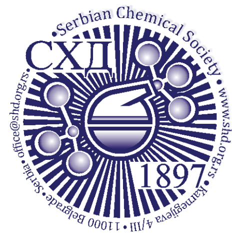

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Stabilization of rose hip oil with pomegranate peel extract during accelerated storage

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Abstract: Rose hip seed oil is a rich source of polyunsaturated fatty acids, as well as tocopherols, carotenoids, sterols, phospholipids, and phenolic compounds. On the other hand, due to the high content of polyunsaturated fatty acids, this oil is prone to oxidation. The aim of this study was to investigate the influence of a natural antioxidant, *i.e.*, pomegranate peel extract, and its combination with butylated hydroxytoluene as a commonly used synthetic antioxidant, on the stability of rose hip oil. The stability of samples without and with different antioxidants was monitored through analysis of the fatty acid composition and measurement of the quality and stability parameters of the oil (peroxide value, *p*-anisidine value, thiobarbituric acid reactive substances inhibition, total phenolic content and antiradical activity) during a storage period of 12 days at 65 °C. Pomegranate peel extract (0.1 %) inhibited more effectively the second stage of oxidation than butylated hydroxytoluene (0.02 %), while the first stage of oxidation was better prevented by the synthetic antioxidant. Furthermore, the addition of pomegranate peel extract increased the total phenolic content of the rose hip oil as well as its antiradical activity. Thus, pomegranate peel extract could be used as a potent natural antioxidant for the stabilization of beneficial but unstable rose hip oil.

Keywords: *Rosa canina*; lipid oxidation; natural antioxidants; thermal stability; oxidative stability; *Punica granatum*.

INTRODUCTION

Rose hip is the pseudo-fructus or pseudocarp of rose plants, which belong to the *Rosa* genus of the *Rosaceae* family. *Rosa canina* is one of the most abundant rose species in Europe.[1] The content of seeds in the fruit is approximately 30–35

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%, while the remaining 65–70 % is pericarp.[2] The seeds were considered as a waste product by the food industry for a long time.[3] The quantity of oil in the rose hip seeds is between 5 and 18 % and it is known as a rich source of polyunsaturated fatty acids (PUFA), as well as tocopherols, carotenoids, sterols, phospholipids and phenolic compounds.[1,4,5] It was reported previously that rose hip seed oil could be used for the treatment of eczema, skin ulcers, neurodermitis, cheilitis, skin scars, as well as for moisturizing and prevention of skin ageing.[6,7] Furthermore, it was noted that topical application of rose hip oil together with oral application of a poly-vitamin preparation of fat-soluble vitamins could exhibit a synergistic effect.[4] Diet supplemented with 15 % rose hip oil caused a hypolipidemic effect in rat plasma as a consequence of the high content of PUFA.[8] Therefore, rose hip oil could be beneficial in various products such as cosmetics, pharmaceutics, and nutraceuticals. However, oils with a high content of PUFA are prone to oxidation. Lipid oxidation is related to the occurrence of unpleasant odors, flavors, and discoloration. Furthermore, during the oxidation, toxic degradation products are formed.[9]

It was reported that nano-encapsulation was able to protect rose hip oil from oxidation under UVA and UVC light.[10] However, this procedure is considered as expensive and complex. Therefore, synthetic antioxidants, such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT) and *tert*-butylhydroquinone (TBHQ), are used usually to delay and prevent lipid oxidation. On the other hand, long-term intake of synthetic antioxidants is related to possible toxic effects and, as a result, the safety of synthetic antioxidants is controversial.[11] Consequently, there is growing interest to replace synthetic with natural antioxidants.[12] According to the literature, antioxidants from the phenolic family are the most active in the stabilization of oils among other natural ingredients.[12] Moreover, by incorporating polyphenol-rich extracts in the oils, a higher intake of such compounds in the diet is enabled, thus, additional health benefits could be expected.[13,14]

It is known that pomegranate (*Punica granatum* L.) peel extract is a valuable source of phenolics, such as ellagitannins, proanthocyanidins, flavonoids, and phenolic acids. Consequently, pomegranate peel extract has a strong antioxidative and anti-microbial activity.[15,16] Therefore, it was speculated that pomegranate peel extract could be used as a natural additive for food preservation. Previously, it was reported that pomegranate peel extract was a more potent antioxidant (at a concentration of 0.1 %) for the stabilization of sunflower oil than BHT (at a concentration of 0.02 %).[16] Furthermore, pomegranate peel extract (10 mg equiv. phenolics/100 g meat) prevented lipid oxidation in cooked chicken patties and it was shown that the efficiency of the extract was higher than vitamin C (50 mg/100 g meat) as well as BHT (10 mg/100 g meat).[17,18] On the other

