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Tel. +39 075 5857912 - Telex 662078 UNIPG - Telefax +39 075 5857939-5852067  
E-mail: ijfs@unipg.it

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Chiriotti Editori s.a.s., Viale Rimembranza 60, I-10064 Pinerolo, Italy  
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## VARIATION OF FAT AND FATTY ACID COMPOSITION OF SOME PISTACHIO GENOTYPES

VARIABILITÀ DEL CONTENUTO IN GRASSI ED IN ACIDI GRASSI  
IN ALCUNI GENOTIPI DI PISTACCHIO

I. ACAR\*, E. KAFKAS<sup>1</sup>, Y. OZOGUL<sup>2</sup>, Y. DOGAN<sup>3</sup> and S. KAFKAS<sup>3</sup>

Pistachio Research Institute, 27060 Gaziantep, Turkey

<sup>1</sup>University of Cukurova, Subtropical Fruits Research and Experimental Center,  
01330 Balcali, Adana, Turkey

<sup>2</sup>University of Cukurova, Faculty of Fisheries, Dept. of Fishing  
and Processing Technology, 01330 Balcali, Adana, Turkey

<sup>3</sup>University of Cukurova, Faculty of Agriculture, Dept. of Horticulture,  
01330 Balcali, Adana, Turkey

\*Corresponding author: e-mail: izzetacar@afae.gov.tr

### ABSTRACT

The aim of the study was to determine the fatty acid composition of some selected pistachio types, two domestic pistachio cultivars (Uzun and Siirt), four Iranian cultivars (Ohadi, Vahidi, Mumtaz and H. Serifi) and an American cultivar (Kerman). The fat content of pistachio seeds ranged from 35.38% (Mumtaz) to 51.68% (Sel-5). The fatty acid composition was determined after harvesting. The fatty acid composition of the pistachio genotypes ranged from 7.45-10.14% saturated fatty ac-

### RIASSUNTO

Lo scopo dello studio è stato quello di determinare la composizione in acidi grassi di alcuni tipi selezionati di pistacchio, due cultivar locali (Uzun e Siirt), quattro cultivar iraniane (Ohadi, Vahidi, Mumtaz e H. Serifi) e una cultivar americana (Kerman). Il contenuto in grassi dei semi di pistacchio è variato tra il 35,38% (Mumtaz) ed il 51,68% (Sel-5). La composizione in acidi grassi è stata determinata dopo la raccolta. La composizione in acidi grassi dei genotipi di pistacchio è va-

- Key words: fat content, fatty acid composition, pistachio, *Pistacia vera* L. -

ids (SFAs), 55.23-77.61% monounsaturated fatty acids (MUFAs) and 13.82-33.11% polyunsaturated fatty acids (PUFAs). The unsaturated/saturated fatty acid ratio varied between 8.74 and 12.34.

riata tra il 7,45-10,14% di acidi grassi saturi (SFA), il 55,23-77,61% di acidi grassi monoinsaturi (MUFA) ed il 13,82-33,11% di acidi grassi polinsaturi (PUFA). Il rapporto acidi grassi insaturi/saturi è variato tra 8,74 e 12,34.

## INTRODUCTION

The genus *Pistacia* is a member of the *Anacardiaceae* family and consists of at least eleven species (ZOHARY, 1952) including *Pistacia vera* L., the cultivated pistachio that has edible nuts and is of considerable economical importance. Pistachio trees have been grown in south Anatolia since the 17<sup>th</sup> century B.C. (OZBEK, 1978). Turkey has a large population of wild pistachio and several pistachio cultivars because it is the genetic centre of pistachio. Iran, the United States, Turkey and Syria are the main pistachio producers in the world, making up over 90% of the world production (FAO, 2006).

