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Phenolic and antioxidant assessment of the flowers, stems, leaves, and fruits of *Rosa pimpinellifolia* and *Rosa canina* at different growth time

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Abstract: Natural plants are abundant in their native habitats and are traditionally used to treat a variety of health conditions. The *Rosa* genus stands out as an important species rich in bioactive compounds. This study, conducted in Türkiye, aimed to analyse the antioxidant and phenolic profiles of methanolic extracts obtained from different parts of *Rosa canina* (*R.c.*) and *Rosa pimpinellifolia* (*R.p.*) collected in 2021 and 2022. The antioxidant activity values of *R.c.* collected in 2021 and 2022 were found to be between 5 102.31–46 396.36 mmol Fe(II)/100 g in ferric reducing antioxidant power (FRAP), 141.92–377.54 mg ascorbic acid equivalents (AA)/kg in total antioxidant capacity (TAC), 2.18–24.68 µg/g in 2,2-diphenyl-1-picrylhydrazyl [DPPH (EC₅₀)] and 34.31–75.77 % in DPPH (% inhibition). Antioxidant activity of *R.p.* collected in 2021 and 2022 ranged from 17 258.44–71 903.20 mmol Fe(II)/100 g, 271.69–479.19 mg AA/kg, 1.02–8.32 µg/g and 50.98–85.57% for FRAP, TAC, DPPH (EC₅₀) and DPPH (% inhibition), respectively. The *R.p.* extracts generally exhibited higher antioxidant activity than those of *R.c.* Considering the total identified phenolic compounds achieved from different plant parts of rosehip for both years, the highest values of total phenolic compounds were determined in *R.c.* leaves (222.08 mg/100 g) in 2021, and *R.p.* leaves (5 465.95 mg/100 g) in 2021.

Keywords: flavonoid content; free radical scavenging; medicinal plants; methanolic extracts; *Rosa* species

In recent years, there has been significant interest in the biological effects and pharmacological potential of natural compounds derived from botanical sources. Among these sources, plants of the *Rosa* genus, specifically *Rosa pimpinellifolia* (commonly referred to as shrub rose) (*R.p.*) and *Rosa canina* (wild rose) (*R.c.*), stand out as important species rich in bioactive compounds. Moreover, numerous plant species belonging to the Rosaceae family hold significant importance due to their utilisation in diverse culinary applications (Polumackanycz et al. 2020). Naturally abundant in their habitats, these plants

have long been used in traditional medicine due to their bioactive compounds, which are effective against a range of health conditions. *Rosa* species have been found to contain a diverse array of phytochemicals, including flavonoids, auronones, phenylethanoids, saponins, steroids, sesquiterpenes, carotenoids, tannins, fatty acids, and volatile compounds (Ghazghazi et al. 2010; Gao et al. 2012; Mármol et al. 2017). Moreover, recent studies have indicated that *R.p.* exhibits condensed tannins, such as catechin, epigallocatechin, and procyanidin B2, as well as anthocyanidins like cyanidin-3-O-glucosides. Addi-

tionally, it contains phenolic acids, including ascorbic acid and caffeic acid, and essential fatty acids, including linoleic, oleic, and linolenic acids (Pashazadeh et al. 2021). These bioactive compounds present in these plants are believed to possess a wide range of biological properties, including antioxidant activity and antimicrobial potential (Jakešević et al. 2009; Szoltyśik et al. 2020). Recent research has indicated the effectiveness of *R.c.* extracts in inhibiting the growth and biofilm formation of methicillin-resistant *Staphylococcus aureus* (Fattahi et al. 2012). Leaves and stems of *R.c.* are often discarded as waste in food processing facilities that deal with rosehips (Barros et al. 2011). However, limited recent studies have indicated that *R.c.* leaves could be a significant source of flavonoids (Cunja et al. 2014; Ieri et al. 2015; Sytar et al. 2018). Additionally, research on *R.c.* stems has reported them to be a good source of polyphenols. Extracts obtained from the stems of various *Rosa* species were found to be potential sources of phenolic compounds for use in the food, cosmetic, and pharmaceutical industries, as indicated by recent research (Ouerghemmi et al. 2020).

Based on the review, a significant amount of work has been conducted on the *Rosa* genus, particularly on *R.c.* fruit; however, less work has been done on the flower, stem, and leaves. There are even fewer studies conducted on *R.p.* fruits, and no literature is available on its flowers, leaves, and stems. The aim of this study is to investigate and compare the antioxidant activity and phenolic profiles of different anatomical parts (flowers, stems, leaves, and fruits) of *R.c.* and *R.p.*, with a focus on understudied plant parts, to explore their potential value for applications in the food and pharmaceutical industries.

MATERIAL AND METHODS

Material. A total of two different rosehip species were chosen as samples from the Gümüşhane region, situated in the Black Sea region of Türkiye, for this study. These are *R. pimpinellifolia* L. (*R.p.*), which is called black rosehip and *R. canina* L. (*R.c.*), which is called red rosehip. Samples of *Rosa* species fruit, flower, stem and leaves were collected separately during the peak growing season 2021 and 2022. Specifically, flowers and leaves were collected in June, while stems and fruits were sampled in September of both years, in accordance with the phenological development stages of the plants. The harvested

R.c. and *R.p.* samples were collected from natural habitats in Gümüşhane province, Türkiye, and taxonomically identified. The voucher specimens were deposited in the Herbarium of the Faculty of Forestry at Karadeniz Technical University under the accession numbers KATO: 24436 and KATO: 24437. The GPS coordinates of the collection sites were approximately 40.488670°N, 39.444719°E for *R.c.* and 40.490539°N, 39.493410°E for *R.p.* The samples were stored at –24 °C until further analysis.

Extraction procedure of *Rosa pimpinellifolia* L. and *Rosa canina* L. Flower, fruit, stem and leaves parts of *R.c.* and *R.p.* were ground via a blender. Approximately 10 g of each sample was mixed with an equal volume (30 mL) of methanol. The mixture was continuously stirred with a shaker (Heidolph Promax 2020, Schwabach, Germany) at room temperature (about 24 °C) for 30 minutes. At the end of the time, solid parts were removed with filter paper. The solid part obtained from the first extraction was added to approximately 30 mL of dichloromethane and stirred continuously with a shaker at room temperature for 30 minutes. Solid parts were again removed with filter paper. Finally, the solid part obtained from the second extraction was added to approximately 40 mL of methanol and stirred with a shaker at room temperature for 24 hours. A solid part of the sample was thrown after being filtered. The liquid part was evaporated using a rotary evaporator (Heidolph, Schwabach, Germany) until a minimal volume remained, and then lyophilised. The methanolic extract of the samples was divided into two parts: one for antioxidant and antimicrobial tests, and the other for phenolic analysis using high-performance liquid chromatography (HPLC).

