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INVESTIGACIÓN

Characterization by chemometry of the most important domestic and foreign olive cultivars from the National Olive Collection Orchard of Turkey

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RESUMEN

Caraterización por quimiometria de las variedades más importantes de aceitunas autóctonas y foráneas procedentes de la Colección Nacional de Cultivos de Aceituna de Turquía.

En este estudio, doce muestras de diferentes variedades de aceituna autóctonas (Memecik, Uslu, Domat, Ayvalik, Çelebi, Memeli, Erkence, Gemlik, Çakir, İzmir Sofralik, Çekişte y Çilli) y nueve muestras de diferentes variedades foráneas (Picholine, Arbequnia, Hojiblanca, Manzanilla, Frontoio, Leccio, Saurani, Baroui and Meski) fueron investigadas. Todas las muestras de aceitunas fueron obtenidas del National Olive Collection Orchard de Kemalpaşa – İzmir, Turquía. Los parámetros básicos cualitativos (acidez, valor de peróxidos e índices espectrofotométrico), escala de color y perfil de ácidos grasos fueron determinados en aceites de oliva virgen obtenidos de las aceitunas de las variedades autóctonas y foráneas, cultivadas en las mismas condiciones pedoclimáticas. Variaciones grandes fueron observadas entre todas las variedades, a pesar de que todas las variedades fueron cultivadas en las mismas condiciones pedoclimáticas. Los aceites extraidos de las 21 muestras obtenidas de variedades autóctonas y foráneas de aceitunas del National Olive Genetic Bank de Turquia fueron clasificados mediante métodos estadísiticos multivariante (ACH) basado en el perfil de ácidos grasos. De acuerdo a los resultados del HCA (método Euclidiano), los aceites obtenidos de las variedades autóctona y foráneas fueron separadas en tres y dos grupos, respectivamente.

PALABRAS CLAVE: Aceite – Ácido graso – Caracterización – Colección nacional – Quimiometría – Turquía – Variedades aceituna.

SUMMARY

Characterization by chemometry of the most important domestic and foreign olive cultivars from the National Olive Collection Orchard of Turkey.

In this study, twelve samples from domestic olive cultivars (Memecik, Uslu, Domat, Ayvalik, Çelebi, Memeli, Erkence, Gemlik, Çakir, İzmir Sofralik, Çekişte and Çilli) and nine samples from foreign olive cultivars (Picholine, Arbequnia, Hojiblanca, Manzanilla, Frontoio, Leccio, Saurani, Baroui and Meski) were investigated. All olive samples were collected from the National Olive Collection Orchard at Kemalpaşa – İzmir, Turkey. Basic qualitative parameters (free fatty acidity, peroxide value and spectrophotometric indexes), color scale and fatty acid profiles were determined in virgin olive oils obtained from domestic and foreign olive cultivars growing in the same pedoclimatic conditions. Large variations were observed among the cultivars, despitethe fact that the cultivars are planted in the same pedoclimatic conditions. Oils extracted from 21 samples obtained from domestic and foreign olive cultivars in the National Olive Genetic Bank of Turkey were classified with the multivariete stastistical method (Hierarchical Cluster Analysis, HCA) based on their fatty acid profiles. According to the HCA results (Euclidian method), the oils obtained from the domestic and foreign cultivars were separated into two and three groups, respectively.

KEY-WORDS: Characterization – Chemometry – Fatty acid – National collection – Oil – Olive cultivars – Turkey.

1. INTRODUCTION

Olives (*Olea europaea* L.) are one of the most important crops in Mediterranean countries, especially Spain, Italy, Greece and Turkey. Virgin olive oil, the main oil used in the Mediterranean diet, is produced using physical methods from the fruits of several cultivars of olive tree. Each one of these cultivars exhibits specific physical and biochemical characteristics, providing the oils with different compositions. (Boskou 1996; Kiritsakis 1998).

The olive tree originated in upper Mesopotamia and the south of Asia. Olives have been grown in Turkey for over 8000 years according to archeological evidence. It has been reported that one of the olive's origin centers is the southeastern part of Turkey, especially the area sorrounded by the Hatay, Mardin and Maraş provinces in the Southeastern Anatolia region of Turkey (Özilbey and Sefer 2008). For this reason, the olive has spread within a wide ecology and has considerable richness in the number of its cultivars in Turkey. Besides the cultivars suitable for oil and table use, there are some others not having any economical importance (Canözer,1991). With the aim of determining the olive germplasm of

Turkey, a large – scale survey was carried out in the olive growing areas of the country in 1968 and 88 domestic cultivars constituting Turkey's olive genetic sources were determined and preserved in an olive gene bank. A collection orchard and propagation area were established on the reasarch institute at Kemalpaşa in 1969. 28 foreign cultivars were added to this collection orchard by grafting their sections on seedlings in the years of 1971 and 1972 (Özilbey and Sefer 2008). A total of 28 Turkish olive varieties and 26 foreign olive cultivars were registered by the Ministry of Agriculture and Rural Affairs of Turkey in 1990, based on their pomological and morphological parameters (Anonymous 1990).

Turkey is the world's fifth largest producer of olive oil and uses different olive varieties for oil production. There are many well known local olive cultivars used for oil in Turkey, many of which are region specific. The economically important Turkish olive cultivars include Ayvalik, Memecik, Memeli, Domat, Gemlik, Erkence, Nizip Yaglik, Kilis Yaglik and Uslu. The aim of the present study is to characterize the most important Turkish and foreign olive cultivars cultivated in the same pedoclimatic conditions in the National Olive Collection of Turkey, Kemalpaşa – İzmir, based on fatty acid profile and other chemical data. Although some studies was reported on the chemical characterization of the most important Turkish olive cultivars (Ersoy *et al*. 2001; Tous *et al*., 2005; Köseoğlu *et al*. 2006; Saygin and Yemişçoğlu 2007; Gürdeniz *et al*. 2008; Kıralan *et al*. 2009; Andjelkovic *et al*. 2009), there is limited or no information available on the comparasion between domestic and foreign cultivars from the National Olive Collection Orchard of Turkey. A series of three analytical determinations were done to determine the chemical profiles of domestic and foreign olive cultivars. The analytical determinations were quality indexes defined by EEC regulations and COI norms which are free fatty acid content (FFA), peroxide value (PV), and UV spectrophotometric characteristics. The fatty acid (FA) profile of domestic and foreign olive cultivars in the National Collection Orchard were subjected to the Hierarchical Cluster (HC) analysis, aimed at establishing differences in FA profiles according to the olive cultivars.

