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ORIGINAL PAPER

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MORPHOLOGICAL AND BIOCHEMICAL DIVERSITY IN *Rosa* SPECIES

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ABSTRACT

The *Rosa* L. is one of the widely grown plants in the world and its flowers and fruits has been used in different parts of the world for centuries. Wild grown *Rosa* plants is one of the most important element of the natural landscape and used as rootstock for roses for centuries as well. In this study the main flower, shrub and fruit characteristics of a large number of *Rosa canina* L. and *Rosa dumalis* Bechst. genotypes naturally found in Ardahan province of Turkey has been studied. All plants found very health conditions and indicated their strong defense mechanism of the genera to harsh abiotic and biotic conditions. The majority of genotypes had attractive flowers. The genotypes exhibited fruit mass between 2.81 g to 4.60 g. SSC (soluble solid content), vitamin C, total phenolic, total flavonoid, total carotenoid, and total anthocyanin content of the genotypes ranged from 15.8–20.6%, 502–714 mg per 100 g FW (fresh weight), 405–507 mg gallic acid equivalent per 100 g FW, 1.02–2.00 mg per g FW, 8.40–13.30 mg per g FW and 4.35–6.98 mg cyanidin-3-glucoside equivalent per liter, respectively. Antioxidant activity was determined between 22.3–30.9 mg ascorbic acid equivalent per g fresh weight. Chlorogenic acid was the major phenolic acids in fruits of *Rosa* ecotypes. Our results indicated promising perspectives for usage of *R. canina* and *R. dumalis* fresh fruits studied with considerable levels of bioactive compounds.

Key words: *Rosa canina*, *Rosa dumalis*, morphological, flower, biochemical diversity

INTRODUCTION

Wild edible fruit species including *Rosa* are found naturally in many parts of the world, especially in rural areas and forests and shows a great morphological and biochemical diversity. They find buyers at high prices with their unique aromas and tastes and generate important source of income for people living in rural areas and forests [Dogan et al. 2014, Ikinci et al. 2015, Eyduran et al. 2015, Akin et al. 2016, Bolaric et al. 2021, Hasanbegovic et al. 2021, Kan 2021].

As opposite to cultivars, wild edible fruits are renowned for their intense flavor and fragrance. They are also more resistant to adverse soil and climatic conditions. Most spontaneous wild fruit species bear small fruits, which accumulate higher levels and wider assortments of volatile molecules and human health content, compared with cultivated varieties [Honkanen and Hirvi 1990]. The natural variation occurring among the wild edible fruits provides a valuable source of novel volatile compounds for breeding new commercial cultivars with improved aroma and resistant to biotic and abiotic conditions [Ulrich and Hoberg 2000, Grygorieva et al. 2021].

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Rosa canina and *Rosa dumalis* are deciduous scrambling shrub form in natural growing habitat and spreads by suckers. They can produce attractive fragrant dark pink or white flowers at the end of spring and early summer. In autumn months they bear scarlet red fruit called as hips which rich in ascorbic acid (vitamin C) [Ercisli 2005, Kan 2021].

Rosa canina and *Rosa dumalis* species appear as the most important element of the natural landscape. It forms a natural plant community together with other plants, especially in forest areas. Due to its thorny structures, it is also used as a fence in open areas, especially on the edges of the fields. Long before vitamin C was discovered, rose hips were used to treat coughs, stomach aches and sore throats, and to make healthy teas and jellies [Uggla et al. 2003, Kan 2021].

Around 30 *Rosa* species are commonly grown in the Turkey's flora and among the *Rosa* species *Rosa canina* and *Rosa dumalis* are the most common and well known for their better fruit characteristics [Ercisli 2005].

The flowers, shrubs and hips (fruits) of *Rosa canina* and *Rosa dumalis* traditionally used in Turkey for centuries. In field conditions both species shows high diversity for the most of the morphological traits because both species propagated by seeds naturally for centuries. The fruits of *Rosa canina* and *Rosa dumalis* have been traditionally used as medicinal plants and for the treatment of a wide variety of human diseases for a long time [Chrubasik et al. 2008, Guimaraes 2010].

Compared with other wild edible fruit species, the fruits of *Rosa* species have very high vitamin C, carotenoid, phenolic acids, phytochemicals etc. content. The plant has a unique therapeutic potential. Its fruits have a strong antioxidant effect due to its high vitamin C, carotenoid, phenolic acids, phytochemicals etc. content [Uggla et al. 2003].

