The effects of conventional heating on phenolic compounds and antioxidant activities of olive leaves

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Abstract Phenolic compounds, antioxidant activities and total phenolic contents of leaves from different olive varieties (Gemlik, Kalamata, Yağlık and Sariulak) were evaluated after conventional drying at different temperatures (50, 60, 70 and 80 °C). The drying process resulted in non-significant effects on olive leaves. The phenolic contents however, varied with drying temperature. The contents of minor total phenolics in Gemlik, Kalamata and Sariulak leaves were 1457.6, 1899.3 and 2179.8 mg GAE/100 g, respectively when dried at 60 °C. The highest total phenolic reduction (23.2%) was observed in Kalamata leaves after drying at 80 °C. The major phenolic compounds in olive leaves were gallic acid (101.2–439.7 mg/100 g), 3,4-dihydroxybenzoic acid (66.7–460.4 mg/100 g), (+)-catechin (39.2–667.8 mg/100 g), 1,2-dihydroxybenzene (15.8–584.8 mg/100 g) and quercetin (33.1–277.7 mg/100 g). It was observed that olive leaves from different varieties are rich in phenolic compounds which are sensitive to heat and varied with drying temperature.

Keywords Olive leave · Phenolic compounds · Drying · Antioxidant activity · HPLC

Introduction

Among different by-products of olive plant, leaves are generally used as animal feed (Boudhrioua et al. 2009). On an average, around one kg of leaves are obtained from a tree per year (Tabera et al. 2004; Ahmad-Qasem et al. 2013). In recent years, aromatic plants gained attention due to biological activities resulting from bioactive compounds present in their different parts. Olive leaves are natural source of bioactives including phenolic compounds that have hypotensive, hypoglycaemic, hypouricaemic, antimicrobial, antioxidant and antiviral effects (Silva et al. 2006; Talhaoui et al. 2014). The major olive leaves' bioactives include oleuropein and its derivatives (hydroxytyrosol and tyrosol), caffeic acid, *p*-coumaric acid, vanillic acid, vanillin, luteolin, diosmetin, rutin, luteolin-7-glucoside, apigenin-7-glucoside, and diosmetin-7-glucoside (Lee et al. 2009). Oleuropein has been a major biophenol found in virtually all studies, with rare exceptions (Ryan et al. 2002). There is considerable variation in oleuropein contents of olive leaves, varying from 5.6 to 108.6 mg/g dry weight in different reports (Ansari et al. 2011; Ranalli et al. 2005; Tayoub et al. 2012). The chemical composition of olive leaves may change with variety, climatic conditions, tree age, agricultural practices, genetics, temperature and extraction procedures (Rahmaniana et al. 2015). The improper storage and transportation can cause undesirable bioactives' degradation and their quality reduction. Dehydration of olive leaves is used to prevent such deteriorations. Additionally, drying is important process before extraction of certain compounds as it former requires moisture reduction in plant material to improve bioactives' recovery (Abaza et al. 2015). Hot air drying is a preferred to carry out drying of plant materials on industrial scale (Ahmad-Qasem et al. 2013). Phenolic compounds are

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considered valuable due to their antioxidant activity. Olive leaves are significant source of phenolic and antioxidant constituents, which can be used in place of synthetic antioxidants. Hence, in order to preserve these bioactive compounds an optimal drying of plant material is generally preferred. The drying temperature and time are significant process parameters to ensure optimal preservation of nutritional and functional values of plant leaves. The aim of this investigation was to determine the effect of conventional drying at different temperature on individual phenolic compounds, total phenolic content and antioxidant activity of olive leaves obtained from different varieties.

Materials and methods

Materials

Olive leaves were collected from Mersin (Silifke) and Manisa districts in Turkey. Leaves from each variety were collected from 25 olive trees and transferred to laboratory in paper bags under cold storage.