2. MATERIALS AND METHODS

2.1. Plant Material and Oil Extraction

Material

Twelve olive samples from the domestic olive cultivars Memecik, Uslu, Domat, Ayvalik, Çelebi, Memeli, Erkence, Gemlik, Çakir, İzmir Sofralik, Çeki te and Çilli were analyzed. Also, nine samples from the foreign olive cultivars Picholine, Arbequnia, Hojiblanca, Manzanilla, Frontoio, Leccio, Saurani, Baroui and Meski were examined. All of the olive samples were manually collected from the National Olive Collection Orchard at Kemalpaşa – İzmir, Turkey in the 2002 – 2003 harvest season (22 – 24 December, 2002). Each cultivar was represented with five or seven trees in the plot . The intevals between the trees were 9 x 9 m. The olive samples was taken from four trees for each cultivar (n= 4). These samples were divided into two main groups as domestic (Turkey) and foreign based on olive cultivation origin. Oils from olive samples were extracted using the Abencor extraction (MC2 Ingenierias y Sistemas, Sevilla – Spain) process. This process, as a small laboratory model of the three phase continuous centrifugation system, determines the industrial yield of the olive based on experimental scale. The apparatus consists of three essential elements, the mill, the malaxor, a number of auxiliary ones and the pulp centrifuge. The processing steps of the Abencor centrifugation method are as follows:

1. Removal of leaves and cleaning of olives (700 g). 2. Milling (by a hammer mill). 3. Malaxation (700 g of olive paste, 20 min at 30°C). 4. Centrifuging of olive paste (5 min, 1500 rpm). 5. Pomace and oily must (olive juice +olive oil). 6. Decanting (the liquid phase into a cylinder to decant for 15 min). 7. Virgin olive oil and vegetable water (olive juice).

200 ml of oil from the olives of each tree were placed in a dark glass bottle and stored in a refrigerator until analysis.

The country of origin and harvest properties of domestic and foreign olive cultivars are shown in Table 1.

2.2. Analytical Methods

Quality Parameters

Determinations of free fatty acids (FFA), peroxide values (PV) and UV absorption characteristics were carried out following the analytical methods described in Regulation EEC/2568/91 and EE/1429/92 of the European Union Commission Regulations. Free fatty acidity (FFA), given as a percent of oleic acid, was determined by titration of a solution of oil dissolved in 1:1 ethanol:ether with ethanolic potash. Peroxide value (PV), expressed in milliequivalents of active oxygen per kilogram of oil (meq O2/kg oil), was determined by reacting oil and 3:2 chloroform:acetic acid with potassium iodide in the dark. The free iodine was then titrated with a thiosulfate solution. K 232 and K 270 extinction coefficients were calculated from UV absorption at 232 and 270 nm, respectively, collected on a UV spectrophotometer (Carry 50 UV-Vis, Varian Inc, Australia), using a 1 % solution of oil in cyclohexane and path length of 1 cm.

Color Determination

Virgin olive oil color was determined according to the quick method for the definition and classification of the color of virgin olive oils [21]. The 60 standard solutions for the color determination were prepared with increasing volumes of 0.04 % bromthymol blue (BTB) in KH2PO4 1/15 M and Na2 PO4 1/15 M

Table 1
The list of domestic and foreign olive cultivars, their geographical origins, phenological properties during harvest and commercial daily use

Cultivar and Their Codes	Origin	Phenological properties	Use
	Domestic Cultivars		
1. Memecik (MCK)	Turkey (Milas - Muğla)	Pink	Oil + Table
2. Uslu (US)	Turkey (Akhisar - Manisa)	Black	Table
3.Domat (DMT)	Turkey (Akhisar - Manisa)	Green	Table
4. Ayvalık (AY)	Turkey (Edremit - Balikesir)	Black	Oil
5. Çelebi (ÇLB)	Turkey (İznik- Bursa)	Black	Table
6. Memeli (MML)	Turkey (Memeli - Izmir)	Black %30 +Violet 70 %	Oil + Table
7. Erkence (EKC)	Turkey (İzmir Peninsula)	Black 60 % + Violet 40 %	Oil
8. Gemlik (GMK)	Turkey (Gemlik – Bursa)	Black	Oil + Table
9. Çakır (ÇKR)	Turkey (Izmir)	Violet 50% + Green 50 %	Oil + Table
10. Izmir Sofralık (IZSF)	Turkey (İzmir)	Green 50 % + Violet 50 %	Table
11. Çekişte (ÇKŞ)	Turkey (Odemiş - İzmir)	Green 50 % +Black 50 %	Table
12. Çilli (ÇL)	Turkey (Kemalpaşa- İzmir)	Green 85 % +Violet 15 %	Table
	Foreign Cultivars		
13. Picholine (PCH)	France	Green	Table + Oil
14. Arbequina (ABQ)	Spain (Catolonia)	Geen 30 % +Violet 30 % + % 40 Black	Oil
15. Hojiblanca (HJB)	Spain (Andalusia)	Green 80 % + Violet 20 %	Oil
16. Manzanilla (MNZ)	Spain (Andalusia)	Green	Oil + Table
17. Frantoio (FRT)	Italy (Tuscany)	Black	Oil
18. Leccio (LC)	Italy (Tuscany)	Black	Oil
19. Saurani (SAU)	Syria	Green / Violet 15 % + Black 85 %	Oil + Table
20. Baroui (BDR)	Tunisia	Green / Violet % 10 + Black 90 %	Oil
21. Meski (MSK)	Tunisia	Black	Table

solutions, according to the established procedure of Gutiérréz and Gutiérréz (1986). The BTB standard was stored in the dark at 20 °C.

Fatty Acid Composition

The cis–*trans* fatty acid contents were determined using a capillary gas chromatographic method described in the European Union Commission. Fatty acid methyl esters (FAMEs) were prepared by saponification/methylation with sodium methylate according to a cold methylation method (Dıraman and Hışıl 2004). The methyl esters of fatty acid were prepared by viogrous shaking of a solution of oil in hexane (0.2 g in 3 ml) with 0.4 ml of 2N methanolic potassium hydroxide. Fatty acid analyses were carried out by gas chromatography (HP 6890) using a DB-23 capillary column (30 m x 0.25 mm ID and 0.25 µm film thickness % 50 cyanopropyl, J & W Scientific, Folsom, CA, USA). A controlled oven temperature program was used. The oven temperature ranged from 170°C to 210°C with an increase of 2°C / min and then held at 210°C for 10 min. The carrier gas was helium (0.5 ml / min) and the injector and detector (FID) temperatures were 250°C. The spilt ratio was 1:100 and the injected volume was 0.2 ml. The identification of FAMEs was performed by comparing each sample to a standard FAMEs reference mixture (Sigma-Aldrich Co.,St. Louis, USA). The squalene analysis was determined from the squalene that appeared in the fatty acid

chromatogram. All fatty acid peak areas were calculated by the HP 3365 Chemistation program and recorded as the peak area percentage (Dıraman and Hışıl 2004; EEC 2002).

