Available online at www.sciencedirect.com
ScienceDirect
Food Chemistry 104 (2007) 1379–1384
Food Chemistry
www.elsevier.com/locate/foodchem

Chemical composition of fruits in some rose (*Rosa* spp.) species

Sezai Ercisli *

Department of Horticulture, Faculty of Agriculture, Ataturk University, 25240 Erzurum, Turkey

Received 27 October 2006; received in revised form 8 December 2006; accepted 30 January 2007

Abstract

Fruits of *Rosa canina*, *Rosa dumalis* subsp. *boissieri*, *Rosa dumalis* subsp. *antalyensis*, *Rosa villosa*, *Rosa pulverulenta* and *Rosa pisiformis* were assayed for total phenolics, ascorbic acid, total soluble solids, total dry weight, total fat, fatty acids, pH, acidity, moisture, fruit colour and macro- and micro-elements. The highest total phenolic content was observed in *Rosa canina* (96 mg GAE/g DW). *Rosa dumalis* subsp. *boissieri* had the highest total fat content (1.85%), followed by *Rosa pulverulenta* (1.81%) and *Rosa canina* (1.78%), respectively. Nine major fatty acids were determined in rose species and α-linolenic acid was found to be dominant for all species. Total soluble solids, total dry weight, moisture and ascorbic acid contents of rose species varied from 29.42% (*Rosa villosa*)–37.33% (*Rosa dumalis* subsp. *boissieri*), 33.85% (*Rosa villosa*)–40.35% (*Rosa dumalis* subsp. *boissieri*), 59.65% (*Rosa dumalis* subsp. *boissieri*)–66.15% (*Rosa villosa*) and 727 mg/100 g FW (*Rosa villosa*) and 943 mg/100 g FW (*Rosa dumalis* subsp. *boissieri*), respectively. Nitrogen and mineral compositions of the rose species, e.g., N, P, K, Ca and Mg, were (averagely): 1.26%, 513 mg/100 g DW, 639 mg/100 g DW, 196 mg/100 g DW and 114 mg/100 g DW, respectively. The present study shows that the native rose genotypes are extremely rich sources of phenolics, carbohydrates and ascorbic acid, demonstrating their potential use as a food or food additive.

Keywords: *Rosa* species; Fruit chemical contents; Minerals; Fatty acids; Phenolics

1. Introduction

The relationship between food and health becomes increasingly significant as consumers now demand healthy, tasty and natural functional foods, that have been grown in uncontaminated environments. There is a desire for a wide variety of choice and willingness to pay more for such foods in order to maintain a healthy, well-balanced diet.

Members of the *Rosaceae* family have long been used for food and medicinal purposes. The physiological functions of *Rosaceae* fruits may be partly attributed to their abundance of phenolics. Phenolics possess a wide spectrum of biochemical activities, such as antioxidant, antimutagenic, anticargionogenic effects, as well as ability to modify gene expression (Nakamura, Watanabe, Miyake, Kohno, & Osawa, 2003; Tapiero, Tew, Ba, & Mathe, 2002). Deep-coloured fruits are good sources of phenolics, including flavonoids, anthocyanins and carotenoids (Cieslik, Greda, & Adamus, 2006; Qian, Liu, & Huang, 2004; Sass-Kiss, Kiss, Milotay, Kerek, & Toth-Markus, 2005; Trappey, Bawadi, Bansode, & Losso, 2005). As a small fruit group, rose hips are very rich in phenolics (Olsson, Andersson, Werlemark, Uggla, & Gustavsson, 2005).

Another healthy function of fruits is their essential fatty acid composition that humans cannot synthesize, and must obtain through diet. Essential fatty acids are long chain polyunsaturated fatty acids derived from linolenic, linoleic and oleic acids. These chemicals regulate numerous body functions, including blood pressure, blood viscosity, immune and inflammatory responses (Pawlosky, Ward, & Salem, 1996; Simopoulos & Salem, 1996).

The genus *Rosa* contains over 100 species that are widely distributed in Europe, Asia, the Middle East and North America (Nilsson, 1997). These deciduous shrubs are widely grown in gardens for their flowers and fruits. The

* Tel.: +90 442 2312599.
E-mail address: sercisli@hotmail.com

0308-8146/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.foodchem.2007.01.053

plants show strong resistance to hard environmental conditions (rocky, inclined places, poor soils and limiting water).

