• Technical

Fatty Acid Composition of Sunflower (*Helianthus annuus* L.) Oil as Influenced by Seed Position[1]

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ABSTRACT

The variation in fatty acid composition of the oil from seeds located in different positions within an individual sunflower head was determined. Each head was divided into three ring-shaped zones and four samples were taken from each zone. Ten heads from an inbred line and ten from an open-pollinated variety were sampled. Position of the seed within the head had a significant effect on the fatty acid composition of the oil. The linoleic and palmitic acid contents of the oil increased and the oleic acid content decreased from the perimeter toward the center of the head.

INTRODUCTION

Environmental modifications of the fatty acid composition of oilseeds are well known (1-3). These effects were apparent when comparing oil composition from sunflowers (*Helianthus annuus* L.) grown at different locations (4,5). Environment can also significantly affect fatty acid composition of the oil from plants grown at the same location and even from individual seeds from the same plant (6). Because fatty acid composition in sunflower is determined largely by the genotype of the seed (7) rather than by the genotype of the maternal parent, genetic studies and selection for fatty acid composition can be initiated on the individual seeds of an F_1 plant, rather than in later generations on an individual plant basis. If selection is to be effective, environmental effects on the position of the seed within the head must be recognized. The following study was initiated to determine the variation in fatty acid composition of the seeds from individual sunflower heads.

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MATERIALS AND METHODS

Ten mature heads (botanically, the capitulum) were selected at random from isolated fields of the inbred line CM 323 and the open-pollinated variety Krasnodarets. Each head was divided into three concentric, ring-shaped zones and each zone was sampled for six adjoining achenes from the 3, 6, 9 and 12 o'clock positions (Fig. 1). Consequently there were 12 samples from each head. After drying, the hulls (pericarp) were removed from the achenes and the seeds ground in a mortar with sand and extracted with petroleum ether. The triglycerides were converted to methyl esters and analyzed by gas chromatography as previously described (8). Relative amounts of the four major fatty acids of sunflower oil, palmitic, stearic, oleic and linoleic, were calculated by means of an electronic digital integrator. The standard deviation for individual fatty acid percentages was ± 0.1%.

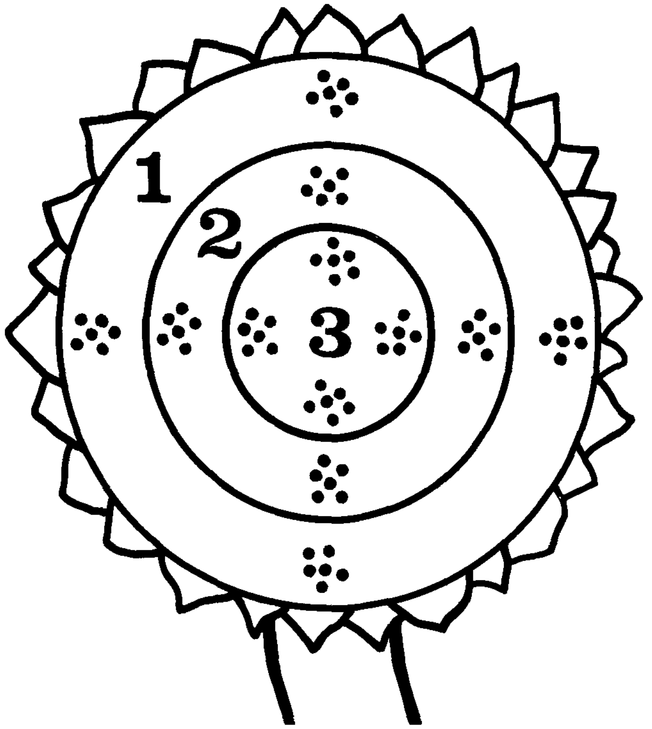

FIG. 1. Diagram of sunflower head showing three concentric, ring-shaped zones from which six-seed samples were taken.

TABLE I

Fatty Acid Composition of Oil from Seeds of Individual Heads of Individual Heads of Sunflower Line CM 323 and Krasnodorets Grown in 1972 and Averaged Over 12 Samples per Head

Line or variety	Head no.	Fatty acid composition, %			
		Palmitic	Stearic	Oleic	Linoleic
CM 323	1	5.6	8.4	28.8	57.1
	2	5.5	8.6	25.8	60.1
	3	6.1	7.8	29.2	57.0
	5	5.7	5.9	27.2	61.2
	5	5.4	6.9	25.5	62.1
	6	6.7	6.4	20.3	66.5
	7	6.2	6.7	24.3	62.8
	8	6.1	7.4	21.4	65.1
	9	6.0	9.6	27.1	57.3
	10	6.6	8.1	30.5	54.9
Mean		6.0	7.6	26.0	60.4
Krasnodarets	1	6.3	4.2	14.6	74.8
	2	5.9	5.4	15.2	73.5
	3	4.6	5.9	18.3	71.3
	4	7.0	5.9	18.4	68.7
	5	6.9	5.8	17.0	70.3
	6	6.9	5.6	17.5	70.0
	7	6.7	5.2	18.2	69.6
	8	7.5	4.7	17.0	70.8
	9	6.3	5.5	18.9	69.3
	10	6.3	5.2	15.6	72.9
Mean		6.5	5.3	17.1	71.1

TABLE II

Fatty Acid Composition of Oil from Seeds of Sunflower Line CM 323 and Variety Krasnodarets Grown in 1972, Sampled at Three Ring Positions and Averaged Over Ten Heads

Line or variety	Position[a]	Fatty acid composition, %			
		Palmitic	Stearic	Oleic	Linoleic
CM 323	1	5.9	7.8	27.2	59.1
	2	5.9	7.3	26.1	60.6
	3	6.1	7.8	24.8	61.3
Krasnodarets	1	6.1	5.6	19.0	69.3
	2	6.3	5.4	17.3	71.0
	3	6.9	5.0	15.0	73.1

[a]1 = outermost 3 cm of head; 2 = ring 3 cm inside ring 1; 3 = center of head.