Iodine values (IV) were calculated from fatty acid percentages using the following formula (Kamal – Eldin, 2006):

IV = (% Monounsaturated Fatty acids x 0.860) + (% Linoleic x 1.732) + (% Linolenic x 2.616)

2.3. Statistical and Multivariate Analysis

Data of olive cultivars (n=4) were presented as mean ± Standard deviation (SD) and were subjected to analysis of variance (ANOVA). Among groups, significant means were compared by Tukey's multiple range tests at a =0.05 level (n – 1= 20). A statistical analysis was performed using the SPSS 10 statistics software (SPSS 2001). Characterization and classification of of the oils from domestic and foreign olive cultivars from the National Olive Collection Orchard of Turkey were carried out in terms of the widely used chemometric method (Angerosa *et al*. 2000), Hierarchical Cluster Analysis (HCA, Euclidian Distance). Multivariate analysis was performed using the SPSS (SPSS 2001).

3. RESULTS AND DISCUSSION

3.1. Free Fatty Acids, Peroxide Value, UV Spectrophotometric Indexes

The results for free fatty acid (FFA), peroxide value (PV), UV coefficients, color scale and squalene percentage are shown in Table 2. FFA values among domestic cultivars were between 0.26 % and 0.89 % as oleic acid (Table 2) while the values ranged from 0.18 % to 0.60 % oleic acid in foreign cultivars (Table 3). FFA has been used traditionally as a basic commercial criterion for grading olive oil. Considering that the acidity values are the result of the lipolytic action of enzymes present in the fruit, it is clear that Erkence and Meski were the most susceptible cultivars to this action. Whenever possible, these olives must be processed directly after harvest.

The peroxide values (PV) in domestic cultivars ranged from 4.00 to 12.59 meq O2 / kg oil and these values for foreign cultivars were between 3.56 to 10.43 meq O2 / kg oil; where all of the total samples had values below 20 meq O2 / kg oil; which is the limit given by the International Olive Oil Council (IOOC 2003) and the Turkish Food Codex (2007). FFA and PV values of all the analysed samples in this study were lower than those suggested by the IOOC (2003) and the Turkish Food Codex (2007) because of rapid oil extraction by the small scale extraction system (Abencor) without olive storage after harvesting.

The ultra violet (UV) absorption values, K 232 and K 270, for domestic cultivar samples were 1.27 – 3.38 and 0.06 – 0.28, respectively, whereas the values for foreign cultivars ranged from 1.45 – 2.46 and 0.12 – 0.21, respectively. The UV absorption extinction coefficient at 232 nm (K 232), is related to the primary oxidation of oil and is indicative of the conjugation of PUFAs. K 270 is an indication of carbonylic compounds, aldehydes and ketones and is related to secondary oxidation products (Boskou 1995; Kiritsakis 1998). The UV absorption values allow an approximation of the oxidation of unsaturated oils. The UV absorption extinction coefficients, particularly K 270, were all below the limits established for extra virgin olive oils by IOOC (2003) and the Turkish Food Codex (2007). The oils of domestic cultivars were classified as extra virgin (9/12 or 75 % with K 270 $\leq$ 0.22), and ordinary (3/12 or 25 % with K 270 $\leq$ 0.33) olive oils while all of foreign cultivar samples were classified as extra virgin (9/9 or 100 % with K 270 $\leq$ 0.22) oils. The differences in UV absorptions, K 232 and K 270 coefficients, may be affected by cultivar, fruit quality, harvest time, oil extraction technique and storage conditions of the fruits after olive harvest (Gutiérréz et al., 1999; Ait Yacine et al. 2003; Andelkovic et al. 2009).

Quality indexes, FFA, PV, extinction coefficients (K_{232} and K_{270}), of domestic and foreign olive cultivar oils were in agreement with those of monocultivar oils collected from different locations of Turkey (Köseoğlu *et al*. 2006; Gürdeniz *et al*. 2008; Andelkovic *et al*. 2009; Kıralan *et al*. 2009), the analytical results of the survey on the regional characterization of the most important Turkish olive oil cultivars including Ayvalik, Memecik, Gemlik, Uslu, Nizip Yaglik and Erkence (Saygın and Yemişçioğlu 2007) and the data from the adaptation project of Medieterreanean olive cultivars (Ersoy *et al*. 2001). There was a wide distribution in FFA, PV and UV absorption, K_{232} and K_{270} values among samples. The variation and significant ($P < 0.05$) differences were determined among the parameters FFA, PV, K_{232} and K_{270} of the oil samples, according to the results of the Tukey Multiple Range Test (Table 2). The variation in quality parameters may be due to agronomic and post-harvest conditions. Low FFA, PV, K_{232} and K_{270} values in the virgin olive oils depend on high quality fruit and the small scale extraction systems.

3.2. Squalene Content

Olive oil contains the largest amount of squalene, a terpenoid hydrocarbon indicating the sterol and having antioxidant properties, among vegetable oils. The amounts of squalene determined in the oil of domestic samples ranged from 0.35 % (Uslu) to 0.87 % (Domat) whereas the value of foreign samples was found between 0.33 % (Frantoio) and 1.30 % (Manzanilla). The differences in squalene levels in olive oils may originate from varieties and altitude where olive trees are grown (Kiritsakis 1998). These findings are generally in accordance with French olive oils (Ollivier *et al*. 2003), in which the values range from 0.74% to 1.14 %. There were

Table 2
The analytical properties of domestic olive cultivar oils in the National Olive Collection Orchard of Turkey at Kemalpaşa – İzmir (n=4)

Cultivar	FFA (%)	PV (mequiv O_2 / kg)	232 nm	270 nm	ΔE	Color	Squalen (%)
MCK	0.40 c ± 0.02	8.66 b ± 0.22	2.05 e ± 0.02	0.06 a ± 0.02	0.003 a	2 – 1	0.57 c ± 0.09
US	0.50 c ± 0.03	12.59 c ± 0.20	3.38 f ± 0.02	0.28 f ± 0.02	0.010 a	0 – 0	0.35 a ± 0.10
DMT	0.23 a ± 0.04	4.60 a ± 0.45	2.02 e ± 0.02	0.10 bc ± 0.02	0.000 a	2 – 2	0.87 g ± 0.06
AY	0.43 c ± 0.02	6.63 a ± 0.27	1.55 bc ± 0.02	0.08 b ± 0.02	0.002 a	2 – 1	0.59 c ± 0.15
ÇLB	0.40 c ± 0.04	12.94 c ± 0.35	2.57 f ± 0.02	0.29 f ± 0.02	0.011 a	2 – 1	0.69 e ± 0.09
MML	0.67 d ± 0.02	5.06 a ± 0.26	1.27 a ± 0.02	0.10 bc ± 0.02	0.001 a	2 – 1	0.73 e ± 0.08
EKC	0.89 e ± 0.02	10.21 b ± 0.19	1.85 cd ± 0.02	0.16 d ± 0.02	0.002 a	2 – 6	0.47 b ± 0.10
GMK	0.44 c ± 0.02	8.36 b ± 0.36	2.41 f ± 0.02	0.27 ± 0.02	0.007 a	2 – 1	0.79 f ± 0.11
ÇKR	0.28 ab ± 0.02	4.00 a ± 0.22	1.42 ab ± 0.02	0.11 c ± 0.02	0.005 a	2 – 1	0.47 b ± 0.15
IZSF	0.29 ab ± 0.01	8.23 b ± 0.32	2.48 f ± 0.02	0.22 e ± 0.02	0.000 a	2 – 2	0.64 d ± 0.13
ÇKŞ	0.26 a ± 0.02	5.37 a ± 0.39	1.55 bc ± 0.02	0.09 b ± 0.02	0.005 a	2 – 1	0.72 e ± 0.12
ÇL	0.26 a ± 0.02	6.42 a ± 0.42	1.67 c ± 0.02	0.08 b ± 0.02	0.001 a	2 – 2	0.71 e ± 0.12

FFA (Free Fatty Acid, oleic acid%), PV (Peroxide Value meq O_2 / kg).