Pistachio has a high nutritional value due to its high protein, vitamin, mineral and unsaturated fat content. The fruit can be consumed as salted or roasted appetizers and are widely used in the food industry, particularly for cream-cakes, desserts, candies, chocolate and ice cream (OKAY, 2002). Recent studies on the mineral, vitamin, protein, fat and fatty acid contents show the nutritional value of pistachio. Pistachio seeds have a low carbohydrate content, approximately 10% (BARGHCHI and ALDERSON, 1989), a protein content of more than 20% (GARCIA *et al.*, 1992; AGAR *et al.*, 1995; KUCUKONER and YURT, 2003) and the lipid content varies from 40 to 63% (GARCIA *et al.*, 1992; AGAR *et al.*, 1995, 1997; YILDIZ *et al.*, 1998; KUCUKONER and YURT 2003; SATIL *et al.*, 2003), all

on a dry weight basis. The nuts contain about 50% oil, with oleic acid being the dominant glyceride, followed by linoleic and palmitic acids (AGAR *et al.*, 1995).

Unsaturated fatty acids are known to have positive effects on human health; they prevent the accumulation of cholesterol and arteriosclerosis (ERSOY and BAYSU, 1986; MARTIN *et al.*, 1986). The fatty acid composition of pistachio oil in Turkish varieties has been found to vary (AGAR *et al.*, 1995; GARCIA *et al.*, 1992; SATIL *et al.*, 2003).

The aim of this study was to characterize the fat and fatty acid composition of some selected pistachio types and compare the results to some domestic and foreign pistachio cultivars.

## MATERIALS AND METHODS

This study was carried out on 14 pistachio genotypes, including 7 standard cultivars and 7 selected types, grown at the Tektek Research Station of Soil and Water Resources Research Institute, located in the Sanliurfa province of Turkey (lat 37° 07' N., long 39° 15' E., altitude 530 m a.s.l.). Two standard domestic pistachio cultivars 'Uzun' and 'Siirt', and four Iranian cultivars, 'Ohadi', 'Vahidi', 'Mumtaz' and 'H. Serifi' and an American cultivar 'Kerman' were studied as well as 7 pistachio types selected from Turkey 'Sel-1 named as Tekin', 'Sel-2', 'Sel-5', 'Sel-10', 'Sel-11 named as Barak Yildizi', 'Sel-14' and 'Sel-15'. Fruit

samples of these cultivars were collected from pistachio trees grafted on *Pistacia khinjuk* rootstock in an irrigated experimental orchard.

### Sampling

Fruit samples were collected at the same age from trees with similar vigour within the same orchard. Fruit of three trees of each genotype were picked at the ripe stage. The fruit was analysed after the pistachio fruit had been dried at 65°C for 48 h. All samplings were used to determine the fat and fatty acid compositions.

### FAME analyses

Lipid extraction was carried out according to BLIGH and DYER (1959). Fatty acid profiles of fat extracted from fruit samples were determined by gas chromatography (GC) of methyl esters. Boron trifluoride/methanol was used to prepare the fatty acid methyl esters (AOAC, 1990).

Twenty-five mg of oil were extracted from samples, placed in a screw cap tube and 1.5 mL of 0.5 M methanolic sodium hydroxide, were added, mixed and heated at 100°C for 7 min. After cooling, 2 mL of boron trifluoride were added and heated again at 100°C for 5 min. The tube was then cooled to 30°-40°C, 1 mL of isooctane was added. The tube was capped and shaken using a whirl mix for 30 s. Five mL of saturated sodium chloride solution was immediately added and the tube was shaken again. The contents were allowed to separate and the top (iso-octane-containing fatty acid methyl esters) layer was removed and the lower layer was extracted again with an additional 1 mL of iso-octane. The two iso-octane extracts were combined and dried over anhydrous sodium sulphate and concentrated to approximately 1 mL with a stream of nitrogen.