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hand, pomegranate peel is usually recognized as a by-product in the production of pomegranate juice.[19]

Apart from the established health benefits of rose hip seed oil and pomegranate seed extract, these valuable products are underestimated. The aim of this study was to investigate the influence of pomegranate peel extract, as a substituent of commonly used synthetic antioxidants (BHT), on the stability of rose hip oil, which is prone to oxidation due to high content of PUFA.

EXPERIMENTAL

Plant material, standards and reagents

Rose hip seeds were purchased from the Institute for Medicinal Plants Research "Dr. Josif Pančić" from Belgrade, Serbia. The pomegranates were collected during November 2018 at a natural locality in the Village Do, Bosnia and Herzegovina. The peel of the pomegranate was manually separated from the seeds, air-dried at room temperature for 4–6 days and ground using a laboratory mill. Subsequently, the peel was sieved and particles ranging between 0.75 and 2 mm were used for the extraction. The following chemicals and reagents were used: acetic acid, hydrochloric acid, ethanol (96 %) and distilled water (Zorka Pharma, Serbia), thiobarbituric acid and 3-chloroacetic acid (Sigma Chemicals Co.), sodium hydroxide and sodium thiosulfate (Alfapanon, Serbia), petroleum ether, 4-methoxyaniline and isooctane (Fisher Chemical, UK), chloroform and potassium iodide (Carlo Erba, Spain), and Folin–Ciocalteu phenol reagent (Sigma–Aldrich). All chemicals were of analytical grade.

Preparation of pomegranate peel extract

Pomegranate peels were extracted by an ultrasound-assisted method, using ethanol (59 vol. %), for 25 min, under a temperature of 80 °C, while solid to solvent ratio was 1:44. These conditions were considered as optimal for the extraction of valuable compounds from pomegranate peels according to Živković *et al.*[19] The dry extract was obtained using a vacuum evaporator at under 50 °C (Laboxact SEM842, KNF, UK), and then stored at 4 °C.

Samples preparation and storage conditions

Ground rose hip seeds were extracted with *n*-hexane for 8 hours using a Soxhlet apparatus. Then, the *n*-hexane was evaporated in a vacuum evaporator at under 50 °C (Laboxact SEM842, KNF, UK). In order to evaluate the influence of pomegranate peel extract on the stability of rose hip oil, the pomegranate peel extract (0.1 %) was added to the oil. Butylated hydroxytoluene (BHT) was used in the maximal allowed concentration (0.02 %) as a positive control. A combination of pomegranate peel extract (0.05 %) and BHT (0.05 %) was added to the oil in order to evaluate a possible synergistic interaction of these antioxidants. Therefore, samples including rose hip oil without antioxidant, with BHT, with pomegranate peel extract, and with the combination of pomegranate peel extract and BHT were placed in dark glass bottles (three different bottles for each sample) with cups made from high-density polyethylene and stored in a thermostat for 3, 6, 9 and 12 days at 65 °C, according to previously published data that one day under a temperature of 65 °C corresponds to the one-month storage at ambient temperature.[20]

Fatty acid composition

The fatty acid composition of the rose hip seed oil was determined according to the method described by Zdunić *et al.*, with slight modifications.[21] The analyses were performed on an Agilent 7890A GC equipped with 5975 C inert XLEI/CI MSD and FID detector con-

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nected by capillary flow technology 2-way splitter with make-up. A DB-23 capillary column (60 m×0.25 mm×0.25 μm) was used. The temperature for the GC oven was from 50 °C (hold for 1 min), then raised to 175 °C at 25 °C min^{-1}, raised to 235 °C at 4 °C min^{-1} and hold for 5 min. Helium was used as the carrier gas at 54.814 psi (constant pressure mode). The sample was analyzed (5 μL of sample was dissolved in 1 mL dichloromethane) in the split mode with split ratio of 10/1. The injection volume was 1 μL. The detector temperature was 300 °C. MS data was acquired in EI mode, with a scan range 40–550 *m*/*z*. The source temperature was 230 °C and quadrupole temperature was 150 °C. The solvent delay was 3 min. Area percent reports, obtained from standard processing of the FID chromatograms, were used as the basis for quantification purposes. The identification of the constituents was performed by comparing their mass spectra listed in the NIST/Wiley spectra libraries, using different types of search (PBM/NIST) and available literature data. Prior to analysis, fatty acid methyl esters were prepared according to the International Association of Official Analytical Communities (AOAC) (Official Surplus Method 965.4).[22]

