Fruit Pomological, Phytochemical Characteristic and Mineral Content of Rosehip Genotypes

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***Abstract*—Rosehips, which are commonly grown in nature in shrub form, are always popular due to their importance in terms of nutrition and health. Because fruits are rich in vitamin C, total phenol and mineral contents and antioxidant activities. Nowadays, there is high demand for natural products. Rosehip grows spontaneously in Turkey. In this study, 9 individuals were examined. Consequently, significant differences were stated according to genotypes for pomological and phytochemical characteristics. Vitamin C, phenol and antioxidant activity were found to affect P and Zn nutrients. Additionally, it was detected that P, K, Ca, Mg, Na Fe, Cu, Zn and Mn contents ranged in 0.09-0.17%, 1.35-1.86%, 1.05-1.44%, 0.43-069%, 50.00-100.00 ppm 28.50-48.30 ppm, 3.30-7.00 ppm, 8.06-12.56 ppm and 50.85-85.35 ppm, respectively. In this context, one of the genotypes has been found promising due to its content.**

***Index Terms*—*Rosa* spp., vitamin C, phenol, antioxidant activity, mineral nutrient**

I. Introduction

Rosehip is of economic value, and has an importance in human health in many countries. This species ranks first among the products collected from nature. As it is known, *Rosa* spp. are used as food, medicinal and ornamental for a long time. Fruits are consumed as fresh, dried, processed, marmalade and herbal tea. Rose hips contain vitamins A, B1, B2, B3, C and K, phenolics and mineral nutrients [1]. The antioxidant effect is caused by vitamin C and phenolics [2]. Therefore, it is important for folk medicine.

Rosa canina has a wide growing area in Europe, Asia and Northwest Africa in the World [3]. It grows in almost every region in our country in native flora [4]. In Anatolia, species such as *R. canina, R. pimpinellifolia, R. horrida, R. phoenica, R. pisiformis, R. foetida* and *R. hemisphaerica* are extensively located. Turkey is one of the origins centres of *Rosa* spp. The rate of spontaneous hybridization is high among the species. Therefore, it reveals a population with wide variations [3]. Selections have been carried out because of rich genetic variability in our country. Consequently, two cultivars have been registered [5].

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In selection breeding, fruit characteristics are evaluated in morphological identification of selected genotypes. In order to evaluate the rosehip population in the natural flora, studies were carried out in some ecology. For this purpose, the average fruit width, height, weight, vitamin C, total soluble solid content, titratable acidy, total dry matter and pH were determined [4], [6], [7].

Nowadays, due to its contribution to human health, the biochemical composition of fruits is remarkable. Addition to the morphological description, biologically active compounds analysis is of great importance. It has been found that wild forms have higher antioxidant activities than cultivars in different fruit species [8].

Therefore, rosehip has a positive effect on health by reducing oxidative stress [9]. Meanwhile their fruits are considered a source of vitamin C [1] and minerals [10]. Also sugar is an important component of the fruit. The majority of the sugar content consists of glucose and fructose [11]. Considering these explanations, studies are carried out on sugar, total phenol, antioxidant activity and mineral content [12].

Recently, consumer attitudes are towards natural products. Rosehip is an important plant that grows spontaneously in our country. It is noteworthy because of the pharmacological properties and antioxidant activity. In the current study, 9 individuals were investigated in terms of fruit, pomological, phytochemical characteristic and mineral content.

II. Materials and Methods

In this study, 9 *Rosa* genotypes obtained from Erzurum and Gümüşhane were used as material in the collection orchard of Ege University, Faculty of Agriculture and Department of Horticulture.

Fruit analyses were carried out on 50 fruits from shrubs. Fruit and stone weights of the harvested samples were determined, and average flesh/stone ratios were calculated. The fruit width and length were measured. Fruit color was measured by a CR400 model Minolta Colorimeter in CIE L* a* b* and the values of chrome (C*) and hue angle (h^o) were calculated by using the $C^* =(a^{*2} + b^{*2})^{1/2}$, $h° = \tan^{-1} (b^*/a^*)$ formula [13].

