Investigation of fatty acid compositions and some pomological characteristics of different olive cultivars during maturation in cool subtropical condition of Turkey

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Abstract

Olive (*Olea europaea* L.) has great genetic variation in Turkey as important crop due to its economic value. There are many cultivars, types and landraces with various morphological characters in different ecological conditions of Turkey, having good potential for productivity, oil quality and table olive characters. The northwestern region of Turkey with cool subtropical climate has most suitable ecological conditions for highest quality olives and olive oils. This research was carried out to pomological characteristics and fatty acid composition of eight local olive cultivars including 'Ayvalık', 'Domat', 'Edincik Su', 'Gemlik', 'Karamürsel Su', 'Memecik', 'Samanlı' and 'Uslu', which widely grown in Turkey. Cultivars were collected in intervals of about 10 days from September 15 to December 22 in 2014. In this research fruit weight (g of 100 fruits), pulp ratio (%), maturity index (MI) and fatty acid composition were determined. As a result of this study, 'Domat', 'Karamürsel Su' and 'Memecik' had the heaviest fruits and 'Memecik' and 'Domat' cultivars had the highest pulp ratio (%). 'Karamürsel Su', 'Gemlik' and 'Samanli' were found to the highest maturity index values at the end of harvesting time. 'Karamürsel Su' 'Domat' and 'Edincik Su' had highest ratios of polyunsaturated fatty acids whereas 'Memecik' and 'Uslu' cultivars had the highest ratios of monounsaturated fatty acids.

Keywords: *Olea europaea* L.*,* domestic cultivars, maturity index, PUFA, MUFA

INTRODUCTION

The Mediterranean diet is rich in virgin olive oil as a source of fat, and in vegetables, fruits, legumes and other plant foods, and low in saturated and trans-fatty acids and cholesterol. The Mediterranean diet is associated with longevity and low cardiovascular risk. It uses mostly olive oil, which contains monounsaturated fatty acids and several minor components with biological activity, as opposed to seed or other oils (Therios, 2009).

Olive has great genetic variation in Turkey as an important crop due to its economic value. There are many varieties, types and landraces having good potential for productivity, oil quality and table olive characters. Northwestern region of Turkey as cool subtropical climate has most suitable ecological conditions for highest quality olives and olive oils.

The maturation of olive fruits lasts several months and development varies according to the growing area, variety, temperature and cultural practices. As fruit color develops some changes occur including fruit weight, moisture content and flesh to pit ratio, fat content and oil compositions (Desouky et al., 2009). During ripening, important chemical changes occur inside the drupes which are related to the synyhesis of organic substances, especially triglycerides, and to other enzymatic activities (Boskou, 1996) that may affect virgin olive oil quality (Montedoro et al., 1986). Generally as the fruit mature, the oil becomes less stable due to the increase of polyunsaturated fatty acids and decrease of the total polyphenol content (Morello et al., 2004; Ayton et al., 2007).

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This research was carried out to pomological characteristics and fatty acid composition of eight local olive cultivars including 'Ayvalık', 'Domat', 'Edincik Su', 'Gemlik', 'Karamürsel Su', 'Memecik', 'Samanlı' and 'Uslu', which widely grown in Turkey. Cultivars were collected in intervals of about 10 days from September 15 to December 22 in 2014.

MATERIALS AND METHODS

Different domestic cultivars including 'Ayvalık', 'Domat', 'Edincik Su', 'Gemlik', 'Karamürsel Su', 'Memecik', 'Samanlı' and 'Uslu' which are used in research were obtained from the living collection of the Olive Germplasm institute, Edremit, Balikesir, Turkey. Samples were collected in periods of about 10 days interval from 15th September to 22th December in 2014 (15.09.2014, 25.09.2014, 08.10.2014, 20.10.2014, 30.10.2014, 10.11.2014, 20.11.2014, 01.12.2014, 11.12.2014 and 22.12.2014).

Although 'Ayvalik' and 'Memecik' are used for oil production and as green table olive, 'Uslu' and 'Gemlik' are used for oil production and as black table olive. 'Domat' is used only as green table olive with stuff materials such as pepper, carrot, almond etc., whereas 'Samanli' is used both as green and black table olive. 'Edincik Su' and 'Karamürsel Su' cultivars contain high water level, therefore these cultivars used for black table olive.

In this research fruit weight (g of 100 fruits), pulp ratio (%), maturity index (MI) and fatty acid composition were determined while olive fruits continues to mature.