Methods

Drying process

About 50–60 g olive leaves for each treatment were placed on stainless steel trays, and then dried in an oven (Nüve FN055 Ankara, Turkey, 55 L volume) at 50, 60, 70 and 80 °C for 24 h. Leaf samples were cooled in desiccator at room temperature, and kept frozen at – 25 °C under nitrogen in sealed bottles.

Sample extraction

For phenolic compounds and antioxidant activity, olive leaves extracts were prepared according to Talhaoui et al. (2014). The ground samples (0.5 g) were added to 10 mL of methanol: water mixture (80/20, v/v). The mixture was sonicated for 30 min, followed by centrifugation at 6000 rpm for 10 min. These steps were repeated twice and the supernatants were collected. The extract was concentrated at 37 °C under vacuum and final volume was made 25 mL using methanol. Extract samples were filtered through 0.45 µm PTFE filter before analysis.

Total phenolic content

The total phenolic content of extracts was determined using Folin-Ciocalteu (FC) reagent according to Yoo et al. (2004). FC (1 mL) was added to the samples and mixed for

5 min. Following the addition of 10 mL of Na₂CO₃, the solution in the tubes was mixed again, and the final volume was adjusted to 25 mL with deionized water. After 1 h, the total phenol contents were determined at a wavelength of 750 nm using a spectrophotometer and calibration curve obtained from gallic acid (0–200 mg/mL) as the standard. The results were presented as mg gallic acid equivalent (GAE)/100 g of fresh weight.

Antioxidant activity

The free radical scavenging activity of leaf extracts was determined using DPPH (1,1-diphenyl-2-picrylhydrazyl) method as reported by Lee et al. (1998). The extract was mixed with 2 mL methanolic solution of DPPH. After shaking vigorously, the sample was kept at room temperature for 30 min. The absorbance was recorded at 517 nm by using a spectrophotometer. The DPPH scavenging capacity was calculated as follows:

$$\text{Inhibition(\%)} = (A_{\text{control}} - A_{\text{sample}}) / A_{\text{control}} \times 100$$

where A_{sample} was the absorbance of samples, and A_{control} was the absorbance of methanolic DPPH solution.

Phenolic compounds

Phenolic compounds were determined using a Shimadzu-HPLC equipped with a PDA detector and an Inertsil ODS-3 (5 µm; 4.6 × 250 mm) column. Gradient elution was performed for separation and a mixture of 0.05% acetic acid in water (A) and acetonitrile (B) as the mobile phase was used. The gradient program was as follows: 0–0.10 min 8% B; 0.10–2 min 10% B; 2–27 min 30% B; 27–37 min 56% B; 37–45 min 8% B. The flow rate of the mobile phase was 1 mL/min at 30 °C, and the injection volume was 20 µL. The peaks were recorded at 280 and 330 nm using a PDA detector. The total running time per sample was 60 min. Phenolic compounds were determined according to the retention time and absorption spectra of peaks of standard compounds. The total peak area was used to quantify the each phenolics.

Statistical analysis

A complete randomized split plot block design was used, and analysis of variance (ANOVA) was performed by using JMP version 9.0 (SAS Inst. Inc., Cary, N.C.U.S.A). All analyses were carried out three times and the results were presented as mean ± standard deviation (SD) (MSTAT C) of independent olive leaves for each variety (Püskülcü and İkiz 1989).