For vitamin C content fruits, 25 ml of oxalic acid (0.4%) was added to 5 g of fruit sample and mixed with

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the blender. This mixture was filtered through a filter paper. The amount of the vitamin C (L-ascorbic acid) was determined with 2,6-dichloroindophenol by using the titrymetric methods of AOAC (1995) [14]. The results are given as mg vitamin C/100 g fresh weight (fw). Total phenol content and antioxidant activity were determined in the fruit samples using methods by Thaipong, et al, (2006) method [15]. Total phenol content was determined by Folin-Ciocalteu method [16]. The results were expressed as mg gallic acid equivalent (GAE)/100 g fw. The FRAP method was used to determine the antioxidant activities. The results were given as µmol trolox equivalent (TE)/g fw [17]. For sugar analysis, dried fruit samples were mixed with ultra pure water (Millipore 18.2 Ώ), homogenized and filtered. The supernatant was filtered through 0.20 µm nylon filters and injected into vials. Then 20 µL extract transferred to the Ultra High Performance Liquid Chromatography (UHPLC) (Thermo Dionex UltaMate 3000 Series, Thermo Scientific, USA). The analysis was carried out isocratically by using Refractive Index Dedektör (RafrateMax521, Erc Inc., Japan) and Hypersil GOLD Amino (150 × 4.6, Thermo Scientific, ABD) columns at a flow rate of 0.1 mL min 1 [18].

For nutrient analysis, the dried samples were ground. The Kjeldahl method for N; the colorimetric method for P; the flame fotometric method for Ca, K and Na; atomic absorption spectrophotometer for Mg, Fe, Cu, Zn and Mn analysis were used [19].

The data were subjected to a variance analysis by using SPSS Statistics 20 statistical package. Significant differences between averages were defined by Duncan test at the $P<0.05$ significant level. The relationship among these values was revealed by conducting Pearson's correlation analysis.

III. RESULTS AND DISCUSSION

A. Fruit Properties

Significant differences in the pomological parameters among different genotypes were recorded (Table I). Average fruit and seed weight are the highest in genotype 3 and the lowest in genotype 2. Variation range for the flesh/stone ratio is described in 1.70 - 4.29. Genotypes 3 (13.68 mm) and 8 (22.53 mm) ranked the first row in terms of average fruit width and length. On the other hand, the average value of fruit width was 11.17 mm and the fruit length value was 19.29 mm. There was a statistically significant difference in color values among genotypes. The highest values (L*, a*, b*, C* and h°) were obtained in genotype 2. In this genotype, the a* value, which expresses the red color, was the maximum. In contrast, it has a light color owing to the L * value is low. Also, the b* (9.75 - 22.57) value identified a high level of variation.

TABLE I. POMOLOGICAL CHARACTERISTIC OF ROSEHIP GENOTYPES

Genotype no	Fruit weight (g)	Stone weight (g)	Flesh/stone ratio	Fruit width (mm)	Fruit length (mm)	L*	a*	b*	C*	h°
1	1.15 cd	0.68 b	1.70 e	11.49 c	16.71 d	30.81 a	24.05 b	13.86 bc	27.77 b	0.52 ab
2	0.69 e	0.16 e	4.29 a	8.90 e	18.53 c	36.01 a	34.09 a	22.57 a	40.89 a	0.59 a
3	1.89 a	0.84 a	2.24 cd	13.68 a	20.60 b	21.71 b	19.01 d	9.75 c	21.36 c	0.47 ab
4	1.02 d	0.46 d	2.25 cd	10.28 d	19.55 bc	30.38 a	22.69 bc	10.02 c	25.20 bc	0.41 b
5	1.25 c	0.59 c	2.14 d	11.38 c	19.23 c	29.22 ab	19.31 d	10.59 c	22.03 c	0.50 ab
6	1.13 cd	0.40 d	2.77 b	10.51 d	19.64 bc	28.10 ab	20.50 cd	10.08 c	22.85 c	0.45 ab
7	1.29 c	0.53 c	2.43 bc	10.47 d	19.69 bc	31.60 a	24.48 b	15.04 b	28.79 b	0.55 ab
8	1.61 b	0.69 b	2.32 bc	12.34 b	22.53 a	29.19 ab	19.66 cd	10.70 c	22.39 c	0.50 ab
9	1.09 cd	0.40 d	2.70 bc	11.46 c	17.16 d	28.22 ab	20.00 cd	10.05 c	22.38 c	0.47 ab
Max.	1.89	0.84	4.29	13.68	22.53	36.01	34.09	22.57	40.89	0.59
Min.	0.69	0.16	1.70	8.90	16.71	21.71	19.31	9.75	21.36	0.41
Mean	1.24	0.53	2.54	11.17	19.29	29.47	22.64	12.52	25.96	0.50

The differences in the means were determined by the Duncan test according to $P \leq 0.05$

These characteristics were also determined for the rosehip genotypes in different locations in our country [20], [21], [7]. The differences can be caused by genotype and environmental conditions. It was stated that the L* value indicating the brightness of the fruits varied from 32 to 37 [22]. This finding is somewhat similar to our results.