Turkey is one of the most important germplasm centres for rose species. Twenty five rose species (about 25% of all rose species) have so far been reported to grow in Turkey (Kutbay & Kilinc, 1996). Although these 25 species are widely spread throughout the country from sea level to altitudes as high as 3000 m, the eastern and middle Anatolia region has the largest native rose population which has arisen from seeds (Ercisli, 2004). Therefore the country is almost a 'native rose museum' of seedling shrubs, mainly from *Rosa canina*, *Rosa dumalis*, *Rosa villosa* and *Rosa pulverulenta* (Ercisli & Guleryuz, 2005). In most parts of Anatolia, fruits (rose hips) of roses have been gathered from scattered sites by peasants since ancient times, as a food (Ercisli, 2005).

Flowers of some rose species, such as *Rosa gallica* and *Rosa damascena*, have been used for 'attar of roses' and 'rose water' production in Anatolia. Turkey also has growing conditions suitable for cultivating high quality rose hips. Rose hips have economic value and are also used for medicinal purposes. In Turkey, the rose has wide use for many purposes and several special traditional products, such as 'rose hip marmalade', 'rose hip pestil' and 'rose hip syrup', made with rose hips, and 'rose hip tea', made with both fruit and roots. (Ercisli & Guleryuz, 2005).

Rose hips are well known for their efficacy in strengthening the body's defence against infection, and particularly the common cold. The fruits, leaves and even roots are boiled in water and used as diuretics and as ingredients in common cold remedies in Turkey (Sen & Gunes, 1996).

Rose hips are also well known to have the highest vitamin C content (300–4000 mg/100 g) among fruits and vegetables. In addition, rose hips contain other vitamins and minerals, carotenoids, tocopherol, bioflavonoids, fruit acids, tannins, pectin, sugars, organic acids, amino acids and essential oils (Chai & Ding, 1995; Demir & Ozcan, 2001; Kadakal, Nas, & Artik, 2002; Uggla, Gao, & Werlemark, 2003; Uggla, Gustavsson, Olsson, & Nybom, 2005). These compounds play an important role in maintaining fruit quality and determining nutritive value. In general, in many rose-growing countries, the fruit is found in natural habitat without chemical fertilizer or irrigation application. Therefore, Turkey is favoured with one of the most important natural fruits (Sen & Gunes, 1996).

It has previously been demonstrated that a wide diversity of phytochemicals exists within *Rosa* genera (Olsson et al., 2005; Uggla et al., 2005). Furthermore, accumulating evidence, suggests that genotype or specie may have a profound influence on the content of bioactive compounds in small fruits (Anttonen & Karjalainen, 2005). In addition, *Rosa* is a wide genus and each rose- growing country has its own endemic rose species. Among species studied in this research, *Rosa pisiformis* and *Rosa dumalis* subsp. *antalyensis* are endemic to Turkey. However, to the best of our knowledge, few data exist regarding fruit properties of endemic Rose species in Turkey. In this study we used six rose species originating from Turkey which have not been studied in detail before.

2. Materials and methods

2.1. Collection and preparation of fruit samples

Fruit samples were collected at the ripe stage from selected ERZ 1 (*Rosa canina*), ERZ 3 (*Rosa dumalis* subsp. *boissieri*), ERZ 4 (*Rosa dumalis* subsp. *antalyensis*), ERZ 5 (*Rosa villosa*), ERZ 9 (*Rosa pisiformis*) and ERZ 12 (*Rosa pulverulenta*) clones from Erzurum, Turkey, in 2005. The fruits were selected according to uniformity of shape and colour. The fruits were then stored in polyethylene bags at −20 °C (up to 1 month) prior to analysis.

2.2. Determination of fruit colour, total soluble solids, total dry weight, pH and acidity

Fruits sampled from shrubs of six *Rosa* species and 100 fruits from each species were used for analyses. All analyses for each species were performed on these 100 fruit samples. Analyses are based on fruit flesh. Seeds are not included in the analyses. Skin colours of rose hips were measured by using a CR-400 chromometer (Konica Minolta, Japan) and measurements recorded as L, a and b values. Colour values for each fruit were computed as means of three measurements taken from opposite sides at the equatorial region of the fruit (Ertekin, Gozlekci, Kabas, Sonmez, & Akinci, 2006). Total dry matter of the fruits was determined according to the methods of AOAC (1984). Total soluble solid contents (TSS) were determined by a digital refractometer (Kyoto Electronics Manufacturing Co. Ltd., Japan, Model RA-250HE) at 22 °C. The pH measurements were made using a digital pH meter (WTW, Germany) calibrated with pH 4 and 7 buffers. Total acidity was measured by the titrimetric method (AOAC, 1984) and expressed as % citric acid.

