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The Role of Roasting on Changes in Oil Contents, Bioactive Properties, Polyphenol Contents and Fatty Acid Profiles of Turpentine (*Pistacia terebinthus* L.) Fruit and Oils

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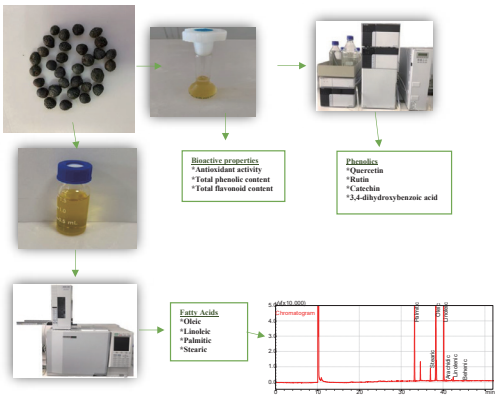
Abstract: In this study, the fluctuations in the oil content, total phenol, total flavonoid, radical scavenging capacity, phenolic constituent profiles and fatty acids of turpentine fruits during roasting of turpentine fruits and oils in the oven and microwave treatments were revealed. Total phenolic amounts of turpentine fruit and oils varied between 153.57 (oven) and 197.86 mgGAE/100 g (control) to 17.68 (control) and 30.65 mg GAE/100 g (oven), respectively. Total flavonoid values of the turpentine fruit and oils were characterized to be between 370.36 (microwave) and 567.50 mg/100 g (control) to 89.64 (oven) and 227.50 mg/100 g (microwave), respectively. While quercetin values of the turpentine fruits change between 171.73 (oven) and 330.88 mg/100 g (control), rutin amounts of fruits were defined to be between 3.66 (oven) and 10.00 mg/100 g (control). Catechin amounts of the turpentine fruits roasted in oven and microwave were specified to be between 3.42 (microwave) and 13.69 mg/100 g (oven). Oleic and linoleic acid contents of the oils extracted from raw and roasted turpentine fruits were assessed to be between 50.19 (oven) and 51.30% (control) to 22.89 (control) and 23.39% (oven), respectively. As a result, the phenolic components of turpentine oils were generally higher than those of turpentine fruits.



Key words: *P. terebintus*, flavonoid, polyphenols, antioxidant activity, fatty acids

1 Introduction

Turpentine (*Pistacia terebinthus* L.; Anacardiaceae family) is a spontaneous plant that spreads in various regions of Turkey (Western and Southern regions), and is called "menengic," in Turkish. Fruits and leaves of turpentine tree with essential oils and resin are used in folk medicine[1)]. Turpentine or terebinth, known as nuts, can be defined as the wild pistachio. Terebinth, which is used especially in soap or coffee making, grows in Southeastern Anatolia and the Mediterranean Region. It may also be called bıttım, melengic, wild nuts or çitlembik among the public. The leaves, fruit and seeds of the terebinth tree contribute separately to human health. Turpentine fruits, whose fruit is dried to obtain coffee, contains high amounts of iron, calcium, potassium, and vitamins A and C. Terebinth plant, which has health benefits, is consumed as nuts or coffee. This plant, which benefits asthma, cough or the upper respiratory tract, has healing effects[2)]. Turpentine is a wild plant commonly found in many Mediterranean countries such as Italy, Greece, Syria, Turkey and Tunisia[3)]. Dif-