Peroxide value

The peroxide value was determined according to the method described in the European Pharmacopeia with a slight modification.[23] The sample (approximately 5 g) was dissolved in a mixture (30 mL) of glacial acetic acid and chloroform (3:2 volume ratio) and a saturated solution of potassium iodide was added and shaken for 1 min. Then, water (100 mL) was added and the mixture was titrated against sodium thiosulfate (0.01 mol L^{-1}) until the disappearance of the yellow color. Afterwards, starch solution (5 mL) was added and titration was continued until the color disappeared. A blank sample was analyzed under the same conditions. The peroxide value of each sample was determined in triplicate and expressed as milli-equivalent of active oxygen per 1 kg of oil (meq. O_2 per kg).

p-*Anisidine value*

The *p*-anisidine value was determined according to the procedure described in the European Pharmacopeia.[23] Firstly, the test solution (a) was prepared by dissolving the oil (approximately 0.5 g) in isooctane (25 mL). Then, test solution (b) was prepared by adding 1 mL of *p*-anisidine solution in glacial acetic acid (2.5 g L^{-1}) to 5 mL of test solution (a). The reference solution was a mixture of isooctane (5 mL) and *p*-anisidine solution in glacial acetic acid. The absorbance of test solution (a) – A_2 and test solution (b) – A_1 after standing for 10 min was measured at 350 nm, while isooctane was used as the compensation liquid in a case of test solution (a) and the reference solution in the case of test solution (b). The *p*-anisidine value was calculated according to Eq. (1), where *m* is the weight of the sample in grams:

$$p\text{-Anisidine value} = \frac{25(1.2A_1 - A_2)}{m} \quad (1)$$

Thiobarbituric acid reactive substances (TBARS) assay

Thiobarbituric acid reactive substances (TBARS) were determined according to the procedure reported by Drinić *et al.* with slight modifications.[24] 3-Chloroacetic acid (15 g) was added in hydrochloric acid (0.25 M, 100 mL) and then thiobarbituric acid (0.375 g) was added to obtain thiobarbituric acid solution. The oil sample (0.5 g) was added to the thiobarbituric acid solution (2.5 mL) and then the mixture was heated in a boiling water bath for 10 min, cooled, sonicated for 30 min and centrifuged at 3000 rpm for 10 min. The absorbance of the sample supernatant was measured at 532 nm.

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Total phenolic content (TPC) and DPPH radical scavenging activity

Methanol extracts of oils were obtained by liquid/liquid extraction of the oil samples (1 g) by methanol (1 mL) three times. In these samples, total the phenolic content and antioxidant activity were measured. Total phenolic content (TPC) was measured according to the Folin–Ciocalteu (FC) method by a slightly modified procedure described by Waterman and Mole.[25] The results are expressed as milligrams of gallic acid equiv. per g of oil (mg GAE g^{-1}). The anti-radical activity of the extract was determined by the DPPH (2,2-diphenyl-1-picryl-hydrazyl) assay with slight modifications.[26] Mixtures of the methanol extract of the oil sample and methanol solutions of DPPH (1400 µL, 40 µg mL^{-1}) were incubated for 20 min in a dark at room temperature. The absorbance of the mixture was measured at 517 nm, while methanol was used instead of the methanol extract of oil as a control. The antiradical activity is expressed in percent of DPPH radical scavenging capacity.

Statistical analyses

All experiments were performed in triplicate and the results are expressed as mean values with the standard deviation. Differences among mean values of collected data were estimated by one-way-analysis of variance (ANOVA) followed by the *post hoc* Tukey's test with significant levels of 95 % ($P < 0.05$). The statistical analysis was performed using MS Office Excel, version 2010.