2.3. Determination of total fat and fatty acid content

Total fat was extracted with n-hexane (60 °C) for 6 h using a Soxhlet extractor and fatty acid composition was analyzed according to a previous method (Anonymous, 2000). Fatty acids were designated (e.g., C18:1 ω9) so that the figures represented, from left to right, the total number of carbon atoms (i.e., 18), the number of double bonds (i.e., 1), the position of the double bond from the ω end of the fatty acyl chain (i.e., ω9).

2.4. Determination of ascorbic acid and total phenolic contents

The amount of ascorbic acid of the rose hips was determined according to the methods of AOAC (1984). Total phenolic contents of rose hips were determined by the Folin–Ciocalteu method (Meda, Lamien, Romito, Mil-

logo, & Nacoulma, 2005). Briefly, aliquots of 0.1 g of lyophilized powder of fruit samples were dissolved in 1 ml of deionized water. This solution (0.1 ml) was mixed with 2.8 ml of deionized water, 2 ml of 2% sodium carbonate (Na_2CO_3), and 0.1 ml of 50% Folin–Ciocalteau reagent. After incubation at room temperature for 30 min, the absorbance of the reaction mixture absorbance was measured at 750 nm against a deionized water blank on a spectrophotometer (Thermo, Model Nicolet 100 UV–Vis). Gallic acid (GA) was chosen as a standard. Using a seven point standard curve (0–200 mg/l), the total phenolic contents in rose hips were determined and results expressed as mg gallic acid equivalents (GAE) g^{-1} dry weight (DW).

2.5. Determination of nitrogen and mineral elements

Total N was determined by the micro-Kjeldahl method (James, 1995). In order to determine the mineral composition of rose hips, samples were burned with a nitric acid and perchloric acid solution, on the hot plate, at 200 °C. Then, the absorbance of the extract was measured by the atomic absorption spectrophotometer. The amounts of minerals were calculated with a standard curve of each element. Phosphorus content of the extract, however, was analyzed by determining the absorbance of the yellow colour, obtained from the Barton reaction, using a spectrophotometer (Thermo, Nicolet 100, UV) at 680 nm, and comparing the results to the standard curve (James, 1995).

2.6. Statistical analysis

The experiment was a completely randomized design with four replications. Data were subjected to analysis of variance (ANOVA) and means were separated by Duncan multiple range test at the $P < 0.05$ significant level.

3. Results and discussion

3.1. Fruit colour, total soluble solids, total dry weight, pH and acidity in the rose hips

The fruit colour, TSS (total soluble solids), TDW (total dry weight), pH and acidity of fruits of rose species are given in Table 1. Significant differences in those parameters among different species were recorded (Table 1).

The fruit colour of rose species were determined as *L* value 48.06 (*Rosa canina*) and 52.02 (*Rosa villosa*), *a* value 40.69 (*Rosa dumalis* subsp. *boissieri*) and 43.31 (*Rosa dumalis* subsp. *antalyensis*) and *b* values 39.39 (*Rosa canina*) and 47.73 (*Rosa villosa*), respectively (Table 1). The *L* values of rose species were previously determined to be between 40 and 51 (Uggla et al., 2005) which are close to our results.

Total soluble solids content of rose species varied from 29.42% to 37.33% and statistically significant variation was observed among the species (Table 1). *Rosa dumalis* subsp. *boissieri* had the highest TSS content (37.33%) in its fruits, followed by *Rosa pulverulenta* (35.44%) and *Rosa dumalis* subsp. *antalyensis* (34.01%), respectively. Total dry weight content of rose species were found to be between 33.85% and 40.35% (Table 1). Parallel to TSS content, *Rosa dumalis* subsp. *boissieri* had the highest TDW content (40.35%), followed by *Rosa pulverulenta* (39.21%). Overall *Rosa villosa* had the lowest TSS (29.42%) and TDW contents (33.85%) among species (Table 1).

