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DETERMINATION OF PHENOLIC CONTENT AND ANTIOXIDANT ACTIVITY OF ROSA CANINA L. FRUITS IN DIFFERENT EXTRACTION SYSTEMS

Određivanje fenola i antioksidacijske aktivnosti plodova *Rosa canina* L. različitim ekstrakcionim sistemima

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Abstract

Phenolic content and antioxidant activity of *Rosa canina* fruit extracts obtained with five different extraction systems were investigated. Extractions were done with water, and aqueous 50% methanol, 50% ethanol, 80% methanol and 80% ethanol. Antioxidant activity was investigated with DPPH, ABTS and FRAP methods using Trolox as a standard. The highest level of phenols (78.83 mg GAE/g), phenolic acids (11.21 mg CAE/g), and proanthocyanidins (29.12 mg CE/g) were found for 50% methanol extract. The highest flavonoid content (1.163 mg RE/g and 0.675 mg QE/g) was determined for 50% ethanol extracts and antocyanin content (0.139 mg CGE/g) for 80% methanol extract. The lowest level of phenols (35.89 mg GAE/g), phenolic acids (4.55 mg CAE/g) and proanthocyanidins (11.93 mg CE/g) had 80% ethanol extract. Flavonoid content (0.341 mg RE/g and 0.214 mg QE/g) was the lowest in water extract and anthocyanidin content (11.93 mg CE/g) in 50% ethanol extract. Antioxidant activity for DPPH was in a range 255.62-407.82 μmol TE/g, for ABTS 312.06-616.10 μmol TE/g and for FRAP 349.33-690.37 μmol TE/g with lowest values for 80% ethanol extract and highest values for 50% methanol extract. Phenols and proanthocyanidins showed high positive correlation with antioxidant activity for DPPH (r^2 =0.927-0.9621), ABTS (r^2 =0.980-0.9935) and FRAP (r^2 =0.9352-0.9633). No correlation was observed for flavonoid and anthocyanidin content with antioxidant activity.

Key words: *Rosa canina* L.*, fruits, phenols, antioxidant activity*

INTRODUCTION – *Uvod*

Genus *Rosa* belongs to Rosaceae family and includes approximately 100 species. Distribution of the genus *Rosa* is very broad and its species can be found in Europe, Asia and Middle East as well as North America (NILLSON, 1997). The *Rosa canina* fruits, also known as rose hips, are generally used in food industry for production of juice, tea, jam, marmalade, and syrup (MOERMAN, 2002; ERCISLI AND GULERYUZ, 2005). Rose hips are used in treatment of cold and influenza, infections

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and inflammation states such as arthritis, rheumatism, as a diuretic, against hemorhoids and diabetes (BLUMENTHAL 1998; ORHAN ET AL. 2007, WINTHER, 2008). On the basis of previous investigations, it is confirmed that rose hips are rich source of different phenolic compounds (phenolic acids, anthocyanidins and flavonoids), vitamin C, tocopherols, carotenoids, fruit acids, fatty acids, tannins, pectins and sugars (DEMIR AND OZCAN, 2001; GAO ET AL. 2000; ERISCLI, 2007, FATTAHI ET AL. 2012, CHRUBASIK ET AL. 2008, WENZIG ET AL. 2008, OLSSON ET AL. 2005, ORHAN ET AL. 2007 AND REFERENCE THEREIN). Antioxidant activity of rose hips extracts have been reported by several researches (GAO ET AL. 2000; SERTESER ET AL. 2008; ERSOY ET AL. 2015; ROMAN ET AL. 2013). Anticancerogenic and antimicrobic effects were also reported (KUMARASAMY ET AL. 2002; TROVATO ET AL. 1996; TROVATO ET AL. 2000). These effects can be connected mainly to high content of antioxidants (flavonoids) in rose hips (KIM ET AL. 2004; NARAYANA ET AL. 2001). Phenols, flavonoids, tannins and vitamins (A, C, E) in plant material possess antioxidant properties (LOLIGER, 1991; BOOTS ET AL. 2008). Rose hips also have very high vitamin C content (30-4000 mg/100 g of fruits) compared with other fruits (ERCISLY 2007).