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ferent organs of the menengiç tree in different regions of the world are used in many ways. Parallel to the increase in consumption demand for natural products, the consumption of its fruit is increasing day by day in the world due to the content of the menengiç plant and it is used in snacks and bakery products in some countries[4]. The leaves and fruits of *Pistacia* are rich in essential oils, polyphenols and various bioactive compounds[5, 6]. Turpentine fruit is a healthy food for nutrition due to its high protein and oil[4, 7]. *Pistacia terebithus* fruits, which generally grow on dry rock slopes and slopes and also in the pine forests of the Taurus Mountains, are consumed as a snack, raw or roasted, and used in bakery products by adding to beverages, especially coffee[8]. It is thought that the oil obtained from the fruits of *P. terebinthus* can be used as cooking oil due to its high content of oleic and linoleic acids, and its unique smell and taste[1]. The physico-chemical properties and nutrient contents of turpentine fruits grown in wild form in Mersin region were examined and it was concluded that they could have important potential uses in the food sector[4]. Turpentine, popularly known as terebinth, is picked up from trees or shrubs in forest areas in the Mediterranean region in August-October, and sold in neighborhood markets, markets, herbalists, and spice shops[4, 9, 10]. Due to its resin components and being rich in tannins, the herb is known to be in a medicinal plant class since ancient times. In general, the used parts of the plant are the roots, young shoots and the fruit. It has been understood from recent studies that turpentine fruits have good antioxidant activity, phenolic content, oil content, fatty acids and tocopherols[11−14]. Among the most fascinating fatty compounds in different types of *Pistacia* fruit oil are oleic and linoleic acids, phenolic constituents, tocopherols and phytosterols[14−16]. The level of oleic acid, one of the monosaturated fatty acids found in pistachio oil, was found to be higher than most of the other frequently used cooking oils[17]. It has been reported that the most common methods used in roasting foods are convection roasting, ultra-fast roasting, pan roasting, fluid bed roasting and microwave roasting[18]. While the internal temperature of the beans is higher than the surface in microwave baking, it is lower in convection and pan roasting treatments, and there is a risk of over-roasting the outer part of the beans even though the beans are not fully used. Therefore, it has been reported that roasting in the microwave results in evenly roasted beans that do not have a burnt surface and have a full flavor[18]. Roasting and expelling processes can affect the color, aroma, composition and quality of the oil during the production of ondiment oils[19]. In addition, a pleasant aroma or taste (nut-like or peanut butter-like) is also developed in the oil during the roasting process and extraction[20]. Therefore, roasting is an important process in making seasoning oil, as the color, quality of the oil can all be affected by the processing conditions during the processing of vegetable oil raw materials into oil. Turpentine fruits are subjected to heat treatments at high temperatures in the production of local coffee and processing into bakery products. Therefore, some physicochemical properties of turpentine fruits may change in their bioactive components, phenolic components and fatty acids content. So, the objective of present investigation was to reveal the fluctuations in the oil content, total phenol, total flavonoid, radical scavenging capacity, phenolic constituent profiles and fatty acids of turpentine fruits during roasting of turpentine fruits and oils in the oven and microwave treatments.

2 Material and Methods

2.1 Material

Turpentine fruits were harvested from *P. terebinthus* plants growing wild in Mersin province (Büyükeceli-Gülnar) in August 2022. Following this, the fruits were packed in a cooled plastic bag, and brought to the laboratory. Then, turpentine fruits were cleaned of impurities.

2.2 Methods

2.2.1 Heat treatment

Turpentine fruits were placed on 0.5 cm thick trays for roasting both in the oven and in the microwave. During roasting, the product was mixed by controlling the height at certain intervals. The *Pistacia terebinthus* fruits were powdered using a grinder, and fruit powders were roasted in an oven (160℃ for 17 min) and a microwave oven (720 W for 15 min).

2.2.2 Determination of moisture

The moisture results of turpentine fruits were measured by the KERN & SOHN GmbH infrared moisture analyser.

2.2.3 Oil content

After the turpentine fruits cleaned of impurities were ground in a laboratory grinder, 10 g of the powdered fruits was weighed into the cartridge. The cartridge was put in the Soxhlet after closing the mouth with cotton. Petroleum ether was used as the solvent in the oil extraction from the turpentine sample and the extraction process was carried out at 50℃ in Soxhlet for 5 hours. At the end of this process, the solvent (petroleum ether) in the extracted oily solvent (miselle) was removed in the evaporator at 50℃. Then, the amount (%) of crude oil remaining in the flask was determined on a weighing basis[21].

2.2.4 Extraction procedure for phenolic and flavonoid

Extraction of turpentine fruits were made according to the study described by Jakopic et al.[22] with some modification. 15 mL of methanol were added into 5 g powdered turpentine samples. Then, after the solution was stand in ultrasonic water-bath for 1 h, it was centrifugated at 6000 rpm for 10 min, and the supernatant was filtered. The

methanol phases collected were removed in an evaporator at 40℃. Then, the extract was dissolved in 25 mL of methanol.

Turpentine fruit oil was extracted according to method stated by Durmaz and Gökmen[23]. After 5 mL of methanol: water (70:30, v/v) was added to the 1 g oil sample, the mixture was stirred by vortex for 1 min. After centrifugation of the mixture was carried out at 6000 rpm/5 min, the supernatant was removed twice. After the extract obtained was washed threefold using 2 mL of *n*-hexane, it was filtered.