TABLE III

Mean Squares for Fatty Acid Composition of Oil from Seeds of Sunflower Line CM 323 and Variety Krasnodarets Grown in 1972 and Sampled from Different Heads and Ring Positions within Heads

Source of variation	df	Mean Squares			
		Palmitic	Stearic	Oleic	Linoleic
Varieties	1	13.69[a]	320.15[a]	4812.26[a]	6656.28[a]
Heads	18	5.24[a]	10.88[b]	77.97[a]	112.96[a]
Positions	2	6.06[a]	3.22[b]	203.83[a]	228.99[a]
Variety *x* position	2	1.68[a]	4.93[a]	11.38[a]	3.60
Head *x* position	36	0.35[a]	0.97	5.21[a]	12.62[b]
Error	180	0.19	0.94	2.35	7.45

[a]Significant at the 1% level.
[b]Significant at the 5% level.

RESULTS AND DISCUSSION

The data show clearly that there are significant differences in fatty acid composition between sunflower heads within a line or a variety (Table I) and between locations (positions) within the head (Table II). Statistical analysis showed that the differences are significant for each of the four fatty acids (Table III). However the differences between clock positions within a ring were not significant for any of the fatty acids. The inbred line CM 323 had more stearic and oleic acids and less palmitic and linoleic acids than the open-pollinated variety Krasnodarets (Table I). The change in fatty acid composition with respect to ring position was in the same direction for both CM 323 and Krasnodarets, but of a different magnitude (Table II). The linoleic and palmitic acid contents increase and the oleic content decreases from the perimeter toward the center of the head. Except for the interaction of head *x* position for stearic acid and the interaction of variety *x* position for linoleic acid, all mean squares were significant (Table III).

The changes in fatty acid composition due to position within the head revealed strong correlations between certain fatty acids (Table IV). The large negative correlation, -0.94, between linoleic and oleic acids is very similar to that reported by others for sunflower varieties grown at several different locations (5,7). However the correlations between stearic acid and oleic, +0.69, or linoleic acids, -0.75, are larger than those reported previously. These correlations indicate that a selection for a certain level of either oleic or linoleic acid may result in a change in the level of the other acid. To a lesser degree, the level of stearic acid may also be expected to change with the selection for oleic and linoleic acids. The relatively low correlation between palmitic and the other acids suggests that the level of this acid might be changed without appreciably altering the others.

There was considerable variation in fatty acid composition of the oil from CM 323 and Krasnodarets, particularly for oleic and linoleic acids (Table V). Considering that fatty acid analyses were conducted on six adjoining seeds, which tends to average genetic effects, even greater variability on a single-seed basis would be expected.

The data presented show that there is variation in fatty acid composition of the oil both from among heads within a line or variety and from seeds of an individual head. As indicated by a significant variety *x* position interaction, the changes in fatty acid composition that we observed may have been different with other varieties or when grown in

TABLE IV

Simple Correlation Coefficients among Fatty Acids from Sunflower Seeds

Fatty acid	Palmitic	Stearic	Oleic
Stearic	-.31[a]	—	—
Oleic	-.38[a]	+.69[a]	—
Linoleic	+.25[a]	-.75[a]	-.94[a]

[a]Significant at the 1% level.

TABLE V

Variation in Fatty Acid Composition of Oil from Seeds of Individual Samples of Sunflower Line CM 323 and Variety Krasnodarets Grown in 1972

Fatty acid	CM 323, %			Krasnodarets, %		
	High	Low	Range	High	Low	Range
Linoleic	72.5	52.6	19.9	78.3	64.6	13.7
Oleic	33.7	14.7	19.0	21.9	10.9	11.0
Stearic	11.4	4.3	7.1	7.9	3.2	4.7
Palmitic	7.6	3.4	4.2	8.2	4.4	3.8

different years. No attempt was made to partition the variations due to genetic and environmental factors. Because the initiation of flowering begins at the outer perimeter of the head and progresses toward the center over a 7-10 day period, individual achenes may develop and mature under different environmental conditions. If the environment changes during a period of rapid oil formation, it will directly influence the fatty acid composition of the oil formed during that period. The fact that variation for fatty acid composition for CM 323 was the same as that for Krasnodarets indicates this environmental effect. CM 323 is highly inbred, and we would expect only minimal variation in fatty acid composition due to variability in the numbers of genotypes present. The major genotype in CM 323 could be one that is more sensitive to environmental fluctuations than the major genotype in Krasnodarets, and this sensitivity is reflected in fatty acid composition of the oil.

These results indicate the need for selective sampling of seeds from sunflower heads to be used in a selection program for fatty acid composition. Statistical analysis indicated that, with the exception of linoleic acid, the variation due to sampling was least for seeds removed from the center ring (ring 2). The means coefficients of variability for palmitic, stearic, oleic and linoleic acids when sampled from ring 1 were 8.0%; from ring 2 were 6.6%; and from ring 3 were 7.1%. Comparison of seeds removed from the center ring of sunflower heads that began flowering on the same day would reflect more accurately the genetic influence on fatty acid composition than comparison of seeds slected at random.

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