Results and discussion

The total phenolic contents and antioxidant activities of olive leaves are presented in Table 1. The antioxidant activities ranged from 87.15 to 87.94% in Gemlik olive leaves at 80 and 60 °C, respectively; from 86.89 to 88.15% in Kalamata olive leaves at 70 and 80 °C, respectively; from 87.05 to 87.84% in Yağlık olive leaves and from 87.63 to 88.31% in Sarıulak olive leaves ($p < 0.05$). Total phenolic contents of Gemlik, Kalamata, Yağlık and Sarıulak olive leaves ranged from 2529.86 to 1457.64, 2610.42 to 1899.31, 2899.31 to 2607.64 and 2871.53 to 2179.86 mg GAE/100 g, respectively. Leaves of Gemlik, Kalamata and Sarıulak varieties (with the exception of Yağlık cultivar), showed the highest decrease in total phenolic contents at 60 °C where a respective decrease from 2529.86 to 1457.64 mg GAE/100 g; 2610.42 to 1899.31 mg GAE/100 g and 2871.53 to 2179.86 mg GAE/100 g were observed. The total phenolic content Yağlık leaves decreased from 2899.31 to 2607.64 mg GAE/100 g when drying temperature increased from 50 to 80 °C. There was no statistically significant difference between the antioxidant values of dried yellow tail olive leaves at 50, 60 and 70 °C. In addition, the total phenol contents of olive leaves of oily varieties dried at 70 and 80 °C ratios were statistically insignificant. According to Silva et al. (2006), total phenolic contents of fresh and dried olive leaves varied from 11.60 to 17.40 g tannic acid (TA)/kg and from 11.70 to 40.10 g TA/kg, respectively. Ahmad-Qasem et al. (2013) reported that the highest total phenolic

content (59.00 mg GAE/g) and antioxidant activity (109 mg Trolox/g for FRAP and 8.30 mg Trolox/g for TEAC) were observed in olive leaves when dried with hot air at 120 °C. The decrease of drying temperature from 120 to 70 °C caused a major reduction of total phenolic content (24%) which may be attributed to higher drying rate. Additionally, polyphenol oxidases, which lead to enzymatic oxidation, may also inactivate at high temperature such as 129 °C. It was determined that total phenolic contents of fresh, dried at 40, 50, 60 and 70 °C were between 1.38 and 2.32 g caffeic acid (CA)/100 g; 2.13–3.48 g CA/100 g; 2.45–4.15 g CA/100 g; 3.05–4.98 g CA/100 g and 4.17–5.38 g CA/100 g, respectively (Boudhrioua et al. 2009). Current results showed differences compared to values reported in literature. These differences can be attributed to temperature applied, variety and climatic factors. The antioxidant activities of leaves of several olive varieties were close to each other and remained unaffected by drying at low temperatures.

Tables 2, 3, 4 and 5 shows phenolic compounds of dried olive leaves. Gallic acid, 1,2-dihydroxybenzene, (+)-catechin, quercetin and 3,4-dihydroxybenzoic acid were the main phenolic compounds of all olive leaves. The highest reduction was observed in 3,4-dihydroxybenzoic acid (from 168.92 to 66.73 mg/100 g), (+)-catechin (from 403.56 to 39.22 mg/100 g), 1,2-dihydroxybenzene (from 330.12 to 15.82 mg/100 g) in Gemlik olive leaves dried at 60 °C ($p < 0.05$) (Fig. 1a). Drying process at 70 °C caused a major decrease in apigenin 7 glucoside (from 226.52 to

Table 1 Total phenolic contents and antioxidant activities of olive leaves

Sample	Temperature (°C)	Antioxidant activity (%)*	Total phenolic content (mg GAE/100 g)*
Gemlik	50	87.57 ± 0.03b	2529.86 ± 0.02a
	60	87.94 ± 0.05a**	1457.64 ± 0.09d
	70	87.41 ± 0.02c	1785.42 ± 0.08c
	80	87.15 ± 0.03c	2274.31 ± 0.05b
Kalamata	50	88.15 ± 0.04a	2610.42 ± 0.02a
	60	87.68 ± 0.02b	1899.31 ± 0.04d
	70	86.89 ± 0.04c	2293.75 ± 0.05b
	80	88.15 ± 0.02a	2004.86 ± 0.03c
Yağlık	50	87.84 ± 0.03a	2899.31 ± 0.02a
	60	87.05 ± 0.04c	2710.42 ± 0.03b
	70	87.52 ± 0.03b	2679.86 ± 0.03c
	80	87.78 ± 0.02a	2607.64 ± 0.05c
Sarıulak	50	87.63 ± 0.05b	2871.53 ± 0.02a
	60	87.73 ± 0.03b	2179.86 ± 0.03c
	70	87.78 ± 0.03b	2860.42 ± 0.02a
	80	88.31 ± 0.04a	2788.19 ± 0.02b