A liquid-liquid extraction procedure was applied to prepare the samples for HPLC analysis. For each sample extract (prepared in methanol), the residue was dissolved in 15 mL of acidified distilled water (pH 2). Liquid-liquid extraction was performed using diethyl ether and ethyl acetate (each 3 × 5 mL). Organic phases from both diethyl ether and ethyl acetate were combined, evaporated at 35 °C, and resuspended in 2 mL of methanol for HPLC after passing through a filter with a 0.45 µm size.

Total phenolic content (TPC) and total flavonoid content (TFC). TPC of methanolic extract of *R.c.* and *R.p.* flower, stem, leaves and fruit were determined with a method previously used and reported by the Folin-Ciocalteu method (Singleton et al. 1999). The Folin-Ciocalteu reaction, which

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occurs under alkaline conditions, easily transfers electrons from the phenol molecule. Briefly, dry extracts (300 µL) obtained separately from different parts in *R.p.* and *R.c.* were solubilised with methanol and combined with 200 µL 2 N Folin-Ciocalteu reagent and 20 µL of various concentrations of gallic acid. The mixture was vortexed, and after a 3-minute incubation, 600 µL of a 10% Na₂CO₃ solution was added. The mixture was vortexed and incubated in the dark at room temperature for 120 minutes. After that, the absorbance of the mixture was measured at 760 nm using a spectrophotometer (IKA, Staufen, Germany), and methanol was used as a blank. Results were expressed as mg gallic acid equivalents (GAE) per 100 g (mg GAE/100 g).

TFC of methanolic extract from samples were determined by Zhishen et al. 1999 with some modifications. According to this method, 500 µL of each extract was dissolved in 3 200 µL of methanol (30% v/v). To the sample in methanol, 150 µL of 0.3 M AlCl₃ and 150 µL of 0.5 M NaNO₂ were added to the test tube. Also, 1 mL of 1 M NaOH was added after 5 min in the same test tube and incubated at room temperature for 10 minutes. Then, the absorbance was measured against a blank at 510 nm. Results were expressed as mg quercetin equivalents (QE) per 100 g (mg QE/100 g). All measurements were performed in triplicate, and results were expressed as the mean ± standard deviation.

Total antioxidant capacity (TAC). TAC was measured in accordance with Prieto et al. (1999) with slight modification. Hydroalcoholic extract (2 500 µL deionised water in 500 µL methanolic extract) of *R.c.* and *R.p.* flower, stem, leaves and fruit in different concentrations ranging from 100 µL to 500 µL was added to each capped test tube individually containing 1 000 µL phosphomolybdenum reagent (28 mM monobasic sodium phosphate and 4 mM ammonium heptamolybdate tetrahydrate in 0.6 M sulphuric acid). The mixture was then vortexed, and the tubes were incubated at 95 °C for 90 minutes. The absorbance was measured at 695 nm after incubation at room temperature. Ascorbic acid was used as a reference standard. All determinations were carried out in three replicates, and the data are presented as mean ± standard deviation.

Free radical scavenging activity (DPPH). DPPH is a commonly used method based on the measurement of the scavenging capacity of antioxidants towards it. This assay was measured in accordance with the method of Molyneux (2004). The scaveng-

ing of 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical was used to identify the radical scavenging activity of the methanolic *R.c.* and *R.p.* flower, stem, leaves and fruit extract. Briefly, the extract solution (100 µL each) was mixed with 3 000 µL of a freshly prepared 10 mM DPPH solution. The mixture was shaken and left to stand at room temperature for 50 min in the dark room. The DPPH radical turns purple in the presence of antioxidants. The change of the absorbance based on colour is monitored at 517 nm against a control using a spectrophotometer. The values were shown as EC₅₀ (µg/g) and DPPH inhibition (%). DPPH inhibition was calculated using the following formula:

$$\text{DPPH inhibition (\%)} = (A_B - A_E)/A_B \times 100 \quad (1)$$

where: A_B – the absorbance of the blank sample at 517 nm; A_E – the absorbance of the sample at 517 nm.

All measurements were carried out in triplicate, and the results are presented as the mean ± standard deviation.

Ferric reducing/antioxidant power (FRAP) assay. Ferric ion-reducing power was conducted as described in the literature (Benzie, Strain 1996). Firstly, FRAP reagent was made by adding 300 mM sodium acetate buffer solution (pH 3.6), 10 mM aqueous TPTZ solution in 40 mM HCl and 20 mM aqueous FeCl₃ solution in a ratio of 10 : 1 : 1. Additionally, the dry extract of *R.p.* and *R.c.* flower, stem, leaves and fruit was dissolved in methanol. Afterwards, 250 µL of the extract solution was added to 2 750 µL of freshly prepared FRAP reagent. The mixture was incubated at 37 °C for 15 min before using a spectrophotometer. The absorbance was measured at 593 nm against a control. Results were expressed as mmol Fe(II)/100 g. All measurements were performed in triplicate and reported as mean ± standard deviation.

Analysis of phenolic profiles by high-performance liquid chromatography (HPLC). The HPLC analysis was performed using an HPLC system (Thermo-Finnigan HPLC, Finnigan Corp., San Jose, CA, USA) equipped with a 1000 series quaternary pump, an autosampler, and a UV detector, and controlled by Empower Build 1154 software (Waters, Milford, MA, USA). The separation of the phenolic compounds was performed using a C18 column (Supelcosil, 25 mm × 4.6 mm × 5 µm). The twenty-five standards were recorded at 278 nm, while quercetin was recorded at 315 nm. The mobile phase consisted of (i) 3% acetic acid in water (A) and

(ii) 3% acetic acid and 25% acetonitrile in water (B). The mobile phase was sonicated before stirring and continuously degassed by the built-in HPLC system. The injection volume was 20 μ L, and the column temperature was kept at 20 °C. The total run-time of the method was 60 minutes. The gradient program began with 90% A for 10 min, decreasing to 80% A at 7 min, 70% A at 5 min, 50% A at 5 min, 20% A at 18 min, 80% A at 10 min and finally 90% A at 5 minutes (Hatipoğlu et al. 2013). Three wavelengths (210, 280 and 360 nm) were chosen for analysis in this study using the HPLC.

Statistical analysis. Data analyses were tested with SPSS version 14.0 for Windows using the non-parametric. Significance was set at $P < 0.05$.

RESULTS

Total phenolic content (TPC) and total flavonoid content (TFC). The comparative data about TPC and TFC are presented in Table 1. As seen in Table 1, TPC in the current study ranged from 321.08 to 6 650.04 mg GAE/100 g for *R.c.*, and 2 294.23 to 11 097.94 mg GAE/100 g for *R.p.* TPC level in flower, stem, leaf and fruit of the *R.p.* were

found to be significantly higher than those in *R.c.* for both years. Additionally, the methanolic extract from the leaves of *R.c.* and *R.p.* showed higher TPC values compared to those from the stems, fruits, and flowers of *R.c.* and *R.p.* for both years. Additionally, significant differences were observed between collecting years for *R.c.* and *R.p.* In 2022, higher TPC values were observed for *R.c.* compared to 2021. However, on the other hand, *R.p.* extract obtained from flower and fruit showed higher TPC values in 2022, while *R.p.* extract in the stem and leaves was found to have higher TPC values in 2021.