RESULTS AND DISCUSSIONS

Fatty acid composition

The fatty acid composition of rose hip oil was determined at the beginning of the experiment in fresh oil (day 0) and after accelerated aging (12 days at 65 °C) in the samples with and without antioxidants (Table I). The rose hip oil samples

TABLE I. Fatty acid composition (%) of rose hip seed oil during storage without or with antioxidants. The results in the table were presented as mean ± standard deviations ($n = 3$); the same letters in the same row are not significantly different according to the Tukey's test, $p < 0.05$; N.I. – non-identified; A – without antioxidant at day 0, B – without antioxidant after 12 days of storage, C – with BHT (0.02 %) after 12 days of storage, D – with pomegranate peel extract (0.1 %) after 12 days of storage, E – with pomegranate peel extract (0.05 %) and BHT (0.01 %) after 12 days of storage

Fatty acid	Conditions				
	A	B	C	D	E
Palmitic acid	4.24±0.22^{a}	4.30±0.41^{a}	4.37±0.44^{a}	5.77±0.47^{b}	4.31±0.28^{a}
Stearic acid	3.01±0.3^{a}	2.97±0.23^{a}	2.85±0.35^{a}	4.96±0.27^{b}	2.82±0.32^{a}
Oleic acid	17.06±1.2^{ab}	17.22±0.96^{ab}	16.78±1.57^{a}	20.62±1.80^{b}	16.77±1.17^{a}
N.I.	0.43±0.02^{ab}	0.46±0.06^{ab}	0.41±0.05^{a}	0.53±0.02^{b}	0.42±0.04^{a}
Linoleic acid	55.01±3.92^{a}	54.84±3.67^{a}	55.02±4.54^{a}	52.04±4.71^{a}	54.96±2.91^{a}
α-linolenic acid	18.21±1.52^{b}	18.04±0.93^{b}	18.67±1.73^{b}	13.56±0.74^{a}	18.68±1.16^{b}
Eicosanoic acid	1.28±0.18^{a}	1.32±0.10^{a}	1.21±0.11^{a}	1.62±0.13^{b}	1.27±0.23^{a}
cis-11-Eicosenoic acid	0.36±0.03^{b}	0.39±0.04^{b}	0.33±0.02^{a}	0.43±0.03^{b}	0.37±0.05^{b}
cis-11,14-Eicosadienoic acid	0.14±0.01^{a}	0.18±0.01^{b}	0.12±0.01^{a}	0.17±0.0^{a}	0.12±0.01^{a}
Behenic acid	0.26±0.02^{b}	0.28±0.02^{b}	0.24±0.02^{a}	0.31±0.02^{b}	0.28±0.02^{b}

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with and without antioxidants were characterized by high content of unsaturated fatty acids (86.82–90.92 %), as well as PUFA (65.77–73.81 %). The oils with high contents of unsaturated fatty acids should be related to the potential health benefits, but also higher susceptibility to oxidation. The main fatty acid in all samples was linoleic acid (52.04–55.02 %), followed by oleic (16.77–20.62 %) and α-linolenic acid (13.56–18.68 %), palmitic (4.24–5.77 %), and stearic acids (2.82–4.96 %). It was reported in the majority of articles that the dominant components in rose hip seed oil are linoleic (35.94–55.70 %), *α*-linolenic (14.30––24.65 %) and oleic acid (13.17–22.82 %).[2,3,5,7,27,28] Variation in the rose hip seed oil composition was probably influenced by different factors, such as genetic, climatic, ecologic, soil conditions, as well as extraction type and conditions.[1,5]

After accelerated aging, the content of linoleic acid (52.04–55.02 %) was not statistically different from that at the beginning (55.01 %) of the experiment in all investigated samples. Statistically higher contents of palmitic and stearic acid were determined in the sample stabilized with pomegranate peel extract after accelerated aging, while the content of *α*-linolenic acid was statistically lower, than at the beginning of the experiment. In the samples with BHT and combination of BHT and pomegranate peel extract, as well as in the sample without antioxidant content of *α*-linolenic, oleic, stearic and palmitic acid was not statistically different from oil at the beginning of the experiment.