There is some evidence that TSS contents of rose species mainly from *Rosa canina*, *Rosa dumalis*, *Rosa pulverulenta* and *Rosa villosa*, which are grown in different agro-climatic regions in Turkey, vary from 14.0% to 40.0% (Demir & Ozcan, 2001; Ercisli, 1996; Kazankaya, Koyuncu, & Balta, 1999; Misirli, Guneri, & Gulcan, 1999; Sen & Gunes, 1996). Our results, in general, were within the limits of these studies. The variation of TSS in rose fruits may be due to different species, types, environmental conditions and nutritional status of orchards. Uggla et al. (2003) previously reported that TDW content varied among rose species (21.7%–34.0%) and, similarly to our study, they found that *Rosa dumalis* had the highest TDW value, while *Rosa villosa* had a lower TDW value than the other species.

In general, rose hips are used for the processing industry to obtain different products, such as jam, jelly and marmalade. Higher TSS and TDW content are desirable fruit characteristics of rose hips and both characteristics are strongly affected by altitude (Ercisli, 1996). According to the results, fruits of *Rosa dumalis* subsp. *boissieri* and *Rosa pulverulenta* were higher TSS and TDW contents than were the other species, suggesting that these species may be better sources for processing.

In the studied species, the acidity and pH varied from 0.91% (*Rosa villosa*) to 2.04% (*Rosa canina*) and 4.07 (*Rosa*

Table 1
Fruit colour, pH, TAc (total acidity), TSS (total soluble solid) and TDW (total dry weight) contents of rose species

Species	Fruit colour			pH	TAc (%)	TSS (%)	TDW (%)
	L	*a*	*b*				
Rosa canina	48.06	41.70ab	39.39a	4.07b	2.04a	33.26b	38.00a
Rosa dumalis subsp. *boissieri*	50.01	40.69a	40.09b	4.33ab	1.18b	37.33a	40.35a
Rosa dumalis subsp. *antalyensis*	49.78	43.31b	41.85b	4.30ab	1.34b	34.01b	36.14b
Rosa villosa	52.02	41.85ab	47.73b	4.73a	0.91c	29.42c	33.85b
Rosa pisiformis	51.14	41.25ab	43.33b	4.58ab	1.26b	31.89c	36.42b
Rosa pulverulenta	51.32	42.33ab	44.85b	4.43ab	1.43b	35.44b	39.21a

Values in the same column with different lower-case letters are significantly different at $P < 0.05$.

canina)–4.73 (*Rosa villosa*), respectively (Table 1). Acid contents of rose species were previously reported to be between 0.3% and 5.0% (Ercisli, 1996; Kovacs, Facsar, Laszlo, & Toth, 2004; Sen & Gunes, 1996). Demir and Ozcan (2001) reported that pH values of rose hips were between 4.34 and 5.12, in accordance with our results.

3.2. Total fat and fatty acid composition of rose hip fruits

The total fat contents of the rose species were found to be between 1.52% (*Rosa villosa*) and 1.85% (*Rosa dumalis* subsp. *boissieri*), respectively (Table 2). *Rosa dumalis* subsp. *boissieri*, which had the lowest moisture content, had the highest total fat (1.85%) among all rose species, followed by *Rosa pulverulenta* (1.81%) and *Rosa canina* (1.78%) (Table 2). Our data indicate that rose species influences total fat content.

Fatty acid analysis showed that rose species studied contained nine major compounds and a great variation of fatty acids was found among species (Table 2). The major fatty acid (averagely) in rose species was α-linolenic acid, followed by palmitic and linoleic acids (Table 2). It is well known that α-linolenic and linoleic acids are two essential fatty acids that humans require. Total peak areas of the mentioned fatty acids were between 86.88% in *Rosa pisiformis* and 97.01% in *Rosa pulverulenta*, respectively (Table 2). 23:0 and 21:1 ω5c are only detected in *Rosa villosa* and *Rosa dumalis* subsp. *boissieri*, respectively (Table 2). The other rose species had no 23:0 and 21:1 ω5c in their fruits. In addition, lauric acid (12:0), was only found in *Rosa canina* and *Rosa pisiformis* and 22:2 ω6c was only found in *Rosa canina* and *Rosa dumalis* subsp. *antalyensis* (Table 2). All species had palmitic (16.4%–26.6%) and α-linolenic acid (33.8%–49.7%), respectively, (Table 2).