The largest subgroup of polyphenols is flavonoids, which are a very important indicator of antioxidant properties in medicinal plants. Findings from Table 1 illustrate that the highest TFC values were found in *R.p.* extract obtained from leaves in 2021, while the lowest value was found in *R.c.* extract obtained from fruit in 2021. The TFC of *R.p.* extract was determined to be relatively higher compared with *R.c.* extract obtained from the same plant part for both years. Additionally, the study revealed differences in TFC values between *R.c.* and *R.p.* extracts obtained from flowers, stems, leaves, and fruits collected from the same region during different years. For example, the TFC values of *R.c.* extract obtained from flow-

Table 1. Total phenolic and total flavonoid contents of *Rosa canina* and *Rosa pimpinelifolia* flower, stem, leaves and fruit

Sample	Year	Plant part	TPC (mg GAE/100 g)	TFC (mg QE/100 g)
<i>Rosa canina</i>	2021	flower	3 010.75 \pm 0.08 ^g	170.29 \pm 0.11 ^d
		stem	4 714.49 \pm 0.00 ^{hij}	190.65 \pm 2.21 ^g
		leaves	6 243.18 \pm 0.06 ^k	201.16 \pm 0.09 ^h
		fruit	3 21.08 \pm 0.01 ^{ab}	88.92 \pm 0.03 ^a
	2022	flower	2 544.54 \pm 0.00 ^{ef}	129.93 \pm 1.11 ^c
		stem	4 825.90 \pm 0.02 ^{hi}	186.12 \pm 0.94 ^{efg}
		leaves	6 650.04 \pm 0.05 ^{kl}	185.75 \pm 0.13 ^{ef}
		fruit	614.02 \pm 0.03 ^{cd}	95.12 \pm 4.02 ^{ab}
<i>Rosa pimpinelifolia</i>	2021	flower	3 840.40 \pm 0.02 ^{bc}	189.25 \pm 0.59 ^{cd}
		stem	4 807.24 \pm 0.00 ^{de}	190.51 \pm 4.82 ^{cde}
		leaves	1 1097.94 \pm 0.02 ^h	223.65 \pm 0.79 ^{ef}
		fruit	2 294.23 \pm 0.02 ^a	123.25 \pm 0.01 ^a
	2022	flower	5 597.84 \pm 0.01 ^f	163.12 \pm 2.08 ^b
		stem	4 472.20 \pm 0.01 ^d	186.35 \pm 3.15 ^{cd}
		leaves	7 528.91 \pm 0.03 ^g	198.45 \pm 0.07 ^{de}
		fruit	3 127.98 \pm 0.16 ^{bc}	128.06 \pm 0.91 ^a

All values are expressed on a fresh weight basis

TPC – total phenolic content; TFC – total flavonoid content

^{a-l}different letters in the same column indicate a significant difference at the 5% level ($P < 0.05$) among the results

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ers in 2021 and 2022 were found to be 170.29 and 129.93 mg QE/100 g, respectively. In contrast, the values for *R.p.* extract in 2021 and 2022 were 189.25 and 163.12 mg QE/100 g, respectively.

Total antioxidant capacity (TAC). The results obtained when testing the antioxidant properties of *R.c.* and *R.p.* flower, stem, leaves and fruit extracts using four different tests are shown in Table 2. This is because a single method is usually insufficient to determine antioxidant activity.

According to Table 2, FRAP, TAC, DPPH (EC₅₀) and DPPH (% inhibition) values of *R.c.* collected in 2021 were found to be between 5 102.31–46 396.36 mmol Fe(II)/100 g, 141.92–373.51 mg AA/kg, 2.76–24.68 µg/g and 34.31–72.55%, respectively. Antioxidant activity of *R.p.* collected in 2021 ranged from 1 7258.44–71 903.20 mmol Fe(II)/100 g, 275.43–406.12 mg AA/kg, 1.91–8.32 µg/g and 50.98–85.57% for FRAP, TAC, DPPH (EC₅₀) and DPPH (% inhibition), respectively. The methanolic extract from *R.c.* leaves in 2021 showed higher antioxidant activity in terms of TAC and FRAP, while the flower extract exhibited the highest DPPH (EC₅₀) value, indicating the lowest antioxidant capacity among the tested parts. Likewise, the antioxidant activity of the

methanolic extract from *R.p.* leaves in 2021, as measured by TAC and FRAP, was found to be higher compared to that of the other plant parts. However, results from the DPPH assays did not consistently support this trend. The results obtained by the DPPH (% inhibition) method for *R.c.* fruit in 2021 and 2022 were about two times lower compared to other tested extracts. While *R.p.* extracts exhibited strong antioxidant activity, the results were not consistently higher than those of *R.c.* In particular, the DPPH (EC₅₀) values (Figure 1C) were lower for *R.p.* in all tested plant parts, indicating stronger antioxidant capacity. Additionally, *R.p.* exhibited similar or higher antioxidant activity in several parts compared to *R.c.* in other assays (Figures 1B and 1D), especially in the fruit and leaves. It is worth noting that the antioxidant activity of the extracts followed the order leaves > stem > flower > fruit only in the FRAP assay. In other methods [TAC, DPPH (EC₅₀), and DPPH (% inhibition)], this pattern was not consistently observed across all plant parts or years. Our study results confirmed that the antioxidant activity of *R.c.* and *R.p.* extracts obtained from flower, stem, leaves and fruit is mainly determined by the amount of phenolic compounds present in the plants.

Table 2. Total antioxidant capacity of *Rosa canina* and *Rosa pimpinelifolia* flower, stem, leaves and fruit

