Sunflowers: America's Neglected Crop[1]

JAMES A. ROBERTSON, Richard B. Russell Agricultural Research Center, ARS, USDA, Athens, Georgia 30604

ABSTRACT

The sunflower, *Helianthus annuus*, is a crop which has been neglected in American agriculture. Sunflower oil from seed grown in the northern U.S. typically contains 70% linoleic acid and has a high ratio of polyunsaturated to saturated fatty acids. This makes it desirable as an edible oil in light of evidence linking saturated fats to high blood cholesterol and incidence of heart disease. In contrast sunflower oil from seed produced in the South generally contains 40-50% linoleic acid. Preliminary studies indicate that southern oil with a lower content of linoleic acid is slightly more stable than northern oil. The effect of planting dates, location and environmental temperatures on the fatty acid composition of northern and southern sunflower oils is reported. Studies also show that potato chips fried in sunflower oil are more flavorful after storage for four weeks than similarly treated chips fried in cottonseed-corn oil mixtures. Sunflower protein is highly digestible (90%) and possesses a high biological value (60%). Protein isolates prepared by the conventional method of extraction are greenish in color due to oxidation of chlorogenic acid. However research underway indicates that development of a nearly white isolate is possible. Analysis of chemical, physical and organoleptic properties indicate that dehulled sunflower kernels can be used in various food products. Defatted meal also can be used as a partial wheat substitute in bread and other bakery products.

[1]Presented at the AOCS Meeting, Atlantic City, October 1971.

INTRODUCTION

The sunflower, *Helianthus annuus*, is a native American wildflower which belongs to the largest family of flowering plants, the Compositae. It is a neglected crop in American agriculture because the significant developments in sunflower breeding which led to the establishment of sunflower as a cultivated crop in the U.S. occurred abroad. The commercial sunflower of today is believed to have originated in Peru or Mexico (1). It was introduced into Europe by the Spaniards in the 16th century and spread over that continent and finally into Russia where selection of superior varieties took place. This was the first significant development in sunflower breeding. These improved varieties were introduced into the U.S. in 1893 through the American Consul-General at St. Petersburg, and within a 3 year span, Oregon reported yields of 1500-2500 lb. of seed per acre from a sowing of 10 lb. to the acre (1). In succeeding years sunflowers became a staple crop in many parts of the U.S. The following was reported in 1943: "American sunflowers grow luxuriantly in much of the country. Much of the seed finds its way into commerce but largely as bird and poultry feed. Missouri raises the largest commercial crop, even exceeding Kansas where the sunflower is the state flower. California is also raising the seed for market" (1). The report goes on to say that the sunflower seed oil industry was discontinued in the U.S. because the labor cost in this country was higher than the labor cost in other countries producing vegetable oils. However in succeeding years large-seeded, low-oil varieties continued to be grown on a small scale in North Dakota and Minnesota for wild bird feed and for confectionary use. These varieties contain 21-33% oil (2-4). Acreage of the low-oil varieties did not exceed 10,000 until 1957. During

TABLE I

Average Composition of Selected Commercial Oilseed Meals[a]

	Sunflower meal		Cottonseed meal		Soybean meal
	Expeller	Solvent extracted	Expeller	Solvent extracted	Solvent extracted
Moisture	7.0	7.0	7.0	9.0	11.0
Ash	6.8	7.7	6.1	6.5	5.8
Crude fiber	13.0	11.0	11.0	11.0	6.0
Ether extract	7.6	2.9	5.8	1.6	0.9
Protein (Nx6.25)	41.0	46.8	41.4	41.6	45.8

[a]See Reference 8.

TABLE II

Fatty Acid Composition of Oil from Sunflower Seed Grown at Different Locations

		Fatty acid composition of oil (area, %)					
Planting location	Variety	Palmitic	Stearic	Oleic	Linoleic	Linolenic	Other fatty acids
Canada[a]	Peredovik	6.1	3.7	16.4	73.7	---	---
Canada[a]	Armavirec	6.0	4.3	18.1	71.6	---	---
Minnesota[b]	Peredovik	5.6	6.5	19.1	67.0	0.1	1.7
Minnesota[b]	Mingren	5.5	4.7	19.5	68.6	0.1	1.7
Davis, Calif.[c]	Peredovik	7.0	4.5	25.0	61.9	$\leq$0.1	1.5
Five Points, Calif.[c]	Peredovik	6.5	3.9	36.7	51.5	$\leq$0.1	1.3

[a]See Reference 21. Mean fatty acid composition of seed from 10 locations in 1964.
[b]See Reference 3.
[c]Robertson, J.A., USDA, ARS, R.B. Russell Agric. Res. Center, Athens, Ga., unpublished data.