*Mean ± SD

**Values within each column followed by different letters are significantly different ($p < 0.05$)

Table 2 Phenolic compounds content of Gemlik olive leaves

Phenolic compounds (mg/100 g)	Gemlik-50 °C	Gemlik-60 °C	Gemlik-70 °C	Gemlik-80 °C
Gallic acid	154.74 ± 0.26*c	141.60 ± 0.85d	158.70 ± 0.30b	188.62 ± 0.33a
3,4-Dihydroxybenzoic acid	168.92 ± 0.59a**	66.73 ± 0.19d	144.63 ± 0.70c	163.24 ± 0.18b
(+)-Catechin	403.56 ± 0.49a	39.22 ± 1.55d	109.11 ± 0.84c	281.44 ± 1.30b
1,2-Dihydroxybenzene	330.12 ± 0.01a	15.82 ± 0.41d	217.86 ± 0.39b	188.74 ± 0.62c
Syringic acid	63.27 ± 0.01a	2.05 ± 0.47d	43.06 ± 0.01b	37.72 ± 0.23c
Caffeic acid	108.24 ± 0.05a	4.75 ± 0.67d	49.08 ± 0.62c	80.18 ± 1.05b
Rutin	94.72 ± 0.25a	64.43 ± 0.53b	30.00 ± 0.07d	51.95 ± 0.69c
p-Coumaric acid	12.07 ± 0.05a	7.26 ± 0.05c	3.48 ± 0.05d	11.37 ± 0.15b
<i>trans</i> -ferulic acid	127.29 ± 0.37a	24.27 ± 0.07c	11.16 ± 0.16d	34.77 ± 0.12b
Apigenin 7 glucoside	226.52 ± 3.03a	113.12 ± 0.06b	5.47 ± 0.25d	16.52 ± 0.14c
Oleuropein	78.88 ± 0.39b	29.96 ± 0.30c	28.14 ± 0.33c	100.78 ± 0.72a
Quercetin	277.77 ± 0.10a	36.07 ± 0.17c	33.18 ± 0.79c	90.39 ± 0.48b
<i>trans</i> -cinnamic acid	15.89 ± 0.15b	16.09 ± 0.17a	12.51 ± 0.10c	1.36 ± 0.02d
Naringenin	38.58 ± 0.68c	63.13 ± 0.43a	52.72 ± 0.50b	14.73 ± 0.10d
Kaempferol	80.75 ± 0.75a	55.59 ± 0.96c	71.27 ± 0.86b	22.68 ± 0.35d
Isorhamnetin	47.03 ± 0.98b	54.15 ± 0.53a	37.25 ± 0.19c	29.36 ± 0.57c

*Mean ± SD

Values within each row followed by different letters are significantly different ($p < 0.05$)Table 3** Phenolic compounds content of Yağlık olive leaves

