Fatty acid compositions of sunflowers (*Helianthus annuus* L.) grown in east Mediterranean region

M.R. Akkaya

Adana Science and Technology University
Faculty of Engineering
Department of Food Engineering
Adana, Turkey

Sunflower (*Helianthus annuus* L.) is a widely cultivated crop on Earth. Although the fatty acid composition mainly depends on genotypic properties of sunflower, ecological properties and climate are also effective on the fatty acid composition. Sunflower oil is classified in three types; standard, mid and high-oleic acid containing types. This study was performed to determine the fatty acid composition of oils extracted from sunflowers grown in East Mediterranean region. Samples were taken from 6 different sunflower varieties planted in three different locations during the harvest season. Oleic acid contents of oils extracted from sunflowers were 41.04-46.15% for standard-oleic acid types and 81.99% for high-oleic acid containing type in average. Average linoleic acid contents were 40.72-46.73% for standard-oleic type and 8.16% for high-oleic acid type. The results of this study showed that oils extracted from sunflower grown in East Mediterranean region had higher oleic acid content. Pre-sowing sunflower seeds classified in standard type turned out to be mid-oleic acid type when grown in this region.

Keywords: East Mediterranean, fatty acid composition, sunflower oil, oleic acid content, temperature.

1. INTRODUCTION

Since they are one of the essential nutrients and have a significant place in human nutrition, oils are nutrients that must necessarily be a part of the food chain for humans to maintain their vital activities. Both vegetable and animal oils and fats are composed of saturated and unsaturated fatty acids. Vegetable oils containing a high percentage of unsaturated fatty acids can be classified in terms of essential fatty acids that must be part of the diet intake because they are not synthesised by the body and have a direct role in human health. Standard type sunflower oil is made up of about 15% saturated and 85% unsaturated fatty acids. About 14-43% and 44-75% of the unsaturated fatty acids are oleic and linoleic acids, respectively. Sunflower oil is not only one of the most important vegetable oils for human nutrition but also one of the best quality vegetable oils for its fatty acid composition. According to the data of the Vegetable Oils and Fats Industrialists Association, the fact that about 50 percent of vegetable oil production is supplied with sunflowers, of which the oil content varies between 22-50%, makes sunflower oil even more important. Previous studies have determined that fatty acid synthesis in oil crops can change due to genetic, ecological, morphological, physiological, and cultural practises and even the same types of oils can show different fatty acid characteristics. As the oleic acid level in sunflower oil increases, the linoleic acid level decreases and vice versa. Their levels can change in accordance with climate conditions. The most important parameter that has a profound effect on the

CORRESPONDING AUTHOR:
Adana Science and Technology University
Faculty of Engineering
Department of Food Engineering
01250 Adana, Turkey
E-mail: mrakkaya@adanabtu.edu.tr

plant growth and fatty acid accumulation is temperature. In the growing season, when the temperature increases, the oleic acid level increases too, but, on the contrary, the linoleic acid level decreases [1]. Temperature also affects the oleic acid content during seed maturation. A one degree increase in temperature results in approximately 2% increase in oleic acid content [2]. Sunflower genotypes also exhibit different properties when they are grown in different conditions [3]. It is well known that the fatty acid content changes according to genotypes and environmental conditions. The determination of the relation between the changes in the fatty acid compositions of oil plants and environmental factors is therefore vital in terms of oil quality. Only then, it will be possible to produce desired oil types by planting the proper plant types in the region of interest.

Fatty acid composition, which affects the physical and chemical characteristics of oils, is not always constant and shows a diversity among the species. Many factors influence in these differences [4]. For this reason, the knowledge of the variations that occur in the fatty acid profile of oil crops under a given condition is very important for oil quality. Oil quality is closely associated with nourishment value, technological and processing features, and the fatty acid composition. The knowledge of the fatty acid composition makes oil production possible for intended purposes. It would be possible to produce proper oils by cultivating the species suitable for desired oil types under suitable conditions [4].

Ecological and climate conditions of the oil crops production area are highly effective on the fatty acid composition. Oils produced from sunflowers grown in Çukurova of East Mediterranean region, which is in hot climate zone, contain a high level of oleic/linoleic acid. Oleic acid contents of these oils may exceed the limits (14.0-39.4) stated in Standard for Named Vegetable Oils Codex Alimentarius Standard no: 'Codex Stan 210-1999' [5] (Tab. I).

