

## Physical and chemical characteristics of five Turkish olive (*Olea europea L.*) varieties and their oils

By Kenan Tanilgan<sup>a</sup>, M. Musa Özcan<sup>b\*</sup> and Ahmet Ünver<sup>b</sup>

<sup>a</sup>Food Engineer, Ankara, Turkey

<sup>b</sup>Department of Food Engineering, Faculty of Agricultural, Selcuk University, 42031 Konya-Turkey  
mozcan@selcuk.edu.tr

### RESUMEN

#### Determinación de propiedades físicas y químicas de cinco variedades de aceitunas de Turquía y de sus aceites

Aceitunas de Turquía de cinco variedades (Gemlik, Kilis, Uslu, Tirilye y Ayvalik) así como sus correspondientes aceites obtenidos por métodos clásicos fueron usados en este estudio. En las aceitunas se determinó la composición proximal (humedad, contenido graso, proteína, cenizas, fibra, y extracto soluble en alcohol), el contenido en minerales y en fenoles. En el caso de los aceites se determinó la composición en ácidos grasos, acidez, insaponificable, índices de Yodo y de saponificación, densidad e índice de refracción. El contenido en aceite de las muestras fue muy variable oscilando entre 17.7 y 43.5% y el de fibra entre 3.6 y 7.0%. El contenido en minerales de las aceitunas fue excelente destacando el elevado contenido en Ca, Fe, K, Mg, Na y P. Los contenidos de K, Na y P fueron superiores en las aceitunas de la variedad Gemlik. Respecto a los aceites los rangos de concentración encontrados para los principales ácidos grasos fueron: ácido oleico entre 65.71 y 83.58%; ácido palmítico entre 8.1 y 15.2%, ácido linoleico entre 3.5 y 15.5% y ácido esteárico entre 2.0 y 3.6%. El contenido en compuestos fenólicos, expresados como equivalentes de ácido gálico y catéquico, fue muy variable. Se encontraron cantidades entre 22.5 y 97.1 mg/kg y entre 12.3 y 98.7 mg/kg cuando se expresan como ácido gálico y catéquico, respectivamente, correspondiendo los contenidos menores a los de la variedad Kilis.

**PALABRAS-CLAVE:** Ácidos grasos – Composición – Fenoles totales – Minerales – Variedades de aceituna

### SUMMARY

#### Physical and chemical characteristics of five Turkish olive (*Olea europea L.*) varieties and their oils

Olive varieties from different locations in Turkey and their natural oils which were obtained using traditional methods were used. Five olive samples were considered for their moisture, crude oil, crude protein, crude ash, crude energy, crude fiber, pH and alcohol-soluble extract. Olives contained approximately 17.7 %-43.5 % olive oil. The crude fiber contents of olive fruits were found to be 5.5 % (Gemlik), 7.0 % (Kilis), 3.6 % (Uslu), 4.2 % (Tirilye) and 5.6 % (Ayvalik). The mineral contents of several olive varieties were determined by ICP-AES and found to be excellent. Olives were found to be rich in Ca, Fe, K, Mg, Na and P minerals. Also, K, Na and P contents of the Gemlik variety were found higher than those of other varieties. The refractive index and density values of the Uslu variety were found to be high and the other varieties had similar values. Oleic acid (65.7 %-

83.6 %) was present in the highest concentration, followed by palmitic (8.1-15.2 %), linoleic (3.5-15.5 %), stearic (2.0-5.6 %) and linolenic (0.1-3.0 %). The total amount of phenols among olive varieties was different. The total phenol content as gallic and catechic acid equivalent in all oil samples ranged from 22.5 to 97.1 mg/kg and 12.3 to 98.7 mg/kg, respectively. The Kilis variety of olives had the lowest total phenol value when compared to the other varieties.

**KEY-WORDS:** Composition – Fatty acids – Minerals – Oil – Olive varieties – Total phenol.

### 1. INTRODUCTION

The olive tree (*Olea europea L.*) grows in a subtropical climate as a traditional main crop, familiar in Mediterranean countries. It probably originates from Mesopotamia and has been cultivated from many centuries in southern European countries bordering the Mediterranean and in North Africa (Karleskind and Wolff, 1998; O'Brein, 1998; Murkovic et al., 2004).