Today, with the widespread use of media tools, people have become more interested in fruits and vegetables, especially their functional properties. Most of the wild edible fruit species, including Rosa species, are very rich in terms of human health promoting substances [Veberic et al. 2009, Barros et al. 2011, Adamczak et al. 2012, Ercisli et al. 2012, Kan 2021].

Evaluation of morphological and biochemical diversity can be helpful for organizing germplasm, selecting parents for hybridization, and producing segregating populations for *Rosa canina* and *Rosa dumalis*. With the rising interest in applying *Rosa* spp. as food information on the improvement behavior of potentially valuable germplasm is essential. This research evaluated twenty *Rosa canina* and *Rosa dumalis* genotypes mainly originating from seed propagated populations native to Turkey.

MATERIAL AND METHODS

Plant material. Full maturated plants have been used in this study for *R. canina* and *R. dumalis* which are naturally grown in Ardahan province, located in the east Anatolia of Turkey. Plants characteristics were searched in 2017 and 2018 (Tab. 1). Two years average of traits are given in Tables. The genotypes pre-selected according to health status, higher yield, and attractive flower and fruit characteristics. All plant material were previously propagated by seeds showing heterozygous situation.

Morphological characteristics. Flower attractiveness were determined in field conditions by observation. Fruit weight was measured by using 0.01 g electronic balance for sensitive weighing, and randomly harvested 40 fruit from different parts of shrubs with four replications were used for measurement. Yield and thorn characteristics of material were determined by observation on site.

Biochemical and bioactive composition

Sample preparation and extraction. For the analyses of biochemical content the harvested fruit was immediately frozen and stored at –20°C until further analysis. During the analysis, the frozen fruits were taken and thawed to 24–25°C. A laboratory blender was used to homogenise the fruit samples (100 g lots of fruits per genotypes) and a single extraction procedure (taking 3 g aliquots transferred inside tubes and extracted for 1 hour with 20 mL buffer including acetone, water (deionized), and acetic acid (70 : 29.5 : 0.5 v/v) [Singleton and Rossi 1965] was carried out.

Total phenolic contents. The total phenolic content (TPC) of the samples was evaluated using the method of Singleton and Rossi [1965]. In this procedure, each extract (1 mL) was mixed with Folin-Ciocalteu's reagent and water 1 : 1 : 20 (v/v). The samples were incubated for 8 min. Then sodium carbonate (10 mL) having a concentration of 7% (w/v) was added. After incubation for 2 h, the absorbance at 750 nm was measured. The total phenolic content was calculated against the reference standard calibration curve of gallic acid. The TPC was expressed as mg of gallic acid equivalents (GAE) per 100 g of fresh sample.

Total carotenoid content. For total carotenoid content, 1 g of fruit sample was homogenized with 5 mL of acetone in a cold porcelain mortar in an ice bath. Then 1 g of anhydrous sodium sulfate (Na_2SO_4) was added to the homogenate, which was elutriated using a paper filter. The filtered solution was made up to 10 mL with acetone and centrifuged at 2600 × g for 10 min. The upper phase was collected and the absorbance of the solution at 662, 645 and 470 nm was measured. Acetone was used as control. Total carotenoid content expressed as mg per g fresh fruit sample [Lichtenhaler 1987].

Total flavonoid content. For total flavonoid content, to each 15 µL of fruit extract, 1.5 mL of methanol (80%, v/v), 100 µL of aluminum chloride solution (10%, w/v), 100 µL of potassium acetate solution (1 mol per L) and 4.78 mL of deionized water were added. After 15 min, the absorbance of the reaction mixture at 420 nm was determined. Total flavonoid content results were calculated from a quercetin standard calibration curve and expressed as mg quercetin equivalent (QUE) per g FW [Chang et al. 2002].

Total anthocyanin content. The total anthocyanin content was measured using the pH differential method of Giusti and Wrolstad [2005] and a UV-visible spectrophotometer. The absorbance was measured both at 533 and 700 nm in buffers solution at pH 1.0 and 4.5. The total anthocyanins were calculated from the absorbance values and molar extinction coefficient value of 29.60. The total anthocyanin content was expressed as mg of cyanidin-3-glucoside equivalent in per liter sample.