Table 3
The analytical properties of foreign olive cultivar oils in the National Olive Collection Orchard of Turkey at Kemalpaşa – İzmir (n=4)

Cultivar	FFA (%)	P V (mequiv O_2 / kg)	232 nm	270 nm	ΔE	Color	Squalen (%)
PCH	0.29 c ± 0.02	4.88 c ± 0.48	1.98 c ± 0.01	0.18 c ± 0.01	0.00 a	2 – 2	0.46 b ± 0.10
ABQ	0.50 e ± 0.03	4.20 b ± 0.16	2.14 c ± 0.03	0.17 bc ± 0.03	0.003 a	2 – 3	0.83 d ± 0.08
HJB	0.21 b ± 0.08	5.00 c ± 0.40	2.46 ± 0.00	0.21 d ± 0.02	0.005 a	2 – 2	0.64 c ± 0.13
MNZ	0.21 b ± 0.05	7.50 e ± 0.20	1.85 b ± 0.03	0.12 a ± 0.03	0.005 a	2 – 1	1.30 f ± 0.20
FRT	0.18 a ± 0.08	6.70 d ± 0.50	2.16 c ± 0.04	0.13 a ± 0.02	0.003 a	2 – 1	0.33 a ± 0.07
LC	0.42 d ± 0.05	10.43 f ± 0.45	2.34 d ± 0.04	0.15 b ± 0.03	0.001 a	2 – 3	0.37 a ± 0.08
SAU	0.51 e ± 0.05	3.56 a ± 0.45	1.47 a ± 0.02	0.17 bc ± 0.03	0.000 a	2 – 2	1.02 e ± 0.15
BDR	0.40 d ± 0.03	6.87 d ± 0.35	1.79 b ± 0.04	0.16 b ± 0.04	0.000 a	2 – 2	0.88 d ± 0.14
MSK	0.60 f ± 0.07	4.00 a ± 0.35	1.45 a ± 0.02	0.12 a ± 0.01	0.020 b	2 – 3	0.69 c ± 0.18

FFA (Free Fatty Acid, oleic acid%), PV (Peroxide Value meq O_2 / kg).

significant differences among the squalene levels of the olive cultivars (Table 3, 4).

3.3. Color determination

The color scale changes in oils of domestic and foreign cultivar samples were between (2/1 – 2/6) and (2/1 – 2/3), respectively. No significant color differences in the oil from a single cultivar have been noted among Turkish olive cultivars, inculuding Ayvalik, Memecik, Domat, Uslu and Erkence from different locations, in two maturity stages (Acar and Ersoy 1996). The data on the color changes were generally similar to the results of these researchers. The color of olive oil is a visual quality indicator for consumers. It may vary among olive oils extracted at different times. The pigments (chlorophylls, pheophytins, xantophylls and carotenes), mostly present in the olive fruit at harvest time, are mainly responsible for the color of the olive oil. As maturity advances, the color of the olive oil turns from light green to golden – yellow and overripe fruit gives olive oil a green to light brown color due to the presence of pheophytins. (Kiritsakis 1998).

3.4. Fatty Acid Composition

The fatty acid (FA) composition is a quality parameter and authenticity indicator of virgin olive oils. As shown in Tables 4 and 5, numerous cis – *trans* isomers of fatty acids were detected in the oil samples produced from important domestic and foreign olive varieties in the National Olive Collection Orchard of Turkey, at Kemalpaşa – Izmir.

Palmitic (16:0), oleic (18:1 n-9 and 1 n-7), linoleic (18:2 n-2) and stearic (C18:0) were measured as major fatty acids. Palmitoleic (16:1 n-7), linolenic (18:2 n-2) and arachidic (20:0) acids were present in small amounts. The variation in the fatty acid composition of the oil samples covered the normal range, since the differences were mainly remarkable for oleic acid, the most abundant fatty acid in olive oil.

MUFA's (Monounsaturated Fatty Acid) e.g. oleic acid are of great importance because of their nutritional implication and effect on the oxidative stability of oils. From the oils of domestic cultivars, Çekiste and Memeli both had a good value of oleic acid and MUFA's (82.10, 83.70 and 79.50, 80.76 %, respectively), while Çelebi showed a modest value (65.85 and 66.89 %) (Table 4). As shown in Table 4, the other domestic cultivars had a considerable value of oleic acid and MUFA's (70.16, 71.24 and 78.18, 79.65 % for Domat and Izmir Sofralik, respectively). From the oils of foreign cultivars, Baroui and Meski, Tunisia origin, both had a good value of oleic acid and MUFA's (80.15, 81.61 % and 79.81, 81.01 %, respectively), while Frontoio and Leccino, Italian origin, showed more modest values (73.18, 73.39 % and 71.35, 73.37 %) (Table 5). The ranges of oleic acid and MUFA's of domestic cultivars, except Çelebi which had a modest level, were generally found similar to foreign cultivars.

Concerning linoleic acid (18:2 n-2), the major PUFAs (Polyunsaturated Fatty Acid), which is much more susceptible to oxidation than MUFAs (16:1 n-7, 17:1 n-8, 18:1 n-9 and 1 n-7), for domestic olive cultivars, ranged from 3.72 % (Çekişte) to 17.98 % (Çelebi) (Table 4) whereas the values in foreign olive cultivars were betweeen 4.09 % (Hojiblanca) and 9.38% (Arbequnia) (Table 5). Compared with foreign cultivars, the domestic cultivars covered a larger range of linoleic acid.

However, the level of palmitic acid (16:0), the major fraction of SFAs (Saturated Fatty Acid) in olive oil, had a content varying from 9.55, (Çilli) to 13.80 % (Gemlik) for domestic olive cultivars and the range of stearic acid (C 18:0) levels in these samples was 1.77 % (Uslu) – 3.90 % (Domat) (Table 4). The level of palmitic acid of foreign cultivars varied from 9.70 (Meski) to 14.90 % (Leccino) and the range of their stearic acid levels was 1.95 % (Saurani and Baroui) – 3.83 % (Hojiblanca) (Table 5). The differentiation of structural isomers of these fatty acids (palmitic and stearic) brings a better knowledge of the chemical composition of olive oil and can be of great interest in their nutritional impact.