In ancient times, the Mediterranean people considered olive oil not only an excellent food but also a healing agent. During the past four decades a renewed interest in the nutritional and health aspects of olive oil has been generated. Olive oil is a key component of the traditional Mediterranean diet, which is believed to be associated with a relatively long life in good health. Virgin olive oil is unique among other vegetable oils because of the high level of particular phenolic compounds, to which, together with the high content of unsaturated fatty acids, the health benefits of olive oil are attributed (Kiritsakis and Markasis, 1984; Visioli and Galli, 1998).

An abundance of oleic acid, a monounsaturated fatty acid, is the feature that sets olive oil apart from other vegetable oils. The Mediterranean diet includes the consumption of large amounts of olive oil, which contains high amounts of phenolic substances (Aparicio and Luna, 2002; Garcia et al., 2003; Murkovic et al., 2004). Olive oil phenols also contribute to the characteristic taste and the high stability of olive oil against oxidation (Tsimidou, 1999). The most important classes of phenolic compounds in olive fruit include phenolic acids, phenolic alcohols, flavonoids and secoiridoids (Vinha et al., 2005).

The aim of this investigation was to determine the physical and chemical properties, mineral

contents, fatty acid composition and total phenol contents of five different olive varieties.

## 2. MATERIALS AND METHODS

### 2.1. Materials

Olive fruits were collected from five different locations (Balıkesir, Bursa, Kahramanmaraş, Manisa and Tekirdağ) in south and west Anatolia in the year 2003. In each location, the chosen cultivars were those predominating in the respective area. The samples were collected during the period when olives are usually harvested for oil production. For each sample (about 1000 g) of olive fruits were manually collected from the same three olive trees, and kept at +4 °C by using.

### 2.2. Methods

The average weight of an olive and its pit were determined by measuring the weights of 30 olive fruits and their pits. The chemical and physical properties (moisture, fruit and pit weight, crude protein, crude oil, crude fiber, crude energy, ash, pH, and alcohol soluble extract, free fatty acids, iodine value, peroxide value, saponification number, unsaponifiable matter and refractive index) were analyzed according to AOAC (1984, 1990). The amounts of oil used for the determination of free fatty acids and peroxide values were 2.0 g and 5 g, respectively. The oil was extracted with diethyl ether (50 °C) in a Soxhlet apparatus. The extract was evaporated in vacuum. The lipid extract was collected in a flask. The extracted lipid was weighed to determine the oil content and stored under nitrogen at 4 °C for further analyses. About 10 g of the oil was heated under reflux and saponified with 5 ml of ethanolic potassium hydroxide solution (20 % w/v) for 2 h. The unsaponifiable matter was extracted three times with 15 ml of petroleum ether, and the extracts were combined and evaporated in a rotary evaporator at 40 °C under reduced pressure. The unsaponifiable residue was weighed. For peroxide value, about 5 g of olive oil was dissolved in a mixture of acetic acid / chloroform (3:2 v/v), and a saturated solution of KI (1 ml) was then added. The liberated iodine was titrated with sodium thiosulphate solution (0.05 M) in the presence of starch as indicator. For the free oil acidity, a known weight of olive oil was dissolved in a mixture of diethyl ether/ethanol (1:1 v/v). The mixture was titrated with potassium hydroxide in methanol (0.05 M) in the presence of phenolphthalein as indicator.

### 2.3. Determination of fatty acids

Fatty acids were derivatized using the boron trifluoride method (Hışıl, 1988). The working conditions of gas chromatography were as follows.

The fatty acid composition for walnut olive samples was determined using a modified fatty acid

methyl ester method as described by Işıl (1998). The oil was extracted three times for 2 g air-dried seed sample by homogenization with petroleum ether. The oil samples (50-100 mg) were converted into fatty acid methyl esters (FAME). FAME (5 µl) were analyzed using a Varian 2100 chromatograph on a fused silica capillary column MN FFAP (10 % diethylene glycol succinate, 50 m × 0.32 mm i.d.; film thickness 0.25 µm), under the following temperature programme: 90 °C (7 min), 5 °C /min to 240 °C (15 min). The flow rate of nitrogen, used as carrier gas, was 6 mL/min. Temperature of both injector and flame ionization detector was 225 °C.

The fatty acids were converted to their methyl esters by heating them in 10% BF<sub>3</sub>-methanol. Commercial mixtures of fatty acid methyl esters were used as reference data for the relative retention times (AOCS, 1990). Results are given as mean values of two replicates.

