

## EVALUATION OF TURKISH OLIVE OIL QUALITY: SOME QUALITY CHARACTERISTICS AND TURKISH FOOD CODEX

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### Abstract

Olive oil is a significant food product that is directly consumed and highly recommended for health. Therefore it must be produced at right and hygienic conditions. This study aimed to evaluate some quality and purity criteria of olive oil samples from different regions and different olive types around Turkey according to regulations of Turkish Food Codex. Free acidity, peroxide number and oil acid compositions of samples were studied for evaluation of quality and purity. According to the results, although free acidity results of all Riviera olive oil samples were in conformity to those in standards; 46% of extra virgin olive oil samples were out of the acceptable limits. Peroxide values of both types (22% of virgin olive oil and 15% of Riviera oil samples) were above the limits given in standards. Fatty acid compositions of linolenic, heptadecanoic and heptadecenoic acid values were not within the legal limits. According to overall results; 46%, 20% and 9% of all samples were out of the standard limits, for free acidity, peroxide value and distribution of fatty acids, respectively. These data provide evidence of the variation in olive oil quality around Turkish olive oil samples.

**Keyword:** *olive oil, quality, food codex*

### Introduction

Olive oil is extracted from olive tree *Olea europaea* L. fruits and consumed directly. It is nutritionally beneficial for health, comprising nutritional compounds of oil acids, vitamins, sterols and phenolic compounds. Since it has some unique antioxidant compounds

(phenolic compounds, tocopherol, other aromatic components), high amount of mono-unsaturated fatty acid (oleic acid), high oxidative stability and it is processed only physically (press, centrifugation, percolation), it is considered as a natural fruit oil or oily

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fruit juice and has numerous different properties in comparison to other edible vegetable oils [1,2]. It is one of the most significant crops in Mediterranean countries and a very important contributor of the Mediterranean diet [3].

Positive effects of extra virgin olive oil on health comprise cardiovascular health, and cancer [4]. Previous studies clearly revealed the antioxidant, inflammatory, and chemotherapeutic effects as well [5]. Epidemiological and nutritional studies mainly focused on PUFAs [6], phenolic compounds and tocopherols [6, 7]. Other clinical studies presented the positive effects of continuous olive oil consumption and its effects on coronary heart diseases, [8], oxidative damage on DNA and RNA [9] and risk of Alzheimer disease [10, 11].

Global olive production has been made mainly around Mediterranean region (90% of all global production). Annual olive production is around 17 million tons and countries of Spain, Italy, Greece, Tunisia, Portugal, and Turkey are among the olive producers. Annual amount of olive production in Turkey was around 1 676 000 tons for the season 2013-2014, with more than 167

millions of trees. Production of olives is quite common for many different regions of Turkey such as; Aydın, İzmir, Muğla, Balıkesir, Bursa, Manisa, Çanakkale, Gaziantep and İçel; in the Aegean, the Marmara, the Mediterranean and the Southeast regions [12]. In Spain, world leader olive oil producer, total amount of olive oil produced was around 825.7 thousand tons in season 2014-2015, while in Turkey it was around 190 thousand tons. USA and European Union member countries are significant world olive oil traders [12].

Olive oil that is unable to be consumed directly is processed into refined olive oil. Refining may comprise processes such as removal of aroma and resin, blanching, in addition to decreasing the free acidity level to below 0.3%. This type of olive oil is so called as refined olive oil. Although undesired properties are eliminated, the specific aroma and flavor of oil is also lost during refining process. Riviera type oil is a mixture of refined olive oil having changing ratios (5-20%) and virgin olive oil [13].

Legal status of olive oil in Turkey is determined according to the rules specified by the Turkish Food Codex standard [14]. High

quality olive oil is hard to produce and expensive and the high costs related to olive trees growing, olive harvest and oil extraction are among the main reasons behind this fact. Therefore adulteration of this valuable product in such approach as blending changing quality olive oil types and marketing them as extra virgin olive oil, quite commonly exists [14]. For prevention of adulteration, it is significant to determine the quality and purity properties of olive oil samples.