Bosnia and Herzegovina posses about 3600 vascular plants existing on its territory with numerous use in traditional and official medicine (REDŽIĆ, 2007; SARIĆ-KUNDALIĆ ET AL. 2010). In recent years, there is growing demand for natural functional food in human diet. Therefore, the purpose of this work was to investigate total content of phenol, flavonoids, phenolic acids, anthocyanins and proanthocyanidins in wild growing rose hips collected from region of Maglaj for the first time. Antioxidant activity was evaluated with three different methods: DPPH, ABTS and FRAP. Correlation between antioxidant activity and content of investigated compounds was also studied.

MATERIAL AND METHODS – *Materijal i metode*

Plant material – *Biljni materijal*

Rosa canina L. fruit sample was collected in broad area of Maglaj region in October 2016 and identified by a plant taxonomist. Voucher specimen was deposited at Department of Ecology at Faculty of Forestry. The fruit was dried in the oven at 40^{o}C and powdered before analysis.

Chemicals and reagents – *Hemikalije i reagensi*

Folin-Ciocalteu's reagent, 1,1-diphenyl-2-picrylhydrazyl radical (DPPH), 2,2-azinobis(3-ethylbenzothiazoline-6-sulphonic acid diammonium salt (ABTS), 2,4,6-tripyridil-S-triazine (TPTZ), 6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid (Trolox), gallic and caffeic acid were obtained from Sigma Chemicals (Germany) and Aldrich (Germany). Quercetin, rutin, aluminium chloride, potassium persulphate, sodium carbonate, absolute methanol and ethanol were obtained from the same companies.

Potassium chloride and ferrous ammonium sulfate were obtained from Kemika Zagreb (Croatia) and butanol from Merck Chemical Suppliers (Germany). All other chemicals and solvents used in the work were of analytical grade.

Sample extracts preparation - *Priprema ekstrakata uzoraka*

Ultrasound extraction was used for preparation of fruit extracts. Following solvents for extraction were used: distillated water, 50% aqueous methanol, 50% aqueous ethanol, 80% aqueous methanol and 80% aqueous ethanol. Dry fruit sample (0.5 g) was extracted twice with 12 mL of specific extraction solvent (ultrasound bath, Elmecs, Italy) for 30 minutes at room temperate. After each step of extraction, extracts were centrifuged at 3000 rpm for 10 minutes. For each extraction solvent, supernatants were combined and volume brings up to 25 mL with an appropriate extraction solvent. Prepared extracts were kept at -20^{o}C until analysis.

Determination of total phenols - *Određivanje ukupnih fenola*

Procedure with Folin-Ciocalteu method described by SINGLETON ET AL. (1974) was used for the determination of total phenols (TP). The absorbance of the coloured product was measured at 765 nm. Appropriate calibration curve was prepared with gallic acid as a standard, and final results were expressed as mg of gallic acid equivalents per gram of dry sample (mg GAE/ g DW).

Determination of total flavonoids – ***Određivanje ukupnih flavonoida***

Total flavonoids (TFr) in plant extracts were determined with method by QUETTIER ET AL. (2000) using rutin as a standard. Aluminium chloride (2% m/v) solution in methanol was used as a reagent. After addition of the reagent, samples were incubated at room temperature for an hour. Absorbance of the samples was measured at 415 nm and sample blank was also used in the same procedure. Calibration curve was constructed with rutin as standard. Results are expressed in rutin equivalents per g of dry fruit (mg RE/g DW). Total flavonoids (TFq) were also determined with quercetin as a standard by method described by (ORDONEZ ET AL. 2006). Absorbance was measured at 420 nm and the results were expressed as qurcetin equivalents per gram of dry sample (mg QE/g DW).

Determination of total phenolic acids – ***Određivanje ukupnih fenolnih kiselina***

Arnow method described by GAWLIC-DZIKI (2012) was used for the determination of total phenolic acids (TPHA) with some modifications. To 1 mL of previously diluted sample, 5 mL of water, 1 mL HCl (0.5 M), 1 mL of Arnow`s reagent (10 g Na_2MoO_4 and 10 g $NaNO_2$ dissolved in 100 mL of distillated water), and 1 mL of NaOH (1M) was added and volume was bring up to 10 mL with distillated water. Standard solutions of caffeic acid were used in preparation of calibration curve and absorbance was measured at 490 nm. Blank was included in all measurements. The results were expressed as caffeic acid equivalents per gram of dry sample (mg CAE/g DW).