Antioxidant capacity

The 2,2-diphenyl-1-picrylhydrazyl assay was conducted according to the method reported by Nakajima et al. [2004]. A 3 µL aliquot of methanol fruit extract was added to 2 mL of DPPH solution. The mixture was shaken and kept at laboratory temperature for 30 min, then its absorbance at 517 nm was determined using a UV spectrophotometer. The DPPH scavenging activity of rosehip extracts was calculated based on ascorbic acid equivalent (AAE) concentration (mg AAE/g FW).

Phenolic acids. In the research, chlorogenic acid, gallic acid, rutin, *p*-coumaric acid, caffeic acid and cinnamic acid were determined. In the separation of phenolic acids with HPLC, the method developed by Rodriguez-Delgado et al. [2001] was modified and used. The samples collected were distilled with distilled water at the ratio of 1 : 1 and after they were centrifuged at 15000 rpm for 15 min, the supernatant was filtered with 0.45 µm millipore filters and then injected to HPLC. The chromatographic separation was conducted by using DAD detector (Agilent. USA) and 250*4.6 mm, 4 µm ODS colon (HiChrom, USA) in Agilent 1100 (Agilent) HPLC system. Solvent A Methanol-acidic acid-water (10 : 2 : 88), Solvent B Methanol-acidic acid-water (90 : 2 : 8) were used as the mobile phase. The separation was conducted at 254 and 280 nm and the flow rate was determined as 1 mL/min and the injection volume was determined as 20 µL. Phenolic acids expressed as µg per g FW.

Statistical analysis. The data were assessed by one-way analysis of variance (ANOVA) with four replications. The least significant difference (LSD) test was used to compare means. There were no differences between years thus data of both years were pooled.

RESULTS AND DISCUSSION

Morphological characteristics. The obtained information about the main morphological characteristics including location of samples, thorn of shrubs, yield of shrubs, flower attractiveness and fruit mass of 20 *Rosa canina* and *R. dumalis* genotypes are given in Table 1.

The genotypes were found at very high altitude between 1565 and 2200 m. Posof district showed lower altitude while Damal district had the highest altitude. Fruit mass were quite variable and changed from 2.81 g to 4.60 g indicating nearly two times higher value between genotypes that had low and high fruit mass values. Genotypes equally showed low and medium thorn on their annual shoots of shrubs and also nearly equal high and very high yield shrub characteristics. Most of the genotypes had very high and high flower attractiveness indicating their high landscape use traits (Tab. 1). Kazankaya et al. [2005] and Celik et al. [2009] reported quite variable fruit mass of wild

Table 1. Some important morphological traits of *R. canina* and *R. dumalis* genotypes

Genotypes	Species	Location	Altitude (m)	Thorn	Flower attractiveness	Yield	Fruit mass (g)
A1	*R. dumalis*	Ardahan	1865	medium	high	very high	3.67 ±0.13
A2	*R. canina*	Ardahan	1880	low	high	high	3.97 ±0.16
A3	*R. canina*	Gole	2058	low	medium	very high	2.81 ±0.10
A4	*R. dumalis*	Gole	2070	medium	medium	high	4.10 ±0.20
A5	*R. canina*	Ardahan	1856	low	medium	high	3.03 ±0.12
A6	*R. dumalis*	Cildir	1948	low	high	very high	3.60 ±0.10
A7	*R. canina*	Cildir	1970	medium	medium	high	4.07 ±0.15
A8	*R. dumalis*	Cildir	1980	medium	high	very high	4.04 ±0.17
A9	*R. canina*	Ardahan	1846	low	medium	very high	3.80 ±0.16
A10	*R. dumalis*	Ardahan	1805	medium	high	high	4.60 ±0.16
A11	*R. canina*	Damal	2180	low	medium	high	4.31 ±0.18
A12	*R. canina*	Damal	2200	medium	medium	high	4.33 ±0.20
A13	*R. dumalis*	Ardahan	1822	low	medium	high	3.80 ±0.13
A14	*R. dumalis*	Posof	1565	medium	high	very high	3.70 ±0.13
A15	*R. canina*	Posof	1611	low	high	high	3.30 ±0.12
A16	*R. dumalis*	Posof	1585	low	high	very high	3.25 ±0.16
A17	*R. canina*	Hanak	1885	low	medium	high	4.14 ±0.15
A18	*R. dumalis*	Hanak	1910	medium	high	very high	4.20 ±0.20
A19	*R. canina*	Hanak	1922	medium	high	very high	4.23 ±0.19
A20	*R. dumalis*	Hanak	1968	medium	high	high	3.66 ±0.11
Significance							**
LSD5%							0.28

grown *Rosa* genotypes between 0.61–4.95 g in different regions of Turkey. The fruit mass of genotypes is found higher compared to previous studies even they grown nature environment without maintenance. All parts of *Rosa* plants including flowers, shoots, leaves and fruits adding value of natural landscape in particular of rural areas.