Olive oil quality is related to many different factors such as olive variety, geographic region, climate conditions, tree properties, olive fruit maturity and harvest time, way of olive collecting, storage conditions, oil processing methods, and mechanical properties of press machines [15]. This study aimed to investigate the quality and purity criteria of some common olive oil samples of extra virgin olive oil and Riviera type olive oil according to Turkish Food legislations.

### Materials

50 different extra virgin olive oil and 20 different refined type samples from producers at 4 different growing regions of Turkey comprising the Marmara region, the Aegean region, the Mediterranean region and the

Southeast region, in two consecutive harvest years of seasons 2012-2013 and 2013-2014. Different regions and provinces were depicted in Table 1. The predominant olive varieties of Gemlik, Ayvalık and Memecik which are grown in a number of regions were chosen as monovarietal types whereas Karma (mixed) types were made by blanching different varieties. List of all olive oil samples used in the study was given in Table 2.

**Table 1.** Provinces at different growing regions

<b>Growing Region</b>	<b>Provinces</b>
The Marmara region	Çanakkale (Küçükkuyu), Balıkesir (Burhaniye, Edremit, Ayvalık) ve Bursa (Orhangazi, Mudanya, Gemlik)
The Aegean region	İzmir (Ödemiş, Bornova), Aydın (Nazilli, Karacasu, Köşk), Manisa (Akhisar)
The Mediterranean region	Muğla (Fethiye), Hatay (Samandağ), Kilis
The Southeast region	Gaziantep

**Table 2.** Olive oil samples used in the study

<b>Olive Oil Sample</b>	<b>Provinces</b>	<b>Type</b>	<b>Variety</b>	<b>Season</b>
N1	Kilis	Extra	<i>Mixed</i>	2012-2013
N2	Kilis	Extra	<i>Mixed</i>	2013-2014
N3	Samandağ/Hatay	Extra	<i>Gemlik</i>	2012-2013
N4	Samandağ/Hatay	Extra	<i>Gemlik</i>	2013-2014
N5	Samandağ/Hatay	Extra	<i>Mixed</i>	2012-2013
N6	Samandağ/Hatay	Extra	<i>Mixed</i>	2013-2014
N7	Küçükkuyu/Çanakkale	Extra	<i>Ayvalık</i>	2012-2013
N8	Küçükkuyu/Çanakkale	Extra	<i>Ayvalık</i>	2013-2014
N9	Altınoluk/Edremit/Balıkesir	Extra	<i>Ayvalık</i>	2012-2013
N10	Altınoluk/Edremit/Balıkesir	Extra	<i>Ayvalık</i>	2013-2014
N11	Nazilli/Aydın	Extra	<i>Memecik</i>	2012-2013
N12	Nazilli/Aydın	Extra	<i>Memecik</i>	2013-2014
N13	Nazilli/Aydın	Extra	<i>Mixed</i>	2012-2013
N14	Nazilli/Aydın	Extra	<i>Mixed</i>	2013-2014
N15	Burhaniye/Balıkesir	Extra	<i>Ayvalık</i>	2012-2013
N16	Burhaniye/Balıkesir	Extra	<i>Ayvalık</i>	2013-2014
N17	Tarsus/Mersin	Extra	<i>Mixed</i>	2012-2013
N18	Tarsus/Mersin	Extra	<i>Mixed</i>	2013-2014
N19	Ödemiş/İzmir	Extra	<i>Memecik</i>	2012-2013
N20	Ödemiş/İzmir	Extra	<i>Memecik</i>	2013-2014
N21	Köşk/Aydın	Extra	<i>Memecik</i>	2012-2013
N22	Köşk/Aydın	Extra	<i>Memecik</i>	2013-2014
N23	Aydın	Extra	<i>Memecik</i>	2012-2013
N24	Aydın	Extra	<i>Memecik</i>	2013-2014
N25	Aydın	Extra	<i>Memecik</i>	2012-2013
N26	Aydın	Extra	<i>Memecik</i>	2013-2014
N27	Gemlik/Bursa	Extra	<i>Gemlik</i>	2012-2013
N28	Gemlik/Bursa	Extra	<i>Gemlik</i>	2013-2014
N29	Bornova/İzmir	Extra	<i>Mixed</i>	2012-2013
N30	Bornova/İzmir	Extra	<i>Mixed</i>	2013-2014
N31	Ayvalık/Balıkesir	Extra	<i>Ayvalık</i>	2012-2013