Fruit weight (g 100 fruits^{-1}) was determined by digital balance (GM2202, Sartorius, Göttingen, Germany). After determining fruit and seed weight, pulp ratio was calculated.

Maturity index (MI) was determined according to the procedure proposed by IOOC (2007) by evaluating the color of the olive skin and pulp.

The harvested olives were crushed with an inox hammer crusher, malaxed for 30 min at 28°C and the oil was separated out by a vertical centrifuge at 8000 rounds min^{-1} (rpm) in Canakkale Onsekiz Mart University. The cold-extracted oil samples, whose spectral data were previously taken, were esterified to get ready for fatty acid composition as described by IOOC (2001) and Egesel et al. (2016). Composition of fatty acids (%) was detected by using gas chromatography (Shimadzu®) with mass spectrometry detector, as described by Kaptanoğlu (2012).

The peaks on the chromatograms were identified in samples that corresponded to the ones with the same retention time in the 37 component FAME mix (Supelco, USA). The results were expressed as the percentage of each FAME in relation to total FAMEs. Mono unsaturated fatty acid (MUFA) and poly unsaturated fatty acid (PUFA) values were calculated by summing up the values of the respective fatty acids.

Data were statistically analyzed using One-way ANOVA by the software "SAS ver. 9" (SAS Institute Inc., Cary, NC, USA). Tukey multiple range test was used to determine the significance of differences between treatments means by (P<0.01).

RESULTS AND DISCUSSION

Pomological characteristics

Results of pomological characteristics of tested cultivars are given in Tables 1-3.

Fruits of all cultivars had MI below 1 expect 'Domat' for the first harvest date (Table 1). During ripening process, fruits changed their skin color to green, yellow, red and purple, respectively. When fruit skin turned to purple, pulp color of the fruit was changing from white to purple. 'Gemlik' and 'Samanli' showed the highest MI at the last harvest date. 'Domat' showed MI of 1.32 in the beginning of research, though this cultivar had the most immature fruits with MI of 3.30 at the last harvest date. Similarly, 'Karamürsel Su' cultivar was determined to have the most mature fruit in the last harvest period of the research, although it had the lowest maturity index at the beginning of the study.

Gündoğdu and Şeker (2011) reported that 'Domat' had immature fruits, whereas 'Gemlik' had the most mature fruits from September to November. 'Domat' cultivar generally harvested at 1-1.5 MI, in Turkey. 'Ayvalik' and 'Memecik' used for oil production have to be harvested at 3.0-4.5 MI, whereas they are harvested at 2-3 MI for green table olive

consumption. 'Gemlik' and 'Uslu' are used both for oil production and as black table olives, so these cultivars have to be harvested at 5 or more MI, in relevant country conditions. Furthermore, 'Samanli' has to be harvested at 1.5-2.5 MI for green table olive, and 5 or more MI if used as black table olive similar as 'Gemlik' cultivar.

Table 1. Changes of maturity index of olive cultivars affected by harvest date.

Harv. date	Ayvalik	Domat	Ed. Su	Gemlik	Kar. Su	Memecik	Samanli	Uslu	MSD[a]
1st	0.80 hB	1.32 fA	0.32 gDE	0.34 gC-E	0.27 hE	0.70 eBC	0.46 gB-E	0.67 gB-D	0.375
2nd	1.35 gAB	1.53 fA	0.97 fB	1.53 fA	0.92 gB	0.97 eB	1.28 fAB	1.28 fAB	0.511
3rd	2.27 fAB	1.72 efCD	2.35 eA	2.08 efA-C	2.28 fAB	1.52 dD	1.82 eB-D	2.35 eA	0.504
4th	2.48 efA-C	2.18 deCD	2.72 eAB	2.42 eBC	2.62 efAB	2.40 cBC	1.93 eD	2.87 dA	0.401
5th	2.69 eCD	2.33 dD	3.18 dBC	3.52 dAB	3.07 deBC	2.73 cCD	2.47 dD	3.88 cA	0.541
6th	3.11 dCD	2.47 cdE	3.25 dCD	4.17 cdA	3.52 dBC	2.82 cDE	3.05 cCD	3.93 cAB	0.474
7th	3.38 cdB	2.62 b-dC	4.52 cA	4.43 bcA	4.04 cA	3.45 bB	3.28 cB	4.03 cA	0.560
8th	3.68 cCD	3.02 a-cD	4.68 bcAB	5.03 abA	4.67 bAB	3.58 bCD	4.20 bBC	4.20 cBC	0.704
9th	4.08 bD	3.10 abE	5.00 abA-C	5.29 aA	5.05 bAB	3.87 abD	4.67 bBC	4.57 bC	0.473
10th	4.83 aC	3.30 aE	5.40 aB	5.50 aB	6.00 aA	4.22 aD	5.48 aB	5.00 aC	0.243
MSD	0.345	0.592	0.449	0.677	0.451	0.507	0.490	0.341	

Data are the means of 3 replicates. Values followed by different capital letters are significantly different on cultivars in same harvest date at $P<0.01$. Values followed by different small letters are significantly different on harvest date in same cultivar at $P<0.01$.