2.2.5 Determination of total phenolic

According to the study conducted by Yoo et al.[24], total phenol contents of turpentine fruit extracts were determined using the Folin-Ciocalteu (FC) chemical. FC (1 mL) was added and mixed for 5 min. Following the addition of 10 mL of Na_2CO_3. the solution in the tubes was mixed again and the final volume was adjusted to 25 mL with deionised water. After pretreatments, the absorbance was read at 750 nm. The results were stated as mg GAE/100 g.

2.2.6 Determination of total flavonoid

The study by Hogan et al.[25] was taken into account for the determination of total flavonoid amounts of fruit extracts. The extract (1 mL) was mixed with 0.3 mL of $NaNO_2$, 0.3 mL of $AlCl_3$ and 2 mL of NaOH, respectively. The absorbance was evaluated at 510 nm with a spectrophotometer. The findings are stated as mg catechin (QE) / 100 g.

2.2.7 Antioxidant activity

The antioxidant capacity results of turpentine fruit extracts was carried out by using 1.1-diphenyl-2-picrylhydrazyl (DPPH) according to the study explained by Lee et al.[26]. After preprocessing, the absorbance values were read at 517 nm. The findings were given as mmol trolox (TE) /kg (fw).

2.2.8 Phenolic compounds

A Shimadzu-HPLC (SCL-10 A VP-Shimadzu, Japan) equipped with a PDA detector and an Inertsil ODS-3 column (5 μm; 4.6×250 mm) was used to determine the amounts of phenolic compounds in extracts extracted from turpentine fruits. A mixture of 0.05% acetic acid in water (A) and acetonitrile (B) was used as the mobile phase in the separation of phenolic compounds. The flow rate of the mobile phase was 1 mL/min at 30℃ and the injection volume was 20 μL. The peaks were recorded at 280 and 330 nm using a PDA detector.

2.2.9 Fatty acid composition

ISO 12966-1 and ISO 12966-2[27] method was used to detect the fatty acids of turpentine fruit oils esterificated, and fatty acids were identified via gas chromatography equipped with flame-ionization detector and capillary column (Tecnocroma TR-CN100, 60 m×0.25 mm, film thickness: 0.20 μm). Column temperature was programmed 120℃ for 5 minutes and increased 240℃ at 4℃/min and held 25 minutes at 240℃.

2.3 Statistical analyses

JMP version 9.0 was applied for the variance analysis (ANOVA) of results obtained. The results were given as mean ± standard deviation (MSTAT C) of turpentine samples and roasting types.

3 Results and Discussion

3.1 The chemical and bioactive compounds of raw and roasted turpentine fruit and oils

The chemical and bioactive compounds of turpentine (*Pistacia terebinthus*) fruit and oils are shown in Table 1. The moisture amounts of raw and roasted turpentine fruits were found between 2.63 (oven) and 5.25% (control). Also, the oil contents of the turpentine fruits were defined to be between 45.8 (microwave) and 46.6% (oven). While total phenolic amounts of turpentine fruits vary between 153.57 (oven) and 197.86 mg GAE/100 g (control), the total phenolic amounts of turpentine fruit oils were specified to be between 17.68 (control) and 30.65 mg GAE/100 g (oven). Total flavonoid quantities of the turpentine fruit and oils were characterized to be between 370.36 (microwave) and

Table 1 Some chemical properties of *Pistacia terebinthus* seed and oil.

Sample	Process	Moisture content (%)	Oil content (%)*	Total phenolic content (mg/100 g)*	Total flavonoid content (mg/100 g)*	Antioxidant activity (mmol/kg)*
Seed	Control	5.25 ± 0.09a**	44.8 ± 0.6c	197.86 ± 4.24a	567.50 ± 12.29a	3.78 ± 0.01
	Oven	2.63 ± 0.21bc	46.6 ± 0.2a	153.57 ± 3.01c	402.26 ± 10.01b	2.32 ± 0.05
	Microwave	2.65 ± 0.24b	45.8 ± 0.4b	156.11 ± 4.01b	370.36 ± 8.44c	2.47 ± 0.01
Seed Oil	Control	–	–	17.68 ± 0.62c	196.07 ± 6.73b	2.50 ± 0.05
	Oven	–	–	30.65 ± 0.16a	89.64 ± 4.45c	3.15 ± 0.21
	Microwave	–	–	26.01 ± 0.12b	227.50 ± 8.33a	3.09 ± 0.14

* Values for control are on fresh basis whereas those for other samples are on dry weight basis.