### Gas chromatographic condition

The fatty acid composition was analysed on a Clarus 500 gas chromatograph with autosampler (Perkin Elmer, Shelton, CT, USA) equipped with a flame ionisation detector and a fused silica capillary SGE column (30 m x 0.32 mm, ID x 0.25 µm, BP20 0.25 UM; SGE Analytical Science Pty. Ltd., Victoria, Australia). The oven temperature was 140°C, held for 5 min, raised to 200°C at a rate of 4°C/min and to 220°C at a rate of 1°C/min, while the injector and the detector temperature were set at 220°C and 280°C, respectively. The sample size was 1 µL and the carrier gas was controlled at 16 ps. The split used was 1:100. Fatty acids were identified by comparing the retention times of FAME with a standard 37 component FAME mixture (Supelco, Catalog No. 18919, Sigma-Aldrich Chemie GmbH, München, Germany). Triplicate GC analyses were performed and the results are expressed in % GC area as a mean value ± standard deviation.

### Statistical analysis

The data were tested for statistical significance using the ANOVA (analysis of variance) test from the statistical package MSTAT (Michigan State University, Lansing), and differences between means were separated with the Duncan's multiple range test ( $p \leq 0.05$ ).

## RESULTS AND CONCLUSIONS

The total fat ratio of pistachio cultivars ranged from 35.38 to 51.68%; the highest value was recorded for 'Sel-5' (51.68%) followed by 'Vahidi' (50.56%) and the lowest values were found in 'Mumtaz' and 'Barak Yildizi' cultivars (35.38 and 38.83%, respectively, Table 1). In general, the total lipid values were lower than those reported in previous studies. OKAY (2002) reported that the total fat ratio of



Table 1 - Fat and saturated fatty acid content (%) of some pistachio cultivars and selected types.

Cultivars and Selected Types	Fat (%)	Saturated fatty acids (%)					
		Myristic C14:0	Palmitic C16:0	Margaric C17:0	Stearic C18:0	Arachidic C20:0	Behenic C22:0
Uzun	41.74±3.45 cd*	0.10±0.01 ab	8.53±0.10 b	0.03±0.00 bc	0.00±0.00 b	0.14±0.00 a	0.02±0.00 a
Siirt	42.11±4.46 cd	0.08±0.02 cd	7.23±0.13 f	0.00±0.00 e	0.76±0.00 a	0.10±0.02 e	0.00±0.00 c
Ohadi	42.12±3.49 cd	0.08±0.00 cd	8.56±0.02 b	0.03±0.01 bc	0.76±0.01 a	0.08±0.00 f	0.00±0.00 c
Vahidi	50.56±0.37 ab	0.07±0.01 de	8.96±0.09 a	0.03±0.00 bc	0.36±0.25 ab	0.08±0.00 f	0.00±0.00 c
Mumtaz	35.38±10.61 e	0.08±0.00 cd	8.55±0.15 b	0.02±0.00 cd	0.00±0.00 b	0.12±0.00 c	0.00±0.00 c
H. Serifî	45.59±3.67 ac	0.09±0.01 bc	9.15±0.04 a	0.02±0.01 cd	0.00±0.00 b	0.00±0.00 h	0.01±0.00 b
Kerman	44.27±0.40 bd	0.07±0.00 de	7.80±0.02 ce	0.03±0.00 bc	0.52±0.00 ab	0.10±0.00 e	0.00±0.00 c
Tekin	41.63±9.62 cd	0.07±0.00 de	7.60±0.06 e	0.52±0.01 a	0.00±0.00 b	0.14±0.01 a	0.00±0.00 c
Sel-2	45.80±0.25 ac	0.07±0.00 de	7.74±0.03 de	0.04±0.01 b	0.00±0.00 b	0.13±0.00 b	0.00±0.00 c
Sel-5	51.68±2.64 a	0.06±0.00 e	7.26±0.12 f	0.03±0.01 bc	0.00±0.00 b	0.10±0.01 e	0.00±0.00 c
Sel-10	46.61±1.03 ac	0.11±0.02 a	9.08±0.20 a	0.04±0.01 b	0.91±0.00 a	0.00±0.00 h	0.00±0.00 c
Barak Yildizi	38.83±5.52 de	0.09±0.01 bc	8.03±0.60 cd	0.03±0.00 bc	0.64±0.00 a	0.11±0.02 d	0.00±0.00 c
Sel-14	43.28±1.89 cd	0.08±0.01 cd	8.64±0.01 b	0.01±0.00 de	0.70±0.03 a	0.07±0.01 g	0.00±0.00 c
Sel-15	45.70±1.85 ac	0.09±0.01 bc	8.09±0.71 c	0.03±0.00 bc	0.71±0.50 a	0.00±0.00 h	0.01±0.00 b