[a]minimum significant difference on Tukey multiple range test by $p<0.01$.

Fruit weights of tested cultivars ranged between 214.0 and 593.2 g at the first harvest date and between 332.1 and 903.5 g at the last harvest date (Table 2). 'Domat' showed the highest fruit weight in all maturity stages, though 'Uslu' had the lightest fruits. Ipek et al. (2015), detected that 'Cakir Yaglik' and 'Uslu' cultivars had the lightest fruits in domestic olive cultivars.

Flesh ratios of fruits of cultivars were varied from 78.16 to 90.06% in all harvest dates (Table 3). 'Domat' and 'Edincik Su' cultivars had the highest fruit pulp rate in all stages of ripening. It is known that the pulp ratio of olive fruits can be affected even from the rainfall regime within the year, even from 10 to 20 days of rainfall changes (Dolek, 2003). Kaynas et al. (2002) reported that pulp ratio of fruits is an important parameter in olive breeding and it must be higher for table olive cultivars.

Fatty acid methyl esters composition

Results of fatty acid composition of cultivars are given in Tables 4-6. Besides monounsaturated and polyunsaturated fatty acids values were calculated by summing up the values of the respective fatty acids on Table 7. The sum of the ratios of palmitoleic acid, heptadecenoic acid, oleic acid and gadoleic acid were used for determining monounsaturated fatty acid, although the sum of the ratios of linoleic acid, linolenic acid were used for calculating ratio of the polyunsaturated fatty acid. In this research some of the most important fatty acids for olive oils were shown. It is known that oleic acid, palmitic acid and linoleic acid are the major fatty acid of the olive oil, although palmitoleic acid, stearic acid and linolenic acid have the secondary importance of FAME in olive oil. Harvest date was also shown to have a significant effect on the fatty acid components.

Palmitic acid (C16:0) is the major saturated fatty acid in olive oils (Table 4). It was decreased with maturity in all olive cultivars. It was ranged between 14.36 and 19.83% at the beginning of the research and varied from 8.62 to 12.27% in the end of the study.

Palmitoleic acid (C16:1) ratio of cultivars were increased during maturation except Ayvalik cultivar that varied from 0.87 to 2.35% (Table 4). Palmitoleic acid ratio ranged between 1.51 and 3.86% in the beginning of study, although it varied from 1.12 to 0.44% at the end of the research, except 'Ayvalik' cultivar.

Table 2. Changes of fruit weight (g) of olive cultivars affected by harvest date.

Cultivars	1[a]	2	3	4	5	6	7	8	9	10	MSD[b]
Ayvalik	214.0 dE	323.7 cDE	325.4 cC	346.5 bcD	355.6 bcD	366.3 bcFE	367.9 a-cDE	378.5 a-cE	426.7 abD	452.4 aD	84.628
Domat	593.2 cA	755.8 bA	773.7 bA	791.1 abA	825.2 abA	827.4 abA	855.7 abA	865.2 abA	892.5 aA	903.5 aA	113.90
Ed. Su	391.2 fB	431.5 efB-D	452.2 deB	462.6 deC	476.9 c-eC	498.7 b-dCD	529.9 a-cC	544.7 abC	574.1 aC	586.1 aC	58.167
Gemlik	301.8 eCD	333.5 deC-E	349.6 c-eC	378.5 b-dD	394.9 a-dD	400.6 a-dDE	418.3 a-cD	431.6 abDE	432.9 abD	458.1 aD	69.424
Kar. Su	399.3 hB	450.6 ghB	494.7 fgB	529.7 e-gB	566.8 d-fB	620.7 c-eB	659.3 cdB	695.1 bcB	761.2 abB	801.9 aB	94.356
Memecik	358.8 dBC	442.6 cdBC	469.9 bcB	490.6 a-cBC	518.4 a-cBC	524.8 a-cBC	526.9 a-cC	547.3 abC	567.7 abC	588.8 aC	102.52
Samanli	261.0 eDE	326.7 deDE	358.9 cdC	385.4 b-dD	386.6 b-dD	433.9 a-cC-E	437.1 a-cCD	455.2 abD	466.2 aD	496.3 aD	79.606
Uslu	231.3 eDE	247.9 deE	262.9 cdD	271.7 bcE	277.9 bcE	279.3 bcF	285.1 bE	287.8 bF	313.3 aE	332.1 aE	20.205
MSD	77.884	110.970	60.339	58.209	57.689	110.260	100.601	63.246	86.677	73.711	

Data are the means of 3 replicates. Values followed by different capital letters are significantly different on cultivars in same harvest date at $P<0.01$.