Significant differences were determined according to genotypes regarding vitamin C, total phenol content and antioxidant activity (Table II). As can be seen, the same genotype was also characterized by highest level of those parameters (genotype 2), whereas the genotype 5 had the lowest values, in general. Minimum and maximum values of vitamin C were determined as 357.68 - 426.95 mg/100g fw, respectively. In terms of total phenol content, the genotypes were categorized under three main groups. Genotype 2, 1 and 4 were the first group, followed by genotype 9, 8 and 6. On the other hand, the values of genotype 7, 5 and 3 were found to be last group. The antioxidant activity in extracts ranged from 25.07 to 195.43 mg GAE/g of fw. For this feature, high variation was found among the genotypes. In other words, the phenol amounts, the vitamin C content and antioxidant activity were more heterogeneous in samples. Glucose and fructose were found to be the major sugar. The same genotype was characterized by the highest level of fructose, glucose and total sugar, accounting for 18.19, 15.10 and 33.29 g/100g dm, respectively. The lowest values were determined in genotype 1, 8 and 9 for fructose and total sugar, whereas this value was found in genotype 2 for glucose.

According to the our results, it is confirmed that the higher and lower levels were found in different rose hips in terms of vitamin C content and total phenol content based on previous studies [23], [1]. On the other hand, phenol content was higher in some investigations [24]. As stated, the phenolic content can be influenced by the extraction and analysis method [25]. For antioxidant activity in rose hip fruits, the method used in our study, had the best results [26]. The total amount of sugar in rosehip fruits is determined as 18.26 and 16.32 g/100g according to the years and it are similar to our findings [27]. The amount of fructose, glucose and total sugars in different *Rosa* species has been demonstrated by other researchers [24], [28]. In addition, fructose (7.96-14.76 g/100g) and glucose content (8.06-12.94 g/100g) have been revealed in rosehip genotypes which are naturally grown in Erzincan region by Özrenk, *et al*. (2012) [6].

In our study, the changes in the examined characteristics according to genotypes were also revealed in previous studies [21]. The differences may be due to genetic variation, environmental conditions, cultural practices, geographic origin, the physiological stage of fruit, extraction technique and analysis method [29].

TABLE II. PHYTOCHEMICAL CHARACTERISTIC OF ROSEHIP GENOTYPES

Genotype no	Vitamin C (mg/100g fw)	Total phenol content (mgGAE/100g fw)	Antioxidant activity (µmol TE/g fw)	Fructose (g/100g dm)	Glucose (g/100g dm)	Total sugar (g/100g dm)
1	373.82 bc	380.99 a	42.64 cde	8.48 f	7.42 ef	15.90 f
2	426.95 a	384.08 a	195.43 a	12.78 d	6.64 f	19.42 e
3	358.33 c	303.59 b	28.17 de	18.19 a	15.10 a	33.29 a
4	360.62 bc	378.26 a	44.15 cd	15.47 b	12.89 b	28.36 b
5	372.45 bc	325.99 b	25.07 e	10.79 e	8.92 d	19.71 e
6	357.68 c	342.44 ab	32.65 de	13.73 cd	8.60 de	22.32 d
7	369.42 bc	324.42 b	56.65 c	14.31 c	10.80 c	25.11 c
8	388.94 b	337.06 ab	139.05b	9.15 f	7.88 de	17.03 f
9	363.64 bc	345.85 ab	58.14 c	9.39 f	7.59 de	16.97 f
Max.	426.95	384.08	195.43	18.19	15.10	33.29
Min.	357.68	303.59	25.07	8.48	6.64	15.90
Mean	374.65	346.97	69.11	12.48	9.54	22.01

The differences in the means were determined by the Duncan test according to P≤0.05

Considering the nutrient content, it was detected that P, K, Ca, Mg and Na contents ranged in 0.09-0.17%, 1.35-1.86%, 1.05-1.44%, 0.43-069% and 50.00-100.00 ppm, respectively (Table III). K content was reported as 1.11-4.54% [6] and 0.42-1.90% [30]. In general, fruits are rich in phosphorus and potassium. Similar situation is expressed by Ercişli, (2007) [4]. According to the findings of other researchers; Ca, Mg and K content were found to be high and P content was low in rosehip fruits [6]. This situation may occur as a result of the difference in genotype, location and ecological conditions.

In our study, Fe, Cu, Zn and Mn values were stated as 28.50-48.30; 3.30-7.00; 8.06-12.56 and 50.85-85.35 ppm, respectively (Table III). It was seen that, Fe and Cu contents were high but Zn and Mn contents were similar according to Özrenk, *et al*. (2012) [6]. The micro element content of different rosehips was also demonstrated by other researchers [4].

