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Comparison of Olive Oils Derived from Certified Organic and Conventional Agricultural Methods

OGUZ DOLGUN†, GULCAN OZKAN* and BUKET ERBAY
Department of Food Engineering, Faculty of Engineering and Architecture
Suleyman Demirel University, 32260 Isparta, Turkey
Fax: (90)(246)2111538; E-mail: gozkan@mmf.sdu.edu.tr

The objective of this study is to compare the fruit properties, quality parameters and chemical composition of Gemlik and Memecik olive oils derived from certified organic and conventional agricultural methods. Olive samples were hand picked at one stage of ripeness index (RI_{VI}) based on the degree of skin and pulp pigmentation. Before extraction, the following fruit properties were measured on each olive sample: width of olive (cm), length of olive (cm), weight of olives (g), weight of stones (g), weight of pulp (g), pulp/stone ratio (g), moisture of olives (%) and the oil content (%) on dry weight basis by Soxhlet method. To execute the experiment, the olives (Gemlik and Memecik) were mechanically processed at industrial level in present oil mill by using three-phase continuous equipment. The organic and conventional oils were analytically tested to determine the differences in fatty acid composition and in the minor components (tocopherols and phenolics). Also the main quality parameters (free acidity, peroxide number, K_{232}, chlorophyll pigments, carotenoids, photometric colour index) were compared. The results showed that there were no consistent differences between the overall properties according to comparison of cultivation types. Only oleic acids were the highest levels in both olive oils of Gemlik and Memecik cultivar grown with the type of organic production methods used in the present experiment.

Key Words: Organic and conventional oil, Memecik, Gemlik, Fruit property, Oil quality parameter, Fatty acid, Phenolic, Tocopherol.

INTRODUCTION

Organic farming is indisputably becoming of growing importance in the agricultural sector of many countries. Market demand for organic products has expanded rapidly over the past decade[1]. Organic farming means holistic production systems which refer 'earth friendly' methods of cultivation and food processing[2]. Turkey has a great potential for organic agriculture, because of its geographic and topographic structure, diverse climate and ecological conditions for various crops (except some

†Sultanhisar Vocational High School Adnan Menderes University, 09470 Aydin, Turkey; E-mail: odolgun@adu.edu.tr

tropical fruits). Furthermore, its extensive production systems have traditionally used small amounts of agrochemicals as compared to countries more advanced in development[2]. Organic production in agriculture was started in Turkey in the mid 1980's and since then gained popularity. Over the last decade it has grown dramatically in size and scope due to the progressive interest in Europe[3,4].

Consumers' need for safe and good quality food has increased during the last few years and thus, healthiness and nutritional value are the basic reasons given by consumers for purchasing organic olive oil. In a recent studies and reviews of the literature, it was also demonstrated the nutritional advantages of organic food and differences in the nutrient composition of organically and conventionally produced food[5,9]. It was also compared a lower nitrate content[6,10-12] and a higher vitamin C content[7,8,10] of organic food than their conventional ones. But there is limited research comparing the effect of production methods on the chemical composition of edible oils. In these studies, it was reported that the fatty acid composition of sunflower seed oil was unaffected by the method of production[13,14], whereas it was found that the oleic acid concentration tended to be higher and the level of LA lower in organic compared to conventional virgin olive oil[15].

The aim of the present study is to compare the composition of a range of commercially available certified organic and conventionally produced olive oils. Before extraction, fruit properties of organic and conventionally cultivated olive from Gemlik and Memecik were evaluated. The organic and conventional oils were analytically tested to determine: (i) the differences in fatty acid composition; (ii) the main qualitative/quantitative differences in the minor components (tocopherols: α-tocopherol, β-tocopherol, γ-tocopherol, δ-tocopherol and phenolics, tyrosol, *p*-coumaric acid, quercetin, luteolin, apigenin); (iii) the main quality parameters (free acidity, peroxide number, K_{232}, chlorophyll pigments, carotenoids, photometric colour index).