** Values are mean ± standard deviation and those with different letters in each column are significantly different ($p < 0.05$)

567.50 (control) to 89.64 (oven) and 227.50 mg/100 g (microwave), respectively. While antioxidant capacities of the turpentine fruits vary between 2.32 (oven) and 3.78 mmol/kg (control), the antioxidant activities of the turpentine oils were assigned to be between 2.50 (control) and 3.15 mmol/kg (oven). Results revealed some changes depending on roasting methods compared to the control. While the moisture results total phenolic, flavonoid results and antioxidant capacity of the turpentine fruits roasted in oven and microwave compared to the control decreased, the oil contents of the turpentine fruits increased. The total phenolic and antioxidant capacity results of roasted fruit oils in both oven and microwave methods increased compared to the control. The oil and total flavonoid results of the oven-roasted turpentine fruits were higher than the microwave-roasted ones. However, the total phenolic and antioxidant capacity results of oven-roasted turpentine fruit oils were higher than those of microwave-roasted fruit oils. The total flavonoid content (89.64 mg/100 g) of the oil of the oven-roasted turpentine fruit was significantly reduced compared to the control (196.07 mg/100 g) and microwave (227.50 mg/100 g). Also, the antioxidant activities of turpentine fruits that were roasted in the oven and microwave were measured to be lower compared to the control, while the antioxidant capacity results of turpentine fruit oils were partially increased. The oil and total flavonoid contents of the oven-roasted turpentine fruits were higher than the microwave-roasted ones. The total flavonoid results of the oils of the oven-roasted-turpentine fruit was significantly reduced (89.64 mg/100 g) compared to the control (196.67 mg/100 g) and microwave (227.50 mg/100 g). The antioxidant capacities of turpentine fruits that were roasted in the oven and microwave were established to be lower compared to the control, while the antioxidant activity values of turpentine fruit oils were partially increased. Ertaş et al.[8] determined 52.4 and 54.0% oil in *P. terebinthus* fats collected from Mardin and Siirt provinces, respectively. Özcan et al.[14] determined 38.93-40.80% oil in turpentine fruits depending on sonication times. Matthaus and Özcan[15] reported that the oil contents of *P. terebinthus* fruits changed between between 38.4 and 45.1 g/100 g. Bentireche et al.[28] determined 0.13 mg GAE/100 g total phenol, 0.09 mg/100 g total flavonoid in turpentine oil. Antioxidant capacity, total phenol and flavonoid amounts of turpentine extracts were recorded between 84.01 and 87.32%, 80.10 and 251.25 mg/100 g to 393.35 and 3413.72 mg/100 g, respectively[14]. Total phenolic and antioxidant capacities of the *P. terebinthus* extracts varied between 12.189 and 36.382 mgGAE/100 g to 8.86% and 64.49%, respectively[29]. Durmaz and Gökmen[23] determined 4.90 μg Trolox Equivalent (TE)/mL-24.79 antioxidant activity value (DPPH) and 7.01-19.61 GAE/mL in 180℃ at different heating times (5, 10, 20, 30 and 40 minutes). Bellifa et al.[30] determined 63.05 mgGAE/g total phenol and 37.03 mgQE/g total flavonoid MeOH extract of *P. terebinthus* fruits. The results obtained regarding bioactive properties of turpentine fruits showed partial differences with the literature values due to probably due to ripening, location, climatic and analytical factors.