Since the oleic acid contents of sunflower exceed the limits stated in the Codex due to the growth conditions, vegetable oil producers have been unfairly accused of imitation and adulteration. In addition, sunflower seeds, which have no information on their fatty acid properties, are sold at lower prices. This study was carried out to determine the fatty acid compositions of the sunflowers planted in a very large area in Çukurova (approximately 5 million decares between 36.6-37.4 north latitude and 34.8-36.2 east longitude) of the East Mediterranean region, to establish a regional data bank and to contribute to creating regional data.

2. MATERIALS AND METHODS

2.1 MATERIALS

In this study, five different standard types of sunflower varieties (Bosfora, LG5550, P63F73, Cadix, LG5580) and a high-oleic type of sunflower variety (Oliva CL) widely planted in the region and pre-sowing seeds which obtained before sowing date from local plant seed sellers were used. Çukurova region was divided into three different locations as Adana, Tarsus and Ceyhan. 500 g sample was taken from five standard types and the high oleic sunflower type harvested between 2015 and 2016, under dry farming conditions in three different production areas of each location.

2.2 FATTY ACIDS ANALYSIS BY GAS CHROMATOGRAPHY

Prior to oil analysis sunflower seeds were cleaned, dried in the oven (40°C for 4 h) [6] until moisture contents fall below 10% and 50 g samples ground in a waring blender (Waring Commercial, USA) 1mm diameter. For crude oil analysis, 5 gr sunflower seed samples were taken after grinding and analysed by Soxhlet extraction (Gerhardt Analytical Systems, Germany) using 150 ml petroleum ether as solvent for 3 h [7]. The extracted crude oils were then used for gas chromatography (GC) analysis after the esterification. 0.5 g oil was transferred into 10 mL-capacity glass tube. Five millilitres n-heptane was added into the tube. 200 µL 2M potassium hydroxide solution in methanol was added to this mixture. After mixing for 20 seconds, upper phase was separated and analysed by GC [8]. The GC was equipped with a capillary column (Fused silica, 100 m × 0.25 mm × 0.2 µm) and a FID detector (Agilent 7890A, Agilent Technologies, USA). The GC conditions used to determine fatty acid methyl ester (FAME) were the same as the following [9]; injection volume: 1µL; temperature program: 175°C for 10 min, 5°C/min to 210°C, 5°C/min to 230°C; final temperature 230°C for 15 min; detector temperature: 260°C; injector temperature: 250°C; gas carrier flow: N_2, 1mL min^{-1}; split: 1:20; total run time: 58.5 min.

Table I - Some fatty acid contents of sunflower oil in Codex Stan 210-1999.

Fatty acids	Sunflower oil (%) (standard)	Sunflower oil (%) (mid-oleic acid)	Sunflower oil (%) (high-oleic acid)
Palmitic acid	5.0 – 7.6	4.0 – 5.5	2.6 – 5.0
Stearic acid	2.7 – 6.5	2.1 – 5.0	2.9 – 6.2
Oleic acid	14.0 – 39.4	43.1 – 71.8	75.0 – 90.7
Linoleic acid	48.3 – 74.0	18.7 – 45.3	2.1 – 17.0
Linolenic acid	0 – 0.3	0 – 0.5	0 – 0.3

2.3 STATISTICAL ANALYSIS

Data were analysed statistically using the JMP 7.0 software package. The experiments were performed in three separate batches with thrice replicates. Statistical data analyses were carried out in a randomised split blocks design; data were subjected to analysis of variance and level of significance among the treatments. The data were compared by the test of LSD, with a significant level at 0.05.

3. RESULTS AND DISCUSSION

3.1 CLIMATIC DATA

When the vegetation climatic data was examined, it was determined that the temperature average in both years (22.8°C and 22.8°C) was higher than the temperature average (22.5°C) for the long term years. At the seed maturation stage that is the most critical period in which the composition of fatty acids is shaped (corresponding to the month of June), the temperature average in both years (25.3°C and 24.8°C) was determined to be lower than the temperature average for long term years (25.6°C). In addition, the temperature average in June was lower in the second year (24.8°C) than in the first year of the test (25.3°C).