Sample	Year	Plant part	FRAP [mmol Fe(II)/100 g]	TAC (mg AA/kg)	DPPH (EC ₅₀) (µg/g)	DPPH (% inhibition)
<i>Rosa canina</i>	2021	flower	14 299.75 ± 0.02 ^f	250.41 ± 0.03 ^b	24.68 ± 0.18 ^a	72.55 ± 0.19 ^a
		stem	27 912.42 ± 0.04 ^{ab}	368.82 ± 0.09 ^a	9.49 ± 0.18 ^{cd}	67.65 ± 0.16 ^{de}
		leaves	46 396.36 ± 0.04 ^d	371.51 ± 0.01 ^a	2.76 ± 0.21 ^b	62.61 ± 0.20 ^d
		fruit	5 102.31 ± 0.04 ^e	141.92 ± 0.04 ^c	13.85 ± 0.11 ^e	34.31 ± 0.12 ^{bc}
	2022	flower	10 747.19 ± 0.04	328.81 ± 0.03	23.47 ± 0.18 ^a	73.67 ± 0.20 ^a
		stem	29 760.22 ± 0.01 ^b	373.51 ± 0.01 ^a	8.56 ± 0.19 ^c	70.03 ± 0.16 ^a
		leaves	35 206.86 ± 0.04 ^c	377.54 ± 0.05 ^a	2.18 ± 0.18 ^b	75.77 ± 0.17 ^a
		fruit	5 936.81 ± 0.03 ^g	143.18 ± 0.03 ^c	13.38 ± 0.14 ^e	39.08 ± 0.16 ^c
<i>Rosa pimpinelifolia</i>	2021	flower	17 258.44 ± 0.07 ^a	375.76 ± 0.03 ^{ab}	7.50 ± 0.17 ^c	80.25 ± 0.18 ^c
		stem	31 754.44 ± 0.02 ^c	355.38 ± 0.02 ^c	6.71 ± 0.15 ^{bc}	50.98 ± 0.13 ^a
		leaves	71 903.20 ± 0.03 ^e	406.12 ± 0.08 ^d	1.91 ± 0.32 ^a	66.44 ± 0.29 ^{ab}
		fruit	17 838.58 ± 0.08 ^a	275.43 ± 0.01 ^f	8.32 ± 0.26 ^d	83.17 ± 0.28 ^g
	2022	flower	25 811.11 ± 0.05 ^b	331.55 ± 0.05 ^a	7.04 ± 0.20 ^c	70.03 ± 0.18 ^e
		stem	36 631.67 ± 0.08 ^{cd}	376.21 ± 0.07 ^{ab}	6.65 ± 0.19 ^{bc}	59.24 ± 0.22 ^{ab}
		leaves	48 652.85 ± 0.07 ^f	479.19 ± 0.04 ^{de}	1.02 ± 0.16 ^a	76.75 ± 0.17 ^{ef}
		fruit	17 821.12 ± 0.05 ^a	271.69 ± 0.02 ^f	7.72 ± 0.09 ^c	85.57 ± 0.01 ^{cd}

All values are expressed on a fresh weight basis

FRAP – ferric reducing antioxidant power; TAC – total antioxidant capacity; DPPH – free radical scavenging activity

^{a–g}different letters in the same column indicate a significant difference at the 5% level ($P < 0.05$) among the results

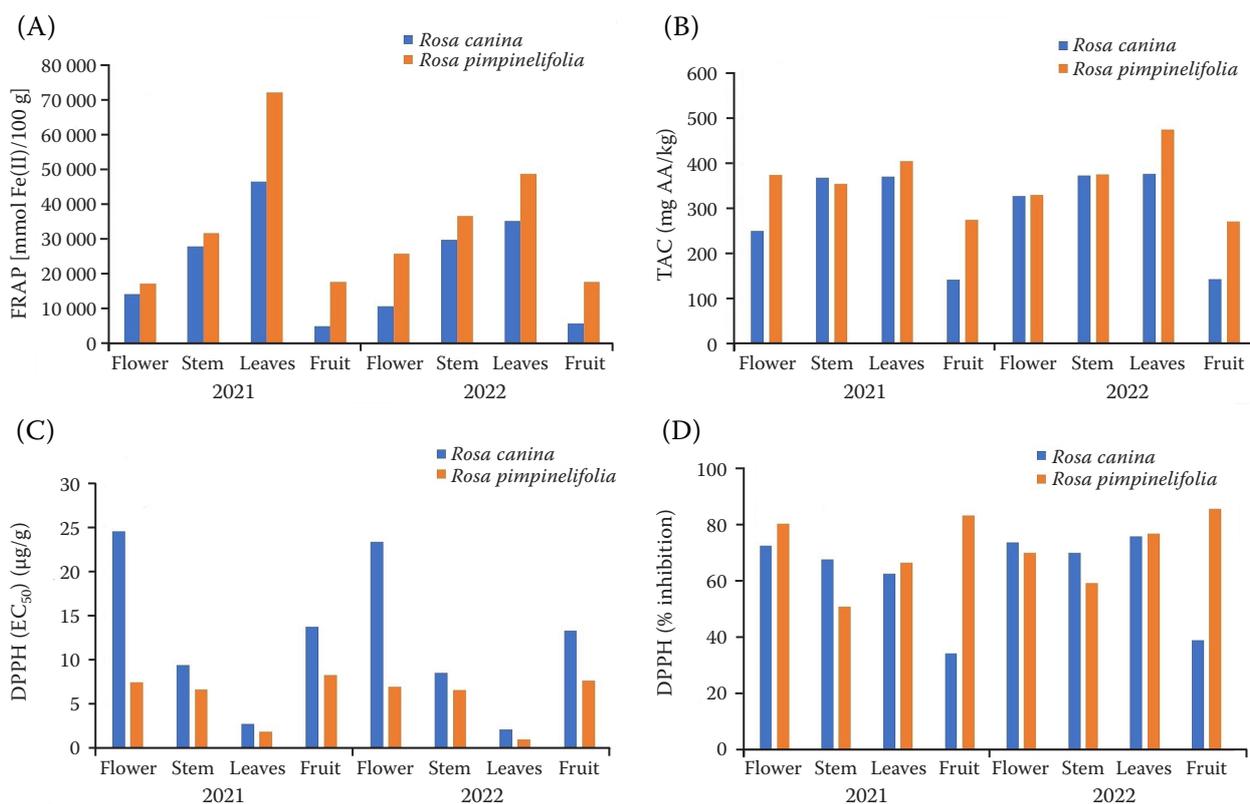


Figure 1. The antioxidant activity of *Rosa canina* and *Rosa pimpinelifolia* extracts using four different test methods (A) ferric reducing antioxidant power (FRAP), (B) total antioxidant capacity (TAC), (C) free radical scavenging activity [DPPH (EC₅₀)], (D) free radical scavenging activity [DPPH (% inhibition)]

Phenolic compounds. The phenolic acid and flavonoid amounts were quantified in two species of rosehip extract obtained from flower, stem, leaves and fruit collected in 2021 and 2022 by the HPLC method. A total of twenty-five phenolic standards were used in this study. The results are given in Tables 3 and 4.