Phenolic compounds (mg/100 g)	Yağlık-50 °C	Yağlık-60 °C	Yağlık-70 °C	Yağlık-80 °C
Gallic acid	395.76 ± 0.53a	286.50 ± 1.71c	394.16 ± 0.27a	254.26 ± 0.84d
3,4-Dihydroxybenzoic acid	218.13 ± 0.06b	171.01 ± 1.65c	240.51 ± 1.41a	115.97 ± 0.80d
(+)-Catechin	548.61 ± 2.90a	431.26 ± 1.90c	490.30 ± 0.40b	293.32 ± 0.21d
1,2-Dihydroxybenzene	518.37 ± 2.84a	241.86 ± 1.28c	413.92 ± 2.16b	163.37 ± 0.07d
Syringic acid	36.03 ± 1.97d	61.08 ± 1.23c	265.67 ± 0.33a	90.38 ± 0.52b
Caffeic acid	30.52 ± 0.58c	68.62 ± 0.74a	13.52 ± 0.01d	33.91 ± 0.29b
Rutin	53.06 ± 0.54d	132.21 ± 1.48a	59.30 ± 0.52c	75.67 ± 0.12b
p-Coumaric acid	12.01 ± 0.10a	12.68 ± 0.12a	7.73 ± 0.08b	5.26 ± 0.08c
<i>trans</i> -ferulic acid	151.33 ± 0.92a	106.97 ± 0.99b	96.25 ± 0.70c	57.17 ± 0.40d
Apigenin 7 glucoside	123.17 ± 0.42a	58.00 ± 0.49c	103.53 ± 0.34b	37.14 ± 0.77d
Oleuropein	71.70 ± 0.07a	35.58 ± 0.19b	25.05 ± 0.04c	26.54 ± 0.34c
Quercetin	123.41 ± 1.15b	124.86 ± 0.82a	119.83 ± 0.46c	123.58 ± 0.12b
<i>trans</i> -Cinnamic acid	10.94 ± 0.08b	11.59 ± 0.05a	6.32 ± 0.06c	5.43 ± 0.09d
Naringenin	56.78 ± 0.65a	41.93 ± 0.53b	29.84 ± 0.34d	32.61 ± 0.31c
Kaempferol	93.89 ± 0.64b	64.68 ± 0.48c	99.92 ± 1.29a	32.09 ± 0.17d
Isorhamnetin	101.70 ± 0.61a	82.24 ± 0.54b	55.27 ± 0.37c	37.79 ± 0.46d

5.47 mg/100 g) and quercetin (from 277.77 to 33.18 mg/100 g) contents. Drying at 80 °C caused a major decrease in (+)-catechin (from 548.61 to 293.32 mg/100 g), 1,2-dihydroxybenzene (from 518.37 to 163.37 mg/100 g) and apigenin 7 glucoside (from 123.17 to 37.14 mg/100 g) contents of Yağlık leaves (Fig. 1b). The amounts of gallic acid, (+)-catechin, 1,2-dihydroxybenzene, and rutin decreased from 356.87 to 101.26 mg/100 g; from 381.11 to

106.40 mg/100 g; from 524.50 to 126.79 mg/100 g and from 117.98 to 34.42 mg/100 g, respectively, when the drying temperature increased from 50 to 70 °C in Kalamata leaves ($p < 0.05$) (Fig. 1c). The lowest 1,2-dihydroxybenzene and quercetin contents were observed in Sariulak leaves when dried at 60 °C. The highest (+)-catechin (667.80 mg/100 g) and 3, 4-dihydroxybenzoic acid (460.47 mg/100 g) contents were determined in leaves