N32	Ayvalık/Balıkesir	Extra Virgin	<i>Ayvalık</i>	2013-2014
N33	Mudanya/Bursa	Extra Virgin	<i>Gemlik</i>	2012-2013
N34	Mudanya/Bursa	Extra Virgin	<i>Gemlik</i>	2013-2014
N35	Küçükkuyu/Çanakkale	Extra Virgin	<i>Ayvalık</i>	2012-2013
N36	Küçükkuyu/Çanakkale	Extra Virgin	<i>Ayvalık</i>	2013-2014
N37	Ayvalık/Balıkesir	Extra Virgin	<i>Ayvalık</i>	2012-2013
N38	Ayvalık/Balıkesir	Extra Virgin	<i>Ayvalık</i>	2013-2014
N39	Ayvalık/Balıkesir	Extra Virgin	<i>Ayvalık</i>	2012-2013
N40	Ayvalık/Balıkesir	Extra Virgin	<i>Ayvalık</i>	2013-2014
N41	Aydın	Extra Virgin	<i>Memecik</i>	2012-2013
N42	Aydın	Extra Virgin	<i>Memecik</i>	2013-2014
N43	Fethiye/Muğla	Extra Virgin	<i>Memecik</i>	2012-2013
N44	Fethiye/Muğla	Extra Virgin	<i>Memecik</i>	2013-2014
N45	Karacasu/Aydın	Extra Virgin	<i>Memecik</i>	2012-2013
N46	Karacasu/Aydın	Extra Virgin	<i>Memecik</i>	2013-2014
N47	Küçükkuyu/Çanakkale	Extra Virgin	<i>Ayvalık</i>	2012-2013
N48	Küçükkuyu/Çanakkale	Extra Virgin	<i>Ayvalık</i>	2013-2014
N49	Orhangazi/Bursa	Extra Virgin	<i>Gemlik</i>	2012-2013
N50	Orhangazi/Bursa	Extra Virgin	<i>Gemlik</i>	2013-2014
R1	Bornova/İzmir	Riviera	<i>Mixed</i>	2012-2013
R2	Bornova/İzmir	Riviera	<i>Mixed</i>	2013-2014
R3	Gemlik/Bursa	Riviera	<i>Mixed</i>	2012-2013
R4	Gemlik/Bursa	Riviera	<i>Mixed</i>	2013-2014
R5	Akhisar/Manisa	Riviera	<i>Mixed</i>	2012-2013
R6	Akhisar/Manisa	Riviera	<i>Mixed</i>	2013-2014
R7	Akhisar/Manisa	Riviera	<i>Mixed</i>	2012-2013
R8	Akhisar/Manisa	Riviera	<i>Mixed</i>	2013-2014
R9	Gaziantep	Riviera	<i>Mixed</i>	2012-2013
R10	Gaziantep	Riviera	<i>Mixed</i>	2013-2014
R11	Nizip/Gaziantep	Riviera	<i>Mixed</i>	2012-2013
R12	Nizip/Gaziantep	Riviera	<i>Mixed</i>	2013-2014
R13	Bursa	Riviera	<i>Mixed</i>	2012-2013
R14	Bursa	Riviera	<i>Mixed</i>	2013-2014
R15	Bornova/İzmir	Riviera	<i>Mixed</i>	2012-2013
R16	Bornova/İzmir	Riviera	<i>Mixed</i>	2013-2014
R17	Bornova/İzmir	Riviera	<i>Mixed</i>	2012-2013

R18	Bornova/İzmir	Riviera	<i>Mixed</i>	2013-2014
R19	Ayvalık/Balıkesir	Riviera	<i>Mixed</i>	2012-2013
R20	Ayvalık/Balıkesir	Riviera	<i>Mixed</i>	2013-2014

## Methods

### 3.2.1 Olive Oil Quality Tests

#### 3.2.1.1 Free acidity (oleic acid, %)

Method of Turkish Standards Institute (Number: TS EN ISO 660) [16] was used to determine the free acidity of the olive oil samples. Free acidity is defined as percent free fatty acid (FFA) content and given as a percentage of oleic acid in Eq. 1.

