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Total Phenolic Compound and Antioxidant Activity Changes in Rosehip (*Rosa* sp.) during Ripening

U. Dolek[1*], M. Gunes[2], N. Genc[3], and M. Elmastas[4]

ABSTRACT

The aim of this study was to determine Total Phenolic Compound (TPC) and antioxidant activity changes depending on the ripening in *Rosa canina*, *R. dumalis*, *R. dumalis* ssp. *boissieri* and *R. villosa* rosehip species. Rosehip fruits were harvested in 6 different times from July to September. TPC content and antioxidant activities were determined by spectrophotometric methods. TPC and antioxidant activities of the studied species increased during ripening. TPC (1510.57 mg GAE 100 g^{-1}/H-6) and antioxidant activities (TEAC: 364.12 µmol trolox equivalent g^{-1}/H-6 and FRAP: 286.79 µmol trolox equivalent g^{-1}/H-6) were higher in *R. dumalis* (MR-15) than the other studied species. There was a high correlation between the TPC and the antioxidant activity. Also, there was a positive correlation between maturation, phenolics and antioxidant activities. This correlation was high in *R. dumalis* and low in *R. canina*. However, it was not possible to express the existence of a relationship between temperature, TPC, and antioxidant activity. It was possible to express the existence of correlations between the color of fruits and some studied characteristics. The correlations between the colors of the fruits and TPC and antioxidant activity of *R. dumalis* were found higher than the other species.

Keywords: Ferric reducing antioxidant power, Harvest time, Phytochemical compounds, TEAC.

INTRODUCTION

Rosehips are bushes having plenty of species and growing in different climate and soil conditions in both hemispheres from sea level to high altitudes. Organs such as fruits, leaves, flowers, and roots of the rosehip bushes are used for different purposes in different countries. Today, the fruits can have both the requirements of functional food and medical usage opportunities. In the last quarter century, the rosehip fruit has come to fore with vitamin C content in the researches. In previous studies, it has also been revealed that it includes several important phytochemical compounds in health-care and it can be used as a functional food ingredient (Andersson *et al*., 2011; Khoo, 2011; Tumbas *et al*., 2012). Due to the fact that the rosehip can grow in natural areas with many species, subspecies, and hybrids, and the cultivation studies are new, it is also a product that can be considered organic.

Fruits are evaluated as a functional food due to their favorable effects on health depending on the antioxidative and antimicrobial effects of phenolic compounds (Pehluvan and Güleryüz, 2004). Recently, the studies on health protective and curative features of the phytochemical which the plants contain have become intensive. The most important biological property of phenolic substances is their having the antioxidant properties. In recent years, individual phenolic compoundshave been studied intensive in

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functional foods and many epidemiological studies have been published that show individual phenolic compounds reduce cancer risk (Elmastas et al., 2015). It is thought that the product can be evaluated as a functional food and can be a reclamation criterion due to high phenolic compound contents. The samples collected from the wild/nature were used in most of the previous studies on determination of rosehip fruit content. Since domestication studies on the rosehips are new and ongoing, it has not been considered in a study for the identification of optimal harvest time or the phytochemicals change. So, in the current study, optimal harvest time has been identified in terms of TPC and antioxidant activity changes in rosehip fruit depending on the harvest time.

MATERIALS AND METHODS

Material

The study was carried out for two years (2011-2012) in the rosehip parcel (established in 2000) in the Research and Application Area of the Gaziosmanpaşa University, Agriculture Faculty, and Department of Horticulture. The research area was located in +40° 20' 1.91" north latitude, +36° 28' 38.44" east longitude. Fruit of rosehip genotypes belonging to the species of *Rosa dumalis* (MR-12 and MR-15), *R. canina* (MR-26), *R. dumalis* ssp. *boissieri* (MR-46), and *R.villosa* (MR-84) obtained by selection were used as the material.

Rosehips were harvested at 6 times from July to September depending on the ripening of the species. Determination of the first four harvest times was based on the color change of the fruits, while the last two times were based on the flesh fruit softening. Accordingly, the period when the fruit color changed from green to yellow was identified as the first Harvest time (H-1); the period when the yellow in the fruit exceeded 50% as the second time (H-2); the period when the fruit turned into orange as the third time (H-3), and the period when the fruit turned into dark orange or red depending on species, as the fourth time (H-4); the period when some softening was observed in the fruit flesh from place to place as the fifth time (H-5) and the period when the fruits were completely softened, as the sixth Harvest time (H-6) (Figure 1). The harvested fruits were kept at -18°C until the analysis time. The fruit color (L*, a*, b*) of species were measured by using the colorimeter (Minolta, model CR–400, Tokyo, Japan).

Preparation of Extracts for Chemical Analysis

The preparation was made by taking nearly 25-30 grams of fruit samples kept in a deep freeze; it was immersed in liquid nitrogen for 5 minutes. Then, the samples were milled using a coffee grinder and 400 mg of these the samples were added to 10 mL (5:1, v:v) of methanol–chloroform solution. After vortexing, the samples were stored in the refrigerator by covering with aluminum foil until analysis. TPC content and antioxidant activity analyses were performed by UV-VIS spectrophotometer (Hitachi U-2900 UV-Vis, Tokyo, Japan). Antioxidant activities were performed by FRAP (Ferric Reducing Antioxidant Power) and TEAC (Trolox Equivalent Antioxidant Capacity) methods which are often used for herbal materials.

Total Phenolic Compound Analysis

The TPC of rosehip fruits was determined by the spectrophotometric method using Folin-Cioceltaus reactive after the extraction in accordance with Slinkard and Singleton (1977) method. TPC of fruit samples was given as mg gallic acid equivalent per 100-gram fruit using the calibration curve.

