Influence of Sumac Extract on the Physico-chemical Properties and Oxidative Stability of Some Cold Pressed Citrus Seed Oils

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Abstract: The acidity values changed between 1.03 mgKOH/100g (control) and 1.11 mgKOH/100g (0.1% extract) for orange oil, 1.06 mgKOH/100g (0.5% extract) and 1.13 mgKOH/100g (0.1% extract) and 1.25 mgKOH/100g (0.5% extract) and 1.31 mgKOH/100g (control) for mandarin oil. The peroxide values were determined between 1.37 meqO₂/kg (0.5% extract) and 1.43 meqO₂/kg (0.1% extract) for orange oil, between 1.24 meqO₂/kg (control) and 1.27 meqO₂/kg (0.1% extract) for lemon and 1.60 meqO₂/kg (0.5% extract) and 1.71 meqO₂/kg (control) in mandarin oil samples. The viscosity values of samples changed between 0.051 Pa.S (control) and 0.065 Pa.S (0.5% extract) for orange, 0.051 Pa.S (control) and 0.067 Pa.S (0.5% extract) lemon and 0.044 Pa.S (control) and 0.057 Pa.S (0.5% extract) in mandarin oil samples. At the end of storage study (28th day), the acidity values significantly changed, and their values ranged between 2.28 mgKOH/100g (0.5% extract) and 3.64 mgKOH/100g (control) in orange, 1.67 mgKOH/100g (0.5% extract) and 2.28 mgKOH/100g (control) in lemon and 1.74 mgKOH/100g (0.5% extract) and 2.36 mgKOH/100g (control) in mandarin oil samples. While peroxide values vary between 11.68 meqO₂/kg (0.5% extract) and 32.57 meqO₂/kg (control) for orange, 12.55 meqO₂/kg (0.5% extract) and 34.63 meqO₂/kg (control) for lemon and between 17.56 meqO₂/kg (0.5% extract) and 37.81 meqO₂/kg (control) for mandarin oils, viscosity values after 28 day storage changed between 0.123 Pa.S (0.5% extract) and 0.675 Pa.S (control) in orange, 0.257 Pa.S (0.5% extract) and 0.697 Pa.S (control) in lemon and 0.215 Pa.S (0.5% extract) and 0.728 Pa.S (control) in mandarin oil samples.

Key words: sumac extract, citrus oils, oxidative stability, viscosity, storage, cold press

1 Introduction

Sumac (Rhus coriaria L.) is traditionally being used as a natural medication. The use of the plant in seasonings and flavoring agents has been the mainstay of indigenous remedies in different dietary cultures around the globe1. Sumac is used as a spice, and has been used in cooking for millennia. About 2000 years ago, the Greek physician Pedenius Dioscorides wrote in his voluminous “De Materia Medica” about the healthful properties of sumac, principally as a diuretic and anti-flatulent4. The leave, stick and seeds of sumac plant contain substantial amounts of several biologically important components, and the most important of those are the phenolic compounds1–8. Sumac is one of the major sources of phenolic, bioactive phytochemical compound and its functional ingredients have widespread and potential usability in chemical and pharmaceutical industries9. Candan and Sökmen10 reported that antioxidative capacity of R. coriaria fruits has been evaluated using in vitro systems. The IC₅₀ value of the sumac extracts, for lipid peroxidation inhibition, was estimated as 1200 µg/mL in the Fe²⁺-ascorbate system10. A previous study about stabilizing food products using sumac extracts included the use of a methanolic extract of the fruits added to sunflower oil stored at 70°C and peroxide values of the stored oil was measured at regular intervals. Sumac extract was found to be very effective in stabilizing the sunflower oil11. Antioxidant properties for stabilizing peanut was also reported in which methanol extracts of R. coriaria fruits and leaves were added to peanut oil at concentration of 1 to 5% (w/v) and it was observed that the formation of hydroperoxide...
2 Material and Methods