Determination of monomeric anthocyanins – *Određivanje monomernih antocijanina*

Determination of total monomeric anthocyanins (TMA) was done with pH differential method described by LEE ET AL. (2005). Absorbance of the samples (diluted at ratio 1:10) was measured at 520 nm and 700 nm at room temperature after 15 minutes). A molar extinction coefficient of cyanidin-3-O-glucoside of 26900 l/mol cm and molar weight (MW) (449.2 g/mol) were used for calculations. Total monomeric anthocyanins were expressed in mg of cyanidin-3-glucoside equivalents per gram of dry fruits (CGE/g DW).

Determination of total proanthocyanidins – *Određivanje ukupnih proantocijanidina*

Total proanthocyanidins (TPA) were determined with butanol/HCl method described by HAGERMAN (2002). Absorbance of the sample was read at 550 nm before and after heating of the samples at 95^{o}C for 40 minutes. As a blank, butanol/HCl mixture was used. The results were expressed as mg of cyanidin chloride equivalents per gram of dry fruit (mg CE/g DW).

Determination of antioxidant activity – *Određivanje antioksidacijske aktivnosti*

DPPH method - DPPH metoda

DPPH method given by BRAND-WILLIAMS ET AL. (1995) and THAIPONG ET AL. (2006) was used in determination of antioxidant activity. Diluted extracts (100 µL) were mixed with 1.9 mL of working DPPH solutions in methanol (A = 1.1 ± 0.02 at 515 nm) and kept in the dark for 30 minutes before measurements. Trolox was used as a standard to prepare a calibration and results were expressed as µmol Trolox equivalents per gram of dry sample (µmol TE/g DW).

ABTS method - ABTS metoda

ABTS method described by RE ET AL. (1999) with some modification given by THAIPONG ET AL. (2006) was used for ABTS assay. Stock solutions of ABTS (7 mM) and potassium persulphate (2.45 mM) were prepared in water and kept in the dark for 16 hours. Equal volumes of the stock solutions were mixed and diluted to absorbance of 1.1 ± 0.02 at 734 nm to prepare ABTS radical cation ($ABTS^{+}$) solution. Freshly prepared solution was used for each assay. Working solution of $ABTS^{+}$ (1.9 mL) was mixed with 100 µL of diluted extracts and after 6 minutes the reduction in absorbance was measured at 734 nm. Calibration curve was prepared with standard solutions of Trolox and the results were expressed as µmol Trolox equivalents per gram of dry sample (µmol TE/g DW).

FRAP method – FRAP metoda

Ferric reducing antioxidant power (FRAP) was measured according to BENZIE AND STRAIN (1999) method. Fresh FRAP reagent was prepared daily by mixing 300 mM acetate buffer, pH 3.6; 10 mM TPTZ in 40 mM HCl acid and 20 mM $FeCl_3$ in the

ratio 10:1:1. FRAP reagent (1.9 mL) wormed at 37°C was mixed with 0.1 mL of the extracts and absorbance was measured after 30 minutes at 593 nm against blank. The blank contained 0.1 ml of methanol instead of the extract. A calibration curve was made with Trolox as a standard and results were expressed as μmol Trolox equivalents per gram of dry sample (μmol TE/g DW).

Statistical analysis- ***Statistička analiza***

All measurements were carried out in triplicate and obtained results are expressed as mean±SD. Regression analysis was used to examine correlation between content of investigated compounds and antioxidant activity.