3.2 The phenolic compounds of turpentine fruit and oils

The phenolic constituents of the turpentine fruits and oils heated in oven and microwave are given in Table 2. The major phenolic constituents of the turpentine fruit and oils were quercetin, rutin, catechin, rutin, 3,4-dihydroxybenzoic acid, syringic acid and caffeic acids, respectively. The these changes were monitored in phenolic compounds of both turpentine fruit and oils compared to the control. While quercetin values of the turpentine fruits change between 171.73 (oven) and 330.88 mg/100 g (control), rutin amounts of fruits were established to be between 3.66 (oven) and 10.00 mg/100 g (control). Also, catechin and 3,4-dihydroxybenzoic acid results of the turpentine fruits roasted in oven and microwave were defined to be between 3.42 (microwave) and 13.69 mg/100 g (oven) to 1.96 (microwave) and 8.01 mg/100 g (oven), respectively. Also, the highest caffeic acid (1.96 mg/100 g) and syringic acid (2.58 mg/100 g) were determined in the turpentine fruits roasted in oven. As for the phenolic components of turpentine oils, while gallic acid results of the oils are detected between 4.08 (control) and 12.06 mg/100 g (microwave), 3,4-dihydroxybenzoic acid results of the oils were characterized to be between 21.80 (microwave) and 33.57 mg/100 g (oven). Also, catechin and rutin values of the turpentine oils heated changed between 30.89 (control) and 69.34 mg/100 g (microwave) to 32.29 (microwave) and 46.26 mg/100 g (oven), respectively. Also, caffeic acid amounts of the oils ranged from 4.94 (control) to 8.43 mg/100 g (oven), while the syringic acid values of the turpentine oils change between 7.16 (control) and 12.89 mg/100 g (oven). The ferulic acid and quercetin contents of the turpentine oils were specified to be between 2.87 (microwave) and 7.23 mg/100 g (oven) to 9.15 (oven) and 41.22 mg/100 g (microwave), respectively. The kaempferol results of the oils were identified to be between 1.46 (microwave) and 13.03 mg/100 g (control). In general, the phenolic components of turpentine fruits and oils heated in both systems showed an increase compared to the control. However, there was a partial decrease in the contents of rutin, *p*-coumaric acid, resveratrol, quercetin and kaempferol in turpentine fruits that were roasted in the oven and microwave. The most reduction was established in rutin and quercetin. In general, the amounts of some phenolic (3,4-Dihydroxybenzoic acid, catechin, caffeic acid, syringic acid) components of the fruits roasted in the oven were determined to be higher than those roasted in the microwave. Oven-roasted fruits showed an advantage in terms of phenolic compounds compared to the control group and microwave. As for the

Table 2 Phenolic compounds of *Pistacia terebinthus* seed and oil*.

Seed (mg/100 g)	Control	Oven	Microwave
Gallic acid	1.20 ± 0.06c**	4.11 ± 0.71b	6.51 ± 0.42a
3,4-Dihydroxybenzoic acid	2.96 ± 0.30b	8.01 ± 0.80a	1.96 ± 0.35c
Catechin	4.06 ± 0.66b	13.69 ± 5.83a	3.42 ± 0.08c
Caffeic acid	1.47 ± 0.76b	1.96 ± 0.56a	1.41 ± 0.45c
Syringic acid	1.93 ± 0.97b	2.58 ± 0.85a	1.44 ± 0.53c
Rutin	10.00 ± 4.03a	3.66 ± 0.28c	4.65 ± 1.15b
p-Coumaric acid	1.50 ± 0.78a	1.21 ± 0.28b	1.19 ± 0.60bc
Ferulic acid	0.62 ± 0.16c	1.10 ± 0.13b	1.14 ± 0.61a
Resveratrol	0.44 ± 0.18a	0.16 ± 0.08c	0.21 ± 0.10b
Quercetin	330.88 ± 2.23a	171.73 ± 5.02c	185.65 ± 3.14b
Cinnamic acid	0.17 ± 0.10b	0.13 ± 0.04c	0.20 ± 0.11a
Kaempferol	1.11 ± 0.28a	0.67 ± 0.28b	0.39 ± 0.11c
Seed oil (mg/100 g)	Control	Oven	Microwave
Gallic acid	4.08 ± 0.59c**	8.39 ± 0.39b	12.06 ± 1.78a
3,4-Dihydroxybenzoic acid	23.36 ± 0.49b	33.57 ± 1.78a	21.80 ± 0.34c
Catechin	30.89 ± 4.76c	55.56 ± 1.01b	69.34 ± 0.59a
Caffeic acid	4.94 ± 0.65c	8.43 ± 0.87a	6.80 ± 0.80b
Syringic acid	7.16 ± 0.76bc	12.89 ± 1.55a	7.18 ± 0.70b
Rutin	36.24 ± 4.36b	44.26 ± 0.24a	32.29 ± 0.15c
p-Coumaric acid	3.04 ± 0.40b	4.29 ± 0.64a	1.66 ± 0.19c
Ferulic acid	5.50 ± 0.57b	7.23 ± 1.08a	2.87 ± 0.26c
Resveratrol	4.72 ± 0.51b	5.08 ± 0.68a	0.96 ± 0.10c
Quercetin	16.58 ± 1.92b	9.15 ± 1.67c	41.22 ± 0.16a
Cinnamic acid	2.44 ± 0.37a	1.24 ± 0.20b	0.65 ± 0.06c
Kaempferol	13.03 ± 0.80a	7.93 ± 1.63b	1.46 ± 0.20c