TABLE III

Average Fatty Acid Composition of Sunflower Varieties Grown in the South

Planting location	Number of varieties	Fatty acid composition of oil (area, %)					
		Saturates		Oleic		Linoleic	
		Range	Average	Range	Average	Range	Average
College Station, Tex.[a]	8	8.7- 9.9	9.2	37.2-59.0	49.2	31.6-52.5	41.3
Experiment, Ga.[b]	21	7.3-11.3	9.1	29.3-60.0	44.6	29.9-61.8	45.9
Cotton Belt[c]	12	9.3-11.8	10.9	38.3-58.8	49.4	31.4-49.7	39.6
Cotton Belt[d]	7	10.2-12.3	11.5	37.3-55.7	46.6	33.8-50.5	41.6

[a]See Reference 22.

[b]See Reference 23.

[c]See Reference 4. From 2-12 sunflower hybrids were grown at 9 locations in the Cotton Belt.

[d]See Reference 4. From 4-7 sunflower open pollinated varieties were grown at 9 locations in the Cotton Belt.

TABLE IV

Fatty Acid Composition of Sunflower Varieties Grown in the South in 1969[a]

Planting location	Number of varieties	Composition of oil (area, %)		
		Saturates	Oleic	Linoleic
Clemson, S.C.	10	11.0	43.6	45.6
Crossville, Ala.	11	11.3	44.8	43.5
Experiment, Ga.	22	11.6	44.8	43.3
Tifton, Ga.	19	11.2	53.0	35.3
Baton Rouge, La.	8	10.1	54.2	34.4
College Station, Tex.	22	9.7	57.6	32.2
Average	---	10.8	49.7	39.1

[a]See Reference 4. Data are average of high-oil hybrid and open pollinated varieties.

the last 4 years, the acreage has varied from 92,000-142,000 (5).

Although production of high-oil varieties in the U.S. started in the 1940's, present day interest began in 1963 when new high-oil varieties, representing the second major improvement abroad, were brought from Russia to Canada. These varieties yielded better than previously grown varieties, were disease and pest resistant, and the seed contained 40-50% oil. In 1967 they were grown commercially for the first time in the U.S. Most of the sunflower seed production since then has been in North Dakota and Minnesota. In 1970 the total harvested acreage of high oil varieties in these two states was 70,000 acres. This year it has been estimated that there are 405,000 acres of both the bird feed and oilseed types under cultivation. This is a 90% increase over last year's crop (5).

Beginning in 1968 sunflowers have been grown as a crop in the South. The interest in this region is due to a general decline in cotton acreage which has resulted in many cottonseed mills having excess capacity, in some cases as high as 30-40%. There was also a need to provide an additional cash crop to farm operators in this area to utilize idle land or to replace crops of marginal profit. As a result of these factors, in 1968 the National Cottonseed Products Association promoted trial plantings of sunflowers. After 3 years of trial plantings, Gandy (6) reported that "observations. . . of farm trial plantings suggest that where a high level of good management has prevailed, sunflowers can be a profitable and competitive crop in certain areas of the Cotton Belt. Harvested yields in excess of 2000 lb. of seed per acre had been obtained with lower product inputs compared to other crops." He also stated, "when unfavorable weather conditions occur, sunflowers appear to respond better than cotton, corn grain sorghums and soybeans."

There still exist certain production problems such as the sunflower head moth, plant diseases, weeds, birds, and poor harvesting techniques which must be considered. In addition the crop has been vexed by varieties that vary in height and maturity. In spite of these problems, the success of sunflowers as a substantial crop in the U.S. will depend on yields per acre and price paid the farmer. M. Kinman, ARS agronomist at the Texas A&M Experiment Station, has developed improved sunflower hybrids which yield up to 30% more than the open pollinated varieties. These hybrids are more uniform in height and maturity, thus simplifying harvesting of the crop and making it more profitable for the farmer (7).