Antioxidant Aactivity Tests

FRAP analysis

FRAP analysis was made in accordance with the spectrophotometric method which

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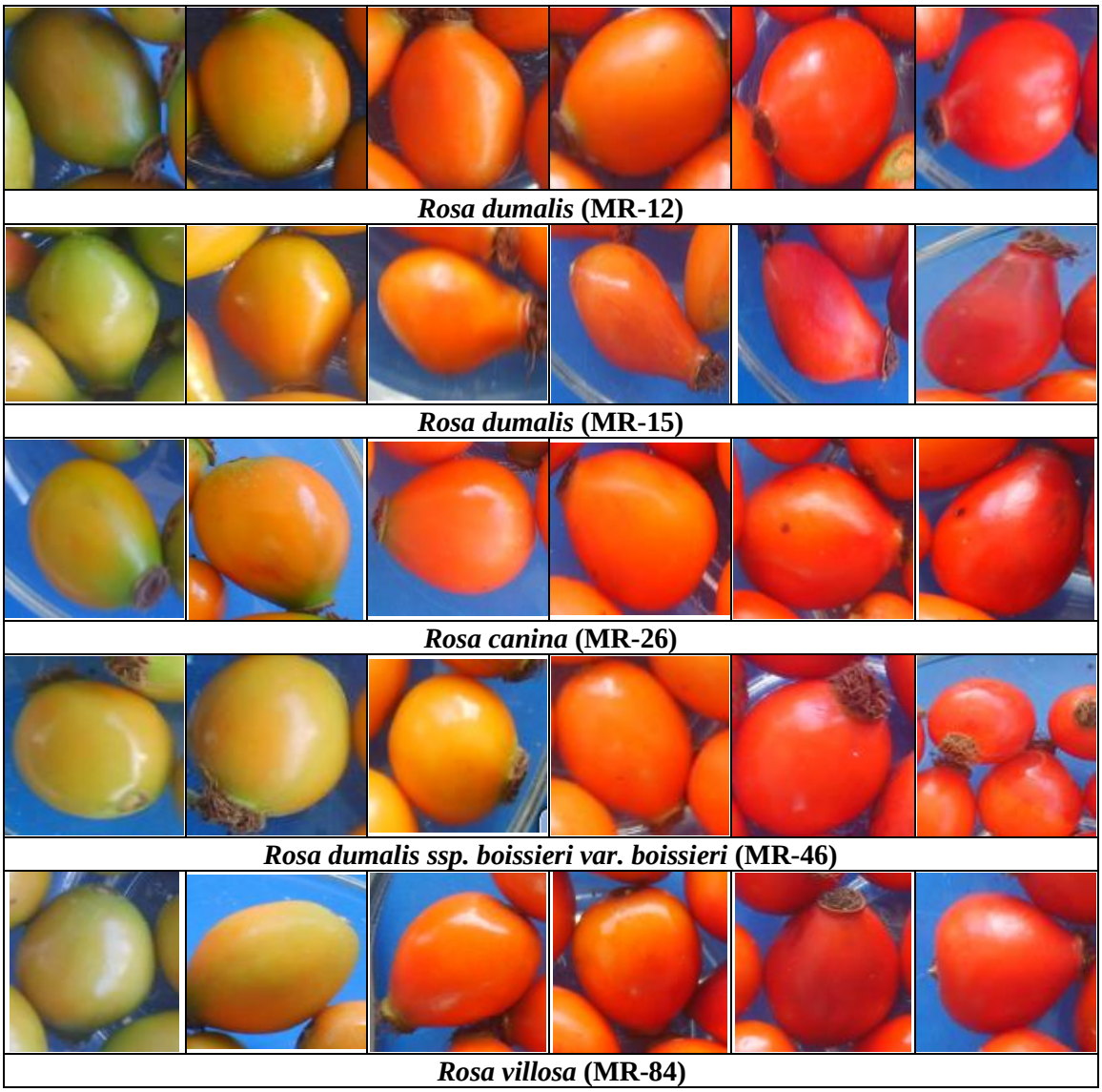

Figure 1. Fruit color of rosehip species at different harvest times.

was developed by Benzie and Strain (1999). It was calculated with Trolox calibration graphic which is used as standard and the results were given as µmol trolox equivalent per g fresh fruit.

TEAC Analysis

TEAC analysis was carried out in accordance with the method applied by Uggla (2004). In accordance with this method, 7 mM ABTS (2,2'-Azino-bis 3-ethylBenzoThiazoline-6-Sulfonic acid) was mixed with 2.45 mM potassiumpersulphate and kept in the dark for 12-16 hours. Then, this solution was diluted with 20 mM sodium acetate (pH 4.5) buffer in the spectrophotometry in the way that it would be absorbed 0.700±0.01 at 734 nm wavelength. It was calculated by Trolox calibration graphic which is used as standard and the results were given as µmol Trolox equivalent per g fresh fruit.

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Statistical Analysis

SPSS (15.0 version) statistic program was used in the statistical analysis of the data obtained. The data were subjected to the analysis of variance (ANOVA) and the difference between the averages were tested at the significance level *of P*< 0.05. The averages were compared with Duncan Multiple Comparison Test. Correlations analyses were computed by Pearson's correlation test.

RESULTS AND DISCUSSION

Total Phenolic Compound

TPC in fruits of rosehip species changed during maturing (Table 1). Although the changes were irregular, TPC increased in general. The highest TPC values among the species (genotypes) were found as 1510.57 [*R. dumalis* (MR-15/H-6)] and 965.81 mg GAE 100 g^{-1} [*R. villosa* (MR-84)/H-6] in the first year. In the second year, TPC was identified as 791.59 [*R. dumalis* (MR-15/H-5)] and 597.46 mg GAE 100 g^{-1} [*R. villosa* (MR-84/H-6)]. The obtained results in this study varied depending on years. It has been reported that climate condition plays an important role in the synthesis of secondary metabolites within years (Olsson *et al*., 2004). Our study is the first research on TPC changes during ripening in rosehip.