As a result of the general evaluation, genotype 2 was different from other genotypes with its properties such as vitamin C, total phenol content, antioxidant activity, fruit color and macro element content. This genotype is shown in Fig. 1.

Figure 1. General view of the fruits of genotype 2.

TABLE III. MACRO AND MICRO ELEMENT CONTENT OF ROSEHIP GENOTYPES

Genotype no	P (%)	K (%)	Ca (%)	Mg (%)	Na (ppm)	Fe (ppm)	Cu (ppm)	Zn (ppm)	Mn (ppm)
1	0.12 c	1.73 b	1.17 cd	0.54 bc	100.00 a	35.25 bc	5.95 ab	9.76 bc	85.35 a
2	0.17 a	1.35 e	1.29 ab	0.69 a	75.00 ab	37.95 b	7.00 a	12.56 a	80.35 a
3	0.09 e	1.49 de	1.17 cd	0.43 d	75.00 ab	37.70 b	6.45 ab	8.06 e	71.55 bc
4	0.13 c	1.67c	1.44 a	0.51 c	75.00 ab	48.30 a	3.30 e	10.51 b	71.25 bc
5	0.14 b	1.76 b	1.05 e	0.57 b	100.00 a	37.35 b	4.95 bcd	9.13 d	62.00 d
6	0.12 c	1.50 de	1.35 ab	0.66 a	75.00 ab	28.50 c	5.55 ab	8.45 e	74.10 b
7	0.13 c	1.65 c	1.08 cd	0.58 b	50.00 b	36.00 b	4.35 cde	10.16 b	62.95 d
8	0.12 c	1.86 a	1.23 bcd	0.45 d	50.00 b	31.85 bc	3.95 de	9.61 bc	50.85 e
9	0.10 d	1.55 d	1.17 cd	0.57 b	100.00 a	36.05 b	3.75 de	11.97 a	67.15 cd
Max.	0.17	1.86	1.44	0.69	100.00	48.30	7.00	12.56	85.35
Min.	0.09	1.35	1.05	0.43	50.00	28.50	3.30	8.06	50.85
Mean	0.13	1.62	1.22	0.55	77.78	36.55	5.03	10.03	69.51

The differences in the means were determined by the Duncan test according to P≤0.05

TABLE IV. THE CORRELATION COEFFICIENTS BETWEEN THE FEATURES OF ROSEHIP GENOTYPES

	SW	FWd	FL	FS	L	a	b	C	h	VitC	TF	AA.	G	F	TS	P	K	Ca	Mg	Na	Fe	Cu	Zn	Mn
FW	0.884**	0.898**	0.605**	0.586**	-0.549**	-0.655**	-0.536**	-0.639**	-0.175	-0.362	-0.607**	-0.323	0.563**	0.268	0.423*	-0.673**	0.356	-0.265	-0.781**	-0.201	-0.142	-0.030	-0.652**	-0.447*
SW		0.895**	0.374	-0.785**	-0.495**	-0.647**	-0.548**	-0.636**	-0.188	-0.433*	-0.454*	-0.473*	0.496**	0.097	0.295	-0.641**	0.546**	-0.385*	-0.849**	-0.010	-0.043	-0.049	-0.701**	-0.299
FWd			0.368	-0.604**	-0.618**	-0.735**	-0.622**	-0.725**	-0.237	-0.445*	-0.503**	-0.410*	0.446*	0.074	0.257	-0.788**	0.348	-0.355	-0.818**	0.056	-0.114	-0.041	-0.581**	-0.336
FL				-0.057	-0.240	-0.319	-0.293	-0.315	-0.169	0.029	-0.374	0.185	0.371	0.332	0.366	-0.111	0.299	0.094	-0.445*	-0.513**	-0.030	-0.165	-0.384*	-0.662**
FS					0.361	0.674**	0.623**	0.676**	0.277	0.586**	0.191	0.706**	-0.333	0.105	-0.103	0.577**	-0.711**	0.309	0.651**	-0.169	-0.080	0.344	0.602**	0.228
L						0.610**	0.560**	0.617**	0.288	0.485*	0.306	0.468*	-0.448*	-0.269	-0.368	0.645**	-0.041	0.121	0.481*	-0.030	0.105	0.050	0.509**	0.161
A							0.864**	0.990**	0.351	0.725**	0.497**	0.670**	-0.351	-0.005	-0.173	0.745**	-0.491**	0.219	0.571**	-0.071	0.148	0.384*	0.612**	0.487**
B								0.926**	0.771**	0.737**	0.405*	0.663**	-0.431*	-0.087	-0.257	0.695**	-0.409*	0.060	0.570**	-0.190	-0.019	0.510**	0.516**	0.408*
C									0.477*	0.750**	0.488**	0.687**	-0.375	-0.021	-0.193	0.758**	-0.476*	0.181	0.585**	-0.107	0.119	0.427*	0.605**	0.475*
h										0.432*	0.137	0.367	-0.375	-0.194	-0.290	0.342	-0.107	-0.173	0.322	-0.295	-0.243	0.435*	0.187	0.148
VitC											0.381*	0.825**	-0.492**	-0.253	-0.380	0.690**	-0.187	0.116	0.377	-0.072	0.070	0.392*	0.521**	0.131
TF												0.370	-0.389*	-0.280	-0.345	0.390*	-0.105	0.369	0.367	0.036	0.205	0.060	0.416*	0.464*
AA.													-0.475*	-0.211	-0.348	0.592**	-0.215	0.182	0.290	-0.290	-0.050	0.216	0.592**	-0.041
G														0.837**	0.952**	-0.435*	-0.133	0.104	0.648**	0.006	0.207	0.290	0.501**	0.199
F															0.964**	-0.138	-0.441*	-0.243	-0.496**	0.003	0.064	-0.449*	-0.299	-0.541**
TS																-0.287	-0.268	0.145	0.151	-0.141	0.165	-0.076	0.172	0.338
P																	-0.133	0.104	0.648**	0.006	0.207	0.290	0.501**	0.199
K																		-0.243	-0.496**	0.003	0.064	-0.449*	-0.299	-0.541**
Ca																			0.151	-0.141	0.165	-0.076	0.172	0.338
Mg																				0.126	-0.159	0.347	0.419*	0.429*
Na																					0.338	0.123	0.117	0.372
Fe																						-0.130	0.265	0.112
Cu																							-0.094	0.562**
Zn																								0.181