$$w_{FFA} = V \times c \times \frac{M}{1000} \times \frac{100}{m} = \frac{V \times c \times M}{10 \times m}$$

(1)

Where;

V = Amount of potassium hydroxide with ethanol consumed (mL)

c = Normality of potassium hydroxide solution with ethanol (N),

M = Molecular weight of oleic acid (= 282g/mol);

m = Sample weight (g)

#### 3.2.1.2 Peroxide value

Determination of Peroxide Number was made according to TS EN ISO 3960 [16] and result given as mili equivalent weight of active O<sub>2</sub>/kg oil [16]. The equation used is given in Eq. 2. This value is accepted as a real indicator for oil oxidation [17]. Sample dissolved in acetic acid- isooctane solution is mixed with potassium iodine solution to form iodine which is titrated with sodium thiosulfate [16].

$$PV = \frac{1000 \times (V - V_0) \times c}{m}$$

(Eq. 2)

Where;

V = Sodium thiosulfate solution volume consumed, (mL)

V<sub>0</sub> = Sodium thiosulfate solution volume consumed for blank, (mL)

c = Exact molarity of sodium thiosulfate solution consumed;

m = Sample weight, (g)

### 3.2.2 Olive oil purity analyses

#### 3.2.2.1 Analysis of fatty acids and isomers

Measurements were made using gas chromatography (GC) according to the conditions given standard [18]. GC details were depicted in Table 3. Results were given as methyl ester %.

**Table 3.** GC conditions

Instrument: Agilent 6890 GC
Detector: FID (Flame Ionization Dedector)
Coloumn: 100 m x 0.25 mm ID, 0.2 µm HP-88
Split Ratio: 1:50
Injector Temperature: 250 °C
Oven Temperature: 120 °C → 230 °C
Detector Tempearture: 280 °C
Detector Gases: Hydrogen (40 ml/min.), Air (450 ml/min.), Helium (30 ml/min.)

#### 3.2.3 Statistical Analyses

The differences among extra virgn olive oil and among Riviera type samples were investigated by one-way analysis of variance (ANOVA) ( $p < 0.05$ ). Detailed examinations for significant differences were made using Duncan's New Multiple Range Test. SPSS 16.0 statistical software (SPSS, Inc., Chicago, IL, USA) was used in all statistical analyses.

## 4. RESULTS and DISCUSSION

### 4.1 Olive Oil Quality Tests

#### 4.1.1 Free acidity and peroxide value

Overall results showed that 23 of all extra virgin olive oil samples were above the legal limit for free acidity given in Turkish Food Codex (0.8%, oleic acid). On the other hand, Riviera type olive oil samples were within the legal limits. Free acidity values of extra virgin olive oil and Riviera olive oil samples according to their growing regions were given in Tables 4 and 5, respectively. he free acidity values among extra virgin olive oil samples changed between 0.28 and 12.69 % oleic acid, while for Riviera type samples the results ranged between 0.11 and 0.96 %. Present findigns were slightly higher than the findings of a previous study [19], in which 10 samples of extra virgin olive oil and 8 samples of Riviera type olive oil had the free acidity levels of changing between 0.41 and 0.93%; and 0.14 and 0.69%, respectively.

Differences among the growing regions were only significant for extra virgin olive oil samples from The Mediterranean region ( $p < 0.05$ ). The Mediterranean region was previously determined as having the highest free acidity levels in a study comprising different growing regions of the North and

South Aegean, Mediterranean and Southeast Anatolia [20]. Early maturation and late harvesting of olives was proposed to be related with the higher acidity values [20, 21]. Higher acidity was also related with the increased enzyme activity as a result of higher than desired water content in olives, pathologic organisms and mechanical problems, and these factors were given as reasons for the hydrolysis of triglycerides, as well [22].