Results in this study were lower than previously reported (3217.28 mg GAE 100 g^{-1}) by Jabłońska-Ryś *et al*. (2009) and (2832.3 mg 100 g^{-1} FW) Abaci *et al*. (2016), but higher than some earlier reports of 609.19 mg GAE 100 g^{-1} (Egea *et al*., 2010); 63.76-424.6 mg GAE g^{-1} extract (Montazeri *et al*., 2011). Murathan *et al*. (2016) reported that the total phenolic content was found the lowest in *R. pimpinellifolia* (1081 mg GAE 100 g^{-1}), and the highest in *R. canina* (6298 mg GAE 100 g^{-1}). TPC in fruits of rosehip species was ranged widely in previous studies (Wang and Zheng, 2001; Wang *et al*., 2003; Keinänen *et al*., 1999; Pincemail *et al*., 2012; Olsson *et al*., 2004). These differences may be related to growth, climatic, and maintenance conditions, and species/varieties.

In other fruit species, a regular change of TPC content depending on harvest time has not been found in previous studies (Fadda and Mulas, 2010; Krüger *et al*., 2011; Miletic *et al*., 2012; Chirinos *et al*., 2010).

When two-year R^2 averages were analyzed (Figure 2), a relationship at a high ratio between the harvests and total phenolic compound was found. It has been found that the total phenolic compounds increase during maturation and reach the highest amount when the fruit skin is fully darkened.

Table 1. TPC values of rosehip species during ripening (mg GAE 100 g^{-1} fresh fruit).[a]

Harvest	*Rosa dumalis* (MR-12)		*Rosa dumalis* (MR-15)		*Rosa canina* (MR-26)		*Rosa dumalis* spp. *boisseri* (MR-46)		*Rosa villosa* (MR-84)	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
H-1	344.99a	284.46ab	1094.51 b	630.45c	516.21b	470.13ab	351.80 b	327.54bc	705.98 c	579.47a
H-2	406.88a	223.52b	1241.74ab	670.81bc	622.27b	409.06ab	387.25 b	285.82c	765.14bc	566.11a
H-3	507.76a	252.83ab	1174.67ab	743.33ab	618.46b	336.53b	498.49ab	341.17bc	756.96bc	535.02a
H-4	521.94a	263.74ab	1258.64ab	632.09c	628.00b	350.71b	643.54a	381.11ab	821.31bc	573.74a
H-5	538.84a	338.44a	1453.32ab	791.59a	796.77a	366.53b	635.91a	370.89b	859.21ab	501.76a
H-6	509.12a	314.45ab	1510.57 a	575.10c	817.49a	538.84a	602.92a	434.96a	965.81 a	597.46a

[a] The difference between the averages indicated by different letters in the same column of the same feature (P< 0.05) is significant.

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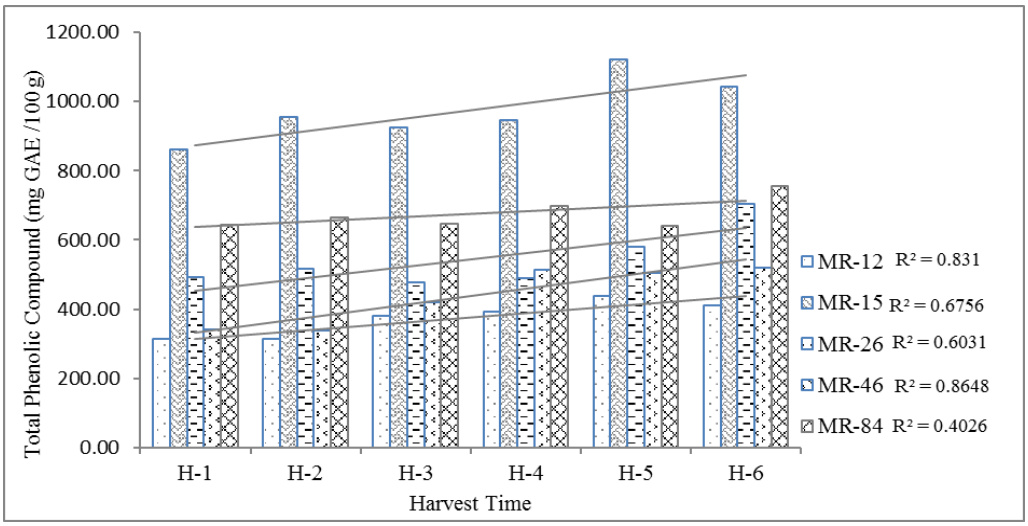

Figure 2. Correlation between TPC and harvest time of rosehip species.

Antioxidant Activities

TEAC

The highest antioxidant activity (TEAC) values (Table 2) among genotypes were found in *R. villosa* (MR-84/H-5) and *R. dumalis* (MR-15/H-6) as 183.48 and 364.12 µmol trolox equivalent/g, respectively, in the first year. TEAC was found as 134.10 [*R.dumalis* spp. *boisseri* (MR-46/H-4)] and 222.69 [*R. dumalis* (MR-15/H-5)] µmol trolox equivalent g^{-1} in the second year. The values obtained in the latter were found as lower than the first year. Analysis of R^2 of two-year means (Figure 3) revealed the existence of a high relationship between the harvest time and antioxidant activity (TEAC), except for *R.canina* (MR-26).

FRAP

The highest antioxidant activity (FRAP) values (Table 3) among genotypes were found as 191.51 (*R. villosa* (MR-84/H-6) and 286.79 [*R. dumalis* (MR-15/H-6)] µmol trolox equivalent g^{-1} in the first year. The

Table 2. The TEAC values of rosehip species during ripening (µmol trolox equivalent g^{-1} fresh fruit**).**[a]

Harvest	*Rosa dumalis* (MR-12)		*Rosa dumalis* (MR-15)		*Rosa canina* (MR-26)		*Rosa dumalis* spp. *boisseri* (MR-46)		*Rosa villosa* (MR-84)	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
H-1	77.43c	95.34ab	316.65b	186.02b	127.69ab	115.40a	74.13c	99.27b	143.93b	92.86a
H-2	81.16bc	91.10b	312.83b	200.87b	131.20ab	124.84a	86.04c	99.12b	159.15ab	91.96a
H-3	82.14abc	93.46b	305.59b	199.45b	107.90b	117.08a	107.78bc	104.63ab	172.72a	90.72a
H-4	105.27a	95.75ab	339.34ab	195.47b	132.61ab	114.42a	146.31ab	134.10a	167.25ab	94.14a
H-5	104.26ab	104.15a	340.87ab	222.69a	141.57a	104.92a	149.40ab	110.15ab	183.48a	86.75a
H-6	100.44abc	100.25ab	364.12a	193.22b	150.79a	114.05a	166.91a	115.06ab	168.49ab	95.71a

[a] The difference between the averages indicated by different letters in the same column of the same feature ($P< 0.05$) is significant.

