51 ± 4.73^{f}	0.621 ± 0.053^{fg}	388.98 ± 11.39^{d}	2.9	18.3	10.36 ± 0.37^{d}
ANOVA	*	***	***	***			***

Values with a different letters in columns denote statistically significant differences (Duncan's test, $P < 0.05$); ^{ns}not significant; $^{*}P < 0.05$; $^{**}P < 0.01$; $^{***}P < 0.001$; antioxidant potency composite index = [(sample score/best score) × 100], averaged for both antioxidant tests (ABTS and DPPH) for each fruit species

The order of antioxidant potency composite index showed a very similar trend as the total phenolics content: dried chokeberries, dried bilberries > dried plums > candied cherries > dried grapes (amber light), dried apricots, candied dates > candied cranberries, dried grapes (amber dark) > dried figs (Table 1). Furthermore, significant correlations between total phenolics content and ABTS assay ($R = 0.9978$, $P < 0.001$), total phenolics content and DPPH assay ($R = 0.9716$, $P < 0.001$), and total phenolics content and antioxidant potency composite index ($R = 0.9931$, $P < 0.001$) were observed. Generally, it is known that total phenolics are highly correlated with antioxidant capacity (Diamanti *et al.* 2012).

Dried chokeberries and dried bilberries' overall antioxidant indices, as well as total phenolics contents (2995 and 2592 mg/100 g DM, respectively) were up to 80% higher than those of any other fruit species tested (Table 1). Only a few studies have investigated the chemical composition of dried chokeberries and dried bilberries. Tumbas *et al.* (2010) obtained distinctly higher total phenolic content of dried fruits of bilberry (273 mg/g DM) compared to our results. Michalczyk *et al.* (2009) reported total phenolics content of 525–905 mg/100 g fresh weight (FW) in dried bilberries.

Vinson *et al.* (2005) investigated the amount and quality of phenol antioxidants in commercial samples of fresh and dried fruits (apricots, cranberries, dates, figs, grapes, plums), and observed that dates have the highest concentration of phenolics among the dried fruits (2129 mg/100 g DM), followed by dried plums (1012 mg/100 g DM), dried cranberries (889 mg/100 g DM), dried grapes (592 mg/100 g DM), dried apricots (479 mg/100 g DM), and dried figs (360 mg/100 g DM). In our study, similar levels of phenolics were obtained for dried plums (565 mg/100 g DM), dried apricots (467 mg/100 g DM), dried figs (195 mg/100 g DM), and dried grapes (400 mg/100 g DM). On the contrary, dictinctly lower phenolics contents were obtained for candied cranberries (197 mg/100 g DM), and candied dates (168 mg/100 g DM).

Total phenolics content of dried dates (195 mg/100 g DM) was found to be higher than that previously reported (Al-Farsi *et al.* 2005; Vallejo *et al.* 2012). Total phenolics content in candied cherries was found to be 497 mg/100 g DM, which is in a good agreement with that given by Juhnevica *et al.* (2011), who investigated the suitability of different sour cherry cultivars for processing, and obtained total phenolics content of 257–657 mg/100 g candied cherries.

The main dietary sources of phenolics are fruits and fruit products (juices, jams, dried fruits), vegetables, cereals, plant-derived beverages (tea, coffee, wine), chocolate, etc. Regarding the recommended daily intakes (RDI), the recommendations made by the companies selling various nutritional supplements rich in phenolics give the range from 50 mg/day to

Table 2. Consumption of dried and candied fruits needed to meet RDI of phenolics

	Average mass of single dried fruit (g)	Total phenolics (mg/100 g dried fruit)	Mass of dried fruits needed to meet RDI of 500–1000 mg/day (g)	Pieces of dried fruits needed to meet RDI of 500–1000 mg/day
Dried				
Plums	5.85 ± 0.96	805.48 ± 11.69	62–124	11–21
Apricots	5.27 ± 0.58	609.43 ± 11.24	82–164	16–31
Figs	5.35 ± 0.67	239.46 ± 1.31	209–418	39–78
Grapes (amber light)	0.33 ± 0.05	466.85 ± 30.52	107–214	325–648
Grapes (amber dark)	0.34 ± 0.05	197.18 ± 9.13	254–507	746–1492
Chokeberries	0.19 ± 0.03	3774.67 ± 53.28	13–26	72–143
Bilberries	0.051 ± 0.007	3028.32 ± 74.93	17–33	324–647
Candied				
Cranberries	0.55 ± 0.04	233.93 ± 4.44	214–427	389–777
Cherries	0.96 ± 0.14	602.51 ± 22.29	83–166	86–173
Dates	5.04 ± 0.94	207.75 ± 5.87	241–481	48–96

1800 mg/day (Mennen *et al.* 2005). Using the data from the United States Department of Agriculture (USDA), the RDI of phenolics from five-a-day servings is > 500 mg/day. This value can be easily increased by 500–1000 mg (Williamson & Holst 2008). Accepting the RDI value from 500 to 1000 mg/day, the amounts of dried or candied fruits that one should consume in order to meet the RDI of phenolics are presented in Table 2. The values given are related only to the samples examined in this study. Dried chokeberries and dried bilberries have the highest amounts of phenolics (3774 and 3028 mg/100 g dried fruit, respectively) and, consequently, their lowest amounts are needed for the consumption in order to meet the RDI of phenolics (13–26 and 17–33 g, respectively). On the other hand, with their lowest amount of phenolics, the highest amount of dried grapes (amber dark) is needed (254–507 g).