* Values for control are on fresh basis whereas those for other samples are on dry weight basis.

** Values are mean ± standard deviation and those with different letters in each row are significantly different ($p < 0.05$)

phenolic components of turpentine oil, in general, most of the turpentine oils heated in the oven had higher phenolic component amounts than both control and microwave. Microwave-heated turpentine oils are richer in gallic acid, catechin, and quercetin than control and oven-heated turpentine oils. As a result, the phenolic component amounts of turpentine oils were generally higher than those of turpentine fruits. On the other hand, most of the phenolic components of the fruits and oils heated in the oven were higher than the control and microwave. However, it showed a significant decrease in quercetin content compared to fruit. It is estimated that the factor causing this increase is mainly related to the relatively polar compounds in the oil accumulated during roasting. In previous studies on *Pistacia* fruits, the most common phenolic components were apigenin, luteolin 7-*O*-glucoside, quercetin, kaempferol[31−34]. It has been determined that better transfer of phenolic compounds to the oil phase is obtained if the oil is obtained from roasted seeds, and this is probably due to the release of phenolic compounds from the bonded structures or chemical changes of the phenolics at high temperatures[33]. It is possible that the possible reason for the increase in the contents of phenolic components of turpentine oils compared to the fruits may be due to the enzyme activity with the heat treatment due to the moisture in the seeds of the heat treatment applied. Thus, when using turpentine, it is thought that the direct use of its oils will be more beneficial since its oils are rich in phenolic components. In addition, if it is evaluated on the basis of components, it is more appropriate to use turpentine fruit directly in foods

Table 3 Fatty acid compositions of the oils extracted from raw and roasted *Pistacia terebinthus* fruits.

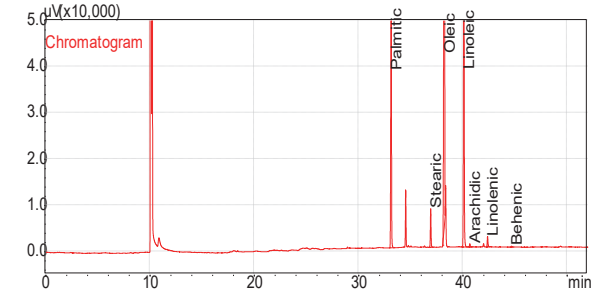
Fatty acids (%)	Control	Oven	Microwave
Palmitic	22.44 ± 0.51c*	23.07 ± 0.28b	23.10 ± 0.58a
Stearic	2.18 ± 0.07c	2.41 ± 0.01a	2.21 ± 0.04b
Oleic	51.30 ± 0.40a	50.19 ± 0.20c	50.74 ± 0.40b
Linoleic	22.89 ± 0.21c	23.39 ± 0.03a	23.07 ± 0.12b
Arachidic	0.19 ± 0.01a	0.16 ± 0.01c	0.17 ± 0.01b
Linolenic	0.69 ± 0.02c	0.75 ± 0.01a	0.70 ± 0.00b
Behenic	0.10 ± 0.04a	0.07 ± 0.00b	ND**

* Values are mean ± standard deviation and those with different letters in each row are significantly different ($p < 0.05$)
** Non detected