Parry et al. (2005) reported that α-linolenic acid was the dominant fatty acid in marionberry, boysenberry, red raspberry and blueberry fruits. Cakir (2003) revealed that sea buckthorn fruits were rich in palmitic and palmitoleic acids. Szentmihalyi, Vinkler, Lakatos, Illes, and Then (2002) showed that the dominant fatty acids in rose hip seeds were linoleic and α-linolenic acids. Johansson, Laakso, and Kallio (1997) screened seed oil fatty acids of 22 common edible berry species and found that, typically, the most abundant fatty acids were linoleic, α-linolenic, oleic and palmitic acids. All those data support our findings. Difference between fatty acid compositions may be due to different phases of biosynthesis of those compounds and the stages of biosynthesis and accumulated of fatty acids.

The fatty acid compounds contribute to the flavour of rose hips, which has a distinct taste rather than aroma. According to literature searched, there is no study on fatty acid content of rose hip flesh. Thus, our fatty acid results may be the first study to provide data that the rose hips possess fatty acids.

3.3. Ascorbic acid and total phenolics in rose hips

The ascorbic acid and total phenolic contents of rose hips are given in Table 3. Ascorbic acid contents of the rose species were found to be 727 mg/100 ml (*Rosa villosa*) and 943 mg/100 ml (*Rosa dumalis* subsp. *boissieri*), respectively, (Table 3). These values are much higher than those reported in other vitamin C-rich small fruits (Pantelidis, Vasilikakis, Manganaris, & Diamantidis, 2007). In previous studies conducted in Turkey, the ascorbic acid content of rose hips was found to range from 140 to 1100 mg/100 ml (Kazankaya et al., 1999; Misirli et al., 1999). Our findings are in agreement with these reports. Total phenolic contents of the rose

Table 3
Ascorbic acid and total phenolic contents of *Rosa* species

Species	Total phenolics (mg GAE/g DW)	Ascorbic acid (mg/100 ml)
Rosa canina	96a	880b
Rosa dumalis subsp. *boissieri*	84b	943a
Rosa dumalis subsp. *antalyensis*	85b	864b
Rosa villosa	73c	727d
Rosa pisiformis	79b	811c
Rosa pulverulenta	94a	923a

Values in the same column with different lower-case letters are significantly different at $P < 0.05$.

Table 2
Total fat (%) and fatty acid contents (%) of rose species

Fatty acid	Fatty acid content (% of total fat)					
	Rosa canina	*Rosa dumalis* subsp. *boissieri*	*Rosa dumalis* subsp. *antalyensis*	*Rosa villosa*	*Rosa pisiformis*	*Rosa pulverulenta*
12:0	4.80	0.00	0.00	0.00	3.58	0.00
16:0	16.4b	24.4a	25.6a	26.6a	19.6b	19.3b
cis-C18:2 ω6	16.0a	20.0a	0.00b	17.5a	16.1a	16.6a
cis-C18:3 ω3	40.5ab	36.6ab	33.8b	46.9a	38.0ab	49.7a
19:0	4.74b	0.00b	12.8a	0.00b	0.00b	0.00b
cis-C19:1 ω6	5.79ab	2.92ab	12.3a	0.00b	9.55ab	11.4a
cis-C21:1 ω5	0.00	4.24	0.00	0.00	0.00	0.00
cis-C22:2 ω6	6.60a	0.00b	6.83a	0.00b	0.00b	0.00b
23:0	0.00b	0.00b	0.00b	7.10a	0.00b	0.00b
Total fat (%)	1.78b	1.85a	1.66c	1.52d	1.59d	1.81a

Values in the same line with different lower-case letters are significantly different at $P < 0.05$.

Table 4
Macro- and micro-element contents of *Rosa* species

Elements	*Rosa canina*	*Rosa dumalis* subsp. *boissieri*	*Rosa dumalis* subsp. *antalyensis*	*Rosa villosa*	*Rosa pisiformis*	*Rosa pulverulenta*
N (%)	0.98c	1.22b	1.30ab	1.24b	1.35a	1.45a
P ppm (DW)	4860c	4950c	5260a	5250a	5120b	5360a
K ppm (DW)	5467c	5775c	6468b	6314b	6622b	7700a
Ca ppm (DW)	2867a	1952b	1647c	1525c	1220d	2562a
Mg ppm (DW)	1254a	1188b	1166b	1056bc	990c	1210a
Fe ppm (DW)	27b	18b	27b	27b	72a	27b
Cu ppm (DW)	27a	9b	12b	12b	12b	15b
Mn ppm (DW)	56a	16c	16c	12c	6d	24b
Zn ppm (DW)	30ab	24ab	18b	18b	42a	24ab