The fatty acid composition of olive oil is an important parameter in the length of its shelf life, which is quantitatively affected by factors such as the olive cultivar used in the production of the oil. From domestic cultivars, the ratios of oleic/linoleic and MUFA/PUFA, which are of great importance for the estimation of oxidative stability, were highest for Çekişte (22.07 and 19.69) and Memeli (16.46 and 15.32), respectively. For the Çelebi cultivar the ratio was lower (3.66 and 3.60) because of the higher linoleic acid level (17.98 %) (Table 4). Among the values for foreign cultivars, they were highest for Hojiblanca (19.32 and 16.73) and Baroui (18.60 and 16.96), respectively. However, for the Arbequnia cultivar the ratio was lower (3.66 and 3.60) because of the higher linoleic acid level (9.38 %) (Table 5). The amount of unsaturated FA's, linoleic and linolenic acids also has great importance from the sensory quality viewpoint of virgin olive oil, as the most important volatiles are produced from these FA's through the lipoxygenase pathway (Morales and Aparicio 1999).

The nutritional (18:2 / 18:3 or n6 / n3) fatty acid ratios of the oil from domestic cultivars ranged from 7.02 (Çekişte) to 30.47 (Çelebi) and the ratios were more than 12 (a value considered to be optimal) in most Turkish olive cultivars in spite of the fact that these values for foreign cultivars ranged from 5.84 (Hojiblanca) to 19.27 (Frontoio) and the ratios were more than 12 in three of the foreign olive cultivars. Also, it is reported that the ratio of linoleic /linolenic determined the bitterness and green perception of oils through the contribution of volatile compounds to virgin olive oil flavor. For example, (E) –hex – 2 –enal contributes to green odor but also has an intense bitter taste. Empirical results on the subject stated that the lower the ratio, the higher the bitterness will be (Mousa *et al.*1996).

Table 4
The concentrations of cis – *trans* isomers of fatty acid in some domestic olive cultivars cultivated in the National Olive Collection Orchard at Kemalpaşa – İzmir, Turkey (n=4)*

Fatty acid	MCK	US	DMT	AY	ÇLB	MML	EKC	GMK	ÇKR	IZSF	ÇKŞ	ÇL
14:0	0.01 ± 0.00 a	0.02 ± 0.00 a	0.01 ± 0.02 a	0.01± 0.00 a	0.02 ± 0.00 a	0.02 ± 0.00 a	0.01 ± 0.00 a	0.01 ± 0.00 a	0.01 ± 0.00 a	0.01 ± 0.00 a	0.01 ± 0.00 a	0.01 ± 0.00 a
16:0	10.85 ± 0.15 ab	10.85 ± 0.18 ab	12.70 ± 0.22 c	11.17 ± 0.32 ab	11.92 ± 0.55 b	10.53 ± 0.48 ab	11.50 ± 0.25 b	13.80 ± 0.74 c	12.92 ± 0.36 c	11.59 ± 0.53 b	10.14 ± 0.26 a	9.55 ± 0.55 a
16:1	0.73 ± 0.19 b	1.02 ± 0.02 c	0.67 ± 0.20 b	0.76 ± 0.22 b	0.49 ± 0.18 a	0.87 ± 0.15 c	0.70 ± 0.33 b	1.40 ± 0.25 d	0.78 ± 0.15 b	1.05 ± 0.25 c	0.86 ± 0.22 c	0.53 ± 0.11 a
17:0	0.03 ± 0.00 a	0.10 ± 0.04 b	0.15 ± 0.03 bc	0.09 ± 0.02 b	0.11 ± 0.02 b	0.04 ± 0.00 a	0.11 ± 0.06 b	0.11 ± 0.02 b	0.06 ± 0.00 a	0.04 ± 0.02 a	0.14 ± 0.02 bc	0.04 ± 0.00 a
17:1	0.06 ± 0.02 a	0.27 ± 0.12 d	0.18 ± 0.08 b	0.16 ± 0.07 b	0.17 ± 0.05 b	0.07 ± 0.02 a	0.21 ± 0.10 c	0.23 ± 0.11 c	0.08 ± 0.02 a	0.09 ± 0.03 a	0.37 ± 0.13 e	0.07 ± 0.02 a
18.0	2.04 ± 0.12 a	1.77 ± 0.14 a	3.90± 0.09 d	2.70 ± 0.09 c	2.02 ± 0.11 a	2.71 ± 0.12 c	2.43 ± 0.21 b	2.79 ± 0.12 c	2.84 ± 0.10 c	2.40 ± 0.12 b	1.80 ± 0.11 a	2.31 ± 0.22 b