### 2.4. Determination of mineral contents

About 0,5g of dried and ground olive fruits were put into a (burnig) cup with 15 ml of pure HNO<sub>3</sub>. The sample was incinerated in a MARS 5 microwave oven at 200 °C. Distilled deionized water and ultra-pure commercial acids were used to prepare all reagents, standards, and olive samples. After the digestion treatment, samples were filtrated through whatman No 42. The filtrates were collected in 50 ml Erlenmayer flasks and analyzed by ICP-AES. The mineral contents of the samples were quantified against standard solutions of known concentrations which were analyzed at the same time. (Skujens, 1998).

The working conditions of ICP-AES were as follows: The Instrument was Varian Vista. Other parameters: RF Power, 0.7-1.5 kW (1.2-1.0 kW for axial); Plasma gas flow rate (Ar), 10.5-151 min<sup>-1</sup> (radial) and 151 min<sup>-1</sup> (axial); Auxiliary gas flow rate (Ar), 1.51 min<sup>-1</sup>; Viewing height, 5-12 mm; Copy and reading time, 1-5 s (max 60 s) and Copy time, 3s (max 100 s).

### 2.5. Determination of total phenol content of olive oil extracts

About 100 g of oil was extracted three times with 500 ml of methanol (water: methanol; 60:40) (Tsimidou et al., 2005). The total phenols in the oil extracts were measured by the Folin-Ciocalteu assay (Tsimidou et al., 1999). The measurement was carried out at 765 nm via UV-spectrophotometer (Shimadzu). Results were expressed as mg of gallic acid and catechin equivalent in one kg oil. Yields of the extracts were based on differences in weight (Singleton and Rossi, 1965).

### 2.6. Statistical analysis

Results of the research were analyzed for statistical significance by analysis of variance

(Düzgüneş et al., 1987). The data from the experiment were subjected to ANOVA using a randomized complete block design with statistical analysis system-ANOVA procedure (Minitab, 1991).

### 3. RESULTS AND DISCUSSION

#### 3.1. Weight of fruits and pits

Differences between the weight of fruits and pits were significant ( $p < 0.01$ ) for all cultivars Table 1. The highest fruit weight was established in the Ayvalık variety. The pit weight of Uslu variety was determined as 0.630 g. Akpınar and Başoğlu (1999) reported that the fruit weight of edible oil fruit was 3.5 g-3.9 g. In other studies, these values were determined as 2.5-4.1 g (Yazıcıoğlu, 1966), and 3.3-4.2 g (Kılıç, 1986), 1.7-3.6 g (Anonymous, 2003) for oil olives. The pit weights according to literature ranged from 0.4 -0.6 g (Akpınar and Başoğlu, 1999), 0.3-0.4 g (Kılıç, 1986) and 0.5-0.8 g (Balatsouras et al., 1982) for some table olives. Anon., (2003) reported the pit weight of edible olive oil fruits as ranging from 0.3-0.5 g. Results were similar to the values found in the literature. Differences may be due to soil characteristics, fertilization and cultivar differences.

#### 3.2. Chemical properties of olive fruits

The chemical properties of olive varieties are given in Table 2. Crude energy, pH and percentage of moisture, crude protein, crude oil, crude fiber, ash, alcohol and soluble extract of the samples were determined as their chemical properties. According to variance analyses, olive variety was

Table 1  
Weight of olive fruits and pits

Cultivars	Fruits (g)	Kernels (g)
Gemlik	2,751 <sup>bc</sup>	0,501 <sup>a</sup>
Kilis	1,539 <sup>d</sup>	0,195 <sup>b</sup>
Uslu	3,140 <sup>ab</sup>	0,630 <sup>a</sup>
Tirilye	2,150 <sup>cd</sup>	0,536 <sup>a</sup>
Ayvalık	3,911 <sup>a</sup>	0,550 <sup>a</sup>

Means with different superscript letters differ significantly ( $n = 30$ ).