**Table 4.** Free Acidity (oleic acid, %) values of extra virgin olive oil samples according to their growing regions

Olive oil growing regions	n	Free Acidity (Oleic acid, %) X
The Mediterranean region	10	3.96 <sup>a</sup>
The Aegean region	28	1.06 <sup>b</sup>
The Marmara region	12	0.84 <sup>b</sup>

\*Different letters in the same coloumn (a,b) represent statistically significant differences in results ( $p < 0.05$ )

**Table 5.** Free Acidity (oleic acid, %) values of Riviera olive oil samples according to their growing regions

Olive oil growing regions	n	Free Acidity (Oleic acid, %) X
The Aegean region	12	0.40
The Southeast region	4	0.46
The Marmara region	4	0.64

Changes in free acidity and peroxide number values of extra virgin and Riviera olive oil samples according to their harvest times were given in Table 6. Average free acidity values of 2012-2013 season extra virgin and Riviera type oil samples were found as 1.28 and 0.39, respectively. On the other hand, same measurements for seasons 2013-2014 were 1.89 and 0.50. Differences between different harvesting seasons were statistically insignificant ( $p > 0.05$ ).

Differences in free acidities of extra virgin and Riviera type olive oil samples due to packaging were statistically insignificant ( $p > 0.05$ ). However generally higher results



free acidity results in plastic bottle types were similar to previous literature findings [23, 24] Overall results for peroxide number values revealed that 11 of extra virgin olive oil samples were above the limit value (20 meq active O<sub>2</sub>/kg) defined in Turkish Food Codex; whereas among the Riviera type olive oil samples; 3 samples were higher than the legal limit (15 meq active O<sub>2</sub>/kg). The lowest peroxide values among extra virgin olive oil samples were in samples N8 of 2013-2014 and N15 of 2012-2013 seasons (7 meq active O<sub>2</sub>/kg). The highest value was detected in sample N23 (51 meq active O<sub>2</sub>/kg) of 2012-2013 season. Average peroxide value results were 19.32 ve 15.36 meq active O<sub>2</sub>/kg for 2012-2013 and 2013-2014 seasons, respectively (Table 6).

**Table 6:** Average free acidity and peroxide number values according to seasons of harvest of extra virgin and Riviera olive oil samples

Type of Olive Oil	Seasons	n	Free Acidity (oleic acid, %) X	Peroxide Number (meq active O <sub>2</sub> /kg oil) X
Extra virgin	2012-2013	25	1.28	19.32
	2013-2014	25	1.89	15.36
Riviera	2012-2013	10	0.39	11.50
	2013-2014	10	0.50	12.50

Extra virgin	2012-2013	25	1.28	19.32
	2013-2014	25	1.89	15.36
Riviera	2012-2013	10	0.39	11.50
	2013-2014	10	0.50	12.50

The lowest and highest values for Riviera type olive oil results were for sample R14 belonging to 2013-2014 season (5 meq active O<sub>2</sub>/kg) and sample R2 (2013-2014 season), 26 meq active O<sub>2</sub>/kg). On the other hand, the average peroxide values in Riviera type olive oil samples were 11.50 ve 12.50 meq active O<sub>2</sub>/kg for 2012-2013 and 2013-2014 seasons, respectively. Differences in peroxide values among extra virgin olive oil samples and Riviera type olive oil samples were insignificant ( $p < 0.05$ ) when different growing regions were considered (Tables 7 and 8). Extra virgin olive oil samples from The Mediterranean region and Riviera type olive oil samples from the Aegean regions had slightly higher average peroxide values than the other regions studied. Peroxide values determined in this current study, were generally higher than the results some

previous literature concerning the similar regions of growth and/or olive varieties [20, 25-27]; although some similar results were also found [28]. The main reason might be the elonged storage periods between production and analyses in addition to negative storage conditions such as light [23, 29]. Average peroxide number values were higher in glass bottle types (19.38 meq active O<sub>2</sub>/kg) in extra virgin olive oil samples, whereas plastic bottle types had higher average peroxide values (12.57 meq active O<sub>2</sub>/kg) in Riviera type olive oil samples.