Values in the same line with different lower-case letters are significantly different at $P < 0.05$.

species were found to be 73 mg GAE/g DW (*Rosa villosa*) and 96 mg GAE/g DW (*Rosa canina*), respectively (Table 3). According to the results, total phenolics of rose hips are higher than black currant (3–4 mg g^{-1}), blueberry (2.70–3.50 mg g^{-1}), strawberry (1.6–2.9 mg g^{-1}) and raspberry (2.7–3.0 mg g^{-1}) (Heinonen, Meyer, & Frankel, 1998). In previous studies, the total phenolic contents of rose species were found to range from 55 to 122 mg GAE/g DW (Gao, Bjork, Trajkovski, & Uggla, 2000; Olsson et al., 2005) which is in accordance with our findings.

The results for total phenolics and ascorbic acid contents clearly show that rose hips could be the richest sources of fruit species. The great differences among the rose species in terms of phenolics and ascorbic acid contents is supposed due to genetic derivation because all plants were of the same age and ecological conditions. It is reported that plant genotype (Scalzo, Politi, Pellegrini, Mezzetti, & Battino, 2005) and cultivation site and technique (Hakkinen & Torronen, 2000) affect total phenolic content in fruit. In Turkey, and in particular in the eastern Anatolia region, local people call rose hips medicine. Our phenolics and ascorbic acid results support this idea. It is clear that phenolic acids prevailing in rose hips explain their sour-astringent taste.

3.4. Mineral elements in rose fruits

The mineral contents of rose species are shown in Table 4. Differences among the rose species were observed based on the mineral compositions (Table 4).

The N values of fruits of rose species varied from 0.98% (*Rosa canina*) to 1.45% (*Rosa pulverulanta*). In some previous studies, conducted in different part of Turkey, it was found that N contents of rose hips were between 1.10 and 1.40% (Demir & Ozcan, 2001; Kadakal et al., 2002). Our results are in accordance with above reports.

The concentrations of P and K in fruits of different rose species were significantly different ($P < 0.05$). The *P*-values varied from 4860 ppm (*Rosa dumalis* subsp. *boissieri*)–5360 (*Rosa pulverulanta*) (Table 4). In some studies conducted on rose hips, *P*-values were found between 1781 and 2200 ppm (Szentmihalyi et al., 2002), indicating lower values than our *P* result. The mineral composition of fruits depended, not only on the species or varieties, but also on the growth environment, such as soil and geographical conditions. The available P content in soils, which we did not study, could affect P uptake by fruit.

The K contents of rose hips were between 5467 ppm (*Rosa canina*) and 7700 ppm (*Rosa pulverulenta*). Kovacs et al. (2004) reported that K contents of fruits of different rose species were 4200–11900 ppm. Our K results were within these limits.

According to our data, the Ca and Mg contents of rose species varied between 1220 ppm (*Rosa pisiformis*) and 2867 ppm (*Rosa canina*) and 990 ppm (*Rosa pisiformis*) and 1254 ppm (*Rosa canina*) (Table 4). In general, our Ca content results were similar to those of Kovacs et al. (2004) and Mg content was similar to that of Szentmihalyi et al. (2002).

The Fe, Cu, Mn and Zn contents were between 18 and 72 ppm, 9 and 27 ppm, 6 and 56 ppm and 18 and 42 ppm, respectively (Table 4). Quantitative results indicated large differences among species (Table 4). Our Fe, Cu, Mn and Zn findings were close to the findings of Szentmihalyi et al. (2002) which were 20 ppm, 6 ppm, 20 ppm and 11 ppm for Fe, Cu, Mn and Zn, respectively.

Regarding the mineral contents (Table 4), the species *Rosa pulverulenta*, for the highest N, P and K contents, *Rosa canina* for the highest Ca, Mg, Cu and Mn contents and *Rosa pisiformis* for highest Fe and Zn contents were the most outstanding ones.