2.1 Material

In this study, orange (Barile cv.), lemon (Interdonato cv.) and mandarin (Clementine cv.) cultivated in Adana and Mersin provinces in Turkey were used to obtain seed oil. Seed from these fruits were separated from pulp manually, and washed with distilled water and dried at room temperature. The dried kernels were milled in laboratory to pass through 60-mesh sieve, and the samples were kept at 4°C before further processing and analyses. Ripened Sumac (Rhus coriaria L.) fruits were collected from Mersin (Gulnar-Buyukceceli) province in Turkey during September 2018 and dried at room temperature. They were ground to a powdered form using a lab scale grinder.

2.2 Method

2.2.1 Cold press

Citrus seed oils from orange, lemon and mandarin were obtained using cold screw extraction process at room temperature, where the initial rotation was 1500 rpm and the final one was approximately 3600 rpm. After broken or damaged citrus seeds and other impurities such as stem and skin were removed, whole seeds were extracted with cold screw press (2-6 liter/h capacity) without heat treatment. The impurities were removed to ensure high quality oil. After pressing, the oil was purified from solid impurities by sedimentation for one week. Sedimentation process followed filtration and storage of the purified oil in hermetically closed colored bottle under the nitrogen at −18°C.

2.2.2 Extraction from sumac fruit

About 10g of ground sumac (Rhus coriaria L.) sample was extracted using Soxhlet apparatus for 5h and methanol was used as solvent. The extracts were filtered using filter paper, and the solvent was removed using rotary evaporator (40°C + Vacuum). In experiment, three different levels (0.1%, 0.3% and 0.5%) of sumac extracts were used as additives to three different citrus seed oils. Sumac extracts at a concentration of 0.1%, 0.3% and 0.5% were added into each 50 mL citrus oil in three petri plates, respectively. Then the oil in the petri plate was thoroughly mixed and kept at 50°C for 28 days. Analyzes were carried out at weekly intervals.

2.2.3 Analysis

The acid value, iodine value, peroxide value, saponification value, unsaponifiable matter, density, refractive index, and viscosity of citrus seed oils were determined using standard methods.

2.2.4 Statistical analyses

The analysis of variance (ANOVA) was performed by using JMP version 9.0 (SAS Inst. Inc., Cary, N.C.U.S.A). All analyzes were carried out three times and the results are mean ± standard deviation (MSTAT C) of citrus oils and sumac extract concentrations.

3 Results and Discussion

The physico-chemical properties of citrus oils treated with sumac fruit extracts are presented in Table 1. The results showed differences depending on extract concentrations and storage periods of citrus oils. Generally, acidity, peroxide values, refractive index, saponification values of treated oil samples decreased with increase of extract concentration at the beginning of storage. While acidity values change between 1.03 mgKOH/100g (control) and 1.11 mgKOH/100g (0.1% extract) in case of orange oil, 1.06 mgKOH/100g (0.5% extract) and 1.13 mgKOH/100g (0.1% extract) in case of lemon oil, 1.25 mgKOH/100g (0.5% extract) and 1.31 mgKOH/100g (control) in mandarin oil, peroxide values varied between 1.37 meqO2/kg (0.5% extract) and 1.43 meqO2/kg (0.1% extract) in case of orange oil, 1.24 meqO2/kg (control) and 1.27 meqO2/kg (0.1% extract) in lemon oil and 1.60 meqO2/kg (0.5% extract) and 1.71 meqO2/kg (control) in mandarin oil at the beginning of storage. Depending on extract concentrations, density and viscosity values of oil samples increased. The density values were between 0.884 mg/mL (control) and 0.899 (0.5% extract) in orange oil, 0.857 (control) and 0.868 mg/mL (0.5% extract) in lemon oil and 0.876 mg/mL (control) and 0.886 mg/mL (0.5% extract) in mandarin oil. The viscosity values ranged between 0.051 Pa.S (control) and 0.065 Pa.S (0.5% extract) in orange seed oil, 0.051 Pa.S (control) and 0.067 Pa.S (0.5% extract) in lemon seed oil and 0.044 Pa.S (control) and 0.057 Pa.S (0.5% extract) in mandarin seed oil.