Table 2  
Chemical properties of olive fruits

Cultivars	Moisture (%)	Crude protein* (%)**	Crude oil* (%)	Crude fiber* (%)	Ash* (%)	Crude energy* (kcal/g)	pH	Alcohol soluble extract* (%)
Gemlik	59,21 <sup>a</sup>	1.4 <sup>a</sup>	24.7 <sup>ab</sup>	5.5 <sup>a</sup>	0.6 <sup>c</sup>	3.1 <sup>ab</sup>	5,420 <sup>ab</sup>	1.8 <sup>ab</sup>
Kilis	43,08 <sup>b</sup>	1.8 <sup>ab</sup>	40.7 <sup>a</sup>	7.0 <sup>a</sup>	1.0 <sup>b</sup>	4.6 <sup>a</sup>	5,037 <sup>c</sup>	2.8 <sup>a</sup>
Uslu	64,72 <sup>a</sup>	0.8 <sup>b</sup>	17.7 <sup>b</sup>	3.6 <sup>b</sup>	0.6 <sup>bc</sup>	2.6 <sup>bc</sup>	5,290 <sup>bc</sup>	1.9 <sup>a</sup>
Tirilye	39,83 <sup>bc</sup>	1.4 <sup>b</sup>	36.0 <sup>ab</sup>	4.2 <sup>c</sup>	1.1 <sup>a</sup>	4.4 <sup>cd</sup>	5,667 <sup>a</sup>	2.2 <sup>b</sup>
Ayvalık	35,30 <sup>c</sup>	2.0 <sup>b</sup>	43.5 <sup>a</sup>	5.6 <sup>b</sup>	1,2 <sup>ab</sup>	4.7 <sup>d</sup>	5,370 <sup>ab</sup>	2.8 <sup>ab</sup>

\* According to wet weight basis; Means with different superscript letters differ significantly ( $n = 3$ ).\*\* Nx6,25;

significant to protein ( $p < 0.05$ ), water, crude oil, fiber, ash, energy, pH and alcohol soluble extract ( $p < 0.01$ ) (Table 2). The varieties Uslu and Tirilye were characterized for exhibiting lower crude protein. The highest crude oil content was 43.5 % (Ayvalık) and the lowest was 17.7 % (Uslu). The crude energy and pH values of all samples were similar. The crude fiber contents of olive fruits were found as 5.5 % (Gemlik), 7.0 % (Kilis), 3.6 % (Uslu), 4.2 % (Tirilye) and 5.6 % (Ayvalık). Energy values were determined between 2.6 and 4.7 (kcal/g). Crude protein contents of samples were established between 2.37 % and 3.52 % (Table 2). Manoukas et al. (1973) determined values to be between 1.5 % and 3.0 %. Canbaş and Fenercioğlu (1989) reported between 1.1 % and 2.2 %. Crude oil contents varied from 43.8 % to 56.2 % (Moussa et al., 1995) whereas, our results were found between 17.7 % and 43.5 %. Our findings are higher than those found in the literature. Kiritsakis and Markakis (1984) reported moisture (50 %), crude oil (22 %), cellulose (5.8 %), protein (1.6 %) and ash (1.5 %) in olive fruit at the green stage. Yazıcıoğlu and Karaali (1983) determined moisture as (46.5 %), oil (43.6 %), crude protein (3.18 %) and ash (2.03 %) in olive fruit. These differences are probably due to variety, growth conditions, harvest time and process parameters.

#### 3.3. Mineral Contents of olive fruits

The mineral contents of several olive varieties were determined by ICP-AES (Table 3) and found to be excellent. Olive fruits have advantages over fruits such as terebinth, (Özcan, 2004). All olive varieties were found to be rich in K, P, Ca, Na, Mg and Fe. Also, K, Na and P contents of Gemlik varieties were found higher than those of other varieties. According to the variance analysis, olive varieties had a significant effect on B, Cu, K and Mg ( $p < 0.01$ ) and on Li ( $p < 0.05$ ) (Table 3). Some mineral contents such as Ca, Fe, K, Mg, P and Zn of olive fruits varied between 481 mg/kg to 1176 mg/kg, 113 to 283 mg/kg, 4724 to 11442 mg/kg, 119 to 275 mg/kg, 605 to 1187 mg/kg and 4.9 to 14.4 mg/kg, respectively (Table 3). Manouskas et al. (1978) reported that fresh olive fruits contained Na (32.0 ppm), K (4571.9 ppm), Ca (331.5 ppm), Mg (124.9 ppm), Mn (1.3 ppm), Fe (12.2 ppm), Zn (7.1

Table 3  
Mineral content of Turkish olive oil (mg/kg)