\*The letters following the numbers indicate different groups determined by Duncan's test ( $p \leq 0.05$ ).

pistachio cultivars ranged from 55.9 to 59.7%, with the highest values found in 'Ohadi' (59.7%), followed by 'Kirmizi' (58.7%), 'Uzun' (56.4%), 'Halebi' (56.1%) and 'Siirt' (55.8%). ACAR (2004) reported that the fat ratio of 'Kirmizi', 'Siirt' and 'Ohadi' cultivars were 43.51, 44.16 and 48.00%, respectively. The fat ratio of 'Badami', 'Ohadi' and 'Mumtaz' cultivars ranged from 55.2 to 60.5% (KAMANGAR *et al.*, 1975). On the other hand, GARCIA *et al.* (1992) reported that the fat ratios of 'Mumtaz', 'Siirt' and 'Ohadi' were 67.2, 54.2 and 56.2%, respectively, while KAFKAS *et al.* (1995) reported values of 60.61, 51.77 and 54.70%, respectively. Differences in the fat content of pistachio cultivars may be due to differences in factors such as growing conditions, crop or season (OKAY, 2002).

The fatty acid content of the experimental genotypes and their ratios are reported in Tables 1 and 2, as well as the percentage of the mean value of 12 fatty acids for each pistachio genotype. Oleic (C18:1n9), linoleic (C18:2n6), palmitic (C16:0), stearic (C18:0), gadoleic (C20:1)

and linolenic (C18:3n3) acids were the most abundant fatty acids.

The predominant saturated fatty acid in the cultivars was palmitic acid (7.23-9.15%), followed by stearic (0.00-0.91%), arachidic (0.00-0.14%) and myristic (0.06-0.11%) acids. Trace levels of margaric acid were found in the cvs except in 'Tekin' (0.52%), and behenic acid was only found in 'Uzun', 'H. Serifî' and 'Sel-15' (Table 1). The highest palmitic acid content was found in 'H. Serifî' (9.15%), followed by 'Sel-10' (9.08%), 'Vahidi' (8.96%). 'Siirt' and 'Sel-5' had the lowest palmitic acid ratio (7.23 and 7.26%, respectively). The highest stearic acid ratio was determined in 'Sel-10' as 0.91% with a stearic acid content of 0.00% in 'Uzun', 'Mumtaz', 'H. Serifî' and 3 selected types. The other saturated fatty acid values were low in all cultivars and selected types.

Unsaturated fatty acids were designated as monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids. Oleic acid (C18:1n9) was the main monounsaturated fatty acid in all pistachio gen-

otypes' seeds (Table 2). The oleic acid level was the highest in 'Siirt' (76.85%) and lowest in 'Ohadi' (54.75%). Oleic acid ratios were over 70% in 4 selected types ('Tekin', 'Sel-2', 'Sel-5' and 'Sel-10') and 2 domestic cultivars ('Uzun' and 'Siirt'). The palmitoleic acid content of the cultivars and selected types varied from 0.06 to 0.41%; 'Siirt' had the highest value, while 'Uzun', 'Tekin' and 'Sel-2' had the lowest. Linoleic acid (C18:2n6) had the highest percentage among the PUFAs and ranged from 13.60 to 32.75% for the cultivars and selected types, whereas the linolenic acid content was low (0.02-0.37%). The cultivars with the highest levels of linoleic acid were 'Ohadi' (32.75%) and 'Sel-14' (29.32%); those with the lowest levels were 'Siirt' (13.60%), 'Tekin' (15.35%) and 'Sel-10' (15.53%). Similarly, the cultivars with the highest linolenic acid levels were 'Vahidi' (0.37%), 'Ohadi', 'H. Serifi' and 'Sel-14' (0.36%); the lowest level was found in 'Tekin' (0.02%).