**Table 7.** Average peroxide number values of extra virgin olive oil samples according to their growing regions

Olive oil sample	n	Peroxide Number (meq active O <sub>2</sub> /kg oil) X
The Mediterranean region	10	18.10
The Aegean region	28	17.32
The Marmara region	12	16.75

**Table 8.** Average peroxide number values of Riviera type olive oil samples according to their growing regions

Olive oil sample	n	Peroxide Number (meq active O <sub>2</sub> /kg oil) X
The Aegean region	12	12.58
The Southeast region	4	10.50
The Marmara region	4	11.75

## Olive Oil Purity Analyses

### 4.2.1. Fatty Acid Composition Results of Olive Oil Samples

The most common fatty acid found in olive oil is the oleic acid and according to the overall results, all samples provided the required legal minimum limits for oleic acid. Moreover, all samples are within the limits for linoleic, palmitic, stearic, arachidic and myristic acids. Average fatty acid % results according to different growing regions were given in Table 9. The highest average oleic acid was 71.34% in the Marmara region, while the lowest result was detected in the Mediterranean region

(65.34 %,  $p<0.05$ ). This might be attributed to the argument that the cooler regions having higher amounts of oleic acid % [31]. Increase in unsaturated fatty acid content with the decrease in temperature was also reported by previous studies [32, 33].

**Table 9.** Average fatty acid % results of extra virgin olive oil samples according to different growing regions

Fatty Acid Composition, %	Growing region			
	The Mediterranean region	The Aegean region	The South east region	The Marmara region
Oleic acid	65.34 <sup>b</sup>	69.99 <sup>a</sup>	69.59 <sup>a</sup>	71.34 <sup>a</sup>
Linoleic acid	9.95 <sup>a</sup>	9.43 <sup>a</sup>	9.47 <sup>a</sup>	8.69 <sup>a</sup>
Linolenic acid	0.65 <sup>a</sup>	0.64 <sup>a</sup>	0.59 <sup>a</sup>	0.60 <sup>a</sup>
Palmitic acid	15.88 <sup>a</sup>	14.91 <sup>a</sup>	15.68 <sup>a</sup>	14.42 <sup>a</sup>
Stearic acid	2.93 <sup>a</sup>	2.51 <sup>b</sup>	2.94 <sup>a</sup>	2.85 <sup>a</sup>
Heptadecanoic acid	0.11 <sup>a</sup>	0.11 <sup>a</sup>	0.11 <sup>a</sup>	0.11 <sup>a</sup>

Heptadecanoic acid	0.07 <sup>b</sup>	0.16 <sup>ab</sup>	0.06 <sup>b</sup>	0.19 <sup>a</sup>
Arachidic acid	0.11 <sup>a</sup>	0.14 <sup>a</sup>	0.24 <sup>a</sup>	0.10 <sup>a</sup>
Eicosenoic acid	0.29 <sup>a</sup>	0.22 <sup>a</sup>	0.06 <sup>a</sup>	0.16 <sup>a</sup>
Palmitoleic acid	1.16 <sup>a</sup>	0.91 <sup>b</sup>	0.99 <sup>ab</sup>	0.90 <sup>b</sup>
Myristic acid	0 <sup>b</sup>	0 <sup>b</sup>	0.01 <sup>a</sup>	0 <sup>b</sup>

\*Different letters in the same line (a,b) represent statistically significant differences in results ( $p<0.05$ )

Results gathered around provinces in the growing regions, displayed that the lowest oleic acid content was in the extra virgin olive acid from Hatay-Samandağ (62.31%, product of season 2013-2014). The highest oleic acid content was also measured in the extra virgin olive oil belonging to 2013-2014 season, in Aydın-Nazilli (78.02 %). Statistically significant and lower ( $p<0.05$ ) stearic acid % was detected the samples from the Aegean region. Differences among different provinces and regions of growing were also common to previous findings [34].

Ten samples of extra virgin olive oil and 8 samples of Riviera type olive oil were studied [19] and according to the results, oleic acid% of extra virgin olive oil samples changed between 71.09 and 74.82 %, while in Riviera type samples it was 70.72-73.23%. In the current study, except for the highest sample (78.02 %); oleic acid content in extra virgin olive oil samples ranged between 62.31-74.94 % and for Riviera samples 67.44-72.41 %. Therefore the findings were close to the

results of their study [19]. However, generally, the literature findings related to oleic acid were higher than the present findings; whereas the palmitic acid contents were generally lower [34, 35]. In samples with lower oleic acid content, the other fatty acids such as palmitic acid and linoleic acid were more dominant with higher values. Average fatty acid % results of extra virgin olive oil samples according to olive varieties in Table 10.