Total flavonoid, total phenolic, total carotenoid, Vitamin C, total anthocyanin, antioxidant capacity and SSC content. Table 2 shows total flavonoid, total phenolic, total carotenoid, vitamin C, total anthocyanin, antioxidant capacity and SSC (soluble solid content) content of *R. canina* and *R. dumalis* genotypes naturally grown Ardahan province of Turkey.

Total flavonoid and total phenolic content greatly varied among *Rosa* genotypes. The highest total flavonoid content was found in genotype A13 as 2.00 mg per g FW while the lowest values exhibited by A14 genotype as 1.02 mg per g FW. Previously total flavonoid content of different *Rosa* species naturally grown as wild in Iran condition were found in the range of 0.70 (*R. hemisphaerica*) and 2.53 mg quercetin equivalent per g FW (*R. canina*) [Shameh et al. 2019]. Our total flavonoid content results are in agreement with previous study conducted in Iran.

Total phenolic content of twenty *Rosa* genotypes were found between 405 mg GAE per 100 g (A16) and 507 mg GAE per 100 g (A9). The results are indicating total phenolic richness of *Rosa* fruits. Previous studies are also indicated this richness and total phenolic content of *Rosa* fruits in different parts of the world were reported between 177–816 mg GAE per 100 g fresh samples [Yoo et al. 2008, Fattahi et al. 2012, Roman et al. 2013]. Total phenolic content of *Rosa* fruits are comparable with some fruit species such as blueberry, elderberry, black currant, blackberry, and raspberry which have high polyphenolic content among fruit species. A number of factors affects total phenolic content of fruits and those factors including genetic background, harvest time, growing conditions, altitude etc.

Carotenoids are natural pigments which are metabolized by plants, algae, and photosynthetic bacteria; which are responsible for the yellow, orange, and red colors in various fruits and vegetables. Rose hips are one of the richest sources of carotenoids. Table 2 presents the total carotenoid contents of *Rosa* genotypes. We found a wide variation on total carotenoid content among 20 *Rosa* genotypes and the lowest values was obtained as 8.40 mg per g FW whereas the highest values were observed as 13.30 mg per g FW (Tab. 2). The results are shown that *Rosa* fruits are rich for carotenoids and its values belongs to genotypes. In a previous study Shameh et al. [2019] found variable total carotenoid content among 21 *Rosa* genotypes belongs to different species. They found the highest and lowest amounts of total carotenoids in *R. damascena* and *R. moschata*, respectively. Andersson et al. [2011] reported total carotenoids content in Rosa fruits between 297 (*R. spinosissima*) 1020 (*R. dumalis*) µg per g dry weight base. Carotenoids as fortified substances in foods and special aspects about carotenoids as health promoters are well presented along with a glance of carotenoids economics.

Rosa fruits are accepted one of the richest vitamin C source among fruit species. As indicated in Table 2, Rosa genotypes differed each other for vitamin C content and the highest vitamin C content was obtained from A3 genotype as 714 mg per 100 g FW, and followed by A9 (703 mg per 100 g FW) and A10 genotype (671 mg per 100 g FW), respectively. The lowest vitamin C content was observed in genotype A15 as 502 mg per 100 g FW (Tab. 2). Our results are comparable with previous studies. Roman et al. [2013] determined lower vitamin C content (112–360 mg per 100 g of fresh rose hips) belonging to different species in Romania. Celik et al. [2009] reported higher vitamin C (604–1032 mg/100 g FW) in fruits of Rosa species in Eastern Anatolia region of Turkey.