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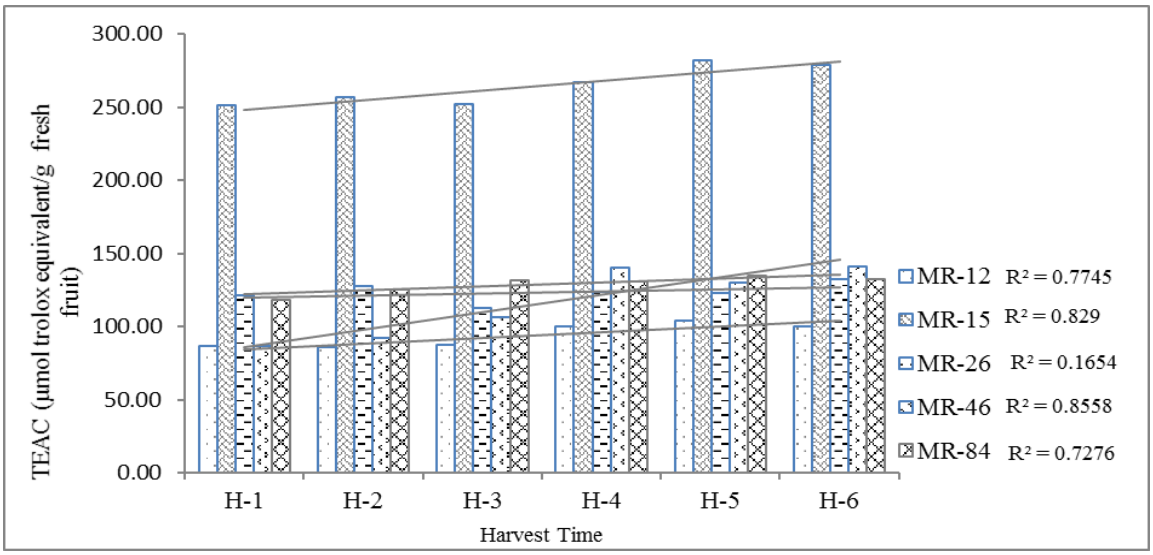

Figure 3. Correlation between TEAC and harvest time of rosehip species.

Table 3. The FRAP values of rosehip species during ripening (µmol trolox equivalent g^{-1} fresh fruit**).** [a]

Harvest	*Rosa dumalis* (MR-12)		*Rosa dumalis* (MR-15)		*Rosa canina* (MR-26)		*Rosa dumalis* spp. *boisseri* (MR-46)		*Rosa villosa* (MR-84)	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
H-1	61.42c	81.98b	212.63c	168.24b	137.47a	100.39a	71.96d	82.80ab	131.46b	124.74a
H-2	73.18bc	76.87b	200.90c	183.90b	106.70a	88.51a	92.41cd	77.38b	156.25ab	121.75a
H-3	76.26abc	76.63b	226.63bc	193.00b	118.28a	84.32a	108.07bc	90.74ab	161.89ab	115.11a
H-4	93.08ab	82.35b	233.72bc	188.62b	121.21a	89.29a	128.04ab	107.48a	170.02a	149.16a
H-5	98.05a	118.73a	258.44ab	238.99a	138.81a	94.04a	131.12ab	102.06ab	184.13a	100.24a
H-6	99.61a	95.60ab	286.79a	212.63ab	132.35a	111.30a	150.54a	98.68ab	191.51a	122.14a

[a] The difference between the averages indicated by different letters in the same column of the same feature ($P < 0.05$) is significant.

values obtained in the second year were found as 149.16 [*R. villosa* (MR-84/H-4)] and 238.99 [*R. dumalis* (MR-15/H-5)] µmol trolox equivalent g^{-1}. The values obtained in the second year were found as lower than the first year. Analysis of R^2 of two-year averages (Figure 4) revealed the existence of a high relationship between the harvest time and FRAP, except for *R. canina* (MR-26).

FRAP and TEAC were found in *R. iberica* as 38.55 and 47.75 mmol TE g^{-1} FW, respectively (Abaci *et al*., 2016). Murathan *et al*. (2016) reported the FRAP as 10.04 for *R. pimpinellifolia* and 103.56 mmol TE g^{-1} for *R. canina*. Some published data on antioxidant activities of *Rosa* species were carried out by different antioxidant determination methods (Roman *et al*., 2013; Wenzig *et al*., 2008; Ghazghazi *et al*., 2010; Jabłońska-Ryś *et al*., 2009; Egea *et al*., 2010). Barros *et al*. (2011) examined rosehip fruits in two periods as mature and immature. In their study, the activity of antioxidants increased in DPPH and decreased in the other studied methods. The results of our study had lower or higher values compared with similar results in the literature, depending on species and