[a]1st harvest date: 15th Sept. 2014; 2nd harv. date: 25th Sept. 2014; 3rd harv. date: 8th Oct. 2014; 4th harv. date: 20th Oct. 2014; 5th harv. date: 30th Oct. 2014; 6th harv. date: 10th Nov. 2014; 7th harv. date: 20th Nov. 2014; 8th harv. date: 1st Dec. 2014; 9th harv. date: 11th Dec. 2014; 10th harv. date: 22nd Dec. 2014.

[b]MSD: minimum significant difference on Tukey multiple range test by $p<0.01$. NS: not significant.

Table 3. Changes of pulp ratio (%) of olive cultivars affected by harvest date.

Cultivars	1[a]	2	3	4	5	6	7	8	9	10	MSD[b]
Ayvalik	78.16 bD	85.17 aA-C	84.46 aC-E	85.03 aC	84.02 abCD	83.65 abBC	82.69 abC	82.75 abCD	83.80 abD	84.51 aD	6.288
Domat	87.39 A	89.52 A	89.58 A	89.75 A	90.03 A	89.38 A	88.36 AB	88.25 AB	89.52 AB	89.28 AB	NS
Ed. Su	87.56 bA	88.31 abA	88.72 abAB	88.90 abA	89.13 abAB	89.19 abA	89.75 abA	89.92 aA	90.34 aA	90.39 aA	2.349
Gemlik	83.63 dA-C	84.28 cdA-C	84.99 b-dB-D	85.93 a-dBC	86.45 a-cBC	86.51 a-cAB	86.86 abAB	87.07 abAB	86.98 abBC	87.59 aBC	2.336
Kar. Su	80.96 fB-D	82.78 efBC	83.60 d-fDE	84.36 c-eC	85.07 b-eC	86.18 a-dAB	86.91 a-cAB	87.48 abAB	88.49 aAB	88.87 aAB	2.795
Memecik	84.26 cAB	87.09 bAB	87.94 abA-C	88.44 abAB	89.00 abAB	89.08 abA	89.12 abA	89.46 aA	89.77 aAB	90.06 aAB	2.356
Samanli	78.88 bCD	82.59 abBC	84.38 aC-E	84.39 aC	83.97 aCD	84.95 aBC	85.00 aBC	85.54 aBC	85.41 aCD	85.55 aCD	4.990
Uslu	79.12 dB-D	80.16 cdC	80.97 b-dE	81.53 b-dD	81.81 a-cD	81.93 a-cC	81.99 a-cC	82.01 a-cD	83.40 abD	84.18 aD	2.524
MSD	5.151	5.297	3.878	2.821	3.224	3.959	3.439	3.514	3.001	2.724	

Data are the means of 3 replicates. Values followed by different capital letters are significantly different on cultivars in same harvest date at $P<0.01$.

[a]1st harvest date: 15th Sept. 2014; 2nd harv. date: 25th Sept. 2014; 3rd harv. date: 8th Oct. 2014; 4th harv. date: 20th Oct. 2014; 5th harv. date: 30th Oct. 2014; 6th harv. date: 10th Nov. 2014; 7th harv. date: 20th Nov. 2014; 8th harv. date: 1st Dec. 2014; 9th harv. date: 11th Dec. 2014; 10th harv. date: 22nd Dec. 2014.

[b]MSD: minimum significant difference on Tukey multiple range test by $p<0.01$. NS: not significant.

Table 4. Changes of palmitic acid (C16:0) and palmitoleic acid (C16:1) on oils of olive cultivars affected by harvest date.