TABLE V

Fatty Acid Composition of
Sunflower Varieties Grown at Crossville, Alabama in 1969[a]

Planting date	Temperature[b]			Composition of oil (area, %)		
	Maximum	Minimum	Mean	Saturates	Oleic	Linoleic
April 17, 1969	95.9 F	67.0 F	81.5 F	11.2	44.9	43.6
May 22, 1969	92.2 F	64.2 F	78.2 F	11.8	37.6	50.3

[a]See Reference 4. Data is average of 2 hybrid and 6 open pollinated high oil varieties.

[b]Mean daily temperature from fertilization to maturity.

TABLE VI

Flavor Evaluation of Potato Chips Stored at Room Temperature[a]

Sample	Frying time, hr	Flavor scores[b,c] Initial	2 Weeks	4 Weeks
Sunflower	2	7.4 } **	7.4 } **	6.6 } +
Cottonseed-corn 70:30	2	5.7	6.5	5.8
Sunflower	12	7.2 } +	7.4 } **	6.3 } +
Cottonseed-corn 70:30	12	6.8	6.7	5.9
Sunflower	20	7.2 } +	7.4 } +	7.0 } +
Cottonseed-corn 70:30	20	6.9	7.0	6.5

[a]See Reference 27.

[b]Scoring scale of 1-10.

[c]+Denotes no significant difference; **Denotes significance at the 1% level.

TABLE VII

Composition and Properties of Vegetable Oils

Composition and property	Alabama sunflower oil	Minnesota sunflower oil	Cottonseed oil
Iodine value	120	131	107
Peroxide value (meq/kg)	0.21	0.41	0.60
% Free fatty acids, as oleic	0.04	0.03	0.45
Color	1 Yellow, 0.1 red	2 Yellow, 0.3 red	6 Yellow, 0.9 red
Stability, 8 hr AOM	18.9	37.2	35.9
Fatty acid content, %[a]			
16:0	6.5	6.5	21.5
18:0	5.0	4.3	3.2
18:1	37.2	22.5	23.2
18:2	50.5	66.4	49.8

[a]Corrected data, calculated by use of response factors determined with standard methyl ester mixtures (Hormel GLC No. 13).

SUNFLOWER USES

Sunflowers are produced for three markets—bird feed, human food, and oil. Recreational feeding of wild birds, caged birds, hamsters, squirrels and other pets consumes large amounts of sunflower seed. Sunflower seed may be dehulled and eaten without processing. The dehulled seed may be roasted in oil and salted, or used as nutmeats and in candy, salads and bakery goods. The seed also may be salted in the shell and eaten directly as in the case of peanuts (2).

Sunflower oil is a high quality oil for cooking and salad oil uses. In Europe it has been used extensively in shortening and margarine. The oil is unusually good for frying foods, popping corn and for other culinary processes where a liquid oil with a high smoke point is desired. In addition sunflower oil with a high linoleic acid content can be used for a number of industrial purposes such as the manufacture of nonyellowing alkyd resins for the paint industry.

Sunflower meal remaining after oil extraction is a high quality protein source for inclusion in livestock rations (8). The composition of the meal varies according to the composition of the seed and the method of processing. The average composition of selected commercial oilseed meals is shown in Table I.

The oil type of sunflower seed has a hull content of 22-28%. This hull must be removed if maximum yield of oil and a high quality meal are to be obtained. If the hull is not removed a meal of excessively high fiber content will be obtained which would present a problem in feeding nonruminant animals. In general high quality sunflower meal should contain not over 10% crude fiber, not less than 40% crude protein and less than 5% oil (9). Sunflower meal is deficient in lysine for growing pigs. For young chickens the meal is deficient in lysine, leucine and threonine and borderline in the sulfur containing amino acids (3). Feeding studies by Waldroup et al. (10) show that sunflower meal can be effectively used in broiler diets to replace up to 50% of soybean oil meal.

Sunflower also offers a promising new source of protein

TABLE VIII

Effect of Heating on the Linoleic Acid Content of Vegetable Oils

Hours heated	Per cent of total fatty acids: Minnesota sunflower oil, Uncorrected[a]	Minnesota sunflower oil, Corrected[b]	Alabama sunflower oil, Uncorrected[a]	Alabama sunflower oil, Corrected[b]	Cottonseed oil, Uncorrected[a]	Cottonseed oil, Corrected[b]
0	63.2	63.2	48.1	48.1	47.5	47.5
120	46.5	28.8	35.1	25.5	45.4	42.5
Per cent decrease	26.4	54.4	27.0	47.0	4.4	10.5

[a]Uncorrected data, calculated by area per cent.