Minerals*	Cultivars				
	Gemlik	Kilis	Uslu	Tirilye	Ayvalik
Al (ns)	12	23	11	19	14
As (ns)	4.9	4,6	1,4	7.2	4,5
B **	70,4 <sup>a</sup>	73,0 <sup>ab</sup>	25,8 <sup>ab</sup>	40,7 <sup>b</sup>	67,7 <sup>ab</sup>
Ca (ns)	481	1176	634	880	1060
Cr (ns)	3,0	4,0	2,0	4,0	5,2
Cu **	2,0 <sup>a</sup>	0,2 <sup>a</sup>	1,2 <sup>a</sup>	2,6 <sup>a</sup>	0,6 <sup>a</sup>
Fe (ns)	180	260	113	206	283
K **	7545 <sup>a</sup>	8588 <sup>b</sup>	4724 <sup>c</sup>	10483 <sup>a</sup>	11442 <sup>a</sup>
Li ***	0,08 <sup>b</sup>	0,11 <sup>b</sup>	0,07 <sup>b</sup>	0,13 <sup>b</sup>	0,19 <sup>a</sup>
Mg **	194 <sup>ab</sup>	275 <sup>a</sup>	119 <sup>c</sup>	261 <sup>abc</sup>	234 <sup>bc</sup>
Mn (ns)	3,1	4,2	1,9	4,5	4,4
Na (ns)	622	743	398	807	794
Ni (ns)	2,4	2,8	1,4	2,4	3,2
P (ns)	902	11,06	605	1187	1143
Pb (ns)	0,2	0,2	0,3	0,5	0,4
V (ns)	1,2	2,4	1,3	2,0	2,3
Zn (ns)	5	7,0	4,9	6,6	14,4

\* According to wet weight basis; Means with different superscript letters differ significantly (n = 3). \*\* Significant at p < 0.01, \*\*\* Significant at p < 0.05, ns: Not significant.

ppm), Cu (0.1 ppm) and P (511.3 ppm). Results were high compared to literature values. This situation is due to the sample analysis which is not done according to fresh basis.

### 3.4. Chemical and physical properties of olive oils

The characteristics of the main chemical properties of olive oils extracted from all varieties are shown in Table 4. According to variance analyses, all olive varieties had significant amounts of free fatty acid, iodine value, saponification value, unsaponifiable matter, refractive index, specific gravity (p < 0.01) and peroxide value (p < 0.05) (Table 5).

Free fatty acid, iodine value, peroxide value, saponification, unsaponifiable matter, refractive index and specific gravity values of all varieties of oils ranged from 0.467-1.700 %, 79.5-92.3, 15.3-22.5 meq/kg, 183.7-190.1 mg KOH/g, 11.9-19.1 g/kg, 1.467-1.467 and 0.910-0.916, respectively (Table 4).

Moussa et al. (1995) established free fatty acid in olive oil as 0.55-0.62 %. Nas et al. (1992) reported that the iodine value was between 77 to 94. The peroxide value of olive oil was determined between 7.3-18.1 meq/kg (Tsimidou et al., 2005). The peroxide values of olive oils obtained from olive fruits collected with different methods in Greece were found between 6.0-47.7 meq/kg (Kritsakis and Markakis, 1984).

Karleskind and Wolff (1998) pointed out that specific gravity, refractive index, and iodine values of olive oil were 0.910-0.196, 1.468-1.470 and 75-94, respectively. In another study, specific gravity, refractive index, unsaponifiable matter and iodine values of olive oil were reported as 0.909-0.915, 1.4680-1.4705, 1.8 % and 80-88 by Sonntag (1979). Refractive index, iodine value and unsaponifiable matter values for oil were reported as 1.468-1.470, 77-94 and 0.5-1.5 % according to Yazicioğlu and Karaali (1983), respectively. Our results, although with fewer differences, were similar to those of found in the bibliography.