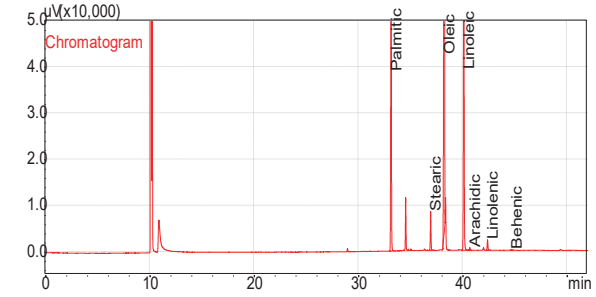
due to its high quercetin content. Özcan et al.[14] revealed that sonicated turpentine fruits contained 129.08-467.78 mg/100 g quercetin, 4.27-14.70 mg/100 g gallic acid, 3.86-9.25 protocatechuic acid, 5.58-21.33 mg/100 g (+)-catechin, 3.81-11.75 mg/100 g 1,2-dihydroxybenzene, 0.95-5.33 syringic acid, 0.48-13.66 caffeic acid and 2.50-4.17 mg/100 g kaempferol. When the findings regarding the phenolic constituent results of turpentine fruits were compared with the previous results on this fruit, it was observed that there were some differences. These changes can be likely due to species, locations, ripe of fruit, harvest time, elevation and climatic factor.

3.3 The fatty acid profiles of the oils extracted from turpentine fruits

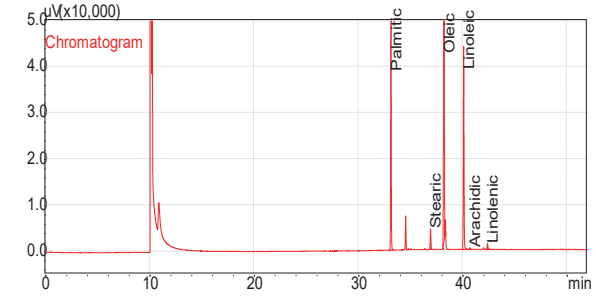
The quantitative values of fatty acids of the turpentine oils heated in oven and microwave methods are offered in Table 3 and Fig. 1. Results exhibited some differences depending on heating types compared to the control. While palmitic acid amounts of the turpentine oils change between 22.44 (control) and 23.10% (microwave), the stearic acid values of turpentine oils were identified between 2.18 (control) and 2.41% (oven). After that, oleic and linoleic acid values of the turpentine oils heated were recorded to be between 50.19 (oven) and 51.30% (control) to 22.89 (control) and 23.39% (oven), respectively. Quantities of other fatty acids of the oils obtained from turpentine fruits were detected below 0.75%. Behenic acid was not found in turpentine oil heated in microwave. Palmitic, stearic, linoleic and linolenic acid values of heat treated turpentine oils increased compared to the control. Palmitic, oleic and arachidic acid results of turpentine oils heated in microwave were detected higher than those heated in oven. While the oleic, linoleic and arachidic acid amounts of turpentine oils heated in both heating systems were quantitatively close to each other, they were found to be statistically different. Monounsaturated fatty acid was



Fruit control



Fruit oven



Fruit microwave

Fig. 1 Fatty acid chromatograms of *P. terebinthus* oils.

slightly more sensitive to heat than polyunsaturated fatty acid. It was observed that monounsaturated fatty acid was slightly more sensitive to heat than polyunsaturated fatty acid. It is thought that the changes in the amount of fatty acids by applying heat treatment are related to the chemical structure of the oil and it is not affected by the heat much by the natural antioxidants in its structure. Durmaz and Gökmen[23] determined 22.52% (40 min)-23.49% (unroasted) palmitic, 1.98% (40 min)-2.09% (unroasted) stearic, 46.66% (20 min)-47.52% (40 min) oleic, 21.64% (unroasted)-22.51% (20 min) linoleic acid and 1.08% (unroasted and 40 min)- 1.15% (20 min) linolenic acids of *P. terebinthus* oils heated in 180℃ at different heating times (5, 10, 20, 30 and 40 minutes). Rosting caused slight changes in fatty acid profile of *P. terebinthus* oil[23]. Durak and Uçak[29] determined 20.62-25.67% palmitic, 0.86-3.08% stearic, 1.00-8.11% palmitoleic acid, 42.13-55.16% oleic, 17.16-29.64% linoleic and 0.08-0.20% arachidic acid in the oils of *P. terebinthus* fruit. Ertaş et al.[8] explained that the oil of turpentine (*P. terebinthus*) fruit provided from Mardin province contained 7.7% palmitic, 3.4% stearic, 67.5% oleic, 18.7% linoleic, 0.3% linolenic acids. In another study, turpentine fruit (*P. terebinthus* L.) oil contained 43.8 to 51.3% oleic, 19.3 to 23.5% palmitic and 19.0 to 25.9% linoleic acids as the concentrations of the dominant fatty acids[15]. Keser et al.[35] determined 24.02% palmitic, 4.17% palmitoleic, 1.83% stearic, 38.19% oleic, 30.27% linoleic, 1.52% linolenic in the oil of ripe *P. terebinthus* fruits. Özcan et al.[14] reported that *P. terebinthus* fruit oil contained 48.02–49.15% oleic, 22.28–23.48% linoleic and 22.10–23.67% palmitic acid as a predominant fatty acids. Obtained fatty acids results were found to be similar to the literature, but partial changes were determined in their amounts. These fluctuations can be likely due to factors such as the genetic structure of turpentine fruits, ripeness and climatic conditions.