Physico-chemical properties of citrus oils treated with different sumac extract concentrations showed remarkable changes after 7th day of storage. The acidity values were between 1.18 mgKOH/100g (0.5% extract) and 1.38 mgKOH/100g (control) for treated orange oil, 1.38 mgKOH/100g (0.5% extract) and 1.48 mgKOH/100g (0.1% extract) lemon oil and 1.47 mgKOH/100g (0.5% extract)
Table 1  Effect of sumac extract addition at different concentrations (0.1-0.5%) on physico-chemical properties of cold pressed orange, lemon and mandarin oils during storage.

| Parameter                        | Storage time (0 day) | Orange (Barlive) oil with sumac extract | Lemon (Interdonato) oil with sumac extract | Mandarin (Clementine) oil with sumac extract |
|----------------------------------|----------------------|----------------------------------------|-------------------------------------------|---------------------------------------------|
| Acidity                          | Control              | 0.1%                                   | 0.3%                                      | 0.5%                                        |
| (mg KOH/100g)                    | Control              | 0.1%                                   | 0.3%                                      | 0.5%                                        |
| Peroxide value                   | Control              | 0.1%                                   | 0.3%                                      | 0.5%                                        |
| Saponification value             | Control              | 0.1%                                   | 0.3%                                      | 0.5%                                        |
| Unsaponifiable matter            | Control              | 0.1%                                   | 0.3%                                      | 0.5%                                        |
| Density                          | Control              | 0.1%                                   | 0.3%                                      | 0.5%                                        |
| Viscosity                        | Control              | 0.1%                                   | 0.3%                                      | 0.5%                                        |
| Storage time (10th day)           | Control              | 0.1%                                   | 0.3%                                      | 0.5%                                        |
| Acidity                          | Control              | 0.1%                                   | 0.3%                                      | 0.5%                                        |
| Peroxide value                   | Control              | 0.1%                                   | 0.3%                                      | 0.5%                                        |
| Saponification value             | Control              | 0.1%                                   | 0.3%                                      | 0.5%                                        |
| Unsaponifiable matter            | Control              | 0.1%                                   | 0.3%                                      | 0.5%                                        |
| Density                          | Control              | 0.1%                                   | 0.3%                                      | 0.5%                                        |
| Viscosity                        | Control              | 0.1%                                   | 0.3%                                      | 0.5%                                        |
| Storage time (14th day)           | Control              | 0.1%                                   | 0.3%                                      | 0.5%                                        |

*Note: Values are means of three replicates ± standard deviation.*
Table 1

| Parameter                  | Orange (Barile) oil with sumac extract | Lemon (Interdonato) oil with sumac extract | Mandarin (Clementine) oil with sumac extract |
|---------------------------|----------------------------------------|--------------------------------------------|---------------------------------------------|
| Control                   | Control                                | Control                                    | Control                                    |
| Viscosity (Pa.S; 25°C)    | 0.138 ± 0.013d                         | 0.157 ± 0.011b                            | 0.169 ± 0.021a                            |
| 0.1%                      | 0.145 ± 0.015a                         | 0.147 ± 0.017c                            | 0.154 ± 0.013c                            |
| 0.3%                      | 0.157 ± 0.009c                         | 0.158 ± 0.015a                            | 0.164 ± 0.003c                            |
| 0.5%                      | 0.157 ± 0.017c                         | 0.161 ± 0.015a                            | 0.161 ± 0.018c                            |
| 0.5%                      | 0.157 ± 0.018c                         | 0.161 ± 0.015a                            | 0.161 ± 0.018c                            |
| Refractive Index (n°d)    | 1.34 ± 0.12a                           | 1.26 ± 0.13a                              | 1.24 ± 0.11a                              |
| 0%                        | 1.26 ± 0.13a                           | 1.24 ± 0.11a                              | 1.24 ± 0.11a                              |
| 0.1%                      | 1.24 ± 0.11a                           | 1.24 ± 0.11a                              | 1.24 ± 0.11a                              |
| 0.3%                      | 1.25 ± 0.12a                           | 1.25 ± 0.12a                              | 1.25 ± 0.12a                              |
| 0.5%                      | 1.27 ± 0.13a                           | 1.25 ± 0.12a                              | 1.25 ± 0.12a                              |
| Iodine value (g/l(100g))  | 0.13a                                  | 0.18a                                     | 0.15b                                      |
| 0%                        | 0.15b                                  | 0.16b                                     | 0.16b                                      |
| 0.1%                      | 0.16b                                  | 0.16b                                     | 0.16b                                      |
| 0.3%                      | 0.16b                                  | 0.16b                                     | 0.16b                                      |
| 0.5%                      | 0.16b                                  | 0.16b                                     | 0.16b                                      |