Harvest date	Palmitic acid (C16:0)								Palmitoleic acid (C16:1)							
	Ayv	Dom	Ed. Su	Gem	Kar. Su	Mem	Sam	Uslu	Ayv	Dom	Ed. Su	Gem	Kar. Su	Mem	Sam	Uslu
15th Sept.	15.52 a	14.36 a	19.83 a	16.33 a	15.45 a	16.34 a	16.02 a	17.57 a	0.87 f	2.48 a	2.07 a	3.14 a	3.86 a	1.51 a	2.57 a	2.51 a
25th Sept.	15.08 b	14.19 a	18.77 b	16.09 ab	14.86 a	14.58 b	13.91 b	15.79 b	1.18 ef	2.39 a	1.89 ab	2.69 b	3.11 b	1.42 a	2.41 ab	2.37 ab
8th Oct.	14.50 c	13.95 a	17.46 c	15.84 b	13.36 b	13.96 c	13.45 bc	14.12 c	1.23 e	2.15 ab	1.60 bc	2.15 c	2.28 c	1.09 b	2.28 a-c	2.04 bc
20th Oct.	13.88 d	12.81 b	17.00 cd	15.73 b	13.23 b	13.33 d	13.23 bc	13.54 c	1.50 de	1.84 bc	1.50 b-d	2.01 c	2.13 cd	0.92 bc	2.21 a-c	1.72 cd
30th Oct.	13.11 e	11.90 c	16.45 de	15.23 c	12.60 bc	12.14 e	12.81 c	12.42 d	1.59 cd	1.54 cd	1.32 c-e	1.56 d	2.00 cd	0.71 cd	2.15 bc	1.49 de
10th Nov.	12.24 f	11.16 d	15.81 e	14.92 c	12.14 cd	11.42 f	11.64 d	11.94 d	1.81 b-d	1.24 de	1.28 c-e	1.42 d	1.88 cd	0.66 de	2.13 bc	1.23 ef
20th Nov.	11.88 f	10.84 de	14.50 f	14.36 d	11.47 de	11.17 f	11.43 d	10.88 e	1.90 bc	1.20 de	1.11 d-f	1.38 d	1.67 d	0.62 de	1.96 cd	1.09 e-g
1st Dec.	11.04 g	10.25 ef	13.99 f	12.30 e	10.94 ef	11.54 ef	11.02 de	10.24 ef	2.01 ab	1.06 de	1.08 d-f	1.24 de	1.03 e	0.58 de	1.57 de	0.87 f-h
11th Dec.	10.77 g	9.84 f	13.30 g	12.11 e	10.21 f	9.80 g	10.81 de	9.49 f	2.12 ab	1.03 de	0.99 ef	0.99 e	0.67 ef	0.50 de	1.30 ef	0.69 gh
22nd Dec.	10.66 g	9.76 f	12.27 h	11.90 e	9.18 g	9.55 g	10.27 e	8.62 g	2.35 a	0.84 e	0.71 f	0.61 f	0.32 f	0.44 e	1.12 f	0.60 h
MSD	0.429	0.680	0.644	0.454	0.936	0.608	0.885	0.839	0.345	0.523	0.459	0.367	0.574	0.245	0.412	0.442

Data are the means of 3 replicates. Means that do not share a letter are significantly different in same cultivar (p<0.01).

Table 5. Changes of stearic acid (C18:0) and oleic acid (C18:1) on oils of olive cultivars affected by harvest date.