When we examined the amount of rainfall during the vegetation period, it was low in both the first (171 mm) and the second years (147.6 mm). The amounts of rainfall during the first and second years were lower than in the average for the long term years (199.2 mm). When June, corresponding to the seed filling phase, is considered, the amount of rainfall in the first year of the experiment was lower (0.3 mm) than the average of long term years (19.6 mm). In the second year of the experiment, it was determined that there was a much higher rainfall (50 mm) than the average for the long-term years (19.6 mm).

Like these results, the number of rainy days in the vegetation period was lower in both years (21 and 26 days) than the average of long term years (30.1 days). The number of rainy days in June was lower in the first year (1 day) than the average for long term years (2.9 days). It was higher than the average for long term years (2.9 days) in the second year of the experiment (3 days).

3.2 OLEIC ACID

Oleic acid contents of pre-sowing seeds and post-harvest samples taken from sunflowers widely planted in the region are given in Table II. The average of oleic acid contents of Oliva CL which is the only high oleic sunflower was found as 81.99%. The average of oleic acid contents of the other five different standard types ranged between 41.04-46.15%.

Oleic acid contents of five different standard types and the high oleic sunflower type changed between 36.37-49.03% and 81.67-82.31%, respectively.

Table II - Oleic acid contents of the pre-sowing seeds and samples obtained from each location.

		Oleic Acid Contents (%)																					
	Variety	Bosfora				LG5550				P63F73				Cadix				LG5580				Oliva CL			
		1st Year		2nd Year	Mean		1st Year	2nd Year	Mean		1st Year	2nd Year	Mean		1st Year	2nd Year	Mean		1st Year	2nd Year	Mean		1st Year	2nd Year	Mean	
Locations	Seed*	21.56	e	20.81	e	D	21.18	31.26	b	29.25	b	C	30.25	22.34	e	23.59	e	C	22.96	25.39	d	26.28	d	B	25.83	21.35	e	19.53	f	C	20.44	84.85	a	78.67	b	81.76	A
	Adana	40.51	c	37.65	d	C	39.08	43.63	a	44.28	a	B	43.95	36.44	d	36.30	d	B	36.37	51.73	a	41.05	c	A	46.39	41.11	c	40.63	cd	B	40.87	84.37	a	79.61	b	81.99	A
	Tarsus	47.14	a	43.70	b	A	45.42	45.27	a	45.23	a	AB	45.25	46.50	a	40.85	c	A	43.67	51.67	a	41.79	c	A	46.73	45.80	a	39.00	d	A	42.40	83.66	a	79.69	b	81.67	A
	Ceyhan	45.30	ab	41.43	c	B	43.37	49.75	a	48.30	a	A	49.03	43.80	b	42.35	bc	A	43.08	48.45	b	42.23	c	A	45.34	42.97	b	43.43	b	A	43.20	84.22	a	80.39	b	82.31	A
	Mean**	44.32		40.93			42.62	46.22		45.94			46.08	42.25		39.83			41.04	50.62		41.69			46.15	43.29		41.02			42.16	84.08		79.90		81.99	
	C.V.	3.25				8.56				2.92				3.23				2.76				1.7													
	Lsd(0,05)	2.16				6.34				1.9				2.36				1.8				2.48													

* Pre-sowing seeds, ** Locations Mean, CV: Coefficient of Variation, Lsd: Least significant difference, Values in the columns with different letters (a–e, A-D) are significantly different (p<0.05)

We found similar results as shown in previous studies [10, 11, 12], but especially oleic acid contents of standard type sunflowers were found to be higher than the studies of Turhan *et al.,* (2010) [13], Merwe *et al.,* (2013) [14] and Kandil *et al.,* (1990) [15]. It is thought that because pre-sowing seeds were grown in a cooler climate than Çukurova, oleic acid content in pre-sowing seeds of standard type sunflowers was lower in these studies. It was also determined in this study that, in some cases, sunflower pre-sowing seeds for oleic acid classified as standard type according to the Codex Alimentarius classification [5] turns into mid-oleic type when it is cultivated in Çukurova in the East Mediterranean Region.