The results obtained in this study are

in agreement with those reported in the literature; palmitic acid was the primary saturated fatty acid in pistachio cultivars and selected types, while palmitoleic acid was only found in trace amounts. Oleic acid was the most common monounsaturated fatty acid, while linoleic acid was the most common polyunsaturated fatty acid (SHOKRAI, 1977; GARCIA *et al.*, 1992; KAFKAS *et al.*, 1995; OKAY, 2002). Myristic acid in the pistachio cultivars was reported by OKAY (2002). ARENA *et al.* (2007) reported that Turkish and Iranian pistachio samples are completely different from Italian and Greek samples with respect to the distribution of fatty acids and sterols. The composition of pistachio oil could therefore be used as a marker to distinguish the geographic origin of the seed.

The total amount of saturated and unsaturated fatty acids and their ratios (unsaturated/saturated) are listed in Table 3. The fatty acid composition of pistachio genotypes led to the following re-

Table 2 - Unsaturated fatty acid content (%) of some pistachio cultivars and selected types.

Cultivars and Selected Types	Unsaturated fatty acids (%)					
	Monounsaturated fatty acids				Polyunsaturated fatty acids	
	Palmitoleic C16:1	Margaroleic C17:1	Oleic C18:1n9	Gadoleic C20:1	Linoleic C18:2n6	Linolenic C18:3n3
Uzun	0.06±0.00 b*	0.04±0.00 b	73.60±0.31 c	0.38±0.01 bc	16.22±0.23 ef	0.29±0.00 abc
Siirt	0.41±0.04 a	0.04±0.01 b	76.85±0.81 a	0.31±0.04 de	13.60±0.00 g	0.22±0.01 abc
Ohadi	0.07±0.00 b	0.05±0.00 ab	54.75±1.96 j	0.36±0.00 cd	32.75±0.16 a	0.36±0.00 ab
Vahidi	0.07±0.01 b	0.06±0.00 a	62.44±0.41 h	0.30±0.00 e	26.37±0.07 c	0.37±0.00 a
Mumtaz	0.09±0.02 b	0.04±0.01 b	67.18±0.45 f	0.39±0.02 bc	22.51±0.54 d	0.17±0.22 bcd
H. Serifi	0.40±0.45 a	0.04±0.01 b	62.95±0.54 gh	0.32±0.00 de	26.13±0.35 c	0.36±0.00 ab
Kerman	0.07±0.00 b	0.05±0.00 ab	63.72±0.45 g	0.45±0.01 a	26.22±0.26 c	0.19±0.25 a-d
Tekin	0.06±0.00 b	0.05±0.00 ab	75.41±0.03 b	0.45±0.01 a	15.35±0.02 f	0.02±0.00 d
Sel-2	0.06±0.00 b	0.05±0.00 ab	73.97±0.06 c	0.43±0.00 ab	16.72±0.07 e	0.15±0.18 cd
Sel-5	0.07±0.00 b	0.04±0.00 b	74.53±0.08 bc	0.38±0.01 bc	16.81±0.25 e	0.14±0.18 cd
Sel-10	0.07±0.01 b	0.05±0.01 ab	72.66±1.86 d	0.18±0.00 f	15.53±0.19 f	0.14±0.00 cd
Barak Yildizi	0.07±0.00 b	0.05±0.00 ab	68.19±0.78 e	0.40±0.04 abc	21.47±2.38 d	0.17±0.23 bcd
Sel-14	0.07±0.01 b	0.05±0.00 ab	59.65±0.08 i	0.32±0.01 de	29.32±0.05 b	0.36±0.00 ab
Sel-15	0.07±0.01 b	0.05±0.01 ab	67.44±0.35 ef	0.41±0.08 abc	22.09±2.13 d	0.18±0.23 a-d

\*The letters following the numbers indicate different groups determined by Duncan's test ( $p \leq 0.05$ ).