**Table 10:** Average fatty acid % results of extra virgin olive oil samples according to olive varieties

Fatty Acid Composition, %	Ayvalık	Gemlik	Memecik	Mixed
Oleic acid	68.87 <sup>a</sup>	71.08 <sup>a</sup>	69.72 <sup>a</sup>	69.56
Linoleic acid	9.76 <sup>a</sup>	7.23 <sup>b</sup>	10.03 <sup>a</sup>	9.30 <sup>a</sup>
Linolenic acid	0.57 <sup>b</sup>	0.58 <sup>b</sup>	0.72 <sup>a</sup>	0.63 <sup>a</sup>
Palmitic acid	15.63 <sup>a</sup>	14.72 <sup>a</sup>	14.27 <sup>a</sup>	15.10 <sup>a</sup>
Stearic acid	2.55 <sup>bc</sup>	3.03 <sup>a</sup>	2.46 <sup>c</sup>	2.75 <sup>ab</sup>
Heptadecanoic acid	0.15 <sup>a</sup>	0.11 <sup>a</sup>	0.06 <sup>a</sup>	0.12 <sup>a</sup>
Heptadecenoic acid	0.22 <sup>a</sup>	0.17 <sup>ab</sup>	0.11 <sup>b</sup>	0.13 <sup>b</sup>
Arachidic acid	0.12 <sup>a</sup>	0.07 <sup>a</sup>	0.15	0.15
Eicosenoic acid	0.38 <sup>a</sup>	0.12 <sup>a</sup>	0.22 <sup>a</sup>	0.14 <sup>a</sup>
Palmitoleic acid	0.88 <sup>a</sup>	1.09 <sup>a</sup>	0.94 <sup>a</sup>	0.96 <sup>a</sup>
Myristic acid	0	0	0	0

\*Different letters in the same line (a,b) represent statistically significant differences in results ( $p < 0.05$ )

**Table 11:** Average fatty acid % results according to the seasons of harvest

Fatty Acid Composition, %	Season of harvest	
	2012-2013	2013-2014
Oleic acid	69.56	69.67
Linoleic acid	8.95	9.73
Linolenic acid	0.63	0.62
Palmitic acid	15.12	14.85
Stearic acid	2.67	2.67
Heptadecanoic acid	0.12	0.11
Heptadecenoic acid	0.16	0.14
Arachidic acid	0.12	0.15
Eikosenoic acid	0.36	0.06
Palmitoleic acid	0.99	0.91
Myristic acid	0	0

As depicted in Table 11, seasons of harvest made only slight differences on the average fatty acid % results of the samples ( $p > 0.05$ ). The comparison of oleic acid % contents of two harvest seasons revealed that, Gemlik had the highest, while Ayvalık had the lowest content of oleic acid %, for both seasons.

These findings were parallel to previous findings [36].

Generally type of packaging had almost no effect on the fatty acid compositions of olive oil samples ( $p > 0.05$ ) as given in Table 12.

**Table 12:** Average fatty acid % results according to the type of packaging

Fatty Acid Composition, %	Type of Packaging		
	Glass	Plastic	Can
Oleic acid	69.68	69.57	69.84
Linoleic acid	9.36	9.31	9.57
Linolenic acid	0.60	0.64	0.60
Palmitic acid	14.99	14.99	14.82
Stearic acid	2.68	2.64	3.02
Heptadecanoic acid	0.13	0.10	0.14
Heptadecenoic acid	0.16	0.14	0.21
Arachidic acid	0.16	0.12	0.21
Eikosenoic acid	0.39	0.13	0.22
Palmitoleic acid	0.91	0.97	0.84
Myristic acid	0	0	0

## CONCLUSION

Results presented in this study, indicated that some of the olive oil samples were not within the required limits given in Turkish Food

Codex standard. Unsatisfactory results are thought to be related with the problems in storage conditions, olive quality, effect of geographical differences and process conditions. On the other hand, fatty acid compositions were within the limits of Turkish standards and these results were indicators of purity but not adulteration. This study was significant as giving idea about the quality problems present in the olive oil products found in the Turkish market and frequent occurrence of unsuitabilities of these products in the legal limit values.

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