Table 2. Biochemical characteristics of *Rosa* genotypes

Genotypes	Total flavonoid (mg QUE/g FW)	Total phenolic (mg GAE/ 100 g FW)	Total carotenoid (mg/g FW)	Vitamin C (mg/100 g FW)	Total anthocyanin (mg/L)	DPPH (mg AAE/ g FW)	SSC (%)
A1	1.98 ±0.17	460 ±18	12.44 ±0.10	518 ±22	4.77 ±0.10	26.3 ±0.5	18.6 ±0.1
A2	1.93 ±0.11	502 ±19	13.10 ±0.13	534 ±25	6.70 ±0.13	24.7 ±0.2	17.8 ±0.2
A3	1.86 ±0.14	507 ±16	10.10 ±0.13	714 ±20	5.76 ±0.12	22.3 ±0.6	20.0 ±0.2
A4	1.79 ±0.11	412 ±11	9.86 ±0.14	511 ±19	4.82 ±0.12	30.7 ±0.2	20.2 ±0.2
A5	1.80 ±0.10	488 ±10	11.55 ±0.10	528 ±20	6.56 ±0.14	25.4 ±0.2	18.6 ±0.2
A6	1.93 ±0.16	460 ±12	11.68 ±0.11	615 ±17	6.25 ±0.15	26.3 ±0.4	19.2 ±0.2
A7	1.27 ±0.10	418 ±11	10.33 ±0.09	526 ±14	6.98 ±0.17	29.9 ±0.3	17.6 ±0.3
A8	1.39 ±0.15	442 ±16	8.89 ±0.10	620 ±18	4.78 ±0.10	27.3 ±0.5	19.9 ±0.3
A9	1.67 ±0.12	507 ±14	9.80 ±0.08	703 ±14	5.85 ±0.13	22.9 ±0.2	18.0 ±0.3
A10	1.88 ±0.08	468 ±12	13.30 ±0.15	671 ±16	5.94 ±0.13	27.0 ±0.4	18.7 ±0.2
A11	1.76 ±0.11	470 ±13	12.40 ±0.13	585 ±14	6.44 ±0.18	27.2 ±0.4	20.4 ±0.4
A12	1.69 ±0.10	489 ±17	13.00 ±0.14	680 ±18	4.77 ±0.09	22.9 ±0.2	20.6 ±0.4
A13	2.00 ±0.17	466 ±10	9.89 ±0.07	590 ±14	5.88 ±0.13	25.3 ±0.3	19.2 ±0.1
A14	1.02 ±0.06	416 ±10	8.81 ±0.09	509 ±12	5.39 ±0.12	30.9 ±0.1	15.8 ±0.1
A15	1.09 ±0.10	424 ±12	9.08 ±0.09	502 ±10	4.35 ±0.08	26.4 ±0.2	16.3 ±0.2
A16	1.14 ±0.09	405 ±10	8.40 ±0.06	520 ±14	6.66 ±0.14	29.7 ±0.2	16.6 ±0.1
A17	1.80 ±0.10	444 ±13	12.40 ±0.09	567 ±17	5.12 ±0.13	25.9 ±0.4	19.1 ±0.4
A18	1.69 ±0.13	491 ±16	13.11 ±0.16	585 ±11	5.81 ±0.14	30.2 ±0.4	18.5 ±0.6
A19	1.83 ±0.12	435 ±12	10.23 ±0.11	562 ±10	4.32 ±0.11	30.2 ±0.1	19.2 ±0.5
A20	1.70 ±0.10	444 ±11	11.50 ±0.09	601 ±14	5.70 ±0.14	25.0 ±0.4	19.9 ±0.3
Significance	**	**	*	**	*	*	*
LSD5%	0.22	39	2.13	96	1.48	2.70	1.32

In general, we found higher vitamin C at higher altitude and lower values at low altitudes. The reason could be explained by higher light exposure and lower oxygen amounts. Light exposure increases the amount of carotene and thus protects ascorbic acid in the fruit, while the lack of oxygen reduces oxidative stress and lessens ascorbic acid breakdown [Yamankaradeniz 1983]. Accumulation of vitamin C in fruits is genotype depend and shows relatively high heritability [Bulley and Laing 2016]. Our results also confirm that fruits of *Rosa* considered to be a natural source of ascorbic acid (vitamin C). Vitamin C has high biological activities including antioxidant and anticancer characteristics [Fan et al. 2014].