Peroxide value

The peroxide value is a widely used index for the estimation of oil oxidative stability. The concentration of peroxides and hydroperoxides formed in the oil during the initial stages of lipid oxidation can be evaluated using this method.[9,29] It is known that oils with higher stability are characterized by a lower peroxide value. According to the obtained results, the peroxide value in the fresh oil without antioxidants was 2.32 meq. O_2 kg^{-1}, which is similar to the previously reported results obtained by Grajzer *et al.* where the peroxide value of fresh cold-pressed rose hip oil (*R. canina*) ranged from 1.2 to 2.1 meq. O_2 kg^{-1}.[30] However, Jakovljević *et al.* recorded a significantly higher peroxide value for rose hip oil obtained by supercritical CO_2 extraction (4.70–29.69 mmol O_2 kg^{-1}), which could be explained by the different extraction parameters.[31] In the present samples, a constant increase of peroxide values was noticed during 12 days of storage at 65 °C with a maximal value of 74.67 meq. O_2 kg^{-1} in the sample without antioxidant (Fig. 1). Oil with pomegranate peel extract as an antioxidant was characterized with the lowest peroxide value among investigated oils until 9 days of storage at 65 °C. On the other hand, after 12 days at 65 °C, a sharp increase in the peroxide value was recorded in all samples, especially in the sample without antioxidant (74.67±4.72 meq. O_2 kg^{-1}) but also in the sample with pomegranate peel extract (72.13±4.56 meq. O_2 kg^{-1}). Lower peroxide

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values after 12 days at 65 °C were noticed for the sample with BHT (43.73±2.76 meq. O_2 kg^{-1}) and in the sample stabilized with a combination of BHT and pomegranate peel extract (57.14±3.61 meq. O_2 kg^{-1}). The present results indicate that pomegranate peel extract could be used as a good antioxidant for the stabilization of rose hip oil, but further studies on the selection of optimal extract concentration are necessary.

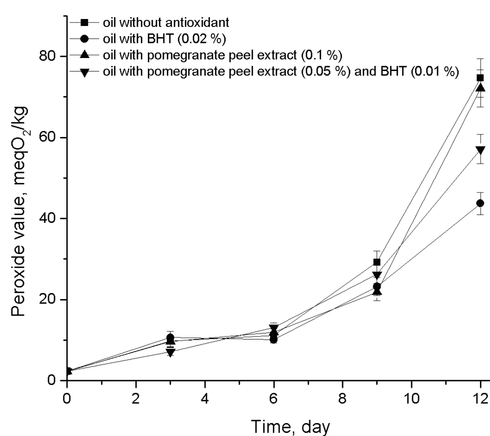

Fig. 1. Peroxide value of rose hip oil with or without antioxidant during accelerated storage.

p-*Anisidine value*

The *p*-anisidine value is a measure of secondary oxidation products (high molecular weight saturated and unsaturated carbonyl compounds) that arise from initially formed peroxides and hydroperoxides in oils and fats.[29,32] The present study showed a minor raise of the *p*-anisidine value in rose hip oil with or without antioxidants during the first 6 days of storage at 65 °C but thereafter, a period of rapid increase in the *p*-anisidine value was noticed (Fig. 2, Table S-I of the Supplementary material to this paper). Moreover, the rose hip oil was characterized by a rather high *p*-anisidine value (7.19) at the beginning of the experiment (day 0), probably due to high carotenoids content and strong color of rose hip oil.[32] On the other hand, such a result is in accordance with the results of Grajzer *et al.*, who reported that *p*-anisidine values of cold-pressed rose hip oils were 2.5 and 7.7, depending on the source.[30] Rose hip oil stabilized with pomegranate peel extract was characterized by the lowest *p*-anisidine value among the investigated samples after 9 and 12 days of storage, 32.91 and 55.89, respectively), indicating significantly better antioxidative activity of pomegranate peel extract than BHT (40.84 and 62.43, respectively) and the combination of BHT and pomegranate peel extract (43.20 and 70.18, respectively).

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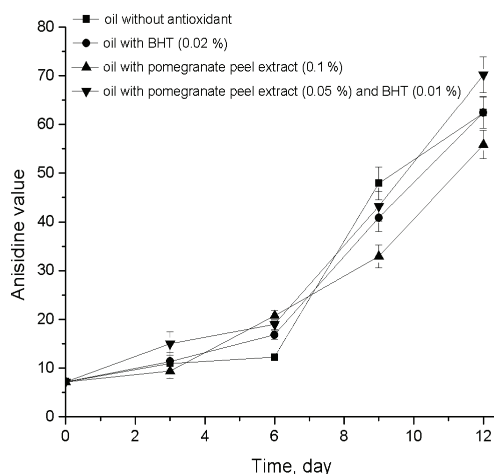

Fig. 2. Anisidine value of rose hip oil with or without antioxidant during accelerated storage.