Flavonols, phenolic acids, and anthocyanins. The contents of individual flavonols, phenolic acids, and anthocyanins in dried and candied fruits, separated and identified by high-performance liquid chromatography (HPLC), are presented in Table 3. A considerable variation was found in phenolic compounds of different fruits. The separation of the following compounds occurred in the order listed (with the retention times given in parenthesis): gallic acid (4.5 min), chlorogenic acid (11.0 min), vanillic acid (13.5 min), caffeic acid (13.8 min), delphinidin (16.2 min), cyanidin (18.4 min), *p*-coumaric acid (18.7 min), ellagic acid (19.7 min), pelargonidin (20.3 min), ferulic acid (20.0 min), rosmarinic acid (22.2 min), myricetin (22.5 min), quercetin (25.2 min), and kaempferol (27.8 min). The HPLC chromatogram of the dried bilberry sample is shown in Figure 2, satisfactory separation of all peaks having been clearly achieved.

Quercetin was found in all samples analysed. The highest concentration of quercetin was found in dried chokeberries (42 mg/100 g DM), followed by dried bilberries (25 mg/100 g DM), and dried apricots (13 mg/100 g DM). Other fruit species revealed a lower quercetin content (1.5–4.5 mg/100 g DM). Since the concentration of quercetin, as a strong antioxidant (Rice-Evans *et al.* 1996), was the highest in dried chokeberries and dried bilberries, it is not surprising that the antioxidant capacities in these two dried fruit species are highly emphasised. Kaempferol was identified in dried plums, dried figs, dried grapes (amber light), dried grapes (amber dark), and dried chokeberries, while myricetin was detected only in dried bilberries and candied cranberries.

As for the phenolic acids, gallic acid was identified in all samples except in candied cranberries. The highest concentration was found in candied cherries (75 mg/100 g DM), and the lowest in dried chokeberries (3.1 mg/100 g DM). A high concentration of chlorogenic acid was detected in dried chokeberries and dried bilberries (58 and 25 mg/100 g DM, respectively). Other fruit species (dried plums, dried apricots, and candied cherries) contained lower chlorogenic acid levels (up to 5.6 mg/100 g DM). Candied cranberries and candied dates had no detectable amounts of *p*-coumaric acid, while other fruit species had comparable contents (1.3–7.3 mg/100 g DM). Ellagic acid was detected only in bilberries and

Table 3. Concentration of individual flavonols, phenolic acids and anthocyanins (mg/100 g DM) in dried and candied fruit species

Fruit	Myricetin	Quercetin	Kaempferol	Acid							Delphinidin	Cyanidin	Pelargonidin
				gallic	chlorogenic	vanillic	caffeic	*p*-coumaric	ellagic	ferulic	rosmarinic			
Dried														
Plums	nd	2.77 ± 0.01	0.93 ± 0.01	21.38 ± 0.02	3.47 ± 0.06	nd	nd	3.21 ± 0.02	nd	nd	3.40 ± 0.01	nd	1.08 ± 0.01	0.22 ± 0.01
Apricots	nd	13.14 ± 0.11	nd	39.58 ± 2.39	5.63 ± 0.13	nd	10.29 ± 0.27	1.35 ± 0.31	nd	nd	nd	nd	0.38 ± 0.01	nd
Figs	nd	4.48 ± 0.05	0.89 ± 0.01	67.01 ± 0.53	nd	nd	nd	2.32 ± 0.19	nd	nd	nd	nd	1.19 ± 0.01	nd
Grapes (amber light)	nd	3.78 ± 0.10	1.49 ± 0.01	70.79 ± 0.33	nd	0.60 ± 0.01	nd	6.65 ± 0.07	nd	2.44 ± 0.01	1.73 ± 0.01	nd	1.17 ± 0.01	nd
Grapes (amber dark)	nd	1.97 ± 0.01	1.10 ± 0.01	72.17 ± 0.23	nd	0.36 ± 0.01	nd	5.01 ± 0.01	nd	0.81 ± 0.01	1.70 ± 0.03	nd	1.14 ± 0.01	nd
Chokeberries	nd	42.28 ± 0.17	1.12 ± 0.01	3.15 ± 0.01	58.23 ± 1.02	nd	nd	7.33 ± 0.06	nd	nd	nd	nd	387.43 ± 0.57	8.88 ± 0.13
Bilberries	7.60 ± 0.23	24.87 ± 0.35	nd	25.40 ± 0.12	25.05 ± 0.47	nd	nd	6.84 ± 0.04						
Candied														
Cranberries	0.23 ± 0.01	2.18 ± 0.01	nd	nd	nd	1.05 ± 0.05	nd	nd	0.55 ± 0.01	nd	nd	404.63 ± 0.67	337.50 ± 0.06	200.05 ± 0.22
Cherries	nd	1.86 ± 0.01	nd	75.41 ± 0.47	2.41 ± 0.19	nd	nd	5.19 ± 0.01	nd	nd	nd	nd	5.17 ± 0.03	nd
Dates	nd	1.48 ± 0.02	nd	58.63 ± 0.33	nd	nd	nd	nd	2.90 ± 0.01	nd	nd	nd	26.16 ± 0.04	0.25 ± 0.01