EXPERIMENTAL

Samples, fruit properties and extraction of olive oil: The present study was carried out in two cultivars (Gemlik and Memecik) which are the conventionally and organically cultivated major cultivars in and constitutes more than 50 % of olive production in the Aegean region and 80 % of olive production in the Marmara region of Turkey[16,17]. These commercial olive orchards are located in Southern Aegean province of Aydin, Turkey. Organic ones are accredited and certified by the International Olive Oil Council. In addition they are approved with certification by the Turkish Ministry of Agriculture and also certified by the International Organic Product Regulatory Organization, ECOCERT. Ten young 10 year old olive trees were identified and carefully marked. Olive samples were hand picked at one stage of ripeness index (RI_{VI}) based on the degree of skin and pulp pigmentation[18]. The following properties were measured on each olive sample: width of olive (cm), length of olive (cm), weight of olives (g), weight of stones (g), weight of pulp (g),

pulp/stone ratio (g), moisture of olives (%) and the oil content on wet and dry weight basis by Soxhlet method. All parameters were determined in triplicate for each sample.

To execute the experiment, the olives (Gemlik and Memecik) were mechanically processed at industrial level in present oil mill by using three-phase continuous equipment (Polat machinery Inc., Aydin, Turkey). The steps of the technological process were as follows: (1) removal of leaves from olive lots; (2) milling of drupes by a hammer crusher; (3) kneading of the resultant paste for 1 h at 35 °C; (4) centrifugation of paste by a three-phase decanter and (5) separation of the oily must into oil and water by means of an automated discharge centrifuge. The paste during centrifugation was fluidized by adding *ca.* 100 L/h of drinking water that was heated at 35 °C. The oil samples were stored in a freezer at -18 ºC until analysis.

Determination of olive oil quality parameters: The following 5 properties were determined to ascertain the quality of the olive oil: degree of free acidity as oleic acid (%), peroxide value (meq O_2/kg oil) and UV extinction coefficient K_{232} in accordance with the Codex Alimentarius[19]. All parameters were determined in triplicate for each sample.

Spectrometric study of content of chlorophyll and carotenoid pigments: For the extraction procedure of pigments from olive oil, 7.5 g of oil was weighed exactly, dissolved in cyclohexane[20] and taken to a final volume 25 mL. The chlorophyll and carotenoid fractions in the absorbtion spectrum were determined at 670 and 472 nm, respectively[20], using a spectrophotometer. Results are given as mg/kg of oil.

The equation C (mg kg^{-1} oil as Pheo α) = 345.3 [A670-(A630+A710)/2]/L, where $A\lambda$ is the absorbance of the oil at the respective wavelength and L is the cell thickness (mm), was applied for the determination of the content of chlorophyll pigments as pheo α[21].

Absorbance and photometric colour index (PCI): The colour of oils was measured using visible absorbance of the olive oil samples in triplicate at wavelengths of 460, 550, 620 and 670 nm against 100 % dichloromethane. The 'PCI' was determined according to the AOCS method[22] (Cc 13c-50, 1991) using the formula:

$$PCI = [1.2*A460 + 67.7*A550 + 41.2*A620] – [56*A670]$$

A = absorbance at a specified wavelength.

Determination of fatty acid composition: The fatty acid composition of the olive oil samples was determined by gas chromatography (GC). Fatty acid composition was performed using a method as given by Marquard[23]. The chromatographic separation was performed in a Perkin-Elmer Auto System XL gas chromatograph equipped with a flame ionizing detector (FID) and a fused silica capillary column (MN FFAP (50 m × 0.32 mm i.d.; film thickness 0.25 μm). It was operated under the following conditions: oven temperature program, 120 ºC for 1 min raised to 240 ºC at a rate of 6 ºC/min and than kept at 240 ºC for 15 min; injector and detector temperatures, 250 and 260 ºC, respectively, carrier gas, helium at flow rate

of 15 cm/s; split ratio, 1/20 mL/min. Fatty acids were identified by comparing retention times with standard compounds. Five fatty acids were considered in this study. These were palmitic acid (C16:0), stearic acid (C18:0), oleic acid (C18:1), linoleic acid (C18:2) and linolenic acid (C18:3) expressed as percentages of fatty acids.