18 : 1 t	0.01 ± 0.00 a	0.02 ± 0.00 a	0.02 ± 0.00 a	0.01 ± 0.00 a	0.01 ± 0.00 a	0.01 ± 0.00 a	0.005 ± 0.00 a	0.01 ± 0.00 a	0.01 ± 0.00 a	0.01 ± 0.00 a	0.01 ± 0.00 a	0.005 ± 0.00 a
18:1	77.12 ± 0.49 d	75.34 ± 0.95 c	70.16 ± 0.56 b	76.93 ± 0.02 d	65.85 ± 1.88 a	79.50 ± 0.66 c	71.87 ± 0.82 b	74.84 ± 1.03 c	75.95 ±0.95. cd	78.18 ± 0.82 d	82.10 ± 1.05 e	75.30 ± 0.02 c
18:2	7.60 ± 0.59 c	9.40 ± 1.02 d	10.74 ±1.05 e	7.00 ± 0.82 bc	17.98 ± 1.77 f	4.83 ± 1.33 ab	11.70 ± 0.98 e	5.51 ± 0.72 b	6.89 ± 0.92 bc	5.20 ± 0.62 b	3.72 ± 0.42 a	10.35 ± 0.62 d
18: 2 t + 18 : 3 t	0.04 ± 0.00 a	0.09 ± 0.01 a	0.06 ± 0.00 a	0.04 ± 0.00 a	0.08 ± 0.01 a	0.02 ± 0.01 a	0.08 ± 0.01 a	0.04 ± 0.00 a	0.02 ± 0.00 a	0.04 ± 0.00 a	0.09 ± 0.01 a	0.06 ± 0.00 a
18: 3	0.63 ± 0.02 c	0.60 ± 0.02 c	0.52 ± 0.05 b	0.33 ± 0.05 a	0.59 ± 0.09 c	0.44 ± 0.02 ab	0.53 ± 0.02 b	0.49 ± 0.04 ab	0.80 ± 0.05 d	0.61 ± 0.09 c	0.53 ± 0.08 b	0.63 ± 0.05 c
20:0	0.38 ± 0.12 b	0.25 ± 0.09 a	0.54 ± 0.10 c	0.43 ± 0.22 b	0.33 ± 0.13 b	0.45 ± 0.21 b	0.37 ± 0.12 b	0.37 ± 0.14 b	0.40 ± 0.23 b	0.42 ± 0.21 b	0.30 ± 0.12 ab	0.45 ± 0.21 b
20:1	0.38 ± 0.08 bc	0.30 ± 0.06 b	0.23 ± 0.09 a	0.30 ± 0.05 b	0.38 ± 0.06 bc	0.32 ± 0.09 b	0.30 ± 0.06 b	0.25 ± 0.07 a	0.28 ± 0.08 ab	0.33 ± 0.05 b	0.37 ± 0.05 bc	0.47 ± 0.04 d
22:0	0.12 ± 0.03 ab	0.06 ± 0.02 a	0.12 ± 0.05 ab	0.13 ± 0.05 ab	0.09 ± 0.02 a	0.13 ± 0.03 ab	0.10 ± 0.03 ab	0.09 ± 0.04 a	0.09 ± 0.05 a	0.08 ± 0.02 a	0.08 ± 0.02 a	0.14 ± 0.07 ab
24:0	0.05 ± 0.00 a	0.03 ± 0.00 a	0.05 ± 0.00 a	0.06 ± 0.01 a	0.04 ± 0.00 a	0.06 ± 0.01 a	0.05 ± 0.02 a	0.04 ± 0.01 a	0.05 ± 0.00 a	0.07 ± 0.01 a	0.05 ± 0.00 a	0.07 ± 0.01 a
TFA	0.05 ± 0.01 a	0.11 ± 0.02 b	0.07 ± 0.02 a	0.05 ± 0.02 a	0.10 ± 0.03 b	0.03 ± 0.00 a	0.09 ± 0.03 ab	0.05 ± 0.02 a	0.03 ± 0.01 a	0.05 ± 0.02 a	0.10 ± 0.02 b	0.06 ± 0.01 a
SFA *	3.48 ± 0.45 a	13.08 ± 0.67 b	17.47 ± 0.86 d	14.59 ± 0.56 c	14.53 ± 0.39 c	3.94 ± 0.44 a	14.57 ± 0.40 c	17.21 ± 0.55 d	16.36 ± 0.96 d	14.61 ± 0.55 c	12.52 ± 0.88 b	12.57 ± 0.56 b
MUFA**	78.26 ± 0.62 e	76.93 ± 0.88 de	71.24± 0.89 b	78.15 ± 0.77 e	66.89 ± 1.25 a	80.76 ± 0.95 f	73.08 ± 1.02 c	76.72 ± 0.62 d	77.10 ± 0.55 e	79.65 ± 0.55 f	83.70 ± 1.02 g	75.77 ± 0.77 d
PUFA***	8.23 ± 0.12 d	10.00 ± 0.18 e	11.26 ± 0.02 f	7.33 ± 0.29 c	18.57 ± 0.98 h	5.27 ± 0.10 a	12.23 ± 0.20 g	6.00 ± 0.15 b	7.69 ± 0.11 cd	5.81 ± 0.25 ab	4.25 ± 0.09 a	10.98 ± 0.12 f
MUFA / PUFA	9.51 ± 0.52 d	7.69 ± 0.62 c	6.33 ± 0.32 b	10.66 ± 0.42 de	3.60 ± 0.22 a	15.32 ± 0.72 h	5.97 ± 0.45 b	12.79 ± 0.52 f	10.02 ± 0.52 d	13.71 ± 0.62 fg	19.69 ± 0.02 i	6.90 ± 0.52 bc
C 16:0 / C 18:2	1.43 ± 0.05 b	1.15 ± 0.05 b	1.18 ± 0.05 b	1.60 ± 0.08 b	0.66 ± 0.05 a	2.18 ± 0.33 c	0.98 ± 0.10 a	2.50 ± 0.88 d	1.87 ± 0.08 c	2.23 ± 0.33 c	2.73 ± 0.10 d	0.92 ± 0.07 a
C 18:1 / C 18:2	10.15 ± 0.92 d	8.01 ± 0.52 c	6.55 ± 0.92 b	10.99 ± 0.02 de	3.66 ± 0.51 a	16.46 ± 0.72 g	6.14 ± 0.82 b	13.58 ± 0.36 f	11.02 ± 0.42 e	15.03 ± 0.92 g	22.07 ± 0.66 h	7.27 ± 0.82 b
Iodine Value	82.54 ± 0.42 c	84.01 ± 0.69 d	81.23 ± 0.52 bc	80.19 ± 0.32 b	90.21 ± 0.02 e	79.33 ± 0.32 b	84.50 ± 0.55 d	76.80 ± 0.10 a	80.32 ± 0.37 b	79.10 ± 0.18 b	79.81 ± 0.22 b	84.74 ± 0.72 d