As a conclusion, the present study shows that the native rose species are an extremely rich source, in particular, of phenolics, carbohydrates, ascorbic acid and some minerals. The results also indicate that there is huge variation among rose species in terms of bioactive compounds. This could be useful for choice of relevant species or genotypes in future plant-breeding studies.

References

Anonymous (2000). *Sherlock microbial identification system*. Version 4 MIS operating manual, Newark, DE, USA.

Anttonen, M. J., & Karjalainen, R. O. (2005). Environmental and genetic variation of phenolics compounds in red raspberry. *Journal of Food Composition Analysis, 18*, 759–769.

AOAC (1984). *Officials methods of analysis* (14th ed.). VA, USA: Association of Official Analytical Chemist, Arlington.

Cakir, A. (2003). Essential oil and fatty acid composition of the fruits of *Hippophae rhamnoides* L. (Sea buckthorn) and *Myrtus communis* L. from Turkey. *Biochemical Systematics and Ecology, 32*, 809–816.

Chai, J. T., & Ding, Z. H. (1995). Nutrients composition of *Rosa laevigata* fruits. *Science Technology in Food Industry, 3*, 26–29.

Cieslik, E., Greda, A., & Adamus, W. (2006). Contents of polyphenols in fruit and vegetables. *Food Chemistry, 94*, 135–142.

Demir, F., & Ozcan, M. (2001). Chemical and technological properties of rose (*Rosa canina* L.) fruits grown wild in Turkey. *Journal Food Engineering, 47*, 333–336.

Ercisli, S. (1996). Selection and propagation of some rose species in Gumushane district. Ph.D. thesis, Ataturk University, p. 190 (in Turkish).

Ercisli, S. (2004). A short review of the fruit germplasm resources of Turkey. *Genetic Resources and Crop Evaluation, 51*, 419–435.

Ercisli, S. (2005). Rose (*Rosa* spp.) germplasm resources of Turkey. *Genetic Resources and Crop Evaluation, 52*, 787–795.

Ercisli, S., & Guleryuz, M. (2005). Rose hip utilization in Turkey. *Acta Horticulturae, 490*, 77–83.

Ertekin, C., Gozlekci, S., Kabas, O., Sonmez, S., & Akinci, I. (2006). Some physical, pomological and nutritional properties of two plum (*Prunus domestica* L.) cultivars. *Journal of Food Engineering, 75*(4), 508–514.

Gao, X., Bjork, L., Trajkovski, V., & Uggla, M. (2000). Evaluation of antioxidant activities of rose hip ethanol extracts in different test systems. *Journal of the Science of Food and Agriculture, 80*, 2021–2027.

Hakkinen, S. H., & Torronen, A. R. (2000). Content of flavonols and selected phenolic acids in strawberries and *Vaccinium* species: influence of cultivar, cultivation site and technique. *Food Research International, 33*, 517–524.

Heinonen, M., Meyer, A., & Frankel, E. (1998). Antioxidant activity of berry phenolics on human low density lipoprotein and liposome oxidation. *Journal Agriculture Food Chemistry, 46*, 4107–4112.

James, G. S. (1995). *Analytical chemistry of foods*. London: Blackie Academic and Professional, pp. 117–120.

Johansson, A., Laakso, P., & Kallio, H. (1997). Characterization of seed oils of wild edible Finnish berries. *Food Research and Technology, 204*(4), 300–307.

Kadakal, C., Nas, S., & Artik, N. (2002). Kusburnu (*Rosa canina* L.) meyve ve cekirdeginin bilesimi ve insan beslenmesi acisindan onemi. *Gida*, Temmuz–Agustos, pp. 111–117 (in Turkish).

Kazankaya, A., Koyuncu, M.A., & Balta, F. (1999). Selection of rose hips naturally growing in Van lake region. In *Proceedings of 3rd national horticultural congress*, 14–17 September 1999, Ankara–Turkey, pp. 642–648.

Kovacs, S., Facsar, G., Laszlo, U., & Toth, M. (2004). Phenological, morphological characteristics of some rose species found in Hungary. *Acta Horticulturae, 690*, 71–76.

Kutbay, H.G., & Kilinc, M. (1996). Taxonomic properties of rose hip species are grown in Turkey. In *Proceedings of rose hip symposium*, Gumushane, pp. 75–83.

Meda, A., Lamien, C. E., Romito, M., Millogo, J., & Nacoulma, O. G. (2005). Determination of the total phenolic, flavonoid and praline contents in Burkina Fasan honey, as well as their radical scavenging activity. *Food Chemistry, 91*, 571–577.