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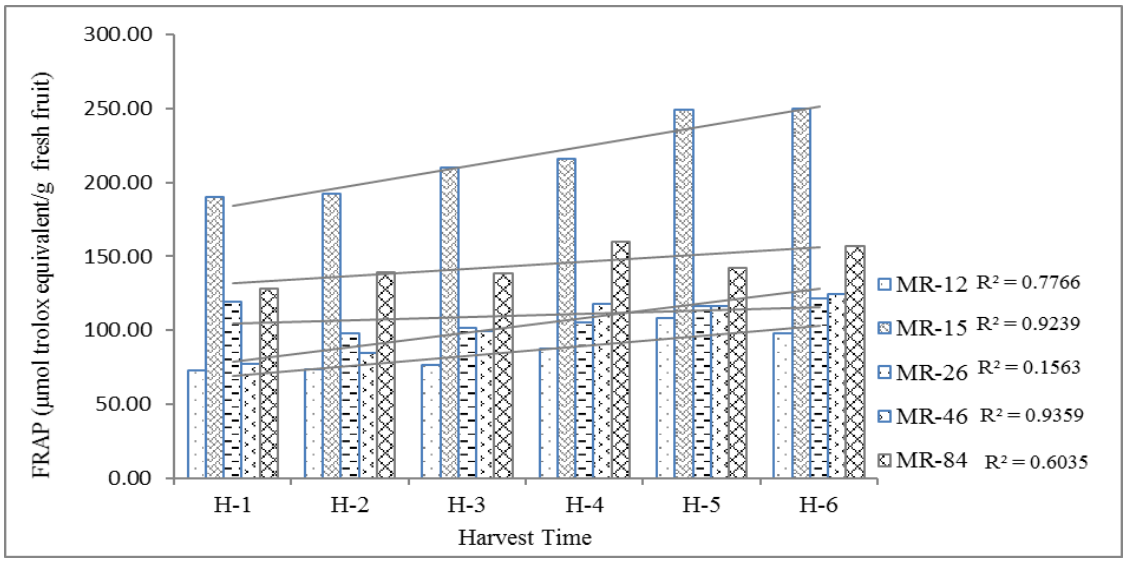

Figure 4. Correlation between FRAP and harvest time of rosehip species.

experiments. It is assumed that these differences may be caused by growing conditions, ecological factors, and species. It was determined that the antioxidant activity of *Rosa* species increased during ripening and reached the highest value when the fruit skin color was fully darkened. Correctly identifying the harvest time when antioxidant activity is high will also contribute to the use of the rosehip product as a functional food.

Correlations between TPC and Antioxidant Activity

There was a positive correlation between TPC and antioxidant activities and they followed an increasing trend depending on the harvest time in all species (Table 4). In the genotypes belonging to *R. dumalis*, the changes depending on the harvest were found statistically significant but insignificant in the other studied species. This case has also revealed the importance of selection of species or varieties. Although the *R. canina* is the first to come to mind when rosehips are mentioned, the relationship between TPC content and antioxidant activities have not been found as significant in this species (Table 4). In rosehips genotypes of different species, phytochemical changes during ripening show very different results. In order to detect these changes more clearly, it will be necessary to carry out further detailed studies with many species of rosehips.

The relationships between TPC and

Table 4. The correlation between phytochemicals (averages of two years).

	Rosa dumalis (MR-12)	*Rosa dumalis* (MR-15)	*Rosa canina* (MR-26)	*Rosa dumalis spp. boisseri* (MR-46)	*Rosa villosa* (MR-84)
TPC	0.912*	0.822*	0.777	0.930**	0.635
TEAC	0.880*	0.911*	0.407	0.925**	0.852*
FRAP	0.881*	0.961**	0.395	0.967**	0.777
TPC / TEAC	0.897*	0.918**	0.727	0.985**	0.269
TPC / FRAP	0.910*	0.886*	0.652	0.986**	0.802
TEAC / FRAP	0.945**	0.937**	0.371	0.986**	0.625

**: Significant at 0.01, *: Significant at 0.05.

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antioxidant activities were evaluated. We found that there was an increase in antioxidant activity depending on the increase in TPC (Figure 5). A high positive correlation was found between the total phenolic compound and antioxidant activity as well as in the correlation analyses in both antioxidant activity tests. Some previous studies have reported a positive correlation between total phenolic compounds, ascorbic acid, and antioxidant activities (Paixão *et al*., 2007; Jabłońska-Ryś *et al*., 2009). Ouerghemmi *et al*. (2016) reported a high correlation between the antioxidant capacity of leaf EtOAc extracts as measured in the DPPH, TEAC, and FRAP assays and their TPC. Conversely, no positive correlation was recorded between TPC of leaf MeOH extracts of studied *Rosa* species and their antioxidant abilities measured in DPPH, TEAC, FRAP and ORAC assays.

Correlations between Temperature and Phytochemicals

The correlations between temperature and phytochemicals in both experimental years are presented in Table 5. During growing season of the first year, the weather was cool, relative humidity was higher, and summer was rainier when compared with the

Table 5. The correlation between average temperatures and phytochemicals.

		2011					2012				
	Average temperature duration[a]	*Rosa dumalis* (MR-12)	*Rosa dumalis* (MR-15)	*Rosa canina* (MR-26)	*R.dumalis* spp. *boisseri* (MR-46)	*Rosa villosa* (MR-84)	*Rosa dumalis* (MR-12)	*Rosa dumalis* (MR-15)	*Rosa canina* (MR-26)	*R.dumalis* spp. *boisseri* (MR-46)	*Rosa villosa* (MR-84)
TPC	1 W	-0.898*	-0.679	-0.677	-0.917*	-0.724	0.042	-0.336	-0.294	0.478	0.207
	1 M	-0.937**	-0.850*	-0.409	-0.976**	-0.878*	0.261	-0.934*	0.749	-0.011	-0.873*
	2 M	-0.898*	-0.695	0.536	-0.929**	-0.797	0.266	0.282	0.585	-0.290	-0.362
	BYH	-0.877*	-0.873*	0.445	-0.859*	-0.759	0.269	0.665	0.645	0.164	-0.118
TEAC	1 W	-0.931**	-0.823*	-0.725	-0.679	-0.829*	-0.145	-0.058	-0.139	0.309	0.887*
	1 M	-0.834*	-0.964**	-0.627	-0.679	-0.650	0.075	0.302	0.856*	-0.075	0.049
	2 M	-0.904*	-0.848*	0.376	-0.567	-0.955**	0.534	0.413	0.717	-0.132	-0.022
	BYH	-0.986**	-0.924**	0.172	-0.818*	-0.735	0.498	0.379	0.717	0.290	-0.470
FRAP	1 W	-0.926**	-0.840*	-0.817*	-0.899*	-0.547	-0.481	-0.325	-0.113	0.464	-0.152
	1 M	-0.969**	-0.962**	-0.677	-0.949**	-0.331	-0.154	0.080	0.805	0.373	-0.820*
	2 M	-0.883*	-0.833*	0.352	-0.851*	-0.518	0.578	0.437	0.651	-0.079	-0.286
	BYH	-0.931**	-0.917*	0.154	-0.917*	-0.434	0.695	0.432	0.570	-0.052	0.123