*mean ± standard deviation; **Values within each row followed by different letters are significantly different (p < 0.05)

and 1.63 mgKOH/100g (0.1% extract) for mandarin oil. Peroxide values at the 7th day of storage changed between 2.63 meqO₂/kg (0.5% extract) and 5.27 meqO₂/kg (control) for orange oil, 4.61 meqO₂/kg (0.5% extract) and 6.35 meqO₂/kg (control) for lemon oil and 5.07 meqO₂/kg (0.5% extract) and 7.98 meqO₂/kg (control) in case of mandarin oil. Partial significant differences were observed in case of refractive index and iodine values of treated oils depending on extract concentrations. The density values were between 0.883 mg/mL (control) and 0.899 mg/mL (0.5% extract) in case of orange oil, 0.855 mg/mL (control) and 0.875 mg/mL (0.5% extract) in lemon oil and 0.875 mg/mL (control) and 0.892 mg/mL (0.5% extract) for mandarin oil. The viscosity values were found between 0.093 Pa.S (control) and 0.109 Pa.S (0.3% extract) in orange oil, 0.105 Pa.S (control) and 0.117 Pa.S (0.3% extract) in lemon oil and 0.098 Pa.S (control) and 1.127 Pa.S (0.1% extract) in mandarin oil.

After 14th day of storage, the acidity values varied between 1.28 mgKOH/100g (0.5% extract) and 1.63 mgKOH/100g (0.5% extract) and 1.74 mgKOH/100g (control) in lemon oil and 1.56 mgKOH/100g (0.5% extract) and 1.83 mgKOH/100g (control) in case of mandarin oil. The perox-
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Fig. 1 Acidity values of citrus oils treated by sumac extract at different concentrations.

ide values changed between 6.48 meqO₂/kg (0.5% extract) and 12.76 meqO₂/kg (control) in orange oil. 8.64 meqO₂/kg (0.5% extract) and 15.67 meqO₂/kg (control) in lemon oil and 11.44 meqO₂/kg (0.5% extract) and 18.46 meqO₂/kg (control) in mandarin oil after 14th day. Partially significant differences were observed among refractive index, iodine and saponification values of sumac treated citrus oils at the 14th day of storage. The saponifiable values of treated oil samples partially decreased with increasing extract concentration. The density values varied between 0.882 mg/mL (control) and 0.897 mg/mL (0.5% extract) in orange oil, between 0.852 mg/mL (control) and 0.877 mg/mL (0.5% extract) in lemon oil and between 0.873 mg/mL (control) and 0.893 mg/mL (0.5% extract) in mandarin oil after treatment with sumac extract. The viscosity values of samples varied between 0.17 PaS (control) and 0.169 PaS (0.3% extract) in orange oil, 0.151 PaS (0.5% extract) and 0.187 PaS (0.1% extract) in lemon oil and 0.127 PaS (0.5% extract) and 0.161 PaS (0.1% extract) in mandarin oil samples.