RESULTS AND DISCUSSION- *Rezultati i diskusija*

Five extraction systems were used to determine total content of phenols, flavonoids, phenolic acids, anthocyanins and proanthocyanidins. The results are presented in Table 1. Total phenols ranged from 35.89 mg GAE/g DW for 80% ethanol extract to 78.83 mg GAE/g DW for 50% methanol extract. TANEVA ET AL. (2016) found that 50% ethanol extracts of rose hip fruit contains higher level of total phenols (69.4 mg GAE/g DW) than water extract (55.4 mg GAE/g DW) which is in agreement with results in this study. ILBAY ET AL. (2013) reported that addition of water to alcohol improve polyphenol extraction so that 50% methanol and 50% ethanol solutions were better extractants than pure alcohols. Also, 50% methanol extracts were richer in content of polyphenols (40.11-43.25 mg GAE/g DW) than 50% ethanol extracts (20.28-26.28 mg GAE/g DW). These results are in agreement with our results but they are generally lower. Results presented in this study were higher than those reported by CORUH AND ERCISLI (2010) (78.13 mg GAE /100 g DW); YILMAZ AND ERCISLI (2011) who found 102 mg GAE/100 g DW, but lower than results given by ERCISLI (2007) who found 96 mg GAE /g DW in rose hips. The highest value of total phenolic acids (11.21 mg CAE/g DW) was obtained for 50% methanol extracts and the lowest value (4.55 mg CAE/g DW) was found for 80% ethanol extracts. The highest content of total proanthocyanidins was found to be 29.12 mg CE/g DW for 50% methanol extracts and the lowest (11.93 mg CE/g DW) for 80% ethanol extracts. Two standards rutin and quercetin were used for determination of total flavonoids. The lowest content of total flavonoids was obtained for aqueous extracts with values of 0.341 mg RE/g DW and 0.241 mg QE/g DW. The highest value of total flavonoids had 50% ethanol extracts (1.163 mg RE/g DW and 0.675 mg QE/g DW). Results for flavonoids are generally higher than those obtained by ADAMCZAK ET AL. (2012) who reported 52 mg QE/100 g DW.

Generally, extraction efficiency for total phenols, flavonoids, phenolic acids and proanthocyanidins was higher for extracts obtained with 50% methanol and 50% ethanol compared to extracts obtained with 80% methanol and 80% ethanol in this study.

The highest level of anthocyanins (0.139 mg CGE/g DW) was found for 80% methanol extracts and the lowest (0.011 mg CGE/g DW) for 50% ethanol. These results are higher than the results given by GUERRERO ET AL. (2010) and MURATHAN ET AL. (2016) with values of 0.38 mg /100 g and 2.75 mg/100 g respectively. Better efficiency of extraction was with 80% methanol and 80% ethanol in comparison to 50% methanol and 50% ethanol extracts. This reason could be different polarity of ethanol and methanol solutions. According to MOKRANI AND MADANI (2016), phenolic acids are better extracted in methanol while flavonoids are better extracted in ethanol.

Also, the most abundant compounds in *Rosa canina* fruits were in decreasing order: phenols, proanthocyanidins and phenolic acids while flavonoids and anthocyanins were the less abundant. Study related to some edible fruits in Bosnia elderberry, bilberry, wild cherry, blackberry, sour cherry showed that total phenols ranged from 12.7 to 0.2 mg GAE/g FW and total anthocyanins were in range 6.8-0.6 mg CGE/g FW for investigated fruits (RIMPAPA ET AL. 2007). We can conclude that rose hips are very rich in phenolic content but anthocyanin content can be considered as a moderate. Rose hips also had lower anthocyanin content but higher total phenolic content compared to *Crataegus monogyna* fruits (0.60-0.82 mg CGE/g DW and 23.34-34.72 mg GAE/g DW respectively) given in our previous research (TAHIROVIĆ ET AL. 2015).

Table 1. Total content of analysed bioactive compounds in different extraction systems.
Tabela 1. Ukupni sadržaj analiziranih bioaktivnih jedinjenja u različitim ekstrakcionim sistemima.

	TP (mg GAE/g)	**TFr** (mg RE/g)	**TFq** (mg QE/g)	**TPHA** (mg CAE/g)	**TMA** (mg CGE/g)	**TPA** (mg CE/g)
H_2O	69.05±2.29	0.341±0.004	0.214±0.001	6.97±0.03	0.103±0.002	26.58±0.07
M-50	**78.83±0.07**	1.021±0.003	0.611±0.003	**11.21±0.07**	0.067±0.002	**29.12±0.12**
E-50	72.69±0.19	**1.163±0.003**	**0.675±0.004**	7.07±0.03	0.011±0.002	25.48±0.17
M-80	51.19±0.13	0.683±0.007	0.385±0.001	5.46±0.03	**0.139±0.02**	17.89±0.05
E-80	35.89±0.15	0.575±0.002	0.350±0.004	4.55±0.02	0.043±0.005	11.93±0.08

* H_2O (water); M-50 (50% methanol); E-50 (50% ethanol); M-80 (80% methanol); E-80 (80% ethanol).
** H_2O (voda); M-50 (50% metanol); E-50 (50% etanol); M-80 (80% metanol); E-80 (80% etanol).*
**TP- total phenols, TFr and TFq – total flavonoids, TPHA – total phenolic acids, TMA – total monomeric anthocyanins, TPA – total proanthocyanidins.
***TP- ukupni fenoli, TFr and TFq – ukupni flavonoidi, TPHA – ukupne fenolne kiseline, TMA – ukupni monomerni antocijanini, TPA – ukupni proantocijanidini*