Findings from Table 3 illustrate that 2-hydroxy cinnamaldehyde (13.10 mg/100 g) was the dominant phenolic compound in the flower extract of *R.c.* in 2021, while sinapic acid (17.58 mg/100 g) was the most abundant in 2022. Likewise, in stem extracts, benzoic acid (13.00 mg/100 g) and sinapic acid (15.16 mg/100 g) were the most dominant compounds in 2021 and 2022, respectively. In leaf samples of *R.c.*, syringaldehyde exhibited the highest concentrations in both years (58.89 ± 3.41 mg/100 g in 2021 and 30.39 ± 2.11 mg/100 g in 2022), clearly exceeding the levels of sinapic acid. Additionally, 2-hydroxy cinnamaldehyde also showed considerable presence (49.56 mg/100 g in 2021 and 53.34 mg/100 g in 2022). For fruit extracts, sinapic acid was the predominant compound in both years, with values of 88.41 mg/100 g in 2021 and 87.19 mg/100 g

in 2022. Besides these major compounds, gallic acid, vanillic acid, vanillin, quercetin, and 2-hydroxy cinnamaldehyde were also detected at varying levels across all plant parts in both years. In contrast, protocatechuic acid, protocatechuic aldehyde, caffeine, syringic acid, sesamol, and myricetin were not detected in any of the *R.c.* samples. Considering the total identified phenolic compounds in different plant parts of *R.c.* over both years, the ranking from highest to lowest is as follows: leaves (222.08 mg/100 g) in 2021, leaves (160.40 mg/100 g) in 2022, fruit (102.63 mg/100 g) in 2021, fruit (94.36 mg/100 g) in 2022, flower (52.42 mg/100 g) in 2022, stem (48.69 mg/100 g) in 2021, flower (44.41 mg/100 g) in 2021, and stem (43.82 mg/100 g) in 2022.

Table 4 presents the phenolic compounds obtained from different plant parts of *R.p.* for the years 2021 and 2022. The amount of phenolic compounds in the flowers of *R.p.* for both years, siring aldehyde (41.26 and 53.75 mg/100 g), myricetin (23.01 and 49.87 mg/100 g) and epigallocatechin gallate (22.45 and 17.99 mg/100 g), were found to be the dominant compounds. When the stem of *R.p.* in 2021

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Table 3. Phenolic composition of *Rosa canina* extracts obtained from flower, stem, leaves and fruit in 2021 and 2022

Compounds	Flower 2021	Flower 2022	Stem 2021	Stem 2022	Leaves 2021	Leaves 2022	Fruit 2021	Fruit 2022
Gallic acid	1.08 ± 0.11	0.82 ± 0.03	1.82 ± 1.10	2.72 ± 0.05	2.89 ± 0.01	1.52 ± 0.01	1.96 ± 0.01	2.95 ± 0.71
<i>p</i> -hydroxy benzoic acid	0.72 ± 0.06	0.92 ± 0.04	6.32 ± 0.19	3.69 ± 0.21	9.63 ± 0.15	6.58 ± 3.33	nd	nd
Chlorogenic acid	nd	nd	nd	nd	nd	1.11 ± 0.23	nd	nd
Caffeic acid	nd	nd	nd	nd	1.96 ± 0.04	nd	nd	nd
Vanillic acid	0.48 ± 0.05	0.01 ± 0.01	0.02 ± 0.06	0.24 ± 0.04	0.55 ± 0.01	0.17 ± 0.03	0.07 ± 0.00	0.03 ± 0.01
<i>p</i> -coumaric acid	nd	nd	nd	nd	1.71 ± 1.12	0.66 ± 0.05	nd	nd
Ferulic acid	0.70 ± 0.06	1.74 ± 0.09	n.d	nd	7.99 ± 1.13	6.47 ± 1.14	1.83 ± 0.09	nd
Sinapic acid	nd	17.58 ± 0.19	9.44 ± 1.21	15.15 ± 0.10	16.78 ± 5.12	nd	88.41 ± 2.10	87.19 ± 3.21
Benzoic acid	3.47 ± 0.12	3.81 ± 0.12	13.00 ± 0.20	10.70 ± 1.10	11.74 ± 1.16	8.31 ± 2.11	0.05 ± 0.01	0.04 ± 0.01
2-hydroxy cinnamaldehyde	13.10 ± 0.10	7.18 ± 0.50	6.55 ± 0.04	1.95 ± 0.06	49.56 ± 2.23	53.34 ± 7.81	0.01 ± 0.00	0.21 ± 0.02
Epigallocatechin	1.83 ± 0.01	0.62 ± 0.02	0.96 ± 1.10	nd	3.34 ± 0.07	2.47 ± 0.50	nd	1.70 ± 0.06
Catechin	0.47 ± 0.03	0.18 ± 0.08	0.08 ± 0.05	nd	nd	nd	nd	nd
Epicatechin	nd	0.65 ± 0.04	nd	nd	1.63 ± 0.03	1.13 ± 0.01	2.20 ± 0.10	nd
Epigallocatechin gallate	1.55 ± 0.10	3.06 ± 0.18	2.07 ± 0.01	3.46 ± 0.18	nd	nd	1.52 ± 0.03	nd
Keracyanin chloride	0.69 ± 0.09	0.41 ± 0.05	1.26 ± 0.21	0.95 ± 0.02	0.94 ± 0.03	0.58 ± 0.04	0.35 ± 0.09	nd
Vanilin	0.92 ± 0.41	0.42 ± 0.09	2.64 ± 0.05	1.58 ± 0.06	2.75 ± 0.19	1.93 ± 0.22	0.68 ± 0.01	2.24 ± 0.11
Siringaldehyde	10.49 ± 0.20	3.84 ± 0.51	1.10 ± 0.04	nd	58.89 ± 3.41	30.39 ± 2.11	3.71 ± 0.15	nd
Epicatechin gallate	3.17 ± 0.02	0.54 ± 0.02	0.31 ± 0.05	0.69 ± 0.08	18.68 ± 3.32	21.86 ± 3.31	1.82 ± 0.02	nd
Quercetin	5.74 ± 0.14	10.64 ± 0.00	3.12 ± 2.23	2.69 ± 0.05	33.04 ± 4.41	23.88 ± 5.12	0.02 ± 0.01	nd
Total	44.41	52.42	48.69	43.82	222.08	160.4	102.63	94.36

The results are given as mg/100 g. All values are expressed on a fresh weight basis
 nd – not detected (protocatechuic acid, protocatechuic aldehyde, caffeine, syringic acid, sesamol, and myricetin were not detected in any of the analysed samples)

Table 4. Phenolic composition of *Rosa pimpinelifolia* extracts obtained from flower, stem, leaves and fruit in 2021 and 2022