The analytical results on 21st day of storage showed that acidity values remained 1.43 mgKOH/100g (0.5% extract) to 1.87 mgKOH/100g (control) in orange oil, 1.63 mgKOH/100g (0.5% extract) to 1.91 mgKOH/100g (control) in lemon oil and 1.61 mgKOH/100g (0.5% extract) to 2.07 mgKOH/100g (0.1% extract) in mandarin oil samples. The peroxide values were found between 8.57 meqO₂/kg (0.5% extract) and 24.76 meqO₂/kg (control) in orange oil, 10.26 meqO₂/kg (0.5% extract) and 28.44 meqO₂/kg (control) in lemon oil and 14.97 meqO₂/kg (0.5% extract) and 31.67 meqO₂/kg (control) in mandarin oil samples. The unsaponifiable matter values were determined between 1.59% (0.5% extract) and 1.69% (control) in orange oil and 1.77% (0.3% extract) and 1.81% (control) in lemon oil. The density values were 0.881 mg/mL (control) to 0.901 mg/mL (0.5% extract) in orange oil, 0.853 mg/mL (control) to 0.879 mg/mL (0.5% extract) in lemon oil and 0.872 mg/mL (control) to 0.880 mg/mL (0.5% extract) in mandarin oil. The viscosity values varied between 0.187 PaS (0.3% extract) and 0.257 PaS (control) in orange oil, 0.178 PaS (0.5% extract) to 0.311 PaS (control) in lemon oil. At the 28th day of storage, acidity values were detected between 2.28 mgKOH/100g (0.5% extract) and 3.64 mgKOH/100g (control) in orange oil, 1.67 mgKOH/100g (0.5% extract) and 2.28 mgKOH/100g (control) in mandarin oil and 1.74 mgKOH/100g (0.5% extract) and 2.36 mgKOH/100g (control) in mandarin oil samples after addition of sumac extracts (Fig. 1). The peroxide values were found between 11.68 meqO₂/kg (0.5% extract) and 32.57 meqO₂/kg (control) in orange oil, 12.55 meqO₂/kg (0.5% extract) and 34.63 meqO₂/kg (control) in lemon oil and 17.56 meqO₂/kg (0.5% extract) and 37.81 meqO₂/kg (control) in mandarin oil samples (Fig. 2). The unsaponifiable matter values of oil samples changed between 1.58% (0.5% extract) and 1.68% (control) for orange, 1.75% (0.3% extract) and 1.80% (control) for lemon, and 1.07% (0.3% extract) and 1.14% (control) for mandarin oil samples. The density values of citrus seed oils treated with sumac extract at different concentrations also showed changes, and varied between 0.880 mg/mL (control) and 0.899 mg/mL (0.5% extract) for orange, 0.851 mg/mL (control) and 0.876 mg/mL (0.5% extract) for lemon and 0.870 mg/mL (control) and 0.879 mg/mL (0.5% extract) for mandarin seed oil samples (Fig. 3). The viscosity values of samples changed between 0.123 PaS (0.5% extract) and 0.675 PaS (control) in orange, between 0.257 PaS (0.5% extract) and 0.311 PaS (control) in lemon oil.
Depending on storage periods of citrus seed oils, the acidity values changed between 1.03 mgKOH/100g (0th day) and 3.64 mgKOH/100g (28th day) for orange oil samples. The acidity values of orange oil containing 0.5% sumac extract were determined to be 1.05 mgKOH/100g (0th day) and 2.28 mgKOH/100g (28th day). The acidity values of lemon oils for control group varied between 1.07 mgKOH/100g (0th day) and 2.28 mgKOH/100g (28th day) while that of samples treated with 0.5% sumac extract changed between 1.06 mgKOH/100g (0th day) and 1.67 mgKOH/100g (28th day). The acidity values of mandarin oils for control group changed between 1.31 mgKOH/100g (0th day) and 2.36 mgKOH/100g (28th day) whereas in case of oil sample with 0.5% sumac extract concentration, acidity value varied between 1.25 mgKOH/100g (0th day) and 1.74 mgKOH/100g (28th day).