DPPH, ABTS and FRAP methods were used to estimate antioxidant activity of *Rosa canina* fruit extracts. Obtained results expressed as Trolox equivalents (TE) are presented in Table 2. The highest antioxidant activity with DPPH, ABTS and FRAP methods was obtained for 50% methanol extracts with values of 407.81, 616.10 and 690.37 μmol TE/g DW respectively. Obtained results were higher than the results reported by ROMAN ET AL. (2013) which were in range 91.28-127.8 μmol TE/100 g fresh pulp for DPPH. Results for FRAP method were also higher than those obtained

by several authors: CUNJA ET AL. (2015) who obtained 63.35-127.8 µmol TE/100 g and DEMIR ET AL. (2014) who found 103.56 µmol TE/g. Some authors reported high values of antioxidant activity in rose hips. MURATHAN ET AL. (2016) obtained for DPPH 97.95 mmol TE/g DW. TANEVA ET AL. (2016) reported for DPPH, ABTS and FRAP methods following values: 295; 368 and 390 mmol TE/g DW for 50% ethanol extracts. We can conclude that investigated fruits are a reach source of antioxidant compounds. Presence of some other compounds with high antioxidant capacity such as vitamin C, pigments and tocopherols can influence on antioxidant activity of the extracts (BARROS ET AL. 2010). The lowest antioxidant activity had 80% ethanol extracts with values of 255.62, 312.06 and 349.33 µmol TE/g DW for DPPH, ABTS and FRAP method respectively. Generally, water, 50% methanol and 50% ethanol extracts had higher antioxidant activity than 80% methanol and 80% ethanol extracts. Also, antioxidant activity decreased in the following order: FRAP>ABTS>DPPH for each extraction system.

Table 2. Antioxidant activity determined with DPPH, ABTS and FRAP methods.
Tabela 2. Antioksidacijska aktivnost određena sa DPPH, ABTS, FRAP metodama.

	DPPH (µmol TE/g)	**ABTS** (µmol TE/g)	**FRAP** (µmol TE/g)
H_2O	382.30±1.52	569.87±0.01	681.67±1.08
M-50	**407.82±0.58**	**616.10±1.08**	**690.37±0.56**
E-50	359.44±0.78	594.56±1.55	643.34±0.42
M-80	278.34±0.35	422.16±1.59	416.15±0.63
E-80	255.62±0.01	312.06±0.69	349.33±0.96

* H_2O (water); M-50 (50% methanol); E-50 (50% ethanol); M-80 (80% methanol); E-80 (80% ethanol).
* *H_2O (voda); M-50 (50% metanol); E-50 (50% etanol); M-80 (80% metanol); E-80 (80% etanol).*
**TE – Trolox equivalents – *ekvivalenti Troloxa*

Regression analysis was used to determine correlation coefficients between analysed phenolic compounds and antioxidant activity (Table 3). High positive correlations were obtained for content of phenols and proanthocyanidins with DPPH, ABTS and FRAP antioxidant activities. Correlation coefficients for phenols ranged from 0.927 to 0.9935 and for proanthocyanidins from 0.9621 to 0.980 for antioxidant methods. Moderate positive correlations were observed between phenolic content and DPPH (r^2= 0.7353), ABTS (r^2= 0.6427) and FRAP (r^2= 0.6144) antioxidant activities. No correlations were found for flavonoid and anthocyanin contents and antioxidant activities which can be related to their lower content in the samples compared to other investigated compounds. Since phenols and proanthocyanidins represents compounds with the highest content in investigated extracts, antioxidant activity can be attributed to the level of these compounds. Phenolic acids in some moderate extend contribute also to antioxidant activity of the extracts. TANEVA ET AL. (2016) found positive

correlation between phenols and DPPH, ABTS and FRAP capacities. Correlation between phenols and DPPH was also reported by ROMAN ET AL. (2013) and ERSOY ET AL. (2015). It was pointed by several authors that different classes of phenolic compounds can be present in the sample, and they can differ in their capacity to scavenge free radicals (PAREJO ET AL. 2002; GHAZGHAZI ET AL. 2010). It was also noticed that important role in antioxidant capacity have collection site, climate, stage of fruit ripeness as reported by several authors (TUMBAS ET AL. 2012, ERSOY ET AL. 2015).