Table 4 Phenolic compounds content of Kalamata olive leaves

Phenolic compounds (mg/100 g)	Kalamata-50 °C	Kalamata-60 °C	Kalamata-70 °C	Kalamata-80 °C
Gallic acid	356.87 ± 0.11b	371.77 ± 0.41a	101.26 ± 0.58d	124.29 ± 0.03c
3,4-Dihydroxybenzoic acid	364.61 ± 2.52a	219.13 ± 0.57b	97.63 ± 1.32c	75.67 ± 0.70d
(+)-Catechin	381.11 ± 1.76a	326.14 ± 0.16b	106.40 ± 1.92d	200.12 ± 0.93c
1,2-Dihydroxybenzene	524.50 ± 1.92a	501.94 ± 1.18b	126.79 ± 1.13d	136.39 ± 0.93c
Syringic acid	114.50 ± 1.01a	76.45 ± 0.30b	43.61 ± 0.96d	55.27 ± 0.33c
Caffeic acid	83.91 ± 0.98b	82.21 ± 0.97b	33.76 ± 0.70c	90.13 ± 0.78a
Rutin	117.98 ± 0.95a	75.70 ± 0.12b	34.42 ± 0.60c	76.07 ± 0.55b
p-Coumaric acid	17.12 ± 0.00a	13.02 ± 0.04c	9.84 ± 0.14d	15.49 ± 0.11b
<i>trans</i> -ferulic acid	43.98 ± 0.22d	118.73 ± 0.49a	58.77 ± 0.21b	54.15 ± 0.38c
Apigenin 7 glucoside	100.16 ± 0.59b	107.96 ± 0.07a	85.29 ± 1.11c	50.57 ± 0.75d
Oleuropein	57.11 ± 0.60b	71.37 ± 0.79a	16.12 ± 0.31d	29.46 ± 0.30c
Quercetin	180.39 ± 1.82a	95.89 ± 0.98c	91.65 ± 1.44d	119.66 ± 1.03b
<i>trans</i> -cinnamic acid	8.57 ± 0.03bc	9.43 ± 0.09b	7.62 ± 0.10c	11.15 ± 0.17a
Naringenin	45.06 ± 0.40b	53.83 ± 0.27a	33.26 ± 0.44c	28.01 ± 0.31d
Kaempferol	64.85 ± 0.56c	204.00 ± 0.44a	31.45 ± 0.11d	82.35 ± 0.62b
Isorhamnetin	72.98 ± 0.57d	103.52 ± 0.34a	86.69 ± 1.08c	97.92 ± 1.12b

Table 5 Phenolic compounds content of Sariulak olive leaves

Phenolic compounds (mg/100 g)	Sariulak-50 °C	Sariulak-60 °C	Sariulak-70 °C	Sariulak-80 °C
Gallic acid	439.71 ± 0.45a	373.67 ± 2.34b	312.52 ± 2.36c	137.25 ± 0.87d
3,4-Dihydroxybenzoic acid	153.67 ± 0.90d	191.30 ± 0.81c	249.71 ± 1.62b	460.47 ± 0.95a
(+)-Catechin	353.02 ± 1.03d	537.76 ± 0.15c	667.80 ± 2.37a	576.92 ± 0.34b
1,2-Dihydroxybenzene	524.01 ± 2.31b	128.74 ± 1.17d	408.21 ± 0.39c	584.87 ± 2.14a
Syringic acid	77.24 ± 1.88c	84.57 ± 0.94b	65.02 ± 1.29d	86.39 ± 1.07a
Caffeic acid	29.65 ± 0.27c	57.35 ± 0.91b	27.73 ± 0.60d	75.48 ± 0.52a
Rutin	57.02 ± 1.02b	51.35 ± 0.29c	36.24 ± 0.28d	84.17 ± 0.68a
p-Coumaric acid	10.29 ± 0.09a	5.80 ± 0.11d	6.92 ± 0.11c	8.71 ± 0.10b
<i>trans</i> -ferulic acid	50.71 ± 0.65d	77.39 ± 0.99c	104.92 ± 1.85b	121.90 ± 1.26a
Apigenin 7 glucoside	68.55 ± 0.67d	125.67 ± 0.52b	88.20 ± 0.82c	128.09 ± 0.55a
Oleuropein	30.27 ± 0.11d	52.93 ± 0.12a	38.72 ± 0.38c	44.74 ± 0.21b
Quercetin	136.64 ± 2.32b	68.84 ± 0.24d	102.66 ± 1.25c	186.23 ± 1.42a
<i>trans</i> -cinnamic acid	9.10 ± 0.16a	6.58 ± 0.05c	5.23 ± 0.03d	7.91 ± 0.04b
Naringenin	40.16 ± 0.86a	38.46 ± 0.52b	32.87 ± 0.47c	25.77 ± 0.15d
Kaempferol	53.35 ± 0.90c	159.29 ± 1.22a	102.30 ± 0.67b	43.10 ± 0.36d
Isorhamnetin	47.93 ± 0.71b	48.62 ± 0.93b	32.55 ± 0.65c	52.94 ± 0.32a