Table 4  
Chemical and physical properties of olive oils

Cultivars	Free fatty acid (% oleic acid)	Iodine value	Peroxide value (meq /kg)	Saponification number (mg KOH/g)	Unsaponifiable matter (g/kg)	Refractive index	Density (g/mL)
Gemlik	1,7 <sup>a</sup>	79,5 <sup>d</sup>	17,5 <sup>ab</sup>	188,5 <sup>b</sup>	11,9 <sup>d</sup>	1,467 <sup>b</sup>	0,910 <sup>b</sup>
Kilis	0,9 <sup>c</sup>	83,6 <sup>b</sup>	22,5 <sup>a</sup>	189,3 <sup>a</sup>	15,4 <sup>b</sup>	1,467 <sup>b</sup>	0,910 <sup>b</sup>
Uslu	1,4 <sup>b</sup>	92,3 <sup>a</sup>	15,4 <sup>b</sup>	190,1 <sup>a</sup>	13,3 <sup>c</sup>	1,469 <sup>a</sup>	0,916 <sup>a</sup>
Tirilye	0,5 <sup>d</sup>	80,5 <sup>cd</sup>	15,5 <sup>b</sup>	183,7 <sup>d</sup>	19,1 <sup>a</sup>	1,467 <sup>b</sup>	0,912 <sup>ab</sup>
Ayvalik	0,5 <sup>e</sup>	82,2 <sup>bc</sup>	15,3 <sup>b</sup>	186,6 <sup>c</sup>	16,0 <sup>b</sup>	1,467 <sup>b</sup>	0,912 <sup>ab</sup>

Means with different superscript letters differ significantly (n = 3).

### 3.5. Fatty acid compositions of olive oils

The fatty acid compositions of olive oils were determined by gas chromatography (Table 5). Oleic acid (65.7-83.6 %) was present in the highest concentration followed by palmitic (8.1-15.2 %), linoleic (3.5-15.5 %), stearic (2.0-5.6 %) and linolenic (0.1-3.0 %). Differences between fatty acids of all oils were significant at  $p < 0.01$  (Table 5).

While the palmitic acid content of the Gemlik variety was found to be low, the stearic acid content of Kilis variety was determined to be high (Table 5). Ollivier et al. (2005) concluded that the palmitic, stearic, oleic, linoleic and linolenic acid contents of olive oil were 8.49-13.72 %, 2.11-2.6 %, 66.36-79.39 %, 5.82-11.85 % and 0.61-0.65 %, respectively. Aparico and Luna (2002) determined that the contents of the main fatty acids of olive oil from Coratina, Koroneiki and Picual varieties ranged between 9.7-11.6 % palmitic, 2.2-2.4 stearic, 78.1-80.3 % oleic, 4.8-5.7 % linoleic and 0.4-0.8 % linolenic acids. Özcan (1992) reviewed 7.5-20.0 % palmitic, 0.5-5.0 % stearic, 56.0-83.0 % oleic, 3.5-20.0 % linoleic acid and 0-1.5 % linolenic acids in olive oil. Yazıcıoğlu and Karaali (1983) reported the main fatty acids of olive oil as (14.3 %) palmitic, (4-12 %) stearic, (64.05 %) oleic and (15-53 %) linoleic.

Our results are similar in fatty acid composition, when compared to the values in the literature. The fatty acid composition in oils is affected by species, genetics, variety, growing conditions, locality, climatic conditions and postharvest treatment (Kiritsakis and Markakis, 1984).

### 3.6. Total phenol contents of olive oils

Table 6 presents the total phenol contents of Gemlik, Kilis, Uslu, Tirilye and Ayvalık olive oils. The content of total phenols in the oil extracts was measured by the Folin Ciocalteu assay (Tsimidou, 1999) and expressed as catechic and gallic acid equivalents. Differences between total phenol contents of oils were significant at  $p < 0.01$  (Table 6).

The total phenol contents as gallic and catechic acid equivalent in all oil samples ranged from 22.5 to 97.1 mg/kg and 12.3 to 98.7 mg/kg, respectively. While the phenol values of oils from the Uslu and Tirilye varieties were found similar, the phenol

Table 6  
Total phenolic content of olive oils (mg/kg)

Cultivars	Catechin equivalent	Gallic acid equivalent
Gemlik	61,5 <sup>ab</sup>	63,3 <sup>b</sup>
Kilis	12,3 <sup>d</sup>	22,5 <sup>d</sup>
Uslu	37,4 <sup>c</sup>	44,3 <sup>c</sup>
Tirilye	38,9 <sup>bc</sup>	45,6 <sup>bc</sup>
Ayvalık	98,7 <sup>a</sup>	97,1 <sup>a</sup>

Means with different superscript letters differ significantly ( $n = 3$ ).

content of oil from the Gemlik variety was higher. The phenol contents of oil from the Ayvalık variety was found higher than the Kilis samples. Montedoro et al. (1992) reported that the total phenol contents of Italian olive oils were found between 50 to 1000 ppm and classified as 50-200 ppm (low), 200-500 ppm (middle) and 500-1000 ppm (high). Our results can be classified as low (50-200 ppm) according to Montedoro et al. (1992). The Total phenol content of commercial olive oil is about 400 mg/kg as caffeic acid equivalent (Garcia et al., 2003). The total phenol contents of oils were effected by maturation, nature of the cultivar and geographical origin (Vinha et al., 2005).