Table 3. Correlation coefficients (r^2) between investigated compounds and antioxidant activity.
Tabela 3. Koeficijenti korelacije (r^2) između ispitivanih jedinjenja i antioksidacijske aktivnosti.

	DPPH	ABTS	FRAP
Phenols	**0.927**	**0.9935**	**0.9352**
Flavonoids (r)	0.1014	0.2086	0.0958
Flavonoids (q)	0.1215	0.2221	0.1118
Phenolic acids	**0.7353**	**0.6427**	**0.6144**
Monomeric anthocyanins	0.0182	0.0205	0.0264
Proanthocyanidins	**0.9621**	**0.980**	**0.9633**

CONCLUSION – *Zaključak*

It can be concluded that content of bioactive compounds in different *Rosa canina* fruit extracts is strongly dependent on extraction system.

The highest level of phenols, proanthocyanidins and phenolic acids was obtained in extracts with 50% methanol while content of flavonoids was the highest in 50% ethanol extract. 80% methanol had the best efficienty for extraction of anthocyanins from fruits.

It was noticed according to the content of phenolic compounds that 50% ethanol and 50% methanol are better extraction solvent systems than 80% ethanol and 80% methanol.

Rosa canina fruit extracts showed high antioxidant activity increasing in the order DPPH<ABTS<FRAP values. The highest antioxidant values with all applied methods had 50% methanol fruit extract.

High positive correlations were determined between phenol and proanthocyanidin contents and DPPH, ABTS and FRAP antioxidant activities, while positive moderate correlation was found for phenolic acid content and antioxidant activity.

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SAŽETAK

U radu je vršeno ispitivanje ekstrakata ploda *Rosa canina* L. (divlja ruža) na sadržaj fenolskih jedinjenja i antioksidacijske aktivnosti. Pripremljeno je pet različitih ekstrakata: vodeni, 50% metanolni, 50% etanolni, 80% etanolni, 80% metanolni, a ekstrakcija je vršena metodom primjene ultrazvuka na sobnoj temperaturi. Ispitivan je ukupni sadržaj fenolskih jedinjenja, flavonoida, fenolskih kiselina, antocijana i proantocijanidina primjenom metoda za spektrofotometrijsko određivanje. Sadržaji ispitivanih jedinjenja kreću se za fenole 35,89-78,83 mg GAE/g; flavonoide 0,341-1,163 mg RE/g; i 0,214-0,675 mg QE/g; fenolske kiseline 4,55-11,21 mg CAE/g; antocijane 0,011-0,139 mg CGE/g i proantocijanidine 11,93-29,12 mg CE/g suhog uzorka.

Najveći sadržaj fenola, fenolskih kiselina i proantocijanidina određen je u 50% metanolnom ekstraktu a najmanji u 80% etanolnom ekstraktu. Najveći sadržaj flavonoida je pokazao 50% etanolni ekstrakt a najmanji vodeni ekstrakt. Sadržaj antocijana je bio najveći u 80% metanolnom ekstraktu a najmanji u 50% etanolnom ekstraktu.

Antioksidacijska aktivnost je u granicama 255,62-407,82 μmol TE/g za DPPH metodu, 312,06-616,10 μmol TE/g za ABTS metodu i 349,33-690,37 μmol TE/g suhog uzorka za FRAP metodu. Najveću antioksidacijsku aktivnost ima 50% metanolni ekstrakt a najmanju 80% etanolni ekstrakt za sve tri ispitivane metode. Generalno, antioksidacijska aktivnost opada u nizu FRAP>ABTS>DPPH za sve ispitivane ekstrakte.

Linearnom regresijom utvrđena je visoka pozitivna korelacija između sadržaja ukupnih fenola i proantocijanidina i antioksidacijske aktivnosti za sve tri ispitivane metode. Koeficijenti korelacije za fenole su u granicama 0,927-0,9935 a za proantocijanidine 0,9621-0,980. Umjerena pozitivna korelacija (0,6144-0,7353) je utvrđena između fenolskih kiselina i antioksidacijske aktivnosti za sve tri metode. Takođe, utvrđeno je da nema značajne pozitivne korelacije između sadržaja flavonoida i proantocijanidina u ispitivanim ekstraktima i antioksidacijske aktivnosti.

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