Compounds	Flower		Stem		Leaves		Fruit	
	2021	2022	2021	2022	2021	2022	2021	2022
Galllic acid	1.86 ± 0.02	2.76 ± 0.05	3.92 ± 0.01	3.35 ± 0.05	10.85 ± 6.61	10.96 ± 3.11	4.01 ± 0.98	4.82 ± 0.12
Protocatechuic acid	1.24 ± 0.03	nd	nd	nd	5.45 ± 1.31	8.10 ± 1.41	nd	nd
<i>p</i> -hydroxy benzoic acid	0.78 ± 0.02	0.94 ± 0.06	7.64 ± 1.07	6.64 ± 1.23	nd	nd	2.10 ± 0.12	1.74 ± 0.09
Chlorogenic acid	2.15 ± 0.05	2.37 ± 0.09	nd	nd	nd	11.52 ± 4.41	6.22 ± 1.13	3.51 ± 1.11
Caffeic acid	nd	nd	nd	nd	2.38 ± 0.11	4.94 ± 1.01	nd	nd
Vanillic acid	0.04 ± 0.00	0.27 ± 0.01	nd	nd	0.01 ± 0.00	nd	nd	nd
<i>p</i> -coumaric acid	nd	nd	nd	1.17 ± 0.41	nd	nd	nd	2.20 ± 0.12
Ferulic acid	6.24 ± 1.02	10.47 ± 3.31	15.91 ± 2.21	4.72 ± 1.11	377.59 ± 6.33	5.43 ± 2.10	3.10 ± 0.59	1.17 ± 0.05
Sinapic acid	nd	nd	nd	nd	3 106.46 ± 88.21	1 454.36 ± 55.21	0.11 ± 0.04	0.07 ± 0.05
Benzoic acid	10.12 ± 4.46	27.42 ± 7.11	0.01 ± 0.02	0.86 ± 0.21	15.25 ± 8.19	7.18 ± 1.12	0.02 ± 0.01	0.01 ± 0.01
2-hydroxy cinnamaldehyde	5.43 ± 0.14	11.62 ± 3.36	0.23 ± 0.07	1.11 ± 0.10	39.78 ± 9.09	11.03 ± 2.65	2.05 ± 0.19	0.08 ± 0.02
Epigallocatechin	1.53 ± 0.09	1.50 ± 0.01	2.58 ± 0.02	0.89 ± 0.01	6.74 ± 2.12	10.73 ± 2.62	9.83 ± 1.16	17.35 ± 2.21
Epicatechin	1.09 ± 0.05	1.90 ± 0.03	1.73 ± 0.04	0.93 ± 0.00	10.36 ± 1.05	5.92 ± 0.39	6.77 ± 1.15	2.78 ± 0.43
Epigallocatechin gallate	22.45 ± 4.10	17.99 ± 6.61	9.79 ± 1.25	4.02 ± 0.02	806.69 ± 36.21	696.06 ± 19.99	1.04 ± 0.76	0.71 ± 0.03
Epicatechin gallate	3.48 ± 1.12	8.12 ± 2.13	4.11 ± 0.00	1.38 ± 0.71	68.83 ± 10.13	32.56 ± 14.11	16.16 ± 3.41	1.47 ± 0.11
Quercetin	22.23 ± 5.53	nd	nd	nd	nd	135.64 ± 31.21	0.01 ± 0.00	0.02 ± 0.01
Myricetin	23.01 ± 3.32	49.87 ± 8.12	nd	1.19 ± 0.01	38.25 ± 11.65	32.87 ± 9.72	4.60 ± 0.94	4.65 ± 1.12
Keracyanin chloride	nd	nd	nd	0.38 ± 0.11	76.15 ± 12.67	nd	1.88 ± 0.15	6.85 ± 1.23
Vanillin	6.89 ± 0.41	12.99 ± 4.87	3.33 ± 0.02	3.95 ± 0.33	90.75 ± 7.77	54.51 ± 18.83	1.97 ± 0.67	2.38 ± 0.31
Siringaldehyde	41.26 ± 4.21	53.75 ± 7.12	nd	nd	810.47 ± 65.21	510.93 ± 51.09	3.02 ± 0.81	2.59 ± 0.12
Total	149.80	201.97	49.24	30.59	5 465.95	2992.74	62.90	52.42

The results are given as mg/100 g; all values are expressed on a fresh weight basis

nd – not detected (protocatechuic aldehyde, caffeine, syringic acid, sesamol, and myricetin were not detected in any of the analysed samples)

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and 2022 were examined, the compounds of ferulic acid (15.91 and 4.72 mg/100 g), epigallocatechin gallate (9.79 and 4.02 mg/100 g) and *p*-hydroxy benzoic acid (7.64 and 6.64 mg/100 g) were determined to be the highest compounds for both years. When leaves are examined in Table 4, it was determined that the identified and quantity of phenolic compounds detected in the leaves were much higher than in other parts of the *R.p.* Especially, quantities of the following components were found remarkably higher in *R.p.* leaves for both years: sinapic acid (3 106.46 and 1 454.36 mg/100 g), epigallocatechin gallate (806.69 and 696.06 mg/100 g) and siring aldehyde (810.47 and 510.93 mg/100 g). In the fruits of *R.p.*, epicatechin gallate was the main compound for 2021 (16.16 mg/100 g), while epigallocatechin was the dominant compound for 2022 (17.35 mg/100 g). Additionally, gallic acid, epigallocatechin, epicatechin, epigallocatechin gallate, vanillin, epicatechin gallate, ferulic acid, benzoic acid, 2-hydroxy cinnamaldehyde and myricetin were found at different levels in all plant parts of *R.p.* for both years. However, protocatechuic aldehyde, catechin, caffeine, syringic acid and sesamol were not found in any of the plant parts of *R.p.* for both years. When considering the identified phenolic compounds from different parts of *R.p.*, the ranking from high to low within the two years is as follows: leaves (5 465.95 mg/100 g) in 2021, leaves (2 992.74 mg/100 g) in 2022, flower (201.97 mg/100 g) in 2022, flower (149.80 mg/100 g) in 2021, fruit (62.90 mg/100 g) in 2021, fruit (52.42 mg/100 g) in 2022, stem (49.24 mg/100 g) in 2021 and stem (30.59 mg/100 g) in 2022.

DISCUSSION

While examining the literature concerning the species *R.c.* and *R.p.* regarding their antioxidant and phenolic profiles, it becomes evident that the focus of research has predominantly centred on the fruit component, with limited attention given to the leaves. However, it is noteworthy that there is a lack of studies specifically addressing the flower and stem aspects of these species. Further research into these unexplored areas could provide valuable insights into their botanical, medicinal, or ecological significance (Kubczak et al. 2020). The results revealed a significant diversity in terms of TPC among the samples examined in this study. In a study examining the TPC of fruits, two different cultivars of *R.p.* ('Papula'