TBARS *value*

For the estimation of rose hip oil oxidation, the TBARS test was also used. Generally, this test was developed for the determination of malondialdehyde (MDA), a compound with the potential mutagenic activity that is formed during secondary oxidation of unsaturated fatty acids.[33] Results of the inhibition of TBARS formation in rose hip oils with or without antioxidants during 12 days of storage at 65 °C are presented in Fig. 3 and Table S-II of the Supplementary material. During the first 9 days of storage, there was no significant difference between the samples and in all of them, a decrease in TBARS inhibition was evident. After 12 days of storage, inhibition of TBARS in rose hip oil stabilized with pomegranate peel extract was significantly different from that that in samples stabilized with BHT or a combination of BHT and pomegranate peel extract. Pomegranate peel extract has inhibited TBARS formation in rose hip oil more effectively than the other investigated antioxidants.

Total phenolic content and antioxidant activity

The total phenolic content (TPC) of fresh rose hip oil was 0.13 mg GAE g^{-1}, which was lower than in the research of Turan *et al.* who reported 0.37 mg GAE g^{-1} in rose hip oil extracted by petroleum ether,[5] but higher than in the case of Grajzer *et al.* who reported TPC values of 783.5 and 570.7 μg kg^{-1} in cold-pressed rose hip, depending on the sample.[30] After 12 days of storage at 65 °C, the TPC was significantly higher in oil with pomegranate peel extract (0.22 mg GAE g^{-1}) than in the sample without antioxidant (0.07 mg GAE g^{-1}), the sample with BHT (0.07 mg GAE g^{-1}) and the sample with a combination of pomegranate peel extract and BHT (0.11 mg GAE g^{-1}, Table S-II). The antiradical activity of fresh rose hip oil was 16.54 %, expressed as % of DPPH radical scavenging activity. After 12 days of storage at 65 °C, the antiradical activities of rose hip oil without

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antioxidant (15.11 %), with BHT (13.52 %) and with a combination of BHT and pomegranate peel extract (14.80 %) were lower than in fresh oil. On the other hand, the antiradical activity of rose hip oil with pomegranate peel extract was significantly higher (29.42 %) than in the other samples after 12 days of storage, as well as in fresh rose hip oil. This result is in accordance with the total phenolic content of the investigated samples. Therefore, rose hip oil stabilized with pomegranate peel extract was fortified with polyphenols, and thus better antiradical activity was achieved, which could be related to higher stability and beneficial health effects.

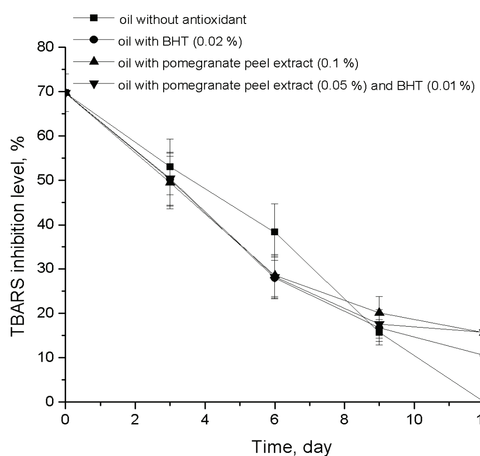

Fig. 3. Inhibition of the level of thiobarbituric acid reactive substances (TBARS) in rose hip oil with or without antioxidant during accelerated storage.

CONCLUSIONS

The results of the resent study indicate that, although rose hip oil is difficult to stabilize due to the high content of PUFA, pomegranate peel extract could be used as an antioxidant for the stabilization of rose hip oil instead of synthetic antioxidant (BHT). Pomegranate peel extract in a concentration of 0.1 % was more effective in inhibition of the second stage of oxidation than BHT at its legal limit (0.02 %), while the first stage of oxidation was prevented better by BHT. Moreover, the addition of polyphenol rich pomegranate peel extract increased the total phenolic content of the rose hip oil as well as its antiradical activity. Therefore, pomegranate peel extract could be used as a potent natural antioxidant for stabilization of beneficial rose hip oil. Further research is needed to find the optimal concentration of pomegranate peel extract that could inhibit oxidation to a higher extent, especially in the first stage of oxidation.

