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EFFECTS OF ECOLOGICAL AND TOPOGRAPHIC CONDITIONS ON OIL CONTENT AND FATTY ACID COMPOSITION IN SUNFLOWER

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Abstract

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Oil concentration and quality in sunflower (*Helianthus annuus* L.) are very much affected by environmental conditions such as temperature, precipitation, relative humidity, cloudiness and so on. Sunflower oil quality is determined by its fatty acid composition. Therefore, the objective of this study was to investigate the effect of ecological and topographic conditions on oil content and fatty acid composition in a standard sunflower hybrid. The samples were taken from six zones determined according to their ecological and topographical features. The results showed that oil content and fatty acid composition significantly changed by ecological and topographic conditions. Oil content in seeds varied 39.82-44.30% depending on location. Percentages of major fatty acids such as linoleic, oleic, palmitic and stearic acid were also significantly affected by growth location. As a result, environment or growth condition had a significant effect on sunflower oil content and fatty acid composition. Therefore, growth location is an important factor for meeting market requirements of sunflower oil in terms of quality.

Key words: Helianthus annuus; ecological; topographical; oil; fatty acids

Introduction

Sunflower is an important edible vegetable oil source as it is one of the most widely cultivated oil crops in the world due to its ability to grow in large semi-arid regions without irrigation. The fatty acid composition determines the use of sunflower oil (Osorio et al., 1995 and Piva et al., 2000). The oil containing a high level of oleic acid is preferred in nutritional use whereas that having higher linoleic content is preferred by paint or fuel industry. Standard sunflower cultivars contain high linoleic acid, moderate oleic acid and low linoloeic acid (Sabrino et al., 2003). Previously, both oil quality and rate in sunflower are well documented by several researchers (Nolasco et al., 2004 and Burton et al., 2004). The fatty acid composition changes depending on genotypes and some other factors such as environmental conditions, planting and harvesting time (Gupta et al., 1994; Baydar and Erbas, 2005; Roche et al., 2006). Flagella et al. (2002) also pointed out that irrigation and early sowing resulted in a significant decrease in

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the oleic/linoleic ratio in high oleic sunflower cultivars. They suggested that activation of aleate desaturase by early sowing and irrigation might have played in this mechanism. Kinman and Earle (1964) stated that the environment has a significant effect on fatty acid composition of sunflower as achenes produced in the cold climates contain 70% linoleic acid whereas those produced in warm or mild climates contain low linoleic acid level (30%). In addition, higher night temperature early during fruit filling results in higher oleic acid percentage (Izquierdo et al., 2002).

The fatty acid composition is also affected by latitude of growing area (Robertson et al., 1978). Lajara et al. (1990) found a negative correlation between linoleic acid content and latitude in Spain. Izequierdo et al. (2006) also stated that growing location had a stronger effect on oleic acid percentage comparing with sowing date. These previous results show that it is important to know oil content and fatty acid composition of sunflower for planning region dependent production pattern and consumption requirements. In the future, as in USA (Brien et al., 2001), there is also need to establish a market based on seed oil content and quality for benefit of both farmers and oil industry.

Although there have been some previous studies indicating effect of environmental conditions on individual fatty acids in oil crops, this study was conducted in a large area with a wide range of fatty acids. Therefore the objective of this project is to determine sunflower oil content and quality such as fatty acid composition in relation to different geographic and climatic conditions. The results of this study will also help and strengthen determination of future agricultural and marketing policy based on oil yield and quality of sunflower.

Materials and Methods

Experimental site located in northwest of Turkey, which provides 90% of Turkey's sunflower production and grows standard-type hybrid sunflower cultivars with regard to oleic acid content. This area was divided into six different zones according to their topographical and climatical features (Figure 1). Seeds of cultivar Sunbro (Syngenta Seed Company) grown in these zones by the farmers were used as plant material. In all these areas sunflower is grown under standard cultivation conditions without irrigation. Seed samples were taken from these areas as the following.

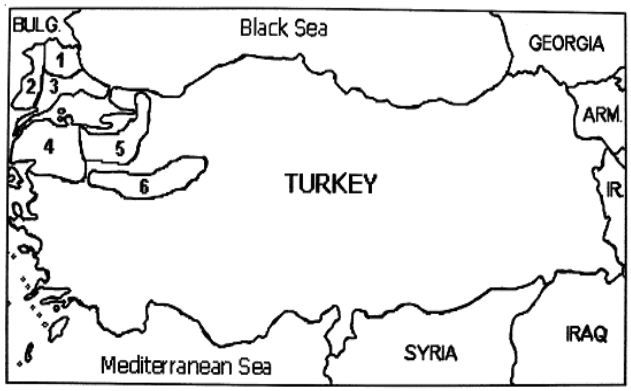

Fig. 1. Experimental sunflower production areas: (1) Kirklareli, (2) Edirne, (3) Istanbul-Tekirdag, (4) Balikesir-Canakkale, (5) Bursa-Kocaeli-Sakarya and (6) Ankara-Kutahya-Afyon

Sampling

Sunflower growing zones were assigned a number and shown on the map (Figure 1). From each zone, 10 samples were taken as replicates in growing season of 2003. Each of 10 samples consisted of three 1 kg achene sub-samples. These three samples were then mixed entirely and 1 kg of seed from the bulked sample, which represents one replication, was used for oil extraction and fatty acid analysis.

Oil Extraction

The seeds randomly taken from each sample were dried in an oven at 40°C for 4 h to reduce moisture up to about 5%. They were then ground with a mill (Fritsch Pulverisette14). The fine meal was extracted with petroleum ether in a Soxhlet type extractor (Pomeranz and Clifton, 1994). The oil extract was evaporated by distillation in a Rotary evaporator (Heildof) at 35°C until the solvent was totally removed. Crude extracts were then weighed.

Fatty Acid Determination

The fine milled sunflower meal (50 mg) was mixed with 1 ml sodium methylate (0.5 mol sodium/l methanol) in a plastic tube by vortexing briefly. The tubes were then kept at 20^0C for 20 min before vortex again. 400 µl isooctane was added and for a few seconds vigorously shaken. In the next step, 200 µl of %5 $NaHSO_4$ was added. After vortexing, the tubes were centrifuged at 1000 rpm for 5 min. Supernatant (150 µl) was removed into a vial. 3 µl of it was injected into GC by using auto sampler unit. A gas-liquid chromatographer (Perkin-Elmer 8600, San Jose, California, USA) was used with a Permabond-FFAP, 25 m x0.25 mm ID, split 1:100. Hydrogen was used as carrier gas with a pressure of 120 kPa.

Statistics

The analysis of variance was performed using the SAS computer package (SAS Institute., 1989). The experimental design was a randomized block design with ten replicates. Least Significant Difference (LSD) test was applied for means separation at 0.05 significance level.

Meteorological and Topographical Data

Meteorological data during sunflower growing season were obtained from the gauging stations in each province (Turkish State Meteorological Service). Topographical data were obtained from Falling Rain Genomics, Inc. (2004). Meteorological and topographical data for each sampling area were given in Table 1. Each value for both meteorological and topographical data represents average value of a growing zone.

Results and Discussion

Data for sunflower seed samples collected from six different locations in Turkey were analyzed to determine the effect of location on fatty acid composition of sunflower oil and the results of analyses were presented in Table 2. Some fatty acids such as caproic, caprilic, kapric, lauric, linolenic, vaccenic, linolelaidic, docosanoic and nervonic were not presented in here as their content were not at detectable level or present in the oil.

According to variance analyses of data, oil rate and most of the fatty acids in sunflower were significantly affected by growth location (Table 2). Some of fatty acids such as heptadesanoic, behenic, eicosadienoic and lignoceric were not significantly affected by location. However, it should be mentioned that the data could be suppressed by the very low contents of these fatty acids in terms of mean separation.

Oil content varied 39.86-44.39% depending on location (Figure 2). The highest oil rate was observed in location assigned as number 4 which has the lowest altitude (Table 1). The temperature of this location was the second highest after location 2. As long as temperature does not cause a heat stress on plants, warmer climates with adequate moisture increase oil

Table 1
Average meteorological and topographical data for the sampling areas during growing season of 2003

Location	Altitude	Longitude	Latitude	Temp., °C	Rainfall, mm	Humidity, %	Cloudiness
1	158.33	41.58	27.59	20.26	211.54	56.07	2.61
2	61.43	41.31	24.45	21.03	220.14	56.22	2.80
3	78.10	41.10	27.66	19.90	157.10	72.52	2.17
4	38.32	40.06	27.44	20.60	111.44	65.15	2.37
5	112.58	40.47	29.74	20.32	200.52	64.64	2.67
6	955.82	39.41	31.21	18.37	131.77	56.90	2.70

Table 2

Variance analyses for oil content (%) and fatty acid components in sunflower seed obtained from six different regions

Oil components	Location (df: 5)	Rep. (df: 9)	Error (df: 45)
Oil rate	22.907***	0.459	3 600
Myristic	<0.001**	<0.001	<0.001
Palmitic	1.865***	0.011	0.102
Palmitolic	0.001***	<0.001	<0.001
Margaric	0.001***	<0.001	<0.001
Heptadesanoic	0.003	0.002	0.002
Stearic	4.792***	0.533	0.747
Oleic	261.132***	18 619	10 942
Linoleic	175.167***	17 808	11 235
g-linolen	<0.001***	0.001	0.001
Arachidic	0.005***	0.001	0.001
Ecosenoic	<0.001***	<0.001	<0.001
Behenic	0.008	0.003	0.004
Erucic	0.005	0.004	0.003
Eicosadienoic	0.011*	0.008	0.004
Lignoceric	0.001	0.001	0.001

* and ***: significant at 0.05 and 0.001, respectively.

content in crops. Sadeghi and Talaii (2000) stated that warmer climate increased fruit size and oil content of olive.

When fatty acid composition in the oil is evaluated, linoleic and oleic which are major fatty acids in sunflower oil changed significantly depending on growing location. The highest linoleic acid content was found in the location 6 which had the highest average altitude and lowest temperature. In this location average percentage of oleic acid was the lowest. Contents of these two fatty acids in other locations also changed inversely. Previous findings by Harris et al. (1978) also confirm that increasing temperature results in an increase in linoleic content of sunflower oil due to the effect of temperature on the activity of the desaturase enzymes that converts oleic to linoleic acid. Similarly, Flagella et al. (2002) pointed out that early sowing time of sunflower in Mediterranean results in a lower oleic/linoleic ratio due to lower temperature in early sowing time. As a result of relatively lower temperature in the location 6, the lowest oleic acid content (20.5152%) was obtained. Roche et al. (2006) also found higher oleic acid content associated with higher temperature in sunflower. Especially night tempera-

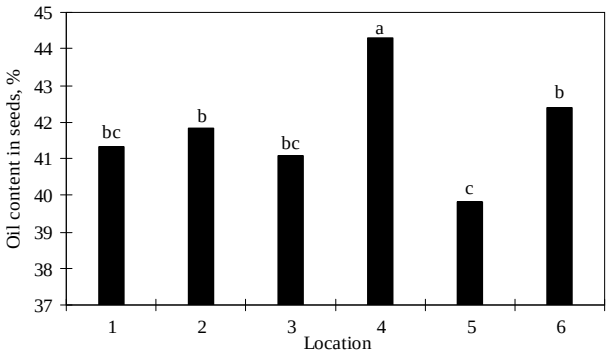

Fig. 2. Oil content of sunflower seeds collected from six different sunflower growing zones in Turkey

ture is an important factor for high oleic acid concentration in sunflower oil (Izquierdo et al., 2006). In addition, although no high oleic acid cultivars are grown in our sampling locations, oleic and linoleic contents in those cultivars are less affected by temperature than in standard cultivars (Flagella et al., 2000). In our study, the highest oleic acid (36.2560%) content was observed in the location 4 where relatively higher temperature had, and the oleic acid content varied inversely with the linoleic acid content.

The other major fatty acids, stearic and palmitic acids were also significantly affected by location. Stearic acid tended to increase in the warmer locations, which shows temperature is an important factor controlling stearic acid biosynthesis. This might be attributed to the enzymatic regulation of the stearate desaturase activity by temperature as in soybean (Chessbrough, 1990). The same result was also found in mutant sunflower lines (Fernandez et al., 2002). On the other hand, palmitic acid did not show the same pattern as it slightly decreased by warmer locations (Table 3). Flagella et al. (2002) investigated effect of sowing time on some fatty acids in sunflower and found that palmitic acid reduced in early sowing compared to late sowing as a result of lower temperature in early sowing growth period.

The minor fatty acids such as myristic, palmitoleic, margaric, g-linolen, arachidic, ecosenoic and eicosadieneoic were also affected by the location. The highest values for myritic (0.0796%), g-linolen (0.0675%) and arachidic (0.3101%) were determined in location 6 where had the highest altitude and lowest average temperature (Tables 1 and 3). In high altitudes, temperature differences were higher than that in low altitudes.

Moreover, night temperature in the high altitudes is generally lower, which affects the fatty acid composition (Izquierdo et al., 2002). Palmitoleic and ecosenoic acids were the highest in the location 4 as oleic acid.

Table 3

Mean values of oil content and fatty acid composition of sunflower (Sunbro) collected from six different regions (Means with the same letter for each line are not significantly different at P=0.05)

Fatty acids, %	Location					
	1	2	3	4	5	6
Myristic (LSD:0.0066)	0.0652 bc	0.0638 c	0.0676 bc	0.0610 c	0.0707 b	0.0796 a
Palmitic (LSD:0.2876)	5.9301 bc	5.8823 c	5.7135 c	5.7385 c	6.1889 b	6.8510 a
Palmitoleic (LSD:0.0164)	0.0993 bc	0.1072 ab	0.0926 bc	0.1172 a	0.0857 c	0.0971 bc
Margaric (LSD:0.0176)	0.0401 a	0.0322 ab	0.0182 bc	0.0123 c	0.0412 a	0.0294 ab
Heptadecenoic	0.0213	0.0299	0.0233	0.0573	0.0171	0.0082
Stearic (LSD:0.7785)	4.8680 a	4.4156 a	4.1542 ab	3.3948 bc	3.3073 c	4.8793 a
Oleic (LSD:0.9795)	29.1600 c	32.3970 b	33.7560 ab	36.2560 a	27.7380 c	21.8770 d
Linoleic (LSD:3.0191)	58.2500 b	55.5640 cd	54.8110 d	52.9430 d	59.9080 b	64.5460 a
g-linolen (LSD:0.0062)	0.0615 ab	0.0540 c	0.0563 bc	0.0554 bc	0.0665 a	0.0675 a
Arachidic (LSD:0.0252)	0.2921 ab	0.2716 b	0.2853 ab	0.2320 c	0.2909 ab	0.3101 a
Ecosenoic (LSD:0.0076)	0.1352 bc	0.1423 ab	0.1355 bc	0.1437 a	0.1313 c	0.1196 d
Behenic	0.7046	0.6652	0.6999	0.6385	0.7008	0.7034
Erucic	0.039	0.099	0.0791	0.0527	0.0616	0.0406
Eicosadienoic(LSD:0.0547)	0.1347 bc	0.1406 abc	0.1872 ab	0.1123 c	0.1914 a	0.1845 ab
Lignoceric	0.1985	0.2254	0.2201	0.2053	0.2145	0.2101

Conclusion

As a conclusion, this large-scale study revealed that different ecological and topographic conditions especially altitude and temperature resulted in significant changes in both seed oil content and fatty acid composition in sunflower. Therefore, growth location is an important factor for meeting market requirements of sunflower seed in terms of oil quality. Apart from growing condition, one should also consider some other factors such as cultivar oil type, planting time and irrigation in order to obtain a desire yield and quality.

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