Breeding for Lipid and Amino Acid Composition in Sunflower[1]

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ABSTRACT

It may be possible to modify fatty acid composition of sunflower oil by appropriate breeding methods. Data are inadequate to judge the possibility of changing the amino acid composition of sunflower protein by breeding.

Attempts to change fatty acid composition of sunflower oil by breeding are in early stages. This author knows of no research on changing amino acid content of the protein. Proper processing of sunflower seed results in a stable, pleasant flavored oil which is often high in polyunsaturated linoleic acid. The protein meal is highly digestible and reasonably well-balanced with regard to amino acids. This writer has not seen fit to divert any of the limited public funds available for sunflower breeding research to changing fatty acid or amino acid composition.

Two types of commercial sunflower varieties are recognized, large seed and oil seed. The large seed type designed for the confectionery and birdfeed trade is low in oil and seldom enters the oilseed processing industry. This discussion will relate only to oilseed sunflowers.

Much of the progress in breeding sunflowers has been in change of gross chemical composition of the seed. From about 1930-1960, Russian workers (6) were able to increase oil content of the whole achene from around 35-50%, primarily by selecting for reduced hull content. Fiber was replaced almost on a per cent for per cent basis by oil. An increase of edible product per acre of approximately 50% was achieved. We expect to increase average yield of edible product per acre by 30% or more by taking advantage of the vigor of controlled hybrids and by breeding for control of pests.

Sunflower oil usually contains a total of 85-91% linoleic and oleic acids, as expected if one is high the other is low. The saturated fatty acids, palmitic and stearic together, usually comprise 9-12% of the oil. Other fatty acids are found in very low amounts. In earlier work (5), we found that the linoleic acid content of oil from northern grown seed was much higher (up to over 70%) than for the same varieties grown in the South (down to less than 20%). Other studies (1,3,4) also have indicated that low temperatures during synthesis of oil resulted in high linoleic acid. We concluded that, "It seems probable that high linoleic acid oil can only be produced in the northern states, at high altitudes, or by late summer planting in southern states," and that, "Linoleic acid content of the oil of sunflowers appears to be under genetic control only as a result of the interaction of flowering date and changes in atmospheric temperature." Fortunately E.D. Putt of the Canada Department of Agriculture did not accept this as conclusive.

Putt et al. (8) were able to demonstrate statistically significant variation in fatty acid composition due to both variety and location. They also found marked differences in linoleic acid content of oil from seed of inbred lines which flowered at the same time and, in one comparison of lines with different flowering dates, the reverse of the expected was encountered. They concluded, "Genetic differences in control of oil quality evidently overcame the usual effect of environmental temperature in this instance." This work is being continued by D.G. Dorrell. Fortunately Dorrell is competent in both genetics and chemistry. After two years work at Morden, Manitoba, he indicated (unpublished) the following range of oil composition with controlled environment:

Saturated fatty acids	8-40%
Oleic acid	12-66%
Linoleic acid	25-80%

He told me, "From the advance made (in selection for extremes) during selection and inbreeding, the heritability appears moderately high."

The preceding discussion is a good example of how research results can lead to general conclusion which fits a current set of circumstances; then, new research may show there are potentially serious exceptions to the data and conclusions. So long as seed samples came from open-pollinated varieties grown under extremely diverse growing conditions, the early conclusions seemed reasonable. The study of oil from seed of self-pollinated inbred lines grown under controlled conditions eliminates most of the averaging of expression of genetic, environmental and interaction effects, and provides much more reliable data upon which to base genetic inferences. It now seems possible to modify the composition of sunflower oil by appropriate breeding methods.

If single cross F_1 hybrid sunflowers are grown commercially, all plants in all fields of a given hybrid will be of essentially the same genotype and all will react in the same manner to the environment. Obviously a sunflower hybrid whose oil contained 40% saturated fatty acids would not be very desirable. On the other hand it may be possible to breed hybrids which will produce high linoleic acid oils even in the southern states. It will be necessary to determine the fatty acid composition of oil of our inbred lines and of the resulting hybrids before they enter commercial production.

Earle et al. (2) reported little variation in amino acid composition of protein from open-pollinated sunflower varieties. Here we have the same problem as in lipid composition—the averaging effects of many genotypes within an open-pollinated variety. I know of no data on amino acid content of inbred lines. Lysine is the first limiting essential amino acid in sunflower protein, as in many other plant proteins. It would seem desirable to breed for higher lysine at the expense of the nonessential glutamic acid. At present there seems no basis for speculation as to whether this may be possible.

The major problem with sunflower protein for human consumption seems to be the development of off colors due to chlorogenic acid and related compounds. Statistically significant differences in chlorogenic acid content of different varieties and hybrids do occur (7). However these differences seem too small to offer much hope of correcting the problem by genetic means.

[1]One of seven papers presented at the Symposium, "The Plant Geneticist's Contribution Toward Changing the Lipid and Amino Acid Composition of Oilseeds," AOCS Meeting, Houston, May 1971.

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