As a consequence of the evaluation of the oleic acid content in sunflowers grown in the area on yearly bases, it was observed, in the second year of the study, that the oleic acid contents in both standard types and the high oleic sunflower decreased. In our opinion, this situation is due to the lower temperature average and more frequent rainy days in June of the second study year corresponding to the seed filling time. Several previous studies support this claim [1, 3, 10, 11, 12, 13, 16, 17, 18, 19, 20, 21, 22]. But there are some studies showing that high oleic sunflowers are hardly or not affected by climate conditions [14, 23, 24, 25]. In this study, climate especially affected the temperature oleic acid contents of the high-oleic type sunflowers even in a small extent when compared to standard type sunflowers and the oleic acid content of the high oleic acid sunflower decreased from 84.08% to 79.90% in the second year of the study. This might be due to the genotypic features of the variety.

As it is inferred from Table VII; year, variety and location had a statistically significant effect ($p < 0.01$) on the oleic acid content according to the variance analysis. According to relation in the parameters, interaction between variety*location ($p < 0.01$) and year *variety* location ($p < 0.01$) was also found as statistically significant.

3.3 LINOLEIC ACID

Linoleic acid contents of pre-sowing seeds and post-harvest samples are shown in Table III. The average of linoleic acid contents of Oliva CL which is the high oleic sunflower was 8.16%. The average of linoleic acid contents of the other five different types ranged between 40.72-46.73%, respectively.

In this study, linoleic acid contents of five different standard types and the high oleic sunflower oil changed between 37.88-50.97% and 7.92-8.37%, respectively. These were in accordance with similar results as shown in previous studies [10, 11, 12, 26], but especially linoleic acid contents of standard type sunflowers were lower than the studies of Turhan *et al.,* (2010) [13], Merwe *et al.,* (2013) [14], Kandil *et al.,* (1990) [15] and Lajara *et al.,* (1990) [27]. Pre-sowing

Table III - Linoleic acid contents of the pre-sowing seeds and samples obtained from each location

	Linoleic Acid Contents (%)																	
Variety	Bosfora			LG5550			P63F73			Cadix			LG5580			Oliva CL		
	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean
Seed*	64.30 a	65.73 a	65.02 A	52.05 a	53.85 a	52.95 A	61.99 a	59.62 b	60.80 A	58.50 a	59.45 a	58.97 A	62.14 a	65.07 a	63.60 A	5.90 e	12.34 a	9.12 A
Locations: Adana	46.98 c	50.11 b	48.55 B	44.01 b	40.93 bc	42.47 B	50.95 c	51.00 c	50.97 B	36.14 d	46.31 b	41.23 B	46.67 bc	45.82 c	46.25 B	6.11 de	10.28 b	8.20 B
Locations: Tarsus	38.22 e	44.25 d	41.23 D	42.44 bc	41.17 bc	41.81 BC	41.53 f	47.36 d	44.45 C	37.32 cd	46.13 b	41.72 B	41.17 d	49.15 b	45.16 B	6.69 de	10.04 b	8.37 AB
Locations: Ceyhan	43.32 d	45.10 cd	44.21 C	37.92 c	37.83 c	37.88 C	45.29 e	44.24 e	44.77 C	39.71 c	44.68 b	42.20 B	45.74 c	43.61 cd	44.68 B	7.23 d	8.61 c	7.92 B
Mean**	42.84	46.49	44.66	41.46	39.98	40.72	45.92	47.53	46.73	37.72	45.71	41.72	44.53	46.19	45.36	6.68	9.64	8.16
C.V.		2.51			7.65			2.21			3.55			3.67			8.05	
Lsd(0,05)		2.22			5.95			1.97			2.91			3.26			1.20	

* Pre-sowing seeds, ** Locations Mean, CV: Coefficient of Variation, Lsd: Least significant difference, Values in the columns with different letters (a–e, A-D) are significantly different ($p<0.05$)

sunflower seeds had higher linoleic acid content when compared to postharvest seeds in this study. The reason for high linoleic acid content in pre-sowing seeds might be due to the fact that they were originally grown in cooler climate when compared to Çukurova. It was also found in this study that, in some cases, sunflower pre-sowing seeds classified as standard type according to the Codex Alimentarius classification [5] turns into mid-oleic type when it is cultivated in Çukurova in the East Mediterranean Region.

Although it was stated in the previous studies [14, 23, 24, 25] that high oleic sunflowers are hardly affected or not affected by climate, climate conditions, especially the temperature affected the linoleic content of the high-oleic type even to a little extent when compared to the standard type sunflowers in this study. Again, it is likely that this is a genotypic feature of the variety.

Year, variety, and location had a statistically significant effect on the linoleic acid content ($p < 0.01$) and the interaction between variety*location ($p < 0.01$) and year*variety*location ($p < 0.01$) was significant (Tab. VII).

3.4 PALMITIC ACID

Palmitic acid contents of pre-sowing seeds and postharvest samples taken from sunflowers widely planted in the region are given in Table IV. Average of palmitic acid contents of Oliva CL was 4.48% and that of the other five standard type sunflowers ranged between 5.50-6.03%.

Palmitic acid contents of five standard type and the high oleic sunflower oil changed between 5.38-6.19% and 4.38-4.60%, respectively. We found some similar results of previous studies [12, 13, 15, 17, 18, 22, 23], but especially palmitic acid contents of standard type sunflowers were lower than those reported in the studies of Izquierdo *et al.,* (2002) [1], Qadir *et al.,* (2006) [3] and Lajara *et al.,* (1990) [27] and higher than those found by Lagravere *et al.,* (2000) [11]. The palmitic acid content of the high oleic sunflower was higher than palmitic acid contents reported by Izquierdo *et al.,* (2002) [1], Flagella *et al.,* (2002) [16] and Izquierdo and Aguirrezabal, (2008) [17]. Palmitic acid contents of both standard type and the high oleic sunflower were in good agreement with the classification by Codex Alimentarius [5].

According to the variance analysis (Tab. VII), variety and location affect palmitic acid content ($p < 0.01$) but the year does not have a statistically significant effect on the palmitic acid content. When the interaction between the parameters is considered, variety*location significantly affects palmitic acid content ($p < 0.05$). The interaction among year*variety*location has no statistical significance.

3.5 STEARIC ACID

Stearic acid contents of pre-sowing seeds and postharvest samples are given in Table V. The average of

Table IV - Palmitic acid contents of the pre-sowing seeds and samples obtained from each location.

		Palmitic Acid Contents (%)																					
	Variety	Bosfora				LG5550				P63F73				Cadix				LG5580				Oliva CL			
		1st Year		2nd Year		Mean		1st Year		2nd Year		Mean		1st Year		2nd Year		Mean		1st Year		2nd Year		Mean	
Locations	Seed*	5.86	b	5.69	bc	5.78	AB	5.43	c	6.91	a	6.17	A	5.96	ab	5.73	a-c	5.84	A	6.18	a	5.82	ab	6.00	A	6.42	ab	6.49	a	6.45	A	3.96	b	3.96	b	3.96	B
	Adana	5.61	bc	5.41	c	5.51	BC	5.85	-c	6.53	a-c	6.19	A	6.19	a	5.64	a-c	5.92	A	5.58	a-c	5.61	a-c	5.60	AB	5.79	cd	5.88	b-d	5.84	B	4.45	a	4.46	a	4.45	A
	Tarsus	6.23	a	5.41	c	5.82	A	5.62	bc	6.68	ab	6.15	A	6.03	ab	5.56	bc	5.80	AB	5.29	bc	5.77	a-c	5.53	AB	6.17	a-c	5.46	d	5.82	B	4.59	a	4.62	a	4.60	A
	Ceyhan	5.51	bc	5.42	c	5.47	C	5.55	bc	5.93	a-c	5.74	A	5.34	c	5.44	bc	5.39	B	5.68	a-c	5.08	c	5.38	B	5.84	cd	5.65	cd	5.75	B	4.37	a	4.38	a	4.38	A
	Mean**	5.78		5.41		5.60		5.67		6.38		6.03		5.85		5.55		5.70		5.52		5.49		5.50		5.93		5.66		5.80		4.47		4.49		4.48	
	C.V.	4.26						11.34						5.98						7						5.23						4.44					
	Lsd(0,05)	0.43						1.22						0.61						0.7						0.55						0.34					

* Pre-sowing seeds, ** Locations Mean, CV: Coefficient of Variation, Lsd: Least significant difference, Values in the columns with different letters (a–e, A-C) are significantly different ($p<0.05$)

Table V - Stearic acid contents of the pre-sowing seeds and samples obtained from each location.

Variety		Stearic Acid Contents (%)																	
		Bosfora			LG5550			P63F73			Cadix			LG5580			Oliva CL		
		1st Year	2nd Year	Mean	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean
	Seed*	5.16 a	4.93 a	5.04 A	7.73 a	6.88 a	7.30 A	7.70 a	7.47 a	7.58 A	5.89 a	5.91 a	5.90 A	5.92 a	5.50 a	5.71 A	2.80 a	2.83 a	2.81 A
Locations	Adana	3.00 bc	2.68 c	2.84 C	3.41 b	3.26 b	3.34 B	3.09 bc	3.01 bc	3.05 B	2.77 bc	3.28 bc	3.03 B	2.86 bc	3.28 b	3.07 B	1.93 c	2.61 ab	2.27 B
	Tarsus	3.49 b	3.28 bc	3.38 B	3.36 b	3.46 b	3.41 B	3.35 b	2.92 bc	3.14 B	2.94 bc	2.63 c	2.78 B	2.66 c	2.95 bc	2.81 BC	2.19 bc	2.49 ab	2.34 B
	Ceyhan	2.85 bc	3.39 b	3.12 BC	3.53 b	3.48 b	3.51 B	2.56 c	3.37 b	2.97 B	2.99 bc	3.33 b	3.16 B	2.38 c	2.69 bc	2.54 C	2.03 c	2.28 bc	2.16 B
	Mean**	3.11	3.12	3.11	3.43	3.40	3.42	3.00	3.10	3.05	2.90	3.08	2.99	2.63	2.97	2.81	2.05	2.46	2.26
	C.V.		10.94			14.91			7.54			10.58			9.75			10.61	
	Lsd(0,05)		0.7			1.16			0.56			0.7			0.61			0.45	

* Pre-sowing seeds, ** Locations Mean, CV: Coefficient of Variation, Lsd: Least significant difference, Values in the columns with different letters (a–e, A-C) are significantly different (*p*<0.05)

stearic acid contents of Oliva CL was 2.26% whereas average of stearic acid contents of the other five sunflowers were in the range of 2.81-3.42%.
However, the stearic acid contents of different standard types and the high oleic sunflower oil changed between 2.54-3.51% and 2.16-2.34%, respectively. The results of this study agree well with the results given in previous studies [3, 11, 15, 17, 18, 23], yet stearic acid contents of standard type sunflowers were lower than those reported in the studies of Izquierdo *et al.,* (2002) [1], Anastasi *et al.,* (2000) [12] and Lajara *et al.,* (1990) [27]. In the case of the high oleic type sunflower, stearic acid content was lower than the value reported by Flagella *et al.,* (2002) [16]. While the stearic acid contents of standard type sunflowers fell into the range stated by the Codex Alimentarius [5], high oleic sunflower had stearic acid content lower than the lowest limit stated for stearic acid content of the high oleic type sunflower by the Codex Alimentarius [5].
Statistical analysis shows that variety and location have significant effect on the stearic acid content (p <0.01) but the year does not affect the stearic acid content. While the interaction between the variety and location significantly affects stearic acid percentages (p <0.01), the interaction among year*variety*location had no statistical significance (Tab. VII).

3.6 LINOLENIC ACID

Linolenic acid contents of the samples taken from sunflowers are shown in Table VI. The average of linolenic acid contents of Oliva CL was found to be 0.27%. The average linolenic acid content of the high oleic sunflower ranged between 0.16% and 0.18%.
Linolenic acid contents of five different standard types and high oleic sunflower oil changed between 0.14-0.18% and 0.26-0.27%, respectively. Linolenic acid contents of both standard type and the high oleic sunflower was higher than those given in the studies of Lagravere *et al.,* (2000) [11], Turhan *et al.,* (2010) [13], Flagella *et al.,* (2002) [16] and Schulte *et al.,* (2013) [28]. Linolenic acid contents of all types of sunflowers are in good agreement with their grouping criteria stated in the Codex Alimentarius [5].
According to the variance analysis (Tab. VII), the variety and location were found to affect linolenic acid statistically (p <0.01). However, the year does not affect the linolenic acid content. When the interactions among the parameters were determined, the interaction between the variety and location had a statistically significant effect (p <0.05) on the palmitic acid percentages but the interaction among the year, variety and location had no significance.