During storage of citrus oils treated with sumac extracts at varying concentrations, peroxide values were observed in the ranges of 1.38 (0th day) and 32.57 meqO₂/kg (28th day) in orange control, 1.24 meqO₂/kg (0th day) and 34.63 meqO₂/kg (28th day) in lemon control group and 1.71 meqO₂/kg (0th day) and 37.81 meqO₂/kg (28th day) in mandarin control samples. The peroxide values of citrus oils with 0.5%
Antioxidant Activity of Sumac (R. coriaria) Extracts

![Fig. 4](image-url)  
**Viscosity values of citrus oils treated by sumac extract at different concentrations.**

sumac extract were determined between 1.37 meqO₂/kg (0<sup>th</sup> day) and 12.55 meqO₂/kg (28<sup>th</sup> day) for orange, 1.26 meqO₂/kg (0<sup>th</sup> day) and 12.55 meqO₂/kg (28<sup>th</sup> day) for lemon and 1.69 meqO₂/kg (0<sup>th</sup> day) and 17.56 meqO₂/kg (28<sup>th</sup> day) for mandarin seed oils. The refractive index values changed between 1.541 (0<sup>th</sup> day) and 1.527 (28<sup>th</sup> day) for orange control while that of lemon oils with 0.5% sumac extract varied between 1.514 (0<sup>th</sup> day) and 1.517 (28<sup>th</sup> day) and in case of mandarin control, 1.491 (0<sup>th</sup> day) and 1.484 (28<sup>th</sup> day). The refractive index values of mandarin oil with 0.5% extract varied between 1.478 (0<sup>th</sup> day) and 1.485 (28<sup>th</sup> day). Depending on storage periods, the density values of control orange oils were measured between 0.884 mg/mL (0<sup>th</sup> day) and 0.880 mg/mL (28<sup>th</sup> day) while the density values of orange oils with 0.5% sumac extract were between 0.899 mg/mL (0<sup>th</sup> day) and 0.899 mg/mL (28<sup>th</sup> day). The density values were between 0.857 mg/mL (0<sup>th</sup> day) and 0.851 mg/mL (28<sup>th</sup> day) control lemon oil whereas that of lemon oil with 0.5% sumac extract varied between 0.868 mg/mL (0<sup>th</sup> day) and 0.876 mg/mL (28<sup>th</sup> day). In addition, density values of control mandarin oil changed between 0.876 mg/mL (0<sup>th</sup> day) and 0.870 mg/mL (28<sup>th</sup> day) while that of mandarin oil with 0.5% sumac extract were determined between 0.886 mg/mL (0<sup>th</sup> day) and 0.879 mg/mL (28<sup>th</sup> day). The viscosity values of control orange oil samples depending on storage times were measured between 0.051 Pa·S (0<sup>th</sup> day) and 0.675 Pa·S (28<sup>th</sup> day) while that of orange oils with 0.5% sumac extract were detected between 0.065 Pa·S (0<sup>th</sup> day) and 0.123 Pa·S (28<sup>th</sup> day). In addition, the viscosity values of control lemon oil changed between 0.051 Pa·S (0<sup>th</sup> day) and 0.698 Pa·S (28<sup>th</sup> day) whereas samples containing 0.5% sumac extract showed a viscosity variation from 0.067 Pa·S (0<sup>th</sup> day) to 0.257 Pa·S (28<sup>th</sup> day). The viscosity values of control mandarin oil changed between 0.044 Pa·S (0<sup>th</sup> day) and 0.728 Pa·S (28<sup>th</sup> day) while that of mandarin oil with 0.5% sumac extract were between 0.057 Pa·S (0<sup>th</sup> day) and 0.215 Pa·S (28<sup>th</sup> day). Hence, the acidity, peroxide and viscosity values of control citrus oils increased with storage time whereas acidity, peroxide, refractive index, unsaponifiable matter and density values of citrus oils treated with sumac extract at different concentrations decreased with increasing storage time. The most effective extract concentration was found to be 0.5% in terms of these parameters. Other concentrations showed partial effects on physico-chemical properties and storage stability of citrus oils. Differences were noted on physico-chemical properties of citrus oils with sumac extracts added at different concentrations and with changes storage periods. These differences can be probably due to physico-chemical properties of both sumac extracts and citrus oils at different