(SFA) Saturated Fatty Acids. (MUFA) Monounsaturated Fatty Acids. (PUFA) Polyunsaturated Fatty Acids. TFA (Total Trans Fatty acids).SQ (Squalene). *Each value is an average of three determinations, and values in the same row with different letters show stastistically significant differences (P<0.05). Each value is expressed as wt % total fatty acid methyl esters.

Table 5
The concentrations of cis – *trans* isomers of fatty acid in some foreign olive cultivars cultivated in the National Olive Collection Orchard at Kemalpaşa – İzmir, Turkey (n=4)*

Fatty acid	PCH	ABQ	HJB	MNZ	FRT	LCN	SAU	BDR	MSK
14:0	0.01 ± 0.00 a	0.01 ± 0.00 a	0.01 ± 0.00 a	0.01 ± 0.00 a	0.01 ± 0.00 a	0.01 ± 0.00 a	0.01 ± 0.00 a	0.01 ± 0.00 a	0.01 ± 0.00 a
16:0	12.77 ± 0.32 c	11.23 ± 0.55 b	10.18 ± 0.77 a	14.22 ± 0.02	13.28 ± 0.33 d	14.90 ± 0.40 e	12.42 ± 0.50 c	11.05 ± 0.45 ab	9.70 ± 0.55 a
16:1	0.75 ± 0.22 a	1.06 ± 0.55 b	0.56 ± 0.15 a	0.95 ± 0.32 b	1.49 ± 0.40 c	1.64 ± 0.51 c	1.20 ± 0.22 b	1.06 ± 0.15 b	0.79 ± 0.35 a
17:0	0.06 ± 0.01 a	0.04 ± 0.02 a	0.21 ± 0.09 b	0.04 ± 0.00 a	0.18 ± 0.08 b	0.04 ± 0.01 a	0.03 ± 0.00 a	0.03 ± 0.00 a	0.08 ± 0.01 a
17:1	0.08 ± 0.02 a	0.08 ± 0.03 a	0.27 ± 0.01 b	0.08 ± 0.02 a	0.32 ± 0.09 b	0.07 ± 0.02 a	0.08 ± 0.02 a	0.08 ± 0.02 a	0.10 ± 0.02 a
18.0	2.90 ± 0.08 c	2.92 ± 0.09 c	3.83 ± 0.25 d	2.11 ± 0.30 a	2.70 ± 0.09 b	2.49 ± 0.11 b	1.95 ± 0.50 a	1.95 ± 0.35 a	2.70 ± 0.21 bc
18 : 1 *t*	0.005 ± 0.00 a	0.01 ± 0.00 a	0.006 ± 0.00 a	0.01 ± 0.00 a	0.008 ± 0.00 a	0.003 ± 0.00 a	0.004 ± 0.00 a	0.003 ± 0.00 a	0.02 ± 0.00 a
18:1	74.88 ± 0.98 cd	73.44 ± 0.52 c	79.02 ± 0.98 e	74.19 ± 0.77 c	73.18 ± 0.88 b	71.35 ± 0.95 a	78.32 ± 0.78 e	80.15 ± 0.50 f	79.81 ± 0.80 ef
18:2	6.83 ± 0.90 b	9.38 ± 0.67 d	4.09 ± 0.52 a	7.05 ± 1.06 bc	7.71 ± 0.87 c	8.17 ± 0.56 c	4.60 ± 0.72 a	4.31 ± 0.59 a	5.40 ± 0.80 ab
18: 2 *t* + 18 : 3 *t*	0.03 ± 0.00 a	0.03 ± 0.00 a	0.08 ± 0.01 a	0.03 ± 0.00 a	0.07 ± 0.01 a	0.02 ± 0.00 a	0.03 ± 0.00 a	0.03 ± 0.00 a	0.02 ± 0.00 a
18: 3	0.80 ± 0.08 c	0.73 ± 0.10 b	0.70 ± 0.09 b	0.63 ± 0.08 b	0.40 ± 0.09 a	0.50 ± 0.09 a	0.55 ± 0.09 a	0.50 ± 0.13 a	0.57 ± 0.11 a
20:0	0.41 ± 0.18 ab	0.49 ± 0.18 ab	0.51 ± 0.21 ab	0.33 ± 0.22 a	0.33 ± 0.22 a	0.39 ± 0.22 a	0.35 ± 0.25 a	0.36 ± 0.23 a	0.39 ± 0.22 a
20:1	0.30 ± 0.18 a	0.35 ± 0.17 a	0.31 ± 0.22 a	0.24 ± 0.21 a	0.21 ± 0.18 a	0.31 ± 0.15 a	0.32 ± 0.15 a	0.32 ± 0.22 a	0.31 ± 0.21 a
22:0	0.10 ± 0.06 a	0.14 ± 0.05 b	0.14 ± 0.04 b	0.09 ± 0.03 a	0.09 ± 0.04 a	0.10 ± 0.08 a	0.12 ± 0.08 a	0.12 ± 0.07 a	0.10 ± 0.06 a
24:0	0.06 ± 0.02 ab	0.08 ± 0.01 b	0.07 ± 0.02 b	0.04 ± 0.00 a	0.03 ± 0.01 a	0.04 ± 0.01 a	0.06 ± 0.01 ab	0.05 ± 0.02 a	0.05 ± 0.02 a
TFA	0.03 ± 0.00 a	0.04 ± 0.01 a	0.09 ± 0.02 b	0.04 ± 0.00 a	0.08 ± 0.02 b	0.02 ± 0.00 a	0.03 ± 0.00 a	0.03 ± 0.00 a	0.04 ± 0.01 a
SFA *	16.31 ± 0.55 c	14.90 ± 0.63 ab	14.95 ± 0.78 ab	16.84 ± 0.45 c	16.62 ± 0.88 c	17.97 ± 0.98 d	14.94 ± 0.68 ab	13.57 ± 0.45 a	13.03 ± 0.29 a
MUFA	75.18 ± 0.56 b	74.93 ± 0.92 b	80.16 ± 0.69 c	75.46 ± 0.89 b	73.39 ± 0.54 a	73.37 ± 0.78 a	79.92 ± 0.39 c	81.61 ± 0.75 c	81.01 ± 0.55 c
PUFA	7.63 ± 0.92 b	10.11 ± 0.55 d	4.79 ± 0.77 a	7.68 ± 0.80 b	8.11 ± 0.90 bc	8.67 ± 0.80 c	5.15 ± 0.90 a	4.81 ± 0.85 a	5.97 ± 0.95 ab
$\frac{MUFA}{PUFA}$	9.85 ± 0.52 d	7.41 ± 0.25 b	16.73 ± 0.90 f	9.82 ± 0.42 d	9.05 ± 0.82 c	8.46 ± 0.62 bc	5.35 ± 0.55 a	16.96 ± 0.80 f	13.57 ± 0.38 e
$\frac{C\ 16:0}{C\ 18:2}$	1.87 ± 0.10 bc	1.20 ± 0.06 a	2.49 ± 0.09 d	2.02 ± 0.02 c	1.72 ± 0.20 b	1.82 ± 0.19 b	2.70 ± 0.29 e	2.56 ± 0.59 e	1.80 ± 0.19 b
$\frac{C\ 18:1}{C\ 18:2}$	10.96 ± 0.66 c	7.83 ± 0.66 a	19.32 ± 0.55 f	10.52 ± 0.88 bc	9.49 ± 0.55 b	8.73 ± 0.42 a	17.03 ± 0.88 e	18.60 ± 0.90 e	14.78 ± 0.88 d
Iodine Value	78.58 ± 0.49 ab	82.60 ± 0.77 c	77.85 ± 0.52 a	78.76 ± 0.52 ab	77.58 ± 0.49 a	78.56 ± 0.56 ab	78.14 ± 0.50 a	77.71 ± 0.55 a	79.48 ± 0.33 b

(SFA) Saturated Fatty Acids. (MUFA) Monounsaturated Fatty Acids. (PUFA) Polyunsaturated Fatty Acids. TFA (Total Trans Fatty acids). SQ (Squalene). *Each value is an average of three determinations, and values in the same row with different letters show stastistically significant differences (P<0.05). Each value is expressed as wt % total fatty acid methyl esters.

For the contents of other fatty acids, palmitoleic (16:1 n-7), linolenic (18:3 n-3) and arachidic (20:0), although their contents changed from one olive oil to another, they were fairly small (Table 3). The linolenic acid (18:3 n-3) level of the oils from domestic and foreign cultivars was below the maximum value fixed by the IOOC (1.0%) and by the Turkish Codex and EU (0.9 %). These findings on linolenic acid are in agreement with the results found in various producing countries of the Mediterranean basin (Gutiérréz et al. 1999; Ersoy *et al.* 2001; Gimeno *et al.* 2002; Ollivier *et al.* 2003; Dıraman and Hışıl 2004; Tous *et al*. 2005; Köseoğlu *et al.* 2006; Saygin and Yemişçoğlu 2007; Gürdeniz *et al.* 2008; Kıralan *et al.* 2009; Andjelkovic *et al.* 2009). The linolenic acid levels of olive varieties, Picholine, Arbequnia, Manzanilla and Leccino, cultivated in Moorocco were higher (more 1%) than our results (Al – Antari *et al.* 2003).

Virgin olive oils are classified into two types based on their fatty acid compositions. The first type of olive oil is characterized by low linoleic and palmitic and high oleic acid contents. The second type has high linoleic and palmitic and low oleic acid contents. The virgin olive oils of the northern Mediterreanean region (like Spanish, Italian, Turkish and Greek) are of the first type, while North African origin oils, especially Tunisia, are of the second type (Kiritsakis 1998). The oils of domestic and foreign olive cultivars from the National Olive Orchard of Turkey exhibited the properties of the first type of oil in the FA profiles despite the Tunisia cultivars belonging to the second type oil. On the other hand, the Tunisia cultivars, Meski and Baroui, were adopted to Turkish conditions.