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### REFERENCES

- AOAC 1984. Official Methods of Analysis, 14th edn. Association Official Analytical Chemists., Arlington, VA.  
 AOAC 1990. Official Methods of Analysis, 15th edn. Association of Analytical Chemists, Washington, DC.  
 AOCS 1990. Official Methods and Recommended Practices, Vol 1, 4th edn. American Oil Chermists Society, Champaign, IL.  
 Akpınar A, Başoğlu F. 1999. Tirilye (Gemlik) Çeşidi Zeytinlerin Konserve Tipi Sofralık Siyah Zeytin Üretimine Uygunluğu Üzerinde Bir Araştırma. *Gıda Teknolojisi*. **4** (2), 66-72. (in Turkish)  
 Anonymous 2003. Available in: [www.zae.gov.tr](http://www.zae.gov.tr) (08.30.2003)

Table 5  
Fatty acid content of olive oils (%)

Cultivars	Palmitic Acid	Stearic acid	Oleic acid	Linoleic acid	Linolenic acid
Gemlik	8,1 <sup>d</sup>	5,6 <sup>a</sup>	81,1 <sup>b</sup>	4,9 <sup>c</sup>	0,4 <sup>b</sup>
Kilis	15,2 <sup>a</sup>	3,8 <sup>b</sup>	75,9 <sup>d</sup>	5,0 <sup>c</sup>	0,1 <sup>c</sup>
Uslu	15,1 <sup>a</sup>	3,5 <sup>b</sup>	65,7 <sup>e</sup>	15,5 <sup>a</sup>	3,0 <sup>a</sup>
Tirilye	10,0 <sup>c</sup>	2,5 <sup>c</sup>	83,6 <sup>a</sup>	3,5 <sup>d</sup>	0,4 <sup>b</sup>
Ayvalık	12,0 <sup>b</sup>	2,0 <sup>d</sup>	79,0 <sup>c</sup>	6,8 <sup>b</sup>	0,2 <sup>bc</sup>

Means with different superscript letters differ significantly ( $n = 3$ ).