Harvest Date	Stearic acid (C18:0)								Oleic acid (C18:1)							
	Ayv	Dom	Ed. Su	Gem	Kar. Su	Mem	Sam	Uslu	Ayv	Dom	Ed. Su	Gem	Kar. Su	Mem	Sam	Uslu
15th Sept.	2.97 a	4.31 a	2.97 a	4.63 a	5.94 a	4.42 a	4.31 a	2.04 a	67.62 d	62.49 f	58.39 f	65.56 g	55.08 f	69.57 e	66.69 h	67.39 h
25th Sept.	2.25 b	4.01 ab	2.78 a	4.02 b	4.85 b	4.24 a	4.00 ab	1.90 ab	67.59 d	63.15 ef	59.03 f	66.44 f	57.47 e	71.54 d	69.21 g	68.42 g
8th Oct.	2.05 bc	3.91 a-c	2.39 b	3.84 b	3.55 c	2.47 b	3.75 bc	1.73 bc	67.81 d	63.47 e	60.39 e	67.62 e	60.54 d	74.16 bc	70.18 f	69.24 f
20th Oct.	1.74 cd	3.75 a-d	2.26 bc	2.84 c	3.40 c	2.39 bc	3.57 c	1.55 cd	68.20 d	64.40 d	61.00 de	68.71 d	60.74 d	74.49 bc	70.74 ef	70.08 e
30th Oct.	1.62 d	3.68 b-d	2.18 b-d	2.76 c	3.39 c	2.30 bc	2.86 d	1.39 de	68.94 c	65.91 c	61.63 d	69.88 c	61.31 d	74.61 bc	71.62 e	71.49 d
10th Nov.	1.55 d	3.51 b-e	2.16 b-e	2.56 cd	3.37 c	2.21 cd	2.57 de	1.23 ef	69.63 b	66.46 bc	61.85 d	70.52 bc	61.28 d	74.96 ab	72.94 d	72.16 c
20th Nov.	1.44 de	3.35 c-e	2.03 c-e	2.21 de	2.39 d	2.36 bc	2.39 ef	1.22 ef	70.01 b	67.03 b	63.00 c	70.86 ab	62.87 c	73.87 bc	73.33 cd	72.74 bc
1st Dec.	1.14 ef	3.20 de	1.99 d-f	2.04 e	2.27 d	1.97 de	2.14 fg	1.12 fg	70.87 a	68.00 a	63.47 bc	70.96 ab	63.97 bc	73.68 bc	74.02 bc	73.37 b
11th Dec.	1.03 f	3.05 e	1.90 ef	1.46 f	2.09 d	1.82 ef	1.90 g	1.00 g	71.05 a	68.13 a	64.18 b	71.06 ab	64.96 b	75.78 a	74.31 ab	74.27 a
22nd Dec.	0.98 f	2.97 e	1.74 f	1.09 f	1.59 d	1.72 f	1.43 h	0.94 g	70.74 a	68.51 a	65.27 a	71.49 a	66.80 a	76.03 a	74.98 a	74.92 a
MSD	0.345	0.569	0.268	0.428	0.866	0.242	0.411	0.193	0.656	0.852	1.086	0.655	1.353	1.161	0.891	0.659

Data are the means of 3 replicates. Means that do not share a letter are significantly different in same cultivar (p<0.01).

Table 6. Changes of linoleic acid (C18:2) and linolenic acid (C18:3) on oils of olive cultivars affected by harvest date.

Harvest date	Linoleic acid (C18:2)								Linolenic acid (C18:3)							
	Ayv.	Dom.	Ed. Su	Gem.	Kar. Su	Mem.	Sam.	Uslu	Ayv	Dom	Ed. Su	Gem	Kar. Su	Mem	Sam	Uslu
15th Sept.	10.30 h	14.39 d	13.46 h	7.38 g	16.96 g	5.38 h	7.70 e	8.17 g	0.84 a	0.62 a	1.02 a	1.06 a	1.08 a	1.11 a	0.94 a	0.80 a
25th Sept.	11.33 g	14.45 d	14.53 g	7.96 f	17.41 fg	5.74 g	8.09 e	9.39 f	0.81 ab	0.59 ab	0.96 a	1.04 a	1.04 a	0.98 ab	0.91 ab	0.73 ab
8th Oct.	12.00 f	14.79 d	15.70 f	8.03 f	18.23 ef	6.01 g	8.21 e	10.92 e	0.77 ab	0.57 ab	0.91 ab	1.01 a	1.01 ab	0.94 b	0.88 a-c	0.68 a-c
20th Oct.	12.39 e	15.65 c	15.94 f	8.25 ef	18.62 e	6.89 f	8.34 e	11.37 de	0.73 a-c	0.54 a-c	0.88 a-c	0.99 a	1.01 ab	0.72 c	0.85 a-c	0.62 a-d
30th Oct.	12.56 de	15.48 c	16.55 e	8.38 ef	19.03 de	8.36 e	9.14 d	11.71 de	0.70 a-c	0.52 a-c	0.74 b-d	0.81 b	1.00 ab	0.71 c	0.80 a-d	0.53 b-d
10th Nov.	12.76 d	16.21 b	17.09 d	8.58 e	19.82 cd	9.07 d	9.41 d	12.07 cd	0.67 a-c	0.48 b-d	0.72 cd	0.75 b	1.00 ab	0.68 c	0.77 a-e	0.48 c-f
20th Nov.	12.86 cd	16.25 b	17.99 c	9.32 d	20.04 bc	10.37 c	9.69 cd	12.85 bc	0.64 bc	0.43 cd	0.63 de	0.73 bc	0.99 ab	0.65 c	0.74 b-e	0.43 d-f
1st Dec.	13.17 c	16.50 b	18.18 bc	11.52 c	20.39 a-c	10.64 bc	10.31 bc	13.38 b	0.57 cd	0.37 d	0.57 d-f	0.72 bc	0.89 ab	0.66 c	0.70 c-e	0.38 ef
11th Dec.	13.51 b	17.12 a	18.54 b	12.53 b	20.79 ab	10.78 ab	10.94 ab	13.63 ab	0.46 d	0.24 e	0.46 ef	0.70 bc	0.77 ab	0.61 c	0.64 de	0.34 ef
22nd Dec.	13.89 a	17.28 a	19.09 a	13.35 a	21.09 a	11.03 a	11.62 a	14.19 a	0.45 d	0.19 e	0.42 f	0.57 c	0.62 b	0.58 c	0.58 e	0.26 f
MSD	0.321	0.546	0.471	0.497	0.901	0.359	0.756	0.804	0.171	0.124	0.186	0.174	0.413	0.169	0.192	0.233