and 'Single Cherry') and *R.c. L.*, it observed that the TPC of *R.p.* cultivar 'Single Cherry' fruits was determined to be 50.13 mg GAE/g, whereas the TPC of *R.c.* fruits was measured to be 21.61 mg GAE/g (Liaudanskas et al. 2021). Another study has also reported that TPC of *R.c.* and *R.p.* fruits were found to be 5.91 mg GAE/g and 18.87 mg GAE/g, respectively (Okan et al. 2019). Kubczak et al. (2020) reported that the TPC of the ethanolic extract obtained from the leaves of *R.c.* was measured to be approximately 220 mg/g, while for the twigs, it was around 225 mg/g. Additionally, the authors reported that there were no remarkable differences in terms of TPC between the ethanolic extracts derived from the leaves and twigs of *R.c.* The range of TPC for *R.c.* leaves, as reported by Polumackanycz et al. (2020), was found between 52.60 and 177.05 mg GAE/g in water extract, while it ranged from 21.5 to 26.9 mg GAE /g in hydromethanolic extract. In the case of TFC, the same authors found a range from 1.03 to 4.85 mg QE/g for the water extract and 0.25 to 0.51 mg QE/g for the hydromethanolic extract. In previous studies, the TFC extract of *R.c.* from Takab was found to contain 2.02 ± 0.03 mg quercetin/100 g, while *R.p.* from Urmia was found to contain 0.41 ± 0.02 mg quercetin/100 g (Fattahi et al. 2012). The presence of antioxidants in plants is of significant interest due to their potential to positively impact human health by combating oxidative stress and reducing the risk of chronic diseases (Kim et al. 2023). Cendrowski et al. (2020) examined the concentration of four different total antioxidant analysis methods they obtained from *Rosa rugosa* fruit extracts using four different extraction methods [aqueous, ethanolic (40%), ethanolic (60%), supercritical, and enzymatic]. In the study, the authors reported that the DPPH value for the ethanolic extract obtained from *R. rugosa* fruit was $994.6 \mu\text{mol Trolox equivalent (TE)/g}$ for the 40% ethanolic extract and $1 069.7 \mu\text{mol TE/g}$ for the 60% ethanolic extract. Additionally, the FRAP value was determined to be $5 019 \mu\text{mol TE/g}$ for the 40% ethanolic extract and $6 801 \mu\text{mol TE/g}$ for the 60% ethanolic extract. Briefly, the literature shows that extracts of *R.c.* and *R.p.* from twigs, leaves, and fruit exhibited antiradical activity. From this perspective, the outcomes of this study are consistent with the existing literature.

Regarding the phenolic profile of *R.c.* and *R.p.*, it has been determined that chlorogenic acid, gallic acid, and vanillic acid are the most abundant phenolic components in *R.p.* fruits (Çakır, Ergen

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2021). In another study examining the phenolic profile of crude extracts obtained from *R.c.* fruits, it was noted that hydroxycinnamic acids constitute the major group among phenolic acids. In this regard, this study aligns with the existing literature (Stănilă et al. 2015). Göztepe et al. (2022) reported the catechin content of rosehips from Türkiye as 347 mg/100 g fresh weight (FW). Similarly, Ghendov-Mosanu et al. (2020) observed catechin to be one of the more abundant compounds in *R.c.* hips, with an average concentration of 4.6 mg/100 g. However, catechin was not found in *R.c.* fruits within our study. Conversely, varying ratios of epicatechin, epigallocatechin, and epigallocatechin gallate were found in different years. Güven et al. (2022) reported the phenolic contents of pseudofruits of *R.p.* and found that benzoic acid (21.9115 mg/g dry extract), caffeic acid (12.5583 mg/g dry extract), and chlorogenic acid (4.8085 mg/g dry extract). In our study, caffeic acid was not detected. Although epicatechin gallate and epigallocatechin were the dominant components in our study, they were not detected in that study. In the study by Kasapoğlu et al. (2023), it is reported that the extract of *R.p.* pseudofruits, obtained through the supercritical fluid extraction method, contains phenolic compounds such as catechin, epicatechin, and quercetin. Finally, the phenolic profile or content of the same plant species differs from that reported in the literature. Researchers have suggested that the primary cause of this distinct phenomenon can be influenced by various factors, including genetic differences, environmental factors, plant maturity levels, disparities in analytical methods, seasonal changes, and even laboratory conditions (Okan et al. 2019; Kasapoğlu et al. 2023; Öz et al. 2023).

CONCLUSION

Natural antioxidants have been intensively researched by the scientific community in recent years due to their effective neutralisation of free radicals, which are crucial for health. In our study, we investigated methanolic extracts from the flowers, leaves, stems, and fruits of *R.c.* and *R.p.* in two different years, 2021 and 2022. In general, leaf extracts of *R.c.* and *R.p.* exhibited higher antioxidant, TPC, and TFC compared to other parts of the plants in both years. Syringaldehyde and 2-hydroxy cinnamaldehyde for flowers, benzoic acid and sinapic

acid for stems, 2-hydroxy cinnamaldehyde and syringaldehyde for leaves, and sinapic acid for fruits were the primary phenolic compounds identified for *R.c.* in both years. *R.p.*, on the other hand, exhibited high levels of syringaldehyde and myricetin in its flowers, p-hydroxybenzoic acid and ferulic acid in its stems, epigallocatechin gallate and sinapic acid in its leaves, and finally, epigallocatechin and chlorogenic acid in its fruits, for both years. Analyses conducted in both 2021 and 2022 showed that the quantity of phenolic compounds detected in the leaves of both plants was the highest among all analysed plant parts. This observation also supports the reliability of the observed high polyphenol and antioxidant levels in the leaves of both plants. In conclusion, our results demonstrate the remarkable potential of *R.c.* and *R.p.*, especially their leaves, as valuable sources of bioactive compounds with antioxidant properties. These findings support their prospective use not only in pharmaceutical and healthcare applications but also as natural additives in food and cosmetic industries. Future studies will focus on standardising extraction methods, evaluating *in vivo* activity, and conducting formulation trials to explore further and validate their industrial applicability.

REFERENCES

- Barros L., Carvalho A.M., Ferreira I.C.F.R. (2011): Exotic fruits as a source of important phytochemicals: Improving the traditional use of *Rosa canina* fruits in Portugal. *Food Research International*, 44: 2233–2236.
- Benzie I.F.F., Strain J.J. (1996): The ferric reducing ability of plasma (FRAP) as a measure of “antioxidant power”: The FRAP assay. *Analytical Biochemistry*, 239: 70–76.
- Cendrowski A., Kraśniewska K., Przybył J.L., Zielińska A., Kalisz S. (2020): Antibacterial and antioxidant activity of extracts from rose fruits (*Rosa rugosa*). *Molecules*, 25: 1365.
- Cunja V., Mikulic-Petkovsek M., Stampar F., Schmitzer V. (2014): Compound identification of selected rose species and cultivars: An insight to petal and leaf phenolic profiles. *Journal of the American Society for Horticultural Science*, 139: 157–166.
- Çakir Ö., Ergen B. (2021): Assessment of wild *R. pimpinellifolia* L. according to mineral content and bioactive compounds. *European Journal of Science and Technology*, 25: 644–649.
- Fattahi S., Jamei R., Hosseini Sarghein S. (2012): Antioxidant and antiradical activities of *Rosa canina* and *Rosa pimpinellifolia*.