dried at 70 and 80 °C, respectively (Fig. 1d). Phenolic compounds of all olive leaves showed statistically significant differences at the most of drying temperatures ($p < 0.05$). However, significant differences between oleuropein and quercetin contents of Gemlik leaves dried at 60 and 70 °C were not observed. Besides, significant differences were observed in syringic acid contents (between 114.50 and 76.45 mg/100 g) of Kalamata leaves dried at 50 and 60 °C temperatures. 3, 4-Dihydroxybenzoic acid contents of Sariulak leaves increased depending on drying

temperatures. Statistically significant differences were observed among phenolic components of four different olive leaves depending on the drying temperature ($p < 0.05$). Ahmad-Qasem et al. (2013) reported that the oleuropein, verbascoside, luteolin-7-o-glucoside, apigenin rutinoside and neohesperidin contents showed respective increases of 69–108.6; 1.5–2.7; 8.9–10.6; 0.70–0.74 and 0.78–1.13 mg/g with increasing drying temperature from 70 to 120 °C. Guinda et al. (2015) determined 8.72, 6.57, 4.46 and 6.13% oleuropein in Picual, Hojiblanca,

Fig. 1 Chromatogram of phenolic compounds (**a** Gemlik; **b** Yağlık; **c** Kalamata; **d** Sariulak). **a** Phenolic compound chromatograms of Gemlik olive leaf extract. **b** Phenolic compound chromatograms of Yağlık olive leaf extract. **c** Phenolic compound chromatograms of Kalamata olive leaf extract. **d** Phenolic compound chromatograms of Sariulak olive leaf extract

Arbequina and Lechin olive leaves, respectively. Kamran et al. (2015) reported that Frantoio olive leaf contained 3.56, 32.75, 34.47, 2.13 and 139.48 mg/kg oleuropein in fresh, air-dried, freeze-dried, oven-dried (60 °C) and oven-

dried (105 °C) leaves, respectively. In another study, polyphenols content ranged from 34.21 to 7.87 mg/g, while oleuropein content changed from 21.03 to 2.79 mg/g in fresh leaves of different cultivars and these contents

decreased after the drying process (Romani et al. 2017). Olive leaves have been found to be rich in phenolic compounds and a comparison of their values with those in literature reveal differences. These differences can be due to variety, drying temperature and time, maturation and harvest time. Additionally, the structure or properties of the plant material and bioactive compounds may cause differences in the effects of the drying temperature on phenolic compounds (Ahmad-Qasem et al. 2013). The differences in phenolic profiles have also been reported for other kinds of plant varieties such as easy to cook and hard to cook kidney beans (Parmar et al. 2017). Hence the varietal difference among plants can also be an important contributing factor for determining the phenolic profile. The presence of these important phenolic compounds having important biological activities show the importance of leaves from different olive varieties for use in the development of functional and nutraceutical products. It has been reported that these bioactive compounds are important phytochemicals that can be used in the prevention of various diseases including cancers, inflammation, cardiovascular issues and other age related health disorders. In addition, these compounds may have antimicrobial and antifungal properties (Ghafoor et al. 2012). Hence more studies may be carried out to evaluate the health benefiting potential of olive leaf phenolic compounds.

Conclusion

Olive leaves were observed to be rich in phenolic compounds. The drying process, which is applied to prevent undesired changes and increase the shelf life of leave, may change phenolic contents and composition. The drying temperature was observed to be a significant parameter in terms of its effects on bioactive compounds of the leaves. The current study showed that low drying temperatures did not significantly affect the antioxidant activities of olive leaves. Drying process caused a minor reduction in total phenolic contents of all leaf varieties. Certain temperature dependent variations in individual phenolic compounds of olive leaves were observed.

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Compliance with ethical standards

Conflict of interest No potential conflict of interest was reported by the authors.

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