- Aparicio R, Luna G. 2002. Characterisation of monovarietal virgin olive oils. *Eur. J. Lipid Sci. Technol.* **104**, 614-627.
- Balatsouras G, Tsibri A, Dalles T, Doutsias G. 1982. Effects of fermentation and its control on the sensory characteristics of Conservolea variety green olives. *Appl. Environm. Microbiol.* **46**, 68-74.
- Canbaş A, Fenercioğlu H. 1989. Adana'da yetiştirilen bazı zeytin çeşitlerinin yeşil ve siyah salamuraya işlenmeleri üzerinde araştırmalar. Bursa I. Uluslararası Gıda Sempozyumu, 242-245, Bursa. (in Turkish)
- Düzgüneş O, Kesici T, Kavuncu O, Gürbüz F. 1987. Araştırma ve Deneme Metotları. Ankara Üniv. Zir. Fak. Yay. No: 295, Ankara.
- Garcia A, Brenes M, Garcia P, Romero C, Garrido A. 2003. Phenolic content of commercial olive oils. *Eur. Food Res. Technol.* **216**, 520-525.
- Hışıl Y. 1988. Instrumental Analysis Techniques (Eng. Fac. Publ. 55). Ege University, Bornova, Izmir (in Turkish).
- Karleskind A, Wolff JP. 1998. Oils and Fats Manual, A Comprehensive Treatise Properties-Production-Applications. Vol. 1, pp 225-233, 11, rue Lavoisier F-75384 Paris Cedex 08.
- Kılıç O. 1986. Sofralık Siyah Zeytin Üretiminde Uygulanabilecek Yeni Yöntemler Üzerine Bir Araştırma. Uludağ üniversitesi Basımevi. 17 s. Bursa. (in Turkish).
- Kiritsakis A, Markakis P. 1984. Effect of olive collection regimen on olive oil quality. *J. Sci. Food Agric.* **35**, 677-678.
- Manoukas AG, Mazomenos B, Patrino M.A. 1973. Amino acid compositions of tree varieties of olive fruit. *J. Agr. Food Chem.* **21**, 215-217.
- Manoukas AG, Grimanis A, Mazomenos B. 1978. Inorganic nutrients in naturel and artificial food of *Dacus oleae larva* (Diptera:tephritidae). *Ann. Zool. Ecol. Anim.* **10**, 123-128.
- Minitab 1991. Minitab Reference Manual (Release 7.1). Minitab Inc. State Coll. PA 16801, USA.
- Montedoro GF, Servili M, Baldioli M, Miniati E. 1992. Simple and hydrolyzable phenolic compounds in virgin olive oil. 1. Their extraction separation and quantitative and semiquantitative evaluation by HPLC. *J. Agric. Food Chem.* **40**, 1571-1576.
- Moussa YM, Metzidakis I, Gerasopoulos A, Kiritsakis A. 1995. The effect of field storage of Koroneiki and Mastoides olives on oil quality characteristics. *Riv. Ital. delle Sost. Grasse.* **LXXII**, 253.
- Murkovic M, Lechner S, Pietzka A, Bratocos M, Katzogiannos E. 2004. Analysis of minor components in olive oil. *J. Biochem. Biophys Methods* **61**, 155-160.
- Nas S, Gökalp HY, Ünsal M. 1992. Bitkisel Yağ Teknolojisi. Atatürk Üniv. Agric Fac. Publ. No.64, pp220, Erzurum, Turkey. (in Turkish)
- Ollivier D, Artaud J, Pinatel C, Durbec JP, Guerere M. 2006. Differentiation of French virgin olive oil RDOs by sensory characteristics, fatty acid and triacylglycerol compositions and chemometrics. *Food Chem.* **97**(3) 382-393.
- O'Brien 1998. Fats and oils. p. 694, Technomic Publishing Co. Inc., Lancaster, Basel, Switzerland.
- Özcan M. 2004. Characteristics of fruit and oil of terebinth (*Pistacia terebinthus L.*) growing wild in Turkey. *J. Sci. Food Agric.* **84**, 517-520.
- Özcan M. 1992. Olive oil: Production Composition, Use. MsC seminer. S.Ü. Graduate School of Natural and Applied Sciences, p. 21, Konya (in Turkish).
- Singleton VL, Rossi JR. 1965. Colorimetry of total phenolics with phosphomolibdic-phosphothungstic acid. *Amer J Enol Vitic.* **16**, 144-158.
- Skujins S. 1998. Handbook for ICP-AES (Varian-Vista) A short Guide To Vista Series ICP-AES Operation. (Version 1.0) Varian Int, Zug.
- Sonntag NOV. 1979. Composition and characteristics of Individual Fats and Oils. In: Swern, D. (ed.), Bailey's Industrial Oil and Fat Products, Vol. 1, 4<sup>th</sup> Ed., New York, NY: A Wiley-Interscience Publ., pp. 368-374.
- Tsimidou ZM 1999. Analysis of virgin olive oil polyphenols. *Semin. Food Anal.* **4**, 13-29.
- Tsimidou ZM, Georgiou A, Koidis A, Boskou D. 2005. Loss of stability of "veiled" (cloudy) virgin olive oils in storage. *Food Chem.* **93**, 377-383.
- Vinha AF, Ferreres F, Silva BM, Valentao P, Gançalves A, Dereina SA, Oliveira MB, Seabra RM, Andrade PB. 2005. Phenolic profiles of Portuguese olive fruits (*Olea europaea L.*): Influences of cultivar and geographical origin. *Food Chem.* **89**, 561-568.
- Visioli F, Galli C. 1998. The effect of minor constituents of olive oil on cardiovascular disease: new findings. *Nutrition Reviews* **56**, 142-147.
- Yazıcıoğlu T. 1966. Bursa İlinde Salamura Zeytinin Elde Olunması, Salamura Zeytinin Bileşimi ve Besin Değeri Üzerinde Bir Araştırma. Ankara Üniversitesi Ziraat Fakültesi Yayınları No: 268, 41 s. Ankara. (in Turkish).
- Yazıcıoğlu T, Karaali A. 1983. Fatty acid compositions of Turkish edible oils. TÜBİTAK Research Institutes, Publ. No. 70, Project No. 0501778203, p 105, Gebze-Kocaeli, Turkey. (in Turkish)

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