nd – not detected

candied cherries, while the caffeic acid was found only in dried apricots (10 mg/100 g DM). The content of ferulic acid was up to 2.4 mg/100 g DM in dried grapes (amber light), and it was also detected in dried grapes (amber dark), and candied dates. Vanillic acid content was up to 1.1 mg/100 g DM in candied cranberries, which is slightly higher than those in dried grapes (amber light) and in dried grapes (amber dark) containing up to 0.36 and 0.60 mg/100 g DM, respectively, while the content of rosmarinic acid was up to 3.4 mg/100 g DM in dried plums, which is slightly higher than dried grapes (amber light) and dried grapes (amber dark) containing up to 1.7 mg/100 g DM.

Regarding the anthocyanins, cyanidin was detected in all fruit samples tested. Cyanidin was the major anthocyanin in dried chokeberries, dried bilberries, and candied cherries with concentrations of up to 387, 337, and 26 mg/100 g DM, respectively. Other fruit species contained cyanidin in the range of 1.1–5.2 mg/100 g DM. The highest amount of pelargonidin was found in dried chokeberries, i.e. 8.9 mg/100 g DM, and moderate amounts of up to 0.22 and 0.25 mg/100 g DM, respectively, were found in dried plums and candied cherries. Delphinidin was found only in dried bilberries in the amount of 405 mg/100 g DM. All these results are summarised in Table 3.

As mentioned above, the drying procedures and genotypes of dried and candied fruits remain completely unknown to us. Under these circumstances is it very difficult to make any kind of comparison with the published reports. Nevertheless, it is noteworthy to mention certain citations. Madrau *et al.* (2010) analysed dried plums obtained by drying fruits of the President cultivar at 60 and 85°C. Chlorogenic acid content was found to be 3.53 mg/100 g DM (drying at 60°C), and 7.67 mg/100 g DM (drying at 85°C), while the *p*-coumaric acid content was 0.42 mg/100 g DM (drying at 60°C), and 1.55 mg/100 g DM (drying at 85°C). These values are in a good agreement with the results obtained in this study (Table 3). On the other hand, Caro *et al.* (2004) examined the main chemical parameters and phenolics contents of two varieties of dried plums (cvs President and Sugar), dried by standard high-temperature (85°C) and low-temperature (60°C) procedures, and obtained quite a high content of chlorogenic acid compared to our samples. On the contrary, dried plums cvs President and Sugar and dried plums in our study revealed comparable *p*-coumaric acid contents.

Dried apricots contained chlorogenic acid in the concentration of 5.63 mg/100 g DM which is rath-