4. CONCLUSIONS

The results of this study indicate that fatty acid compositions of sunflower oils may show diversity de-

Table VI - Linolenic acid contents of the pre-sowing seeds and samples obtained from each location.

	Variety	Linolenic Acid Contents (%)																	
		Bosfora			LG5550			P63F73			Cadix			LG5580			Oliva CL		
		1st Year	2nd Year	Mean	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean
Locations	Seed*	0.13 bc	0.12 c	0.12 B	0.12 c	0.13 c	0.12 B	0.11 d	0.12 d	0.11 C	0.12 c	0.12 c	0.12 B	0.12 d	0.12 d	0.12 B	0.25 cd	0.25 d	0.25 B
	Adana	0.16 ab	0.16 a-c	0.16 A	0.17 ab	0.15 b	0.16 A	0.15 bc	0.14 c	0.14 B	0.17 a	0.15 b	0.16 A	0.18 ab	0.17 bc	0.18 A	0.28 a-d	0.26 a-d	0.27 A
	Tarsus	0.17 a	0.15 a-c	0.16 A	0.18 a	0.16 ab	0.17 A	0.17 a	0.15 a-c	0.16 A	0.16 ab	0.15 ab	0.16 A	0.18 ab	0.17 c	0.18 A	0.26 b-d	0.27 a-c	0.26 A
	Ceyhan	0.16 ab	0.18 a	0.17 A	0.16 ab	0.17 ab	0.17 A	0.16 ab	0.17 a	0.17 A	0.16 ab	0.16 ab	0.16 A	0.19 a	0.18 a-c	0.18 A	0.27 a-d	0.28 ab	0.27 A
	Mean**	0.16	0.16	0.16	0.17	0.16	0.17	0.16	0.15	0.16	0.16	0.15	0.16	0.19	0.17	0.18	0.27	0.27	0.27
	C.V.		14.15			7.47			7.45			6.19			5.48			5.16	
	Lsd(0,05)		0.039			0.021			0.019			0.016			0.016			0.024	

* Pre-sowing seeds, ** Locations Mean, CV: Coefficient of Variation, Lsd: Least significant difference, Values in the columns with different letters (a–e, A-C) are significantly different ($p<0.05$)

pending on the genotype and the region. Climate conditions, especially high temperature and lower amounts of rains during the seed filling time, also make oleic acid content increase. For this reason, oleic acid contents of oils produced from sunflowers grown in the East Mediterranean region is higher. Oils produced especially from standard type sunflower may turn up to be mid-oleic sunflower oil because of the climate conditions. This feature of the region is an advantage because oils with high oleic acid content are more resistant to high temperature and oxidation. This is also advantageous since food industry demands high quality vegetable oils. In this study, the fatty acid contents of oils produced from sunflowers grown in the region were determined; it would therefore be possible to make oil production suitable for the desired features and obtain products with a high quality for intended purposes.

Oil seeds must be considered as strategic products in Turkey as it has been worldwide, since only 25% of raw materials for vegetable oil production in Turkey is met by national production and oil seed and raw materials for vegetable oil importation and vegetable oil exportation are important for commerce. Because the oils produced from the sunflowers grown in Çukurova of the East Mediterranean region are high quality products, a detailed product support policy must be provided for the sunflower oil producers in this region. Additionally, the classification of sunflower oils according to oleic acid content should be indicated on the label of the oils in the trade.

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Table VII - Analysis of variance of sunflowers according to year, variety and location.

Parameters	Oleic Acid	Linoleic Acid	Palmitic Acid	Stearic Acid	Linolenic Acid
Year	0.0021**	0.0015**	0.986NS	0.5156NS	0.1328NS
Variety	<.0001**	<.0001**	<.0001**	<.0001**	<.0001**
Location	<.0001**	<.0001**	0.0080**	<.0001**	<.0001**
Variety * Location	<.0001**	<.0001**	0.0450*	<.0001**	0.0413*
Year * Variety * Location	0.0002**	<.0001**	0.201NS	0.4771NS	0.5876NS

* p< 0.05, ** p< 0.01: Significance level, NS: Non-significant

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