<https://doi.org/10.17221/163/2023-HORTSCI>

- lifolia* fruits from West Azerbaijan. Iranian Journal of Plant Physiology, 2: 523–529.
- Gao X., Yang L., Shu L., Shen Y., Zhang Y., Hu Q. (2012): Aurone constituents from the flowers of *Rosa rugosa* and their biological activities. Heterocycles, 85: 1925–1931.
- Ghazghazi H., Miguel M.G., Hasnaoui B., Sebei H., Ksontini M., Figueiredo A.C., Pedro L.G., Barroso J.G. (2010): Phenols, essential oils and carotenoids of *Rosa canina* from Tunisia and their antioxidant activities. African Journal of Biotechnology, 9: 2709–2716.
- Ghendov-Mosanu A., Cristea E., Patras A., Sturza R., Niculaia M. (2020): Rose hips, a valuable source of antioxidants to improve gingerbread characteristics. Molecules, 25: 5659.
- Goztepe B., Kayacan S., Bozkurt F., Tomas M., Sagdic O., Karasu S. (2022): Drying kinetics, total bioactive compounds, antioxidant activity, phenolic profile, lycopene and β -carotene content and color quality of rosehip dehydrated by different methods. LWT, 153: 112476.
- Güven L., Özgen U., Sevindik H.G., Ağan İ., Koca M., Turan İ., Demir S., Aliyazicioğlu Y. (2022): Evaluation of LC-MS/MS analysis and *in vitro* biological activities of *Rosa pimpinellifolia* root, pseudo-fruit, and seed extracts. International Journal of Life Sciences and Biotechnology, 5: 480–503.
- Hatipoğlu G., Sökmen M., Bektaş E., Daferera D., Sökmen A., Demir E., Şahin H. (2013): Automated and standard extraction of antioxidant phenolic compounds of *Hyssopus officinalis* L. ssp. *angustifolius*. Industrial Crops and Products, 43: 427–433.
- Ieri F., Innocenti M., Possieri L., Gallori S., Mulinacci N. (2015): Phenolic composition of “bud extracts” of *Ribes nigrum* L., *Rosa canina* L. and *Tilia tomentosa* M. Journal of Pharmaceutical and Biomedical Analysis, 115: 1–9.
- Jaksevic M., Håkansson Å., Adawi D., Jeppsson B., Rumpunen K., Ekholm A., Ahrné S., Molin G. (2009): Antioxidative protection of dietary rosehips and polyphenol active lactobacilli in mice subjected to intestinal oxidative stress by ischemia-reperfusion. Microbial Ecology in Health and Disease, 21: 193–202.
- Kasapoğlu K.N., Kruger J., Barla-Demirkoz A., Gültekin-Özgülven M., Frank J., Özçelik B. (2023): Optimization of supercritical carbon dioxide extraction of polyphenols from black rosehip and their bioaccessibility using an *in vitro* digestion/caco-2 cell model. Foods, 12: 781.
- Kim M., Jang H., Kim W., Kim D., Park J.H. (2023): Therapeutic applications of plant-derived extracellular vesicles as antioxidants for oxidative stress-related diseases. Antioxidants, 12: 1286.
- Kubczak M., Khassenova A.B., Skalski B., Michlewska S., Wielanek M., Aralbayeva A.N., Murzakhmetova M.K., Zamaraeva M., Skłodowska M., Bryszewska M., Ionov M. (2020): Bioactive compounds and antiradical activity of the *Rosa canina* L. leaf and twig extracts. Agronomy, 10: 1897.
- Liaudanskas M., Noreikienė I., Zymonė K., Juodytė R., Žvikas V., Janulis V. (2021): Composition and antioxidant activity of phenolic compounds in fruit of the genus *Rosa* L. Antioxidants, 10: 545.
- Mármol I., Sánchez-de-Diego C., Jiménez-Moreno N., Ancín-Azpilicueta C., Rodríguez-Yoldi M.J. (2017): Therapeutic applications of rose hips from different *Rosa* species. International Journal of Molecular Sciences, 18: 1137.
- Molyneux P. (2004): The use of the stable free radical diphenylpicrylhydrazyl (DPPH) for estimating antioxidant activity. Songklanakarin Journal of Science and Technology, 26: 211–219.
- Okan O.T., Serencam H., Baltaş N., Can Z. (2019): Some edible forest fruits their *in vitro* antioxidant activities, phenolic compounds and some enzyme inhibition effects. Fresenius Environmental Bulletin, 28: 6090-6098.
- Ouerghemmi S., Sebei H., Siracusa L., Ruberto G., Saija A., Khebour Allouche F., Dhaouadi K., Cimino F., Cristani M. (2020): LC DAD ESI MS and HPLC DAD phytochemical investigation and *in vitro* antioxidant assessment of *Rosa* sp. stem pruning products from different northern areas in Tunisia. Phytochemical Analysis, 31: 98–111.
- Öz M., Ucuncu O., Baltacı C., Said Fidan M., Karatas S.M. (2023): Chemical composition and biological activities of essential oils from the flowers and leaves of *Celtis planchoniana* K.I.Chr. Journal of Essential Oil Bearing Plants, 26: 576–589.
- Pashazadeh H., Özdemir N., Zannou O., Koca I. (2021): Antioxidant capacity, phytochemical compounds, and volatile compounds related to aromatic property of vinegar produced from black rosehip (*Rosa pimpinellifolia* L.) juice. Food Bioscience, 44: 101318.
- Prieto P., Pineda M., Aguilar M. (1999): Spectrophotometric quantitation of antioxidant capacity through the formation of a phosphomolybdenum complex: Specific application to the determination of vitamin E. Analytical Biochemistry, 269: 337–341.
- Polumackanycz M., Kaszuba M., Konopacka A., Marzec-Wróblewska U., Wesolowski M., Waleron K., Buciniński A., Viapiana A. (2020): Phenolic composition and biological properties of wild and commercial dog rose fruits and leaves. Molecules, 25: 5272.
- Singleton V.L., Orthofer R., Raventos R.M.L. (1999): Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteu reagent. In: Lester P. (ed.): Methods in Enzymology. Vol. 299. New York, Academic Press: 152–178.
- Stănilă A., Diaconeasa Z., Roman I., Sima N., Măniuțiu D., Roman A., Sima R. (2015): Extraction and characterization

<https://doi.org/10.17221/163/2023-HORTSCI>

- of phenolic compounds from rose hip (*Rosa canina* L.) using liquid chromatography coupled with electrospray ionization-mass spectrometry. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, 43: 349–354.
- Sytar O., Hemmerich I., Zivcak M., Rauh C., Brestic M. (2018): Comparative analysis of bioactive phenolic compounds composition from 26 medicinal plants. *Saudi Journal of Biological Sciences*, 25: 631–641.
- Szołtysik M., Kucharska A.Z., Sokół-Łętowska A., Dąbrowska A., Bobak Ł., Chrzanowska J. (2020): The effect of *Rosa spinosissima* fruits extract on lactic acid bacteria growth and other yoghurt parameters. *Foods*, 9: 1167.
- Zhishen J., Mengcheng T., Jianming W. (1999): The determination of flavonoid contents in mulberry and their scavenging effects on superoxide radicals. *Food Chemistry*, 64: 555–559.

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