* Significant at P<0.05, ** Significant at P<0.01. ns: Non-significance.
Abbreviations: FW: fruit weight; SW: stone weight; FS: flesh/stone ratio; FWd: fruit width; FL: fruit length; L: L*; a: a*; b: b*;h: h°; C: C*; VitC: vitamin C; TF: total phenol; AA: antioxidant activity; G: glucose; F: fructose; TS: total sugars; P: phosphorus; K: potassium; Ca: calcium; Mg: magnesium; Na: sodium; Fe: iron; Cu: copper; Zn: zinc

B. Correlation Among Traits

The correlation coefficients between the features of rose hips genotypes are shown in Table IV. Accordingly, the highest correlation was determined between fruit weight and width, stone weight. Moreover, fruit weight and stone weight were highly correlated (r = 0.884). Thus, large fruits showed a larger stone, increasing the ratio of flesh/stone. Fruit weight showed a significantly positive correlation to fruit width (r = 0.898). Fruit weight, stone weight and width had a negative and strong correlation with over color L*, a*, b* and C* value. A very strong correlation occurred between vitamin C and antioxidant activity (r = 0.825). Vitamin C has antioxidant activity. The relationship between vitamin C and color values was found. Fruit color and vitamin C content are determined during the harvest stage. The amount of carotenoid which gives the fruit red color is high in this period [31]. Although some studies showed a correlation between total phenols and antioxidant activity, this was not observed in the present study [32]. Relationships between fruit properties and nutrient elements were also examined. Fruit weight, stone weight and width were found to have a strong but negative correlation to P, Mg, Zn and fruit color value. Nutrients have different effects on color values. Vitamin C, phenol and antioxidant activity were not found to affect nutrients in general, except P and Zn. These elements are important in terms of antioxidant activity. In this context, Zn is indicated as an antioxidant mineral [31].

IV. CONCLUSIONS

Rosehips rank the first row in terms of non-wood forest products. In addition to its medicinal use, rosehip is also valuable for nutritional purposes, as known. This species contains vitamin C, phenol content, antioxidant activity and nutrition element. Thus, fruits are valuable as a source of natural antioxidant. It was seen that genotype number 2 possess some characteristics (vitamin C, total phenol content, antioxidant activity, fruit color and macro element) compared to the others. This genotype can be consumed as herbal tea because of its small fruit.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Nihal Acarsoy Bilgin, Fatih Şen, Bülent Yağmur and Bilge Türk made the analysis; Adalet Mısırlı had provided material collection; Nihal Acarsoy Bilgin and Adalet Mısırlı wrote the paper and all authors had approved the final version.

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