Data are the means of 3 replicates. Means that do not share a letter are significantly different in same cultivar (p<0.01).

Table 7. Change of ratio of MUFA and PUFA on oils of olive cultivars affected by harvest date.

Harvest date	Mono unsaturated fatty acid (%)								Poly unsaturated fatty acid (%)							
	Ayv	Dom	Ed. Su	Gem	Kar. Su	Mem	Sam	Uslu	Ayv	Dom	Ed. Su	Gem	Kar. Su	Mem	Sam	Uslu
15th Sept.	69.19	65.35	61.13 g	69.22	59.52 e	71.68	69.95 d	70.36	11.14 g	15.01 f	14.48 g	8.44 f	18.04 e	6.49 g	8.64 f	8.97 f
25th Sept.	69.46	65.88	61.54 fg	69.65	60.96 e	73.50	72.21 c	71.23	12.14 f	15.04 f	15.49 f	9.00 ef	18.45 de	6.72 fg	9.00 f	10.12 e
8th Oct.	69.70	65.94	62.42 e-g	70.25	63.07 d	75.78	72.97 bc	71.70	12.77 e	15.36 f	16.61 e	9.04 ef	19.24 cd	6.95 f	9.09 f	11.60 d
20th Oct.	70.33	66.53	62.88 d-f	71.20	63.01 cd	75.90	73.38 b	72.12	13.12 de	16.19 de	16.82 de	9.24 e	19.63 c	7.61 e	9.19 ef	11.99 d
30th Oct.	71.13	67.72	63.22 c-e	71.95	63.31 cd	75.81	74.00 b	73.30	13.26 d	16.00 e	17.29 cd	9.19 e	20.03 bc	9.07 d	9.94 de	12.24 d
10th Nov.	71.99	67.96	63.39 c-e	72.42	63.16 cd	76.08	75.28 a	73.70	13.43 cd	16.69 cd	17.81 c	9.33 e	20.82 ab	9.75 c	10.18 d	12.55 cd
20th Nov.	72.43	68.46	64.30 b-d	72.75	64.54 bc	74.91	75.45 a	74.12	13.50 cd	16.68 cd	18.62 b	10.05 d	21.03 a	11.02 b	10.43 cd	13.28 bc
1st Dec.	73.36	69.21	64.74 a-c	72.80	65.00 b	74.66	75.59 a	74.52	13.74 bc	16.87 bc	18.75 b	12.24 c	21.28 a	11.30 ab	11.01 bc	13.76 ab
11th Dec.	73.46	69.31	65.34 ab	72.58	65.63 ab	76.62	75.61 a	75.23	13.97 ab	17.36 ab	19.00 ab	13.23 b	21.56 a	11.39 ab	11.58 ab	13.97 ab
22nd Dec.	73.59	69.41	66.13 a	72.57	67.12 a	76.78	76.10 a	75.73	14.34 a	17.47 a	19.51 a	13.92 a	21.71 a	11.61 a	12.20 a	14.45 a
MSD	NS	NS	1.673	NS	1.527	NS	1.119	NS	0.433	0.551	0.647	0.646	0.948	0.371	0.791	1.015

Data are the means of 3 replicates. Means that do not share a letter are significantly different in same cultivar (p<0.01). NS: not significant.

Concentration of stearic acid (C18:0) level was decreased owing to saturated fatty acids turned into unsaturated fatty acids during maturation (Table 5). Therefore 'Domat' cultivar (2.97%) had the highest stearic acid ratio at the end of the study while Uslu (0.94%) and 'Ayvalik' cultivar (0.98%) had the lowest ratio.