storage times. In addition, these differences might also resulted due to the biochemical reactions of citrus oil and sumac extracts. In general, the partial rise in the viscosity of citrus oils may be due to partial polymerization of the oil in the presence of oxygen. Almost all the concentrations of sumac extracts affected peroxide values and acidity values of citrus oils. Generally, the highest effect on acidity and peroxide values were observed by the 0.5% concentrations of sumac extract. Sumac, which is grown in Mediterranean and Southeastern Anatolian regions of Turkey, was utilized by Özcan and Akgül<sup>11, 17</sup> for sunflower oil stability and observed beneficial effects. Bashash et al.<sup>18</sup> reported that water extracts of sumac exhibited effective antioxidant and radical scavenging activities as compared extracts prepared in other solvents. The antioxidant capacity values were between 58.802% (Brown
sumac powder) and 82.566% (Brown sumac fruit) for sumac extract ethanol, between 81.243% (Brown sumac powder) and 86.709% (red sumac powder) for sumac distilled water extract9. Mazaheri Tehrani et al.18 reported that the antioxidant activity, free radical scavenging and reducing capacity of sumac extract in ethanol were higher than those of the aqueous one. It has been observed that the three types of sumac seed extracts (SSEs) exhibited different antioxidant activities in another study19 wherein the methanolic SSEs contained larger amounts of phenolic and flavonoid compounds and have higher antioxidant activities than those of aqueous or ethanolic SSEs. Staghorn sumac (Rhus hirta L.) is a native tree in Eastern Canada whose fruit has been used by aboriginal peoples to treat various illnesses, and has recently been found to be a good source of antioxidants20. Oxidative stability of black cumin, coriander and niger crude and stripped seed oils was determined and compared. According to results, oxidative stabilities of crude oils were stronger than their stripped counterparts and the order of oxidative stability was as follows: coriander > black cumin > niger seed21. The antioxidant properties of potato peels and sugar beet pulp, in comparison with synthetic antioxidant, were investigated. The order of oxidative stability was as follow: TBHQ > potato peels > BHT = sugar beet pulp > BHA22. Kıralan and Ramadan23 investigated the effect of heating and microwave treatment on the levels of volatile oxidation products and the stability of safflower (Carthamus tinctorius L.), sesame (Sesamum indicum) and canola (Brassica napus L.) cold-pressed oils. 2-Heptenal and 2,4-heptadienal isomers were determined as key constituents in canola oil, while hexanal and 2-heptenal are found in high levels in safflower and sesame oils in oven conditions23. Current study also reports an effective utilization of sumac extracts, prepared in methanol, for stabilizing certain physico-chemical properties of citrus oil stored for 28 days at higher than ambient temperatures. Further studies can be carried out on evaluating functional and biological properties of citrus seed oil containing sumac fruit extract.

4 Conclusion

It can be inferred that after addition of sumac flower extract to oil samples from seed of orange, lemon and mandarin different physico-chemical properties were affected. For instance, the peroxide and acidity values increased with storage but they were kept lower in samples containing extracts in comparison to control whereas viscosity was observed to higher in control (without extract) at the end of storage in citrus oil samples. The concentration of extract in the oil samples also showed partial changes in the studied parameters and the most profound effects were observed at highest extract concentration (0.5%) used in this study.

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