Table 3 - Total saturated (%) and unsaturated fatty acid content (%) of some pistachio cultivars and selected types.

Cultivars and Selected Types	Saturated fatty acids (SFA)	Unsaturated fatty acids (USFA)			Unsaturated/Saturated
		Monounsaturated fatty acids (MUFA)	Polyunsaturated fatty acids (PUFA)	Total Unsaturated fatty acids (USFA)	
Uzun	8.82 bd*	74.08 d	16.51 fg	90.59 bc	10.27
Siirt	8.17 de	77.61 a	13.82 i	91.43 ab	11.19
Ohadi	9.51 ab	55.23 k	33.11 a	88.34 e	9.29
Vahidi	9.50 ab	62.87 i	26.74 c	89.61 cd	9.43
Mumtaz	8.77 bd	67.70 g	22.68 d	90.38 bc	10.31
H.Serifi	9.27 ac	63.71 hi	26.49 c	90.20 bc	9.73
Kerman	8.52 cd	64.29 h	26.41 c	90.70 bc	10.65
Tekin	8.33 ce	75.97 b	15.37 h	91.34 ab	10.97
Sel-2	7.98 de	74.51 cd	16.87 f	91.38 ab	11.45
Sel-5	7.45 e	75.02 c	16.95 f	91.97 a	12.34
Sel-10	10.14 a	72.96 e	15.67 gh	88.63 de	8.74
Barak Yildizi	8.90 bd	68.71 f	21.64 e	90.35 bc	10.15
Sel-14	9.50 ab	60.09 j	29.68 b	89.77 cd	9.45
Sel-15	8.93 bd	67.97 fg	22.27 de	90.24 bc	10.11

\*The letters following the numbers indicate different groups determined by Duncan's test ( $p \leq 0.05$ ).

sults: saturated fatty acids (SFAs) ranged in the interval of 7.45-10.14%; monounsaturated fatty acids (MUFAs) ranged in the interval of 55.23-77.61%; polyunsaturated fatty acids (PUFAs) ranged in the interval of 13.82-33.11%.

The unsaturated/saturated fatty acids ratios varied between 8.74 and 12.34, and these results are in agreement with previous studies (AGAR *et al.*, 1995, 1997; KAFKAS *et al.*, 1995; OKAY, 2002; SEFEROGLU *et al.*, 2006). It was also observed that the proportion of these fatty acids changed significantly among the genotypes. According to some researchers, the fatty acid composition of nuts can be affected by ecological conditions, variety, location, geographical origin, and technical and cultural practices (PARCERISA *et al.*, 1993; KOYUNCU *et al.*, 1997; BALTA *et al.*, 2006). In the present study, the fatty acid profile of pistachio nuts was generally dominated by MUFAs and PUFAs (Table 3).

Oleic and linoleic acid, the two major fatty acids in pistachio, are of inter-

est due to their beneficial effects on human health. Consumers are especially interested in unsaturated FAs, because PUFAs are a natural preventive of cardiovascular disease (MELGAREJO and ARTES, 2000). Recently, it has been reported that MUFAs were as effective as PUFAs in reducing low-density-lipoprotein cholesterol in humans (MENSINK and KATAN, 1989). In this study, five potential health-promoting cultivars are identified: 'Ohadi', has the highest linoleic acid content, and 'Sel-5', 'Siirt', 'Sel-2' and 'Tekin', with the most USFAs. On the other hand, 'Sel-5' is potentially the most beneficial to human health because it has the lowest SFA value.

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