Misirli, A., Guneri, M., & Gulcan, R. (1999). The phenological and pomological properties of rose hips growing in Izmir–Kemalpasa district. In *Proceedings of 3rd national horticultural congress*, Ankara–Turkey, pp. 760–764.

Nakamura, Y., Watanabe, S., Miyake, N., Kohno, H., & Osawa, T. (2003). Dihydrochalcones: evaluation as novel radical scavenging antioxidants. *Journal Agriculture Food Chemistry, 51*, 3309–3312.

Nilsson, O. (1997). Rosa. In P. H. Davis (Ed.). *Flora of Turkey and the East Aegean Islands* (Vol. 4, pp. 106–128). Edinburgh: Edinburgh University Press.

Olsson, M. E., Andersson, S., Werlemark, G., Uggla, M., & Gustavsson, K. E. (2005). Carotenoids and phenolics in rose hips. *Acta Horticulturae, 490*, 249–253.

Parry, J., Su, L., Luther, M., Zhou, K. Q., Yurawecz, M. P., Whittaker, P., et al. (2005). Fatty acid composition and antioxidant properties of cold-pressed marionberry, boysenberry, red raspberry and blueberry seed oils. *Journal of Agricultural and Food Chemistry, 53*(3), 566–573.

Pawlosky, R. J., Ward, G., & Salem, N. (1996). Essential fatty acid uptake and metabolism in the developing rodent brain. *Lipids, 31*(Suppl.), S103–S107.

Pantelidis, G. E., Vasilikakis, M., Manganaris, G. A., & Diamantidis, Gr. (2007). Antioxidant capacity, phenol, anthocyanin and ascorbic acid contents in raspberries, blackberries, red currants, gooseberries and cornelian cherries. *Food Chemistry, 102*, 777–783.

Qian, J.-Y., Liu, D., & Huang, A.-G. (2004). The efficiency of flavonoids in polar extracts of *Lycium chinense* Mill fruits as free radical scavenger. *Food Chemistry, 87*, 283–288.

Sass-Kiss, A., Kiss, J., Milotay, P., Kerek, M. M., & Toth-Markus, M. (2005). Differences in anthocyanin and carotenoid content of fruits and vegetables. *Food Research International, 38*, 1023–1029.

Scalzo, J., Politi, A., Pellegrini, N., Mezzetti, B., & Battino, M. (2005). Plant genotype affects total antioxidant capacity and phenolic contents in fruit. *Nutrition, 21*, 207–213.

Sen, S.M., & Gunes, M. (1996). Some chemical and physical properties of roses are grown in Tokat provinces in Turkey. In *Proceedings of 1st National Rose hip Conference*, 4–7 September, 1996, Gumushane–Turkey, pp. 231–239 (in Turkish).

Simopoulos, A. P., & Salem, N. (1996). Fatty acids and lipids from cell biology to Human disease. *Lipids, 31*(Suppl.), S1–S2.

Szentmihalyi, K., Vinkler, P., Lakatos, B., Illes, V., & Then, M. (2002). Rose hip (*Rosa canina* L.) oil obtained from waste hip seeds by different extractions methods. *Bioresource Technology, 82*, 195–201.

Tapiero, H., Tew, K. D., Ba, G. N., & Mathe, G. (2002). Polyphenols: do they play a role in the prevention of human pathologies? *Biomedicine and Pharmacotheraphy, 56*, 200–207.

Trappey, A., II, Bawadi, H. A., Bansode, R. R., & Losso, J. N. (2005). Anthocyanin profile of mayhaw (*Cretaegus opaca*). *Food Chemistry, 91*, 665–671.

Uggla, M., Gao, X., & Werlemark, G. (2003). Variation among and within dog rose taxa (*Rosa* sect. *caninae*) in fruit weight, percentages of fruit flesh and dry matter, and vitamin C content. *Acta Agriculturae Scandinavica Section B, Soil and Plant Science, 53*, 147–155.

Uggla, M., Gustavsson, K-E., Olsson, M. E., & Nybom, H. (2005). Changes in colour and sugar content in rose hips (*Rosa dumalis* L. and *Rosa rubiginosa* L.) during ripening. *Journal of Horticultural Sciences and Biotechnology, 80*(2), 204–208.