Anthocyanins responsible for the attractive colors, red, purple, and blue, are in fruits and vegetables and strongly affects consumers behavior. Berries, currants, grapes, and some tropical fruits have high anthocyanins content. Red to purplish blue-colored leafy vegetables, grains, roots, and tubers are the edible vegetables that contain a high level of anthocyanins. *Rosa* fruits are also rich for anthocyanins. The highest total anthocyanin content of genotypes was obtained from A7 genotype as 6.98 and followed by A2 (6.70) and A12 (6.66) as mg cyanidin-3-glucoside equivalent per L of fresh fruit. Among the 20 genotypes A15 showed the lowest total anthocyanin content as 4.35 mg cyanidin-3-glucoside equivalent per L of fresh *Rosa* fruits (Tab. 2). Due to rich anthocyanin content, *Rosa* fruits frequently studied for their anthocyanin composition. The main anthocyanin group in in *R. canina* and *R. dumalis* fruits was previously reported as cyanidin-3-glucoside [Guimaraes et al 2013]. In Chile *Rosa* is one of the widely grown wild fruits and Guerrero et al. [2010] reported average 0.38 mg/100 g total anthocyanin content in *Rosa* fruits. In Iran, *Rosa* species grown also widely and Shameh et al. [2019] found a great variation on total anthocyanin content between 1.80 and 15.86 mg per L among different *Rosa* species. In another study conducted in Turkey, Yildiz and Alpaslan [2012] reported the amount of total anthocyanins in wild grown *Rosa* fruits as 28.2 mg per L. It is obvious that the amount of anthocyanins can be dependent on environmental factors such as temperature, light intensity, nutrition, pH and ascorbic acid [Roobha et al. 2011].

Table 2 presents DPPH values of 20 *Rosa* genotypes and it was obvious that genotypes are differed each other for DPPH values. We found a great difference among genotypes and they showed DPPH values between 22.3–30.9 mg ascorbic acid equivalent per g FW (Tab. 2). Previous studies conducted on *Rosa* fruits showed that they have strong antioxidant activity. For example, Shameh et al. [2019] used a number of *Rosa* fruits and found significant differences in antioxidant activity among genotypes belongs to different *Rosa* taxa. They indicated that among species *R. hemisphaerica* showed the lowest (3.80 mg AAE per g FW) and *R. canina* fruits had the highest antioxidant activity (37.60 mg AAE per g FW). In another study conducted in Turkey revealed that antioxidant capacity is variable among genotypes and species of *Rosa* taxa [Demir et al. 2014]. In Romania, Cunja et al. [2015] studied on biological activity of *Rosa* fruits and found that *R. canina* fruit had the highest antioxidant activity among species. Along with specie and genotypes, growing conditions, ripening degree etc. affect biological activity of fruits.

Table 2 presents soluble solid content (SSC) of 20 *Rosa* genotypes sampled from Ardahan province of Turkey. The genotypes exhibited SSC content between 15.8–20.6% (Tab. 2). The genotypes found higher altitude showed higher SSC content. In Turkey several studies conducted on wild grown *Rosa* and SSC content were found between 12–36% [Balta and Cam 1996, Kazankaya et al. 2001, Celik et al. 2015] which in agreement with our present results. SSC of fruit species not only defines its nutritional value but also gives an insight into the allocation of carbon compounds to sink organs. They influence of taste and flavour of fruits. It is an important food analysis way for evaluating fruit quality as well.

Phenolic acids. The amount of phenolic acids in *Rosa* fruits were found in a descending order chlorogenic acid > gallic acid > *p*-coumaric acid > caffeic acid > cinnamic acid (Tab. 3).

Chlorogenic acid, gallic acid, *p*-coumaric acid, caffeic acid and cinnamic acid were in range of 35.8 μg per g FW (A10 genotype) – 77.8 μg per g FW (A18 genotype); 22.3 μg per g FW (A1 genotype) – 64.3 μg per g FW (A12 genotype); 12.1 μg per g FW (A20 genotype) – 43.3 μg per g FW (A5 genotype); 7.2 μg per g FW (A16 genotype) – 20.1 μg per g FW (A5 genotype) and 3.7 μg per g FW (A15 genotype) – 9.2 μg per g FW (A8 genotype), respectively (Tab. 3). Shameh et al.