Determination of tocopherol composition: In the tocopherol analyses, the HPLC method of Lampi *et al.*[24] was modified. Tocopherols (α, β, γ and δ-tocopherol) were evaluated by high-performance liquid chromatography with direct injection of an olive oil samples in a mixture of heptane:tetrahydrofuran (95:5) solution. Detection and quantification was carried out with a SCL-10Avp System controller, SIL-10ADvp Autosampler, LC-10ADvp pump, CTO-10 Avp column heater and fluorescence detector with wavelengths set at 295 nm for excitation and 330 nm for emission. The 150 cm × 4, 6 mm i.d. column used was filled with Supelcosil Luna, 5µ (Supelco, Inc. Bellefonte, PA). The mobile phase consisted of heptane/THF (95/5) (v/v) at a flow rate of 1.2 mL/min and the injection volume 10 µL. The data were integrated and analyzed using the Shimadzu Class-VP Chromatography Laboratory Automated Software system. Standard samples of α, β, γ and δ isomers of tocopherol (Sigma Chemical Co., St. Louis, Mo., USA) were dissolved in hexane and used for identification and quantification of peaks. The amount of tocopherols in the oils was calculated as mg tocopherols in kg oil using external calibration curves (r = 0.999), which were obtained for each tocopherol standard.

Determination of phenolic composition: The contents of phenolic composition in the olive oil samples were determined by the modified method of Caponio *et al.*[25]. Phenolics of the olive oil samples were isolated from a solution of oil extract in hexane by triple-extraction with water:methanol (60:40, v/v). The solvent was evaporated in a rotary evaporator at 35 ºC under vacuum. The residue was dissolved in methanol and then filtered by a 0.45 µm pore size membrane filter (Vivascience AG, Hannover, Germany). Detection and quantification was carried out with a SCL-10Avp system controller, a SIL-10AD vp Autosampler, a LC-10AD vp pump, a DGU-14a degasser, a CTO-10 A vp column heater and a diode array dedector with wavelengths set at 278 nm. The 250 × 4, 6 mm i.d., 5 µm column used was filled with Luna Prodigy, 5 µ. The flow rate was 1 mL/min, injection volume was 10 µL and the column temperature was set at 30 °C. Gradient elution of two solvents was used: Solvent A consisted of: acetic acid-water (2:98 v/v), solvent B: methanol and the gradient programme used is given Table-1. The data were integrated and analyzed using the Shimadzu Class-VP Chromatography Laboratory Automated Software system. The amount of phenolic compounds in the extract was calculated as mg 100 g^{-1} herb using external calibration curves, constructed for each pure phenolic standard. All determinations were carried out in triplicate and the results were averaged.

Statistical analysis: Results of the research were tested for statistical significance by one-way ANOVA. Differences were considered statistically significant at the $p \leq 0.05$ level.

TABLE-1
SOLVENT GRADIENT CONDITIONS WITH LINEAR GRADIENT

Final time (h)	3	20	28	35	45	60	62	70	75	80
A%*	95	75	72	70	65	63	55	50	20	0
B%	5	25	28	30	35	37	45	50	80	100

*A (solvent): Acetic acid-water (2:98 v/v), B (solvent): Methanol.

RESULTS AND DISCUSSION

Fruit properties data of organic and conventional Memecik and Gemlik olive cultivar were given in Table-2. All cultivars were harvested the same Ripeness Index. The olives had black epidermis and violet pulp almost to the pit. There were insignificant differences between organic and conventional cultivation from the fruit properties of Gemlik cultivar point of view. But weight of pulp, weight of olive and length of olive of organic and conventional Memecik cultivars were found considerable different each of them. In addition to this, various fruit properties were influenced by the type of cultivars. In this study the highest data of weight of stone, pulp and olive (g), width of olive (cm) and yield of oil /dry matter (%) were found as 0.83-0.93, 3.28-4.12, 4.38-4.81, 1.78-1.79 and 29.55-31.47 in Memecik cultivar, respectively. However, moisture of olives (%) was found the highest value as 62.62-65-12 in Gemlik cultivar. Nergis and Engez[17] were reported that the moisture content (%), number of fruits per kg and flesh to stone ratio of Memecik cultivar were found as among 48.9-54.5, 222-258 and 3.6-4.8 at various stages of ripening. In Gemlik the weight of olive and stone (g), moisture content (%) and crude oil (%) were 2.75, 0.5, 59.21 and 24.7, respectively[26]. In the other studies, fruit weight (g) of Gemlik cultivar determined as between 3.5 and 3.9 [27]. Results were similar to the values found in the literature. Differences may be due to harvest time, soil characteristics, fertilization and climate.

TABLE-2
FRUIT PROPERTIES OF ORGANIC AND CONVENTIONAL
MEMECIK AND GEMLIK OLIVES

Fruit properties	Gemlik cultivar		Memecik cultivar	
	Organic (n = 100)	Conventional (n = 100)	Organic (n = 100)	Conventional (n = 100)
Ripeness Index	6.35	6.00	6.15	6.21
Harvesting Date	21.12.2008	21.12.2008	27.12.2005	27.12.2008
Weight of stone(g)	0.68 ± 0.06 b[1]	0.63 ± 0.04 b	0.93 ± 0.06 a	0.83 ± 0.06 a
Weight of pulp (g)	3.09 ± 0.06 bc	2.73 ± 0.17 c	4.12 ± 0.28 a	3.28 ± 0.37 b
pulp/stone ratio (g)	4.59 ± 0.34 a	4.35 ± 0.14 ab	4.44 ± 0.40 ab	3.95 ± 0.32 b
Weight of olive (g)	3.66 ± 0.06 c	3.50 ± 0.04 c	4.81 ± 0.12 a	4.38 ± 0.13 b
Width of olive (cm)	1.64 ± 0.07 b	1.67 ± 0.03 b	1.78 ± 0.04 a	1.79 ± 0.01 a
Length of olive (cm)	2.18 ± 0.16 b	2.10 ± 0.07 b	2.21 ± 0.08 b	2.56 ± 0.17 a
Moisture of olives (%)	52.62 ± 1.74 a	65.12 ± 0.63 a	58.21 ± 2.71 b	58.16 ± 2.07 b
Yield of oil/dry matter (%)	26.96 ± 1.53 b	29.43 ± 2.47 ab	29.55 ± 2.25 ab	31.47 ± 0.91 a

[1]Differences between means indicated by the same letters are not statistically significant ($P \leq 0.05$; one-way ANOVA followed by Duncan's test).

It was demonstrated in Table-3 that the various olive oil quality parameters are influenced by the type of cultivation. K_{232}, chlorophyll pigments, carotenoids and photometric colour index (PCI) of Gemlik and carotenoids, free acidity and peroxide value of Memecik showed statistically significant differences between olive oils from organic and conventional cultivation. Organic Gemlik olive oil had higher K_{232} value (1.93) and lower chlorophyll pigments (20.16 mg/kg oil), carotenoids (16.23 mg/kg oil) and photometric colour index (4.71). However both organic and conventional cultivars of Gemlik had the same free acidity and peroxide value. The olive oil from organically cultivated Memecik olive trees exhibited higher free acidity (1.79 % as oleic acid), lower peroxide value (11.57 meq O_2/kg oil) and lower carotenoids (6.50 mg/kg oil). In addition to this, chlorophyll pigments, carotenoids, chlorophyll pigments as Pheo α, peroxide value and free acidity of olive oils were influenced by the type of cultivars. Free acidity and peroxide value of Gemlik olive oil were reported as 1.7 % oleic acid and 17.5 meq O_2/kg oil[26]. In other study, free acidity as oleic acid (%) and K_{232} of Gemlik olive oil were determined[28] as 0.42 and 1.818. Ozkan *et al.*[29] were reported that K_{232} value, total carotenoid, total chlorophyll and chlorophyll pigments as pheo α of virgin olive oil from Gemlik cultivar harvested four different ripeness stages were found as between 1.46-2.19, 12.05-23.51 (mg/kg oil), 11.28-33.96 (mg/kg oil) and 2.19-25.98 (mg/kg oil) at different four harvest time. Ocakoglu *et al.*[30] were reported that peroxide value (meq O_2/kg oil) of Gemlik and Memecik cultivar were as 8.68 and 9.93 for 2005 harvest year and 13.45 and 9.57 for 2006 harvest year, respectively. A previous article of olive oils from organic and conventional cultivated olives[15] showed that the organic olive oil had lower acidity value, lower peroxide index, higher stability and higher organoleptic scoring. The literature and the samples values analyzed in this work had similar results in general but differences of value can be due to growing conditions, climatic conditions, locality and postharvest treatment.

TABLE-3
OLIVE OIL QUALITY PARAMETERS OF ORGANIC AND CONVENTIONAL MEMECIK AND GEMLIK OLIVES

Fruit properties	Gemlik olive oil		Memecik olive oil	
	Organic (n = 3)	Conventional (n = 100)	Organic (n = 100)	Conventional (n = 100)
K_{232}	1.93 ± 0.47 a†	1.24 ± 0.17 b	1.65 ± 0.05 ab	1.86 ± 0.00 a
Chlorophyll pigments (mg/kg oil)	17.02 ± 1.18 b	20.16 ± 2.43 a	12.82 ± 1.66 c	12.74 ± 0.86 c
Carotenoids (mg/kg oil)	14.99 ± 0.69 b	16.23 ± 0.67 a	6.50 ± 0.78 d	7.95 ± 0.40 c
Chlorophyll pigments as Pheo α (mg/kg oil)	1.53 ± 0.06 a	1.45 ± 0.03 a	0.31 ± 0.10 b	0.28 ± 0.00 b
Photometric Color Index (PCI)	3.24 ± 0.81 b	4.71 ± 0.82 a	4.92 ± 0.85 a	5.32 ± 0.39 a
peroxide value (meq O_2/kg oil)	7.90 ± 0.07 c	8.28 ± 0.00 c	11.57±0.21 b	12.07 ± 0.35 a
Free acidity as oleic acid (%)	0.45 ± 0.00 c	0.45 ± 0.00 c	1.79 ± 0.05 a	1.71 ± 0.03 b

†Differences between means indicated by the same letters are not statistically significant ($p \leq 0.05$; one-way ANOVA followed by Duncan's test).

The fatty acid compositions of organic and conventional olive oils from Gemlik and Memecik olive cultivars were given in Table-4. Oleic acid (53.26-62.82 %) was found in the highest concentration followed by linoleic acid (16.59-26.87), palmitic acid (11.96-14.71), stearic acid (3.14-4.18 %) and linolenic acid (0.62-0.70 %). Tanilgan *et al.*[26] reported the main fatty acids of Gemlik olive oil as (81.1 %) oleic acid, (8.1 %) palmitic acid, (5.6 %) steraric acid, (4.9 %) linoleic acid and (0.4 %) linolenic acid. Oleic acid, palmitic acid and linoleic acid were also found as major constituent of Memecik and Gemlik cultivars[17,28]. Differences between all fatty acids except oleic acid values of both organic and conventional olive oils were insignificant at $p \leq 0.05$. The oleic acid in organic olive oils of Gemlik and Memecik cultivar were determined higher concentration than conventional ones. The oleic acid values (%) of organic Memecik, conventional Memecik, organic Gemlik, conventional Gemlik olive oils were as 62.82, 61.96, 54.75 and 53.26, respectively. At the same time, all fatty acid compositions were influenced by the type of cultivars. Gutierrez *et al.*[15] were also reported that the percentage of oleic acid tends to be higher and the amounts of linoleic acid lower in organic compared to conventional virgin olive oil. However, Samman *et al.*[14] determined that no significant differences in oleic acid and linoleic acid levels were observed among the conventional and organic olive samples. Present results are similar in fatty acid composition, when compared to the values in the literature. The differences can be explained that fatty acid composition in olive oils is affected by species, variety, growing conditions, postharvest treatment and harvest time[31].

TABLE-4
FATTY ACID COMPOSITIONS OF ORGANIC AND CONVENTIONAL MEMECIK AND GEMLIK OLIVES

Fatty acids (%)	Gemlik olive oil		Memecik olive oil	
	Organic (n = 3)	Conventional (n = 3)	Organic (n = 3)	Conventional (n = 3)
C16:0	11.96 ± 0.05 b†	12.40 ± 0.08 b	14.41 ± 0.23 a	14.71 ± 0.45 a
C18:0	4.10 ± 0.11 a	4.18 ± 0.04 a	3.14 ± 0.03 b	3.19 ± 0.09 b
C18:1	54.75 ± 0.25 c	53.26 ± 0.65 d	62.82 ± 0.18 a	61.96 ± 0.41 b
C18:2	26.26 ± 0.02 a	26.87 ± 0.37 a	16.59 ± 0.31 b	17.14 ± 0.57 b
C18:3	0.66 ± 0.06 a	0.68 ± 0.03 a	0.62 ± 0.12 a	0.70 ± 0.08 a

†Differences between means indicated by the same letters are not statistically significant ($p \leq 0.05$; one-way ANOVA followed by Duncan's test).

The content of tocopherols in the organic and conventional olive oils from Gemlik and Memecik cultivars are shown in Table-5. The contents of the tocopherols were significantly affected by the cultivar type ($p \leq 0.05$). By comparing data from the table, all the isomers of tocopherols (α, β, γ, δ) in Gemlik olive oil were higher than in Memecik olive oil. α-Tocopherol was the most abundant tocopherol as between 42.30 and 112.00 ppm in the all samples. β, γ and δ-Tocopherols were found in low concentrations compared to α-tocopherol. Results obtained from the tocopherol analyses can be summarised as follows: γ and δ-tocopherol contents were changed in olive oils of both Gemlik and Memecik cultivars to the cultivation

TABLE-5
TOCOPHEROL COMPOSITIONS OF ORGANIC AND CONVENTIONAL MEMECIK AND GEMLIK OLIVES.

Tocopherols (ppm)	Gemlik olive oil		Memecik olive oil	
	Organic (n = 3)	Conventional (n = 3)	Organic (n = 3)	Conventional (n = 3)
α-tocopherol	1120.00 ± 9.00 a[1]	536.50 ± 0.50 b	423.00 ± 1.00 c	443.50 ± 33.50 c
β-tocopherol	3.74 ± 0.13 b	4.82 ± 0.04 a	2.88 ± 0.02 c	2.77 ± 0.01 c
γ-tocopherol	9.17 ± 0.11 b	13.23 ± 0.06 a	7.71 ± 0.01 c	7.56 ± 0.02 d
δ-tocopherol	0.88 ± 0.01 b	1.28 ± 0.02 a	0.54 ± 0.00 d	0.60 ± 0.01 c
α-tocopherol	1120.00 ± 9.00 a[1]	536.50 ± 0.50 b	423.00±1.00 c	443.50 ± 33.50 c

[1]Differences between means indicated by the same letters are not statistically significant ($p \leq 0.05$; one-way ANOVA followed by Duncan's test).

type. Differences between α and β tocopherol values of both organic and conventional Gemlik olive oils were also significant at $p \leq 0.05$. However α and β tocopherols in organic and conventional olive oils from Memecik had statistically insignificant results. While contents of α-tocopherol in Gemlik organic olive oil and γ-tocopherol in Memecik organic olive oil were found higher than conventional oils, β, γ and δ-tocopherols of Gemlik conventional olive oil and δ-tocopherol of Memecik conventional olive oil were higher than organic oils. With our best knowledge, there is no detailed information about comparison of all isomers of tocopherols in olive oil from organic and conventional cultivars. Only Gutierrez *et al.*[15] have demonstrated that the α-tocopherol in olive oil was influenced by the type of cultivation. They were reported that α-tocopherol contents in organic olive oils were 1.3 times higher than conventional ones. The present value of α-tocopherol of Gemlik cultivar was similar when compared to the value of in this literature. However, this theory cannot be valid to all cases. Because genetic factors and geographic areas, particularly altitude affect tocopherol composition[32].

Tyrosol, *p*-coumaric acid, quercetin, luteolin and apigenin were found as phenolics in olive oils of organic and conventionally cultivated olive from Gemlik and Memecik (Table-6). The contents of the phenolics were significantly affected by the cultivar type and cultivation type. Only luteolin content in Gemlik olive oil were not changed to the cultivation type. While tyrosol, *p*-coumaric acid, quercetin and apigenin content of Gemlik conventional olive oil was higher than conventional olive oil, tyrosol, *p*-coumaric acid, quercetin and luteolin in Memecik conventional olive oil was higher. Only apigenin in Memecik conventional olive oil was more abounded than organic ones. Variation in phenolic compounds in some Turkish olive oils has been studied recently. Nergiz and Unal[33] reported that main phenolic acid in Turkish olive oils were vanillic acid (0.33-0.83 mg/kg oil), syringic acid (0.49-1.46 mg/kg oil) and *p*-coumaric acid (0.5-10.37 mg/kg oil). Ocakoglu *et al.*[30] were also determined ferulic acid, cinnamic acid, hydroxytyrosol, tyrosol, vanillic acid, vanillin, *p*-coumaric acid, luteolin and apigenin for Memecik olive oil and cinnamic acid, hydroxytyrosol, tyrosol, vanillic acid, vanillin, *p*-coumaric acid, luteolin, apigenin, 4-hydroxyphenyl-

TABLE-6
PHENOLIC COMPOSITIONS OF ORGANIC AND CONVENTIONAL MEMECIK AND GEMLIK OLIVES

Phenolics (ppm)	Gemlik olive oil		Memecik olive oil	
	Organic (n = 3)	Conventional (n = 3)	Organic (n = 3)	Conventional (n = 3)
Tyrosol	0.27 ± 0.01 d†	0.35 ± 0.00 c	0.72 ± 0.05 a	0.52 ± 0.02 b
p-Coumaric acid	0.02 ± 0.00 c	0.04 ± 0.00 a	0.02 ± 0.00 b	0.01 ± 0.00 d
Quercetin	0.14 ± 0.01 b	0.20 ± 0.01 a	0.13 ± 0.00 b	0.05 ± 0.00 d
Luteolin	1.19 ± 0.01 b	1.61 ± 0.01 b	19.19 ± 18.82 a	0.50 ± 0.00 c
Apigenin	0.44 ± 0.01 b	0.62 ± 0.00 a	0.07 ± 0.00 d	0.17 ± 0.01 c

†Differences between means indicated by the same letters are not statistically significant ($p \leq 0.05$; one-way ANOVA followed by Duncan's test).

acetic acid, 2,3-dihydroxybenzoic acid and 4-hydroxybenzoic acid for Gemlik olive oil. These results were in accord with most of our results about difference between phenolic compositions of cultivar type. Olive oils studied demonstrate that the differences in phenols may be explained by genetic factors and geographic areas, particularly altitude[32]. But there was no study comparison of the phenolic compounds of olive oils grown conventionally and organically for discussion according to our best knowledge.

In conclusion, our findings did not provide evidence of major differences in physical, physicochemical and chemical properties of olive oil between conventionally and organically grown olives. Only oleic acids in both olive oils of Gemlik and Memecik cultivar grown with the type of organic production methods used in the present experiment were the highest levels, compared with a conventional method. However it was not determined stable results for other properties according to comparison of cultivation types.

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