SUPPLEMENTARY MATERIAL

Additional data are available electronically at the pages of journal website: https:// //www.shd-pub.org.rs/index.php/JSCS/index, or from the corresponding author on request.

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ИЗВОД

СТАБИЛИЗАЦИЈА УЉА СЕМЕНА ШИПУРКА ЕКСТРАКТОМ КОРЕ НАРА ПОД УСЛОВИМА УБРЗАНОГ СТАРЕЊА

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Уље семена шипурка богато је полинезасићеним масним киселинама, али и супстанцама као што су токофероли, каротеноиди, стероли, фосфолипиди и полифеноли. Услед високог садржаја полинезасићених масних киселина ово уље лако подлеже оксидацији. Стога, циљ овог рада је био упоредити стабилност уља семена шипурка уз додатак природног антиоксиданса – екстракта коре плода нара, као и комбинације природног и синтетског антиоксиданса тј. екстракта коре плода нара и бутил-хидрокси-толуена са често коришћеним синтетским антиоксидансом, бутил-хидрокси-толуеном. Стабилност узорка са или без додатка антиоксиданса праћена је испитивањем садржаја масних киселина и мерењем параметара квалитета и стабилности уља (пероксидног броја, анизидинског броја, инхибиције продуката липидне пероксидације, укупног садржаја полифенола, антиоксидативне активности) у току чувања од 12 дана на 65 °C. Екстракт плода коре нара у концентрацији од 0,1 % је показао већу ефикасност у инхибицији секундарне оксидације у односу на бутил-хидрокси-толуен који је у концентрацији од 0,02 % био ефикаснији у заштити уља од примарне оксидације. Додатак екстракта коре плода нара утицао је на повећање садржаја полифенола у уљу семена шипурка, као и на побољшање стабилности и повећање антирадикалске активности. На основу добијених резултата може се закључити да је екстракт коре плода нара потентан антиоксиданс који може бити коришћен за стабилизацију корисног, али нестабилног уља семена шипурка.

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REFERENCES

1. I. Mármol, C. Sánchez-de-Diego, N. Jiménez-Moreno, C. Ancín-Azpilicueta, M. J. Rodríguez-Yoldi, *Int. J. Mol. Sci* **18** (2017) 1137 (https://doi.org/10.3390/ijms18061137)
2. F. Çelik, F. Balta, S. Ercişli, A. Kazankaya, I. Javidipour, *J. Food Agric. Environ*. **8** (2010) 482
3. K. Szentmihályi, P. Vinkler, B. Lakatos, V. Illés, M. Then, *Bioresour. Technol.* **82** (2002) 195 (https://doi.org/10.1016/S0960-8524(01)00161-4)
4. M. Kiralan, G. Yildirim, *Springer Chem*. **43** (2019) 803 (https://doi.org/10.1007/978-3-030-12473-1_43)
5. S. Turan, R. Solak, M. Kiralan, M. F. Ramadan, *Grasas Aceites* **69** (2018) 248 (https://doi.org/10.3989/gya.1114172)
6. P. Valerón-Almazán, A. J. Gómez-Duaso, N. Santana-Molina, M. A. García-Bello, G. Carretero, *JCDSA* **5** (2015) 161. (https://doi.org/10.4236/jcdsa.2015.52019)
7. M. Dąbrowska, E. Maciejczyk, D. Kalemba, *Eur. J. Lipid Sci. Technol.* **121** (2019) 1 (https://doi.org/10.1002/ejlt.201800440)
8. I. Gonzalez, M. Escobar, P. Olivera, *Rev. Esp. Fisiol.* **53** (1997) 199 (https://doi.org/10.1002/ejlt.201800440)