Oleic acid (C18:1) is the major fatty acid of olive oils. Ratio of oleic acids showed increase in all olive cultivars during maturity (Table 5). Oleic acid content of tested cultivars varied from 55.08% ('Karamursel Su') to 69.57% ('Memecik') in the first harvest period and from 65.25% ('Edincik Su') to 76.03% ('Memecik') in the last stage of ripening. As a result of study, oleic acid ratio had lower in table olive cultivars.

Linoleic acid (C18:2) increased during ripening (Table 6). It was determined that linoleic acid varied from 5.38 to 14.39% in the beginning of the research and ranged between 21.09% and 11.03% at the end of the study. Linoleic acid showed higher rate in table cultivars such as 'Karamursel Su' and 'Edincik Su' had the highest linoleic acid ratio.

Linolenic acid (C18:2) decreased during maturation on the fruits of tested cultivars (Table 6). Linolenic acid ratio of tested cultivars varied from 1.11% ('Memecik') to 0.62% ('Domat') in the first harvest period of the study and it was ranged between 0.62% ('Karamursel Su') and 0.19% ('Domat') in the last stage of ripening.

Gutiérrez et al. (1999), explained that decrease of palmitic acid to a dilution effect caused by constant quantity. Rising of oleic acid, increased by the active triglyceride biosynthesis, and linoleic acid, produced by oleat desaturase enzyme reaction, resulting in a reduction of the relative amount of palmitic acid bound to the triglycerides. As a result of this study, linolenic and palmitic acid contents of the olive oil decrease while oleic and linoleic acid increases during maturation.

The chemical structure of olive oil consists of saturated and poly unsaturated fatty acids (15-15%) and mainly mono unsaturated fatty acids (70%). It is important for oxidative stability for olive oil. Consequently, olive cultivars for oil production purpose such as 'Ayvalik' and 'Uslu' cultivars have less PUFA and high MUFA ratio. It was observed that both of MUFA and PUFA ratios increased while the olive fruits ripened, whereas proportion of saturated fatty acids decreased. MUFA content of tested cultivars varied from 71.68% ('Memecik') to 59.52% ('Karamursel Su') in the first harvest period and it was ranged between 66.13% ('Edincik Su') and 76.78% ('Memecik') in the last stage of ripening (Table 7). Table olive cultivars such as 'Edincik Su', 'Karamursel Su' and 'Domat' showed lowest MUFA ratios in the whole of harvest dates.

'Karamursel Su' cultivar had the highest PUFA ratio (18.04%) in the beginning of the research, although 'Memecik' cultivar had the lowest PUFA ratio (6.49%). Similar to the MUFA content, PUFA was ranged between 21.71% ('Karamursel Su') and 11.61% ('Memecik') in the last stage of ripening (Table 7). Table olive cultivars such as 'Edincik Su', 'Karamursel Su' and 'Domat' showed highest PUFA ratios in the whole of harvest dates.

Olive oil contains more oleic acid and less linoleic and linolenic acids than other vegetable oils, that is, more monounsaturated than polyunsaturated fatty acids. This renders olive oil more resistant to oxidation because generally, the greater the number of double bonds in the fatty acid, the more unstable and easily broken down by heat, light, and other factors the oil is (Anonymous, 2018).

CONCLUSIONS

During the ripening process of olives, fruit weight, flesh ratio, maturity index increased in all tested cultivars. On the other side, 'Domat' cultivar had the largest fruits and also 'Edincik Su' had the highest pulp ratio in all harvest periods.

This study shows that the fatty acid compositions of the olive oils vary widely, depending primarily on the cultivar but also on the degree of fruit ripening. It was determined that genetic factors were affected the differences of pomological characters and fatty acid composition of olive varieties, because of olive cultivars grown under same conditions and same ecology.

Fatty acid analysis at various stages of maturity indicated that individual fatty acids vary considerably in proportion during fruit development. This is of importance to olive oil

producers in selecting oil with good stability and a superior nutritional fatty acid profile. Olive oil is considered to be highly nutritional oil due, in part, to the high level of monounsaturated oleic acid (Faine et al., 2006).

Olive oil is more stable to oxidation than other vegetable oils due to includes low linolenic acid. However 'Edincik Su', 'Karamursel Su' and 'Domat' cultivars were determined higher rate with respect to poly unsaturated fatty acids (PUFA) such as linoleic acid than other cultivars, mono unsaturated fatty acids (MUFA) such as oleic acid determined lower percentage. Therefore olive oils obtained by 'Edincik Su', 'Karamursel Su' and 'Domat' cultivars were oxidized faster and easier than other cultivars olive oils.

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