**: Significant at 0.01, *: Significant at 0.05.

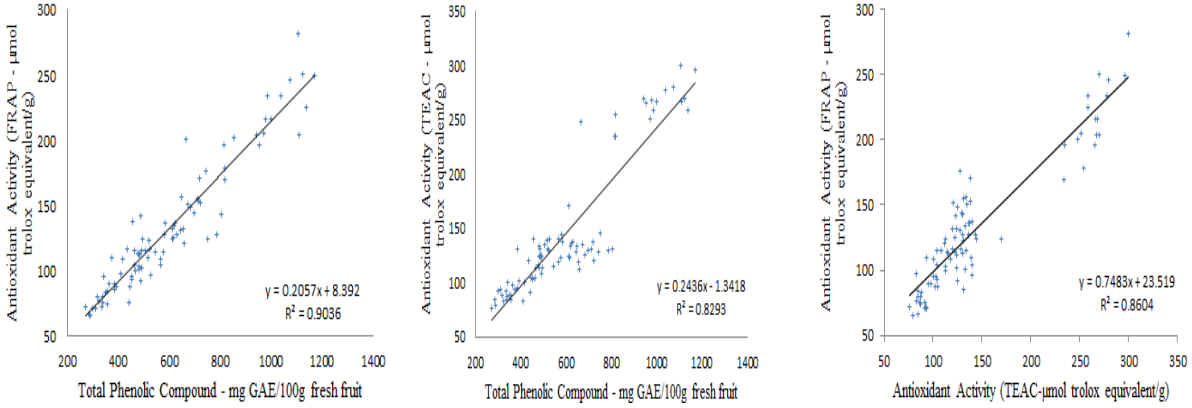

Figure 5. The correlations between antioxidant activities and total phenolic compound of rosehip species.

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second year (Figure 6). In the the first year, there was a high negative correlation between temperature changes and TPC and antioxidant acitvities in the studied species, while a low positive correlation was observed in the second year (Table 5). Andersson *et al*. (2011) have found that there is a high negative correlation of lighting and temperature with lycopene, prolycopene, total carotene and total carotenoids amount and a positive correlation for total chlorophyl-a. As a result, it has been seen that there are significant differences between the years. In order to identify the factors affecting these differences, further studies should be conducted under controlled conditions for correct results.

Correlations between Phytochemicals and Color

It has been investigated whether there is a correlation between the colors of rosehip fruits with phytochemicals depending on the harvests. The related obtained data are summarized in Table 6. A negative correlation

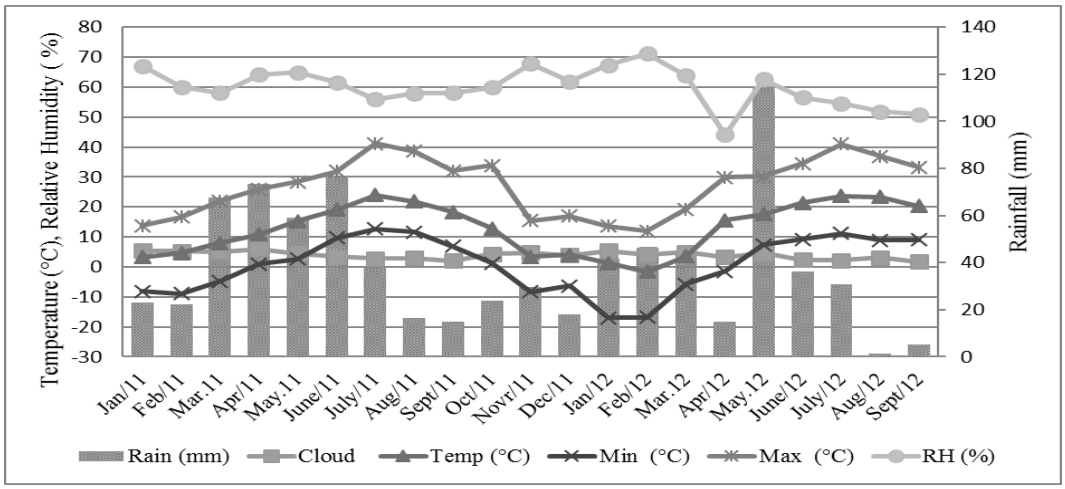

Figure 6. Monthly variations in weather parameters: Monthly mean Temperature (Temp), monthly Maximum temperature (Max), monthly Minimum temperature (Min), monthly mean Relative Humidity (RH), monthly Rainfall (Rain) and monthly mean Cloudiness (Cloud) during the first and second growing seasons.

Table 6. The correlation between phytochemicals and *L**, *a**, *b** values of rosehips (average of two years).