Table 3. Phenolic acids in fruits of *Rosa* genotypes (µg per g FW)

Genotypes	Chlorogenic	Gallic	Rutin	*p*-coumaric	Caffeic	Cinnamic
A1	37.4 ±0.03	22.3 ±0.02	17.1 ±0.02	12.5 ±0.02	9.3 ±0.02	6.3 ±0.01
A2	64.7 ±0.06	53.6 ±0.04	30.3 ±0.02	22.2 ±0.02	12.3 ±0.01	5.1 ±0.01
A3	55.7 ±0.06	50.1 ±0.02	40.3 ±0.03	25.6 ±0.05	9.9 ±0.02	4.0 ±0.02
A4	48. 3 ±0.07	42.2 ±0.03	33.7 ±0.05	23.3 ±0.04	11.7 ±0.02	6.6 ±0.01
A5	70.6 ±0.03	61.6 ±0.07	58.3 ±0.05	43.3 ±0.03	20.1 ±0.03	6.2 ±0.01
A6	61.2 ±0.04	54.3 ±0.03	46.2 ±0.06	34.9 ±0.03	11.1 ±0.02	4.9 ±0.01
A7	71.7 ±0.08	61.3 ±0.10	44.4 ±0.03	36.3 ±0.04	14.3 ±0.014	4.3 ±0.02
A8	52.8 ±0.06	44.3 ±0.07	39.3 ±0.04	28.4 ±0.03	15.6 ±0.01	9.2 ±0.01
A9	69.3 ±0.05	54.5 ±0.03	39.4 ±0.05	27.2 ±0.03	20.0 ±0.03	5.3 ±0.02
A10	35.8 ±0.06	30.1 ±0.04	25.3 ±0.03	17.3 ±0.03	7.3 ±0.02	5.1 ±0.02
A11	50.8 ±0.07	42.4 ±0.03	30.5 ±0.07	19.3 ±0.03	11.3 ±0.01	4.7 ±0.02
A12	72.4 ±0.05	64.3 ±0.04	57.9 ±0.06	39.3 ±0.04	18.1 ±0.02	5.5 ±0.01
A13	60.3 ±0.04	50.2 ±0.05	48.5 ±0.06	32.0 ±0.05	10.1 ±0.02	7.0 ±0.02
A14	64.3 ±0.05	57.6 ±0.05	49.2 ±0.05	33.3 ±0.04	12.3 ±0.02	3.9 ±0.01
A15	55.2 ±0.08	40.9 ±0.04	30.4 ±0.04	26.3 ±0.03	14.3 ±0.01	3.7 ±0.02
A16	42.9 ±0.04	29.2 ±0.06	23.2 ±0.03	13.0 ±0.02	7.2 ±0.02	5.5 ±0.01
A17	38.2 ±0.06	34.3 ±0.07	25.6 ±0.03	20.2 ±0.03	10.4 ±0.02	4.4 ±0.01
A18	77.8 ±0.05	61.5 ±0.06	54.1 ±0.08	39.3 ±0.04	13.0 ±0.03	4.1 ±0.02
A19	58.3 ±0.07	50.1 ±0.02	40.2 ±0.06	34.0 ±0.01	9.1 ±0.02	6.0 ±0.02
A20	45.2 ±0.04	40.4 ±0.03	29.2 ±0.05	12.1 ±0.04	10.1 ±0.02	6.6 ±0.01
Significance	**	**	**	**	*	*
LSD 5%	2.9	3.0	2.2	2.0	0.7	0.4

[2019] studies on phenolic acid content of *Rosa* species in Iran and reported that *Rosa* fruits mostly include chlorgenic acid (5.7–186 µg per g FW) and gallic acid (4.1–164 µg per g FW) and they determined a great variability on those compounds among genotypes and species. In Turkey Demir et al. [2014] studied on fruits of *Rosa* species and they revealed that chlorgenic acid, gallic acid, *p*-coumaric acid and caffeic acid were dominant. Our findings are good agreement with results of above studies. Chlorogenic acids has been associated with the reduction of oxidative and inflammatory stress conditions [Liang and Kitts 2016].

CONCLUSIONS

The study revealed that there were a huge genotypic diversity for most of the parameters searched in *Rosa canina* and *Rosa dumalis*. Considering genotypes, in particular A1, A2, A6, A8, A10, A14, A15, A16, A18, A19 and A20 were found to be high flower attractiveness and could be used for landscape planning. A1, A3, A6, A8, A9, A14, A16, A18 and A19 were found promising with very high yield characteristics, A10, A11 and A12 for high fruit mass, A2, A3 and A9 for higher total phenolic content, A3 and A9 for higher vitamin C content and A3, A9 and A12 with a higher antioxidant capacity making them suitable as functional foods.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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