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9. A. A. Mohdaly, I. Smetanska, M. F. Ramadan, M. A. Sarhan, A. Mahmoud, *Ind. Crops Prod.* **34** (2011) 959. (https://doi.org/10.1016/j.indcrop.2011.02.018)
10. R. V. Contri, I. C. Kulkamp-Guerreiro, S. J. da Silva, L. A. Frank, A. R. Pohlmann, S. S. Guterres, *AAPS PharmSciTech* **17** (2016) 863
11. M. Taghvaei, S. M. Jafari, *J. Food Sci. Technol.* **52** (2015) 1272 (https://doi.org/10.1007/s13197-013-1080-1)
12. F. Shahidi, P. Ambigaipalan, *J. Funct. Foods* **18** (2015) 820 (https://doi.org/10.1016/j.jff.2015.06.018)
13. F. Shahidi, *Food Nahrung* **44** (2000) 158 (https://doi.org/10.1002/1521-3803(20000501)44:3<158::AID-FOOD158>3.0.CO;2-L)
14. S. Akhtar, T. Ismail, D. Fraternale, P. Sestili, *Food Chem.* **174** (2015) 417 (https://doi.org/10.1016/j.foodchem.2014.11.035)
15. I. Živković, K. Šavikin, G. Zdunić, J. Živković, D. Bigović, N. Menković, D. Radin, *Nat. Med. Mat.* **38** (2018) 31 (http://dx.doi.org/10.5937/leksir1838031Z)
16. S. Iqbal, S. Haleem, M. Akhtar, M. Zia-ul-Haq, J. Akbar, *Food Res. Int.* **41** (2008) 194 (https://doi.org/10.1016/j.foodres.2007.11.005)
17. B. M. Naveena, A. R. Sen, R. P. Kingsly, D. B. Singh, N. Kondaiah, *Int. J. Food Sci. Technol.* 43 (2008) 1807 (https://doi.org/10.1111/j.1365-2621.2007.01708.x)
18. B. M. Naveena, A. R. Sen, S. Vaithiyanathan, Y. Babji, N. Kondaiah, *Meat Sci.* **80** (2008) 1304 (https://doi.org/10.1016/j.meatsci.2008.06.005)
19. J. Živković, K. Šavikin, T. Janković, N. Ćujić, N. Menković, *Sep. Purif. Technol.* **194** (2018) 40 (https://doi.org/10.1016/j.seppur.2017.11.032)
20. Y. M. Chong, S. K. Chang, W. C. M. Sia, H. S. Yim, *Food Biosci.* **12** (2015) 18 (https://doi.org/10.1016/j.fbio.2015.07.002)
21. G. Zdunić, D. Gođevac, K. Šavikin, D. Krivokuća, M. Mihailović, Z. Pržić, N. Marković, *Chem. Biodivers.* **16** (2019) e1900053 (https://doi.org/10.1002/cbdv.201900053)
22. *AOAC method, Official Surplus Method 965.4, Fatty Acids in Oils and Fats, Preparation of Methyl Esters*, Final Action 1984, Surplus, 1965
23. *Pharacopoeia European*, 8th ed., Council of Europe, Strasbourg, 2014
24. Z. Drinić, J. Mudrić, G. Zdunić, D. Bigović, K. Šavikin, *Nat. Med. Mat.* **39** (2019) 40 (http://dx.doi.org/10.5937/leksir1939040D)
25. P. G. Waterman, S. Mole, *Analysis of phenolic plant metabolites*, Blackwell Scientific, Oxford, 1994 (ISBN 0632029692)
26. M. S. Blois, *Nature* **181** (1958), 1199
27. R. Nowak, *Acta Soc. Bot. Pol.* **74** (2005) 229
28. H. Ilyasoğlu, *Int. J. Food Prop.* **17** (2014) 1591 (https://doi.org/10.1080/10942912.2013.777075)
29. E. N. Frankel, *Lipid oxidation*, Woodhead Publishing, Cambridge, 2005 (ISBN 9780953194988)
30. M. Grajzer, A. Prescha, K. Korzonek, A. Wojakowska, M. Dziadas, A. Kulma, H. Grajet, *Food Chem.* **188** (2015) 459 (https://doi.org/10.1016/j.foodchem.2015.05.034)
31. M. Jakovljević, T. Moslavac, M. Bilić, M. Aladić, K. Bakula, S. Jokić, *Croat. J. Food Sci. Technol.* **10** (2018) 197 (https://doi.org/10.17508/CJFST.2018.10.2.08)
32. A. Ismail, G. Bannenberg, H. B. Rice, E. Schutt, D. MacKay, *Lipid Technol.* **28** (2016) 55 (https://doi.org/10.1002/lite.201600013)
33. A. Papastergiadis, E. Mubiru, H. Van Langenhove, B. Meulenaer, *Agric. Food. Chem.* **60** (2012) 9589 (https://doi.org/10.1021/jf302451c).

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