Species (Genotype)	TPC			TEAC			FRAP		
	L	*a*	*b*	*L*	*a*	*b*	*L*	*a*	*b*
R. dumalis (MR-12)	-0.964**	0.920**	-0.958**	-0.926**	0.812*	-0.942**	-0.871*	0.776	-0.892*
R. dumalis (MR-15)	-0.770	0.755	-0.784	-0.863*	0.789	-0.900*	-0.901*	0.855*	-0.932**
R. canina (MR-26)	-0.547	0.493	-0.618	-0.209	0.135	-0.277	-0.253	0.087	-0.359
R.dumalis spp. *boisseri* (MR-46)	-0.981**	0.929**	-0.987**	-0.963**	0.911**	-0.970**	-0.986**	0.956**	-0.990**
R. villosa (MR-84)	-0.489	0.360	-0.520	-0.899*	0.972**	-0.859*	-0.775	0.746	-0.759

**: Significant at 0.01, *: Significant at 0.05.

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was found between *L** and *b** values and TPC, TEAC, and FRAP, while *a** positive correlation was found between a value and TPC, TEAC, and FRAP. There was also a statistically significant relation between *R. dumalis* (MR-12) and *R.dumalis* spp. *boisseri* (MR-46). No relationship between color and phytochemical changes has been detected in the other species. Here, the striking point is this: The genotypes belonging to *R. dumalis* species are generally orange and the red color appears in the late period. When TEAC and FRAP values were examined, it was observed that the change depending on the color measures is higher compared with TPC values. From this point of view, it can be said that turning into the full color of the fruit is the phase when the antioxidant level is the highest.

CONCLUSIONS

The results of the study showed positive correlations between TPC, TEAC, and FRAP changes in rosehip fruits during ripening. According to our results, it can be said that the rosehip fruits do not change TPC and antioxidant activities with temperature changes significantly. When the correlation between *L**, *a**, *b** values and phytochemical substances were evaluated, it was concluded that there was a correlation between color changes and TPC, TEAC and FRAP, but this correlation was not valid for all species. To obtain a product with high TPC and antioxidant activity in rosehips, it is necessary to delay the harvest and choose the correct species and/or variety.

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REFERENCES

1. Abaci, Z. T., Zarifikhosroshahi, M., Kafkas, E. and Sevindik, E. 2016. Chemical Composition, Volatiles, and Antioxidant Activity of *Rosa iberica* Stev. Hips. *Acta Sci. Pol-Hortorum Cultus.*, **15(1):** 41-45.
2. Andersson, S. C., Rumpunen, K., Johansson, E. and Olsson, M. E. 2011. Carotenoid Content and Composition in Rosehips (*Rosa* spp.) during Ripening, Determination of Suitable Maturity Marker and Implications for Health Promoting Food Products. *Food Chem.*, **128(3):** 689-696.
3. Barros, L., Carvalho, A. M. and Ferreira, I. C. 2011. Exotic Fruits as a Source of Important Phytochemicals: Improving the Traditional Use of *Rosa canina* Fruits in Portugal. *Food Res. Int.*, **44(7):** 2233-2236.
4. Benzie, I. F. and Strain, J. 1999. Ferric Reducing/Antioxidant Power Assay: Direct Measure of Total Antioxidant Activity of Biological Fluids and Modified Version for Simultaneous Measurement of Total Antioxidant Power and Ascorbic Acid Concentration. *Method Enzymol.*, **299:** 15-27.
5. Chirinos, R., Galarza, J., Betalleluz-Pallardel, I., Pedreschi, R. and Campos, D. 2010. Antioxidant Compounds and Antioxidant Capacity of Peruvian Camu Camu [*Myrciaria dubia* (HBK) McVaugh] Fruit at Different Maturity Stages. *Food Chem.*, **120(4):** 1019-1024.
6. Egea, I., Sánchez-Bel, P., Romojaro, F. and Pretel, M. T. 2010. Six Edible Wild Fruits as Potential Antioxidant Additives or Nutritional Supplements. *Plant Food. Hum. Nutr.*, **65(2)**: 121-129.
7. Elmastas, M., Telci, İ., Akşit, H. and Erenler, R. 2015. Comparison of Total Phenolic Contents and Antioxidant Capacities in Mint Genotypes Used as Spices. Turk. *J. Biochem.*, **40(6)**: 456-462.
8. Fadda, A. and Mulas, M. 2010. Chemical Changes during Myrtle (*Myrtus communis* L.) Fruit Development and Ripening. *Sci. Hort.*, **125(3):** 477-485.
9. Ghazghazi, H., Miguel, M. G., Hasnaoui, B., Sebei, H., Ksontini, M., Figueiredo, A., Pedro, L. and Barroso, J. 2010. Phenols, Essential Oils and Carotenoids of *Rosa canina* from Tunisia and Their Antioxidant Activities. *Afr. J. Biotechnol.*, **9(18):** 2709-2716.

[DOR: 20.1001.1.16807073.2018.20.4.6.4]