[b]Correction factor-ratio of the concentration of saturated acids before and after heating.

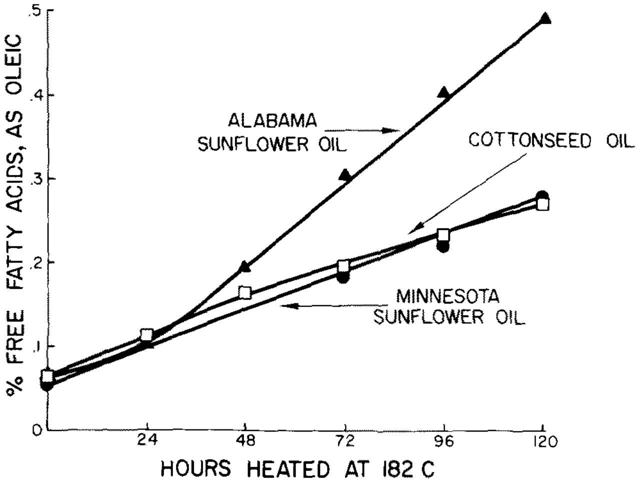

FIG. 1. Change in free fatty acids of vegetable oils upon heating.

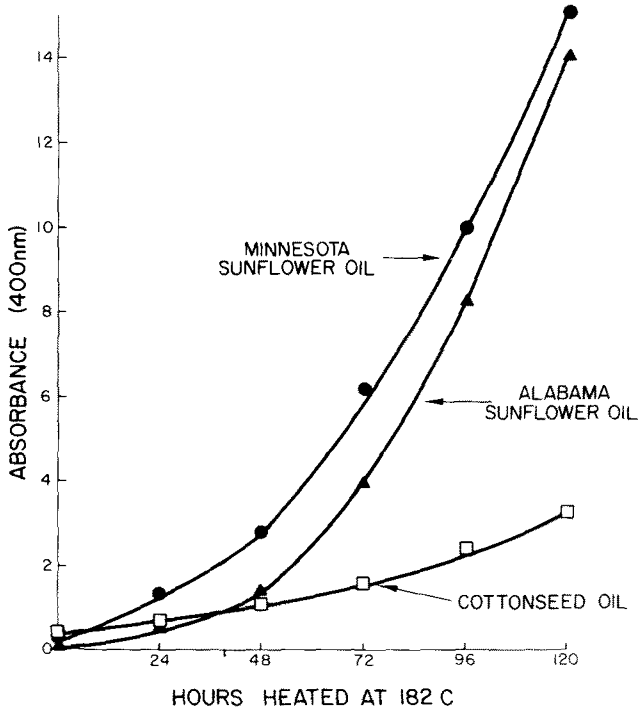

FIG. 2. Change in color intensity of vegetable oils upon heating. Total absorbance was determined by multiplying dilution of heated oils in cyclohexane by absorbance at 400 nm.

for human food. Biological studies reviewed by Clandinin (9) show that high quality sunflower protein is equal to soybean protein and superior to most vegetable proteins in terms of digestibility and is quite comparable in biological value. However a major problem in making protein isolate from sunflower seed meal, by the conventional methods of extraction at alkaline pH followed by precipitation at the isoelectric pH, is the development of a dark green color which limits the use of sunflower protein isolates in the food industry. This color is due to oxidation of chlorogenic acid, a tannin-like compound that functions as part of the oxidase systems in plants and is present in appreciable amounts in sunflower seed (11,12).

Cater et al. (13) reported that extraction of sunflower meal with 0.25% aqueous sodium sulfite at alkaline pH followed by isoelectric precipitation and extraction of the precipitate with 50% isopropanol produced an isolate which was nearly white. However the isolate still contained compound(s) which imparted a tan to brown color to the protein solution at progessively more alkaline pH's.

Talley et al. (14) investigated the food uses of sunflower seeds, meal and flour. They found that dehulled and roasted kernels were very acceptable as a nut substitute in cakes, cