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FATTY ACID COMPOSITION OF SUNFLOWER OIL FROM DIFFERENT VARIETIES AND LOCATIONS

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Though sunflower oil is recognized as a high quality edible and cooking oil it has some undesirable features. Its semi-drying feature causes polymerization when the oil is heated during production of French-fried potatoes or similar food processing. This leads to objectionable gumming of the vessels and stirring equipment. Reduction of the iodine number or drying quality may overcome this objection and provide broader markets for the oil. An opinion, that the oil would find wider use in the paint industry if its drying quality were improved, has also been expressed. Thus two opposite channels for the breeder to alter sunflower oil present themselves.

Rather striking developments have occurred recently in identification of atypical oils within species of oilseed crops. Examples include the zero erucic acid strains of rapeseed (Brassica napus) (6) turnip rape (B. campestris) (1), and the low iodine oils in safflower (Carthamus tinctorius) (3). Such observations raise the possibilities of similar work in sunflowers.

It is well recognized that iodine number, or degree of unsaturation, in seed oils varies inversely with the amount of heat received during development of the seed. In sunflowers, for example, Kinman and Earle (4) in data from tests in Texas to Minnesota found the highest linoleic acid content or iodine numbers from the northern sites or where the seed matured in lower temperatures. Furthermore, they observed that an early variety which flowered before peak summer temperatures at College Station, Texas, produced the highest linoleic acid content among 14 entries. The same variety had the lowest linoleic acid content at Crookston, Minnesota, where other later entries matured during the cooler weather of the last part of the growing season. In their opinion linoleic acid content was "under genetic control only as a result of the interaction of flowering date and changes in atmospheric temperature".

Kinman and Earle (4) reported a high correlation (r = .991 between linoleic acid content and iodine number and considered that the latter could be used to calculate the linoleic acid content. Likewise, in safflower Knowles (5) found high correlations between iodine number and linoleic acid as well as oleic acid. The two acids were strongly negatively correlated.

This paper gives data on fatty acid composition of oil from varieties and inbred lines of sunflowers. They suggest that genetic factors operating independently of environment govern composition of the oil and provide some information on the relationship of the different fatty acids.

MATERIALS AND METHODS

Co-operative tests of eight varieties were grown at 10 locations in 1963 and 14 locations in 1964. Three varieties were common at seven stations in the two seasons. Palmitic, stearic, oleic and linoleic acid were determined, by gas-liquid chromatography, in oil from the open-pollinated seed using duplicate samples from the entries of each test. R. B. Carson, Analytical Chemistry Research Service, Canada Department of Agriculture made the analyses.

The second group of data consists of the fatty acid content of oil from composite samples of 50 seeds of 129 inbred lines produced at Morden in different years. The lines had been carried as bulked lines after one to nine generations of selection in single plant progenies. After data on the bulk samples were obtained, the upper portions of 42 single seeds in each of seven lines, 199 seeds of Peredovik, and 108 in each of Armavirec and Advent were analyzed. Dr. B. M. Craig, Prairie Regional Laboratory National Research Council, Saskatoon, Saskatchewan, provided the analyses and correlation coefficients between the different acid contents. He used a gas chromatograph equipped with an electronic integrator, which allows a sample to be analyzed in 3 to 5 minutes.

RESULTS AND DISCUSSION

Table 1 shows representative results from the Co-operative tests. F values for stations were significant at $P = .01$ for all acids in both seasons and for iodine number in 1964. The F values for varieties were also significant at $P = .01$ in all instances except for palmitic acid. The F values for varieties were one-third to one-tenth of the size of those for stations indicating a greater effect due to environment than genetic constitution. There was no significant interaction for varieties x stations in either year.

Combining the data of the three varieties grown in the two seasons gave significant F values at $P = .01$ for years in stearic and linoleic acids and for varieties, stations and years x stations interaction in the three acids, - stearic, oleic and linoleic. One exception was an F value barely exceeding $P = .05$ for varieties in linoleic acid. The other first order interactions of varieties x stations, and varieties x years and the second order interaction of years x varieties x stations were not significant. In palmitic acid only the years x stations interaction was significant.

Linoleic acid contents were higher than any reported by Kinman and Earle (4). Those of 1964 for Advent, Commander and Peredovik were higher than in 1963 and were accompanied by a corresponding decrease in stearic acid rather than oleic acid.

Significant differences in acid contents occurred between some varieties requiring the same number of days to mature. This was true for the separate seasons and for the combined data of the two years. Thus there is evidence that genetic control independent of temperature effects is governing acid content. In flax and rape (2, 7) composition of the oil depends on the genotype of the seed rather than that of the plant bearing it. Likely the same holds for sunflowers. Recognizing that sunflowers are a cross-pollinated crop differences between varieties in composition of oil should have been reduced or eliminated. That they remained is further evidence of genetic control of oil composition.

Table 1

Mean per cent fatty acid in oil of sunflower varieties
in 1963 and 1964 Co-operative Tests

Variety	Palmitic		Stearic		Oleic		Linoleic		Iodine No.	Days to Mature	
	1963	1964	1963	1964	1963	1964	1963	1964	1964	1963	1964
Advent	6.04	6.08	5.07	3.76	18.30	18.00	70.62	72.08	138.0	124	124
Commander	5.96	6.01	4.77	3.18	18.17	17.74	71.13	72.98	139.6	124	125
Peredovik	6.14	6.08	5.50	3.72	16.62	16.44	71.77	73.68	139.1	124	124
VNIIMK 8931	6.40	-	5.70	-	16.01	-	71.92	-	-	125	-
Smena	6.01	-	5.59	-	16.64	-	71.81	-	-	125	-
Armavirec	-	5.98	-	4.31	-	18.09	-	71.56	136.2	-	110
Ienissei	-	6.15	-	3.96	-	17.74	-	72.07	136.8	-	110
L.S.D.P. = .05	-	-	0.30	0.40	0.74	0.95	0.74	1.11	1.1	-	-
L.S.D.P. = .01	-	-	0.40	0.52	0.98	1.20	0.98	1.46	1.4	-	-
Two-year means over eight stations											
Advent	6.14	-	4.37	-	17.75	-	71.55	-	-	-	124
Commander	5.95	-	3.99	-	17.64	-	72.26	-	-	-	125
Peredovik	6.15	-	4.57	-	16.25	-	72.85	-	-	-	124
L.S.D.P. = .05	-	-	0.25	-	0.68	-	1.02	-	-	-	-
L.S.D.P. = .01	-	-	0.33	-	0.91	-	-	-	-	-	-

Table 4 Per cent fatty acid in oil of bulked seed of some inbred lines

Line	Date of bloom	Palmitic	Stearic	Oleic	Linoleic
CM 32	30-7-59	7.3	4.2	16.5	72.0
CM 177	30-7-59	6.9	4.9	40.3	47.9
CM 150	31-7-59	6.0	4.9	20.5	68.6
CM 132	31-7-59	7.0	6.9	35.9	50.2
CM 13	4-8-59	7.6	3.3	17.8	71.3
CM 83	4-8-59	5.5	8.7	33.1	52.7
CM 255	22-7-61	7.2	4.2	13.4	75.2
CM 79	22-7-61	6.5	9.7	34.7	49.1
CM 302	24-7-63	7.4	2.5	13.0	77.1
CM 308	6-8-63	7.3	7.0	30.5	55.2

In summary the data show that there are good prospects for changing the composition of sunflower oil independently of flowering date, particularly with respect to the two main components oleic and linoleic acid. Variation in stearic acid also indicates changes in the proportion of this acid are possible through breeding. Absence of a significant regression of linoleic acid on iodine number and lack of any strong relationship between the four component acids, except for oleic-linoleic, point up the need for more study in this area to determine the sequence of synthesis and if more than a single system is involved.

At present plants are growing from the remnant portions of seeds selected for high and low levels of the four acids. These should provide some information on parent-progeny relationships and lead to establishment of lines with greater divergence in analysis than those existing. Some of the present lines with the lowest linoleic acid content are being increased to provide small bulk samples of oil for tests on shelf life and other requirements of the food industry. Investigations on inheritance of the different types of oil and on the sequence of acid synthesis, the latter jointly with lipid researchers, are expected to follow.

REFERENCES

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Table 5 Simple correlation coefficients between different pairs of fatty acids in inbred lines and varieties (Courtesy B. L. Craig, Prairie Regional Laboratory, National Research Council, Saskatoon, Sask.)

Column No.	O-L	S-L	P-L	L-Sat	P-O	S-O	O-Sat	P-S	P-Sat	S-Sat
CM 83	-.82**	-.71**	-.23	-.64**	-.24	.21	.09	.50**	.72**	.96**
88	-.91**	-.48**	-.13	-.45**	-.16	.22	.05	-.08	.66**	.69**
132	-.98**	-.55**	.55**	-.22	-.62**	.39*	.00	-.39*	.26	.79**
142	-.95**	-.70**	-.39*	-.77**	.23	.50**	.53**	.09	.57**	.87**
177	-.98**	-.48**	.12	-.13	-.31*	.36*	-.09	.07	.87**	.55**
198	-.89**	-.01	.11	-.12	-.33*	.11	-.33*	-.39*	.98**	-.21
203	-.96**	.17	.34*	.34	-.56**	-.34*	-.58**	.29	.91**	.66**
CM 83-203	-.98**	-.54**	-.19	-.66**	.17	.41**	.52**	-.33**	.22	.85**
Inbreds	-.97**	-.55**	.13	-.49**	-.20	.45**	.33*	.39*	.27*	.78**
Armavirec	-.80**	-.48**	-.31**	-.04	-.05	.02	-.04	.02	.58**	.83**
Advent	-.91**	-.37*	.02	-.11	-.22	.03	-.11	-.12	.46**	.82**
Peredovik	-.96**	-.65**	.29**	.23	-.41**	.44**	.23	-.21	.29**	.87**
Overall	-.98**	-.53**	-.20	.49**	.15	.40**	.49**	-.28**	.32**	.82**

O - Oleic; L - Linoleic; P - Palmitic; S - Stearic; Sat - Palmitic + Stearic
Degrees of Freedom - CM 83, 88, 132, 177, 198, 203-40; CM 142 - 39; CM 83-203 - 291
Inbreds - 127; Armavirec, Advent - 106; Peredovik - 197; Overall - 835.

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