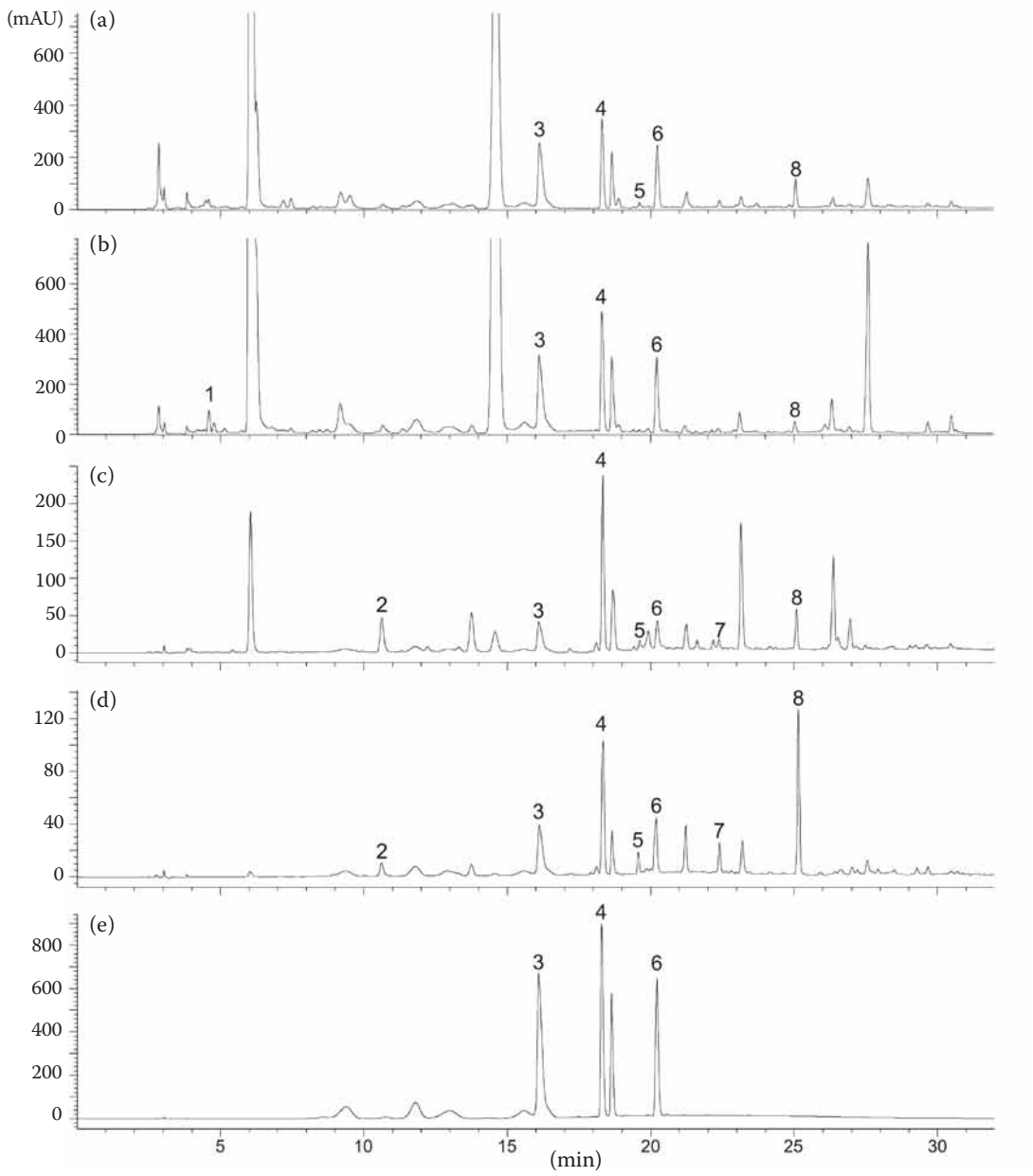


Figure 2. HPLC chromatogram of dried bilberries detected at 260 nm (a), 280 nm (b), 329 nm (c), 360 nm (d), and 520 nm (e)

Peaks identifications: 1 – gallic acid; 2 – delphinidin; 3 – cyanidin; 4 – ellagic acid; 5 – pelargonidin; 6 – myricetin; 7 – quercetin

er lower than thatt given in a previous report of 37 mg/100 g DM for the apricot cv. Cafona dried at 75°C (Madrau *et al.* 2009). On the other hand, the apricot fruits cv. Pelese showed a different behaviour than Cafona apricots, as chlorogenic acid was completely destroyed by the drying process.

Zhao and Hall III (2008) determined the contents of phenolics in Thompson seedless dried grapes depending on the extraction solvent. The highest contents obtained of gallic acid, ferulic acid, and kaempferol were 12.30, 0.979, and 31.65 mg/100 g, respectively. Comparing to our results, gallic acid content was higher (0.22–12.30 mg/100 g DM), while kaempferol concentration was lower (1.10–1.49 mg/100 g DM) than those reported by Zhao and Hall III (2008). On the other hand, the content of ferulic acid was in a good agreement (0.81–2.44 mg/100 g).

CONCLUSION

Seven dried and three candied fruit species, commonly consumed and commercially available in local grocery stores in Serbia, were analysed for total phe-

nolics content and antioxidant capacity. Significant correlation between total phenolics content and antioxidant potency composite index (R = 0.9931, P < 0.001) was observed. Regarding the highest levels of phenolics content and antioxidant capacity, dried chokeberries and dried bilberries are strongly distinguishable from other fruit species analysed. High performance liquid chromatography revealed significant contents of the selected flavonols, phenolic acids, and anthocyanins, present in dried and candied fruits. Health aspect consequently arises from the analyses performed. Regarding the recommended daily intake of phenolics (500–1000 mg/day), it was concluded that among all the fruits tested, the lowest amounts of dried chokeberries and dried bilberries are required for consumption in order to meet the RDI of phenolics.

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