10. Jabłońska-Ryś, E., Zalewska-Korona, M. and Kalbarczyk, J. 2009. Antioxidant Capacity, Ascorbic Acid and Phenolics Content in Wild Edible Fruits. *J. Fruit Ornam. Plant Res.,* **17(2):** 115-120.
11. Keinänen, M., Julkunen-Tiitto, R., Mutikainen, P., Walls, M., Ovaska, J. and Vapaavuori, E. 1999. Trade-offs in Phenolic Metabolism of Silver Birch: Effects of Fertilization, Defoliation, and Genotype. *Ecol.,* **80(6):** 1970-1986.
12. Khoo, G. M. 2011. Bioactive Plant Foods. PhD. Thesis, Department of Food Sciences (IFK), Faculty of Agricultural Sciences (DJF), Aarhus University, Denmark.
13. Krüger, E., Dietrich, H., Schöpplein, E., Rasim, S. and Kürbel, P. 2011. Cultivar, Storage Conditions and Ripening Effects on Physical and Chemical Qualities of Red Raspberry Fruit. *Postharvest Biol. Tech.,* **60(1):** 31-37.
14. Miletic, N., Popovic, B., Mitrovic, O. and Kandic, M. 2012. Phenolic Content and Antioxidant Capacity of Fruits of Plum cv. 'Stanley' (*Prunus domestica* L.) as Influenced by Maturity Stage and on-Tree Ripening. *Aust. J. Crop Sci.,* **6(4):** 681.
15. Montazeri, N., Baher, E., Mirzajani, F., Barami, Z. and Yousefian, S. 2011. Phytochemical Contents and Biological Activities of *Rosa canina* Fruit from Iran. *J. Med. Plant. Res.,* **5(18):** 4584-4589.
16. Murathan, Z., Zarifikhosroshahi, M., Kafkas, E. and Sevindik, E. 2016. Characterization of Bioactive Compounds in Rosehip Species from East Anatolia Region of Turkey. *Ital. J. Food Sci.,* **28(2):** 314-325.
17. Olsson, M. E., Ekvall, J., Gustavsson, K.-E., Nilsson, J., Pillai, D., Sjöholm, I., Svensson, U., Akesson, B. an Nyman, M. G. 2004. Antioxidants, Low Molecular Weight Carbohydrates, and Total Antioxidant Capacity in Strawberries (*Fragaria*× *ananassa*): Effects of Cultivar, Ripening, and Storage. *J. Agric. Food Chem.,* **52(9):** 2490-2498.
18. Ouerghemmi, S., Sebei, H., Siracusa, L., Ruberto, G., Saija, A., Cimino, F. and Cristani, M. 2016. Comparative Study of Phenolic Composition and Antioxidant Activity of Leaf Extracts from Three Wild *Rosa* Species grown in Different Tunisia Regions: *Rosa canina* L., *Rosa moschata* Herrm. and *Rosa sempervirens* L. **Ind.** *Crop. Prod.,* **94:** 167-177.
19. Paixão, N., Perestrelo, R., Marques, J. C. and Câmara, J. S. 2007. Relationship between Antioxidant Capacity and Total Phenolic Content of Red, Rosé and White Wines. *Food Chem.,* **105(1):** 204-214.
20. Pehluvan, M. and Güleryüz, M. 2004. Ahududu ve Bögürtlenlerin İnsan Saglıgı Açısından Önemi. *Bahçe*, **33(1-2):** 51–57.
21. Pincemail, J., Kevers, C., Tabart, J., Defraigne, J. O. and Dommes, J. 2012. Cultivars, Culture Conditions, and Harvest Time Influence Phenolic and Ascorbic Acid Contents and Antioxidant Capacity of Strawberry (*Fragaria x ananassa*). **J. Food Sci.,** 77 (2): C205-C210.
22. Roman, I., Stănilă, A., and Stănilă, S. 2013. Bioactive Compounds and Antioxidant Activity of *Rosa canina* L. Biotypes from Spontaneous Flora of Transylvania. *Chem. Cent. J.,* 7(1): 73.
23. Slinkard, K. and Singleton, V. L. 1977. Total Phenol Analysis: Automation and Comparison with Manual Methods. *Am. J. Enol. Vitic.,* **28(1):** 49-55.
24. Tumbas, V. T., Čanadanović-Brunet, J. M., Četojević-Simin, D. D., Ćetković, G. S., Đilas, S. M. and Gille, L. 2012. Effect of Rosehip (*Rosa canina* L.) Phytochemicals on Stable Free Radicals and Human Cancer Cells. *J. Sci. Food Agric.,* **92(6):** 1273-1281.
25. Uggla, M. 2004. Domestication of Wild Roses for Fruit Production. ed.??? Vol. 480. Swedish University of Agricultural Sciences, Alpnard, Swedish.
26. Wang, S. Y., Bunce, J. A., and Maas, J. 2003. Elevated Carbon Dioxide Increases Contents of Antioxidant Compounds in Field-Grown Strawberries. *J. Agric. Food Chem.,* **51(15)**: 4315-4320.
27. Wang, S. Y., and Zheng, W. 2001. Effect of Plant Growth Temperature on Antioxidant Capacity in Strawberry. *J. Agric. Food Chem.,* **49(10):** 4977-4982.
28. Wenzig, E., Widowitz, U., Kunert, O., Chrubasik, S., Bucar, F., Knauder, E., and Bauer, R. 2008. Phytochemical Composition and *In Vitro* Pharmacological Activity of Two Rosehip (*Rosa canina* L.) Preparations. *Phytomed.,* **15(10):** 826-835.

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تغییرات ترکیبات فنلی کل و فعالیت آنتی اکسیدانی در میوه رُز (*Rosa* sp.) در طی دوره رسیدن میوه

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چکیده

هدف پژوهش حاضر تعیین تغییرات ترکیبات فنلی کل (TPC) و فعالیت آنتی اکسیدانی در میوه رُز بر حسب زمان رسیدن میوه گونه های رُز R. dumalis ssp.boissieri ،Rosa canina, R. dumalis و R.villosa بود. میوه رُز در شش زمان مختلف در بین ماه های ژولای تا سپتامبربرداشت شد. محتوای TPCو فعالیت آنتی اکسیدانی با روش اسپکتروفتومتریک تعیین شد. TPCو فعالیت آنتی اکسیدانی گونه های مطالعه شده در طی دوره رسیدن افزایش یافت. مقدار TPC (1510.57 mg GAE/100g/H-6)و فعالیت آنتی اکسیدانی (TEAC: 364.12 µmol trolox equivalent/g/H-6و FRAP: 286.79 µmol trolox equivalent/g/H-6) در گونه R. dumalis (MR-15)بیشتر از دیگر گونه های مطالعه شده بود. همچنین، همبستگی مثبت زیادی بین TPCو فعالیت آنتی اکسیدانی بود. نیز، همبستگی مثبتی بین رسیدن میوه، مواد فنلی، و فعالیت های آنتی اکسیدانی وجود داشت. این همبستگی در R. dumalis زیاد و در R. canina کم بود. با اینهمه ، تعیین وجود رابطه بین درجه حرارت، TPC، و فعالیت آنتی اکسیدانی ممکن نشد. اما، وجود رابطه همبستگی بین رنگ میوه ها و بعضی ویژگی های مطالعه شده امکان پذیر شد. همچنین، همبستگی های بین رنگ های میوه ها و TPC و فعالیت های آنتی اکسیدانی در R. dumalis بیشتر از گونه های دیگر بود.

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