According to the results of the Tukey multiple range tests (Table 3), there were wide variations and significant ($P < 0.05$) differences among the fatty acid profiles of the oils of domestic and foreign olive cultivars from the National Olive Orchard of Turkey. The variations in the fatty acid profiles of olive oil samples were found to be different depending on the cultivar, because they were planted in the same pedoclimatic condition, extracted by the same procedure (Abencor) and harvested on the same date but only varied in the genetic parameter factor (Boskou 1996; Kiritsakis 1998). Therefore, the fatty acid profile may be an important factor for identifying monocultivar olive oils.

The distribution of fatty acids in the oils of domestic cultivars was in agreement with those of authors working on Turkish olive oil varieties (Ersoy *et al*. 2001; Dıraman and Hışıl 2004; Tous *et al*., 2005; Köseoğlu *et al*. 2006; Saygin and Yemişçoğlu 2007; Gürdeniz *et al*. 2008; Kıralan *et al*. 2009; Andjelkovic *et al*. 2009) and these values for foreign cultivars were similar to those reported for foreign olive oil varieties (Gutiérréz et al 1999; Gimeno *et al.* 2002; Ollivier 2003; Poiana and Mincione 2004; Tous *et al*. 2005).

With respect to the analysis, the levels of total *trans* isomers for the oils of domestic and foreign olive cultivars ranged from 0.03 – 0.11 % and 0.02 – 0.09 %, respectively. According to official norms, the amount of total *trans* fatty acids in virgin olive oils should be a maximum 0.1 %. The total levels of *trans* fatty acid isomers (sum of elaidic acid (C 18:1 *t*) and (C 18:2 *t* + C 18:3 *t*) of oil samples, except for the Uslu cultivar, were generally within acceptable limits of IOOC's regulations, the EU and the Turkish Food Codex standards. This distribution of *trans* fatty acids was similar to the one reported for Turkish virgin olive oils by other authors (Ersoy *et al*. 2001; Dıraman and Hışıl 2004; Saygin and Yemişçoğlu 2007).

The iodine values (IV) of all oil samples were calculated according to their fatty acid compositions. The IV values were within the limits specified by the Turkish Food Codex Standard. The saturated (SFAs) and unsaturated (MUFAs and PUFAs) levels of olive oils had effects on the IV of samples. Compared with foreign cultivars, domestic cultivars contain higher levels of IV and the values were found between (77.58 – 79.48) and (76.80 – 90.21), respectively.

3.5. Chemometric classification of domestic and foreign olive cultivars

In Figures 1 and 2, the dendrograms on the HCA results (Euclidian method) of domestic and foreign olive cultivars from the National Olive Collection Orchard of Turkey, (Research Institute for Olive Culture), respectively can be seen.

In this work, the oils obtained from economically important olive cultivars (12 domestic and 9 foreign) from the National Olive Collection Orchard of Turkey (Research Institute for Olive Culture) were classified with the multivariete stastistical method (Hierarchical Cluster Analysis, HCA) based on the fatty acid profiles.

According to the HCA results (Euclidian method), the oils obtained from the 12 domestic olive varieties are separated into three groups, as follows, based on their fatty acid profiles (Figure 1):

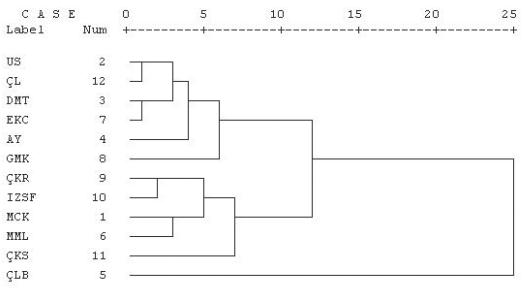

Figure 1.
The dendogram on Hierarchical Cluster Analysis (HCA) results concerning the classification of some domestic olive cultivars in the National Olive Collection Orchard at Kemalpaşa – İzmir, Turkey, on their fatty acid profiles.

Group one is made up of (Uslu [US], Çilli [ÇL], Domat [DMT], Erkence [EKC], Ayvalik [AY] and Gemlik [GMK]). Group two is comprised of (Çakır[ÇKR], İzmir Sofralık [İZSF], Memecik[MCK], Memeli [MM] and Çekişte[ÇKŞ]), while group three is made up of (only Çelebi [ÇLB]).

The foreign olive cultivars in the Collection Orchard were divided into two groups:

The first group (Saurani [SAU], Baroui [BDR], Hojablanca [HJB] and Meski[MSK]) and the second group (Frantoio [FRT], Leccino [LC], Picholine[PCH], Manzanilla [MNZ] and Arbequnia [ABQ]) (Figure 2) based on their fatty acid profiles.

The HCA results indicated a clear predominance in most of the samples from the same source (sub-region or the geographical location). It was seen that most of North – South Aegean virgin olive oil samples resembled each other consecutively. Also, HCA results indicated some similarities among the Turkish olive cultivars. For instance, Ayvalik, Uslu, Domat, Erkence and Ayvalik cultivars from North Aegean and Çakir, İzmir Sofralik, Memecik and Çekişte cultivars from South Aegean were classified in the same groups (Figure 1). Similar grouping based on the fatty acid profile was observed in foreign cultivars. For instance, Tunisia and Italian origin cultivars resembled each other consecutively (Figure 2).

4. CONCLUSIONS

The fatty acid profile of virgin olive oils of the domestic and foreign olive cultivars grown in the same pedoclimatic conditions showed considerable differences among cultivars. Hence, fatty acid compositions are useful for distinguishing the monovarietial olive oils belonging to particular cultivars. In light of the results obtained in this study, a more detailed study is required to establish whether the determined differences in the chemical properties of oils from domestic and foreign olive cultivars in the National Olive Gen Bank are mainly due to agronomical and climate variables or, to the processing practice employed by the olive oil plants. Furthermore, in order to confirm the differrences among the oils of domestic cultivars, especially Ayvalik, Memecik, Gemlik, Erkence, Uslu and Domat the most important olive cultivars of Aegean region – Turkey, in the National Gen Bank must be studied over cultivars in their origin location.

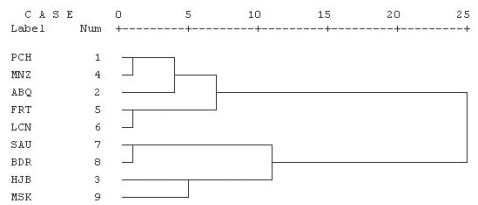

Figure 2.
The dendogram on Hierarchical Cluster Analysis (HCA) results concerning the classification of some foreign olive cultivars in the National Olive Collection Orchard at Kemalpaşa – İzmir, Turkey, on their fatty acid profiles.

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