3.4 Principal component analysis (PCA)

PCA was performed to evaluate the effect of heat treatment on phenolic constituents of seed and seed oil of turpentine (Fig. 2). PCA modeling showed about 77.377% of described variance for PC1; 16.390% of variance for PC2. Dihydroxybenzoic acid (0.985), caffeic acid (0.937), syringic acid (0.964), rutin (0.977), coumaric acid (0.907), ferulic acid (0.975) and resveratrol (0.914) had high positive correlation with PC1. Seeds of turpentine were located in the negative area of PC1, while seed oils were located in the positive area of PC1, and also contained higher amounts of phenolic compounds except quercetin. The highest quercetin content was observed in the control seed of turpentine.

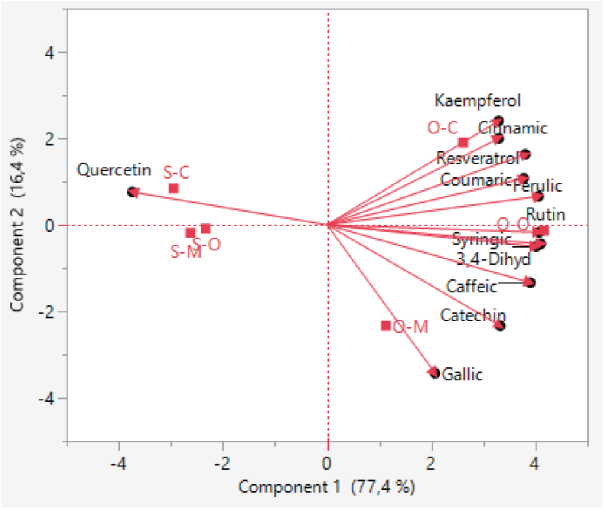


Fig. 2 Biplot graph drawn with results of PCA (S-C: Seed-Control, S-O: Seed-Oven, S-M: Seed-Microwave, O-C: Oil-Control, O-O: Oil-Oven, O-M: Oil-Microwave).

4 Conclusion

As a results, while the moisture, total phenolic, total flavonoid and antioxidant capacity results of the turpentine fruits roasted in oven and microwave compared to the control decreased, the oil yields of the turpentine fruits increased. The oil content and total flavonoid content of the oven-roasted turpentine fruits were higher than the microwave-roasted ones. The antioxidant activities of turpentine fruits that were roasted in the oven and microwave were measured to be lower compared to the control, while the radical scavenging capacity results of turpentine fruit oils were partially increased. The total phenolic and antioxidant capacity results of oven-roasted turpentine fruit oils were higher than those of microwave-roasted fruit oils. In general, the phenolic components of the oils and turpentine fruits heated in the oven and microwave showed an increase compared to the control. On the other hand, most of the phenolic components of the fruits and oils heated in the oven were higher than the control and microwave. In general, the phenolic components of turpentine fruits and oils heated in the oven and microwave showed an increase compared to the control. The most reduction was detected in rutin and quercetin. Oven-roasted fruits showed an advantage in terms of phenolic compounds compared to the control group and microwave. As for the phenolic components of turpentine oil, in general, most of the turpentine oils heated in the oven had higher phenolic component amounts than both control and microwave. But, microwave-heated turpentine oils are richer in gallic acid, catechin, and quercetin than control and oven-heated turpentine oils. Palmitic, stearic, linoleic and linolenic acid values of heat treated turpentine fruit oils increased compared to the control.

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Conflicts of Interest

No conflict of interest.

Availability of Data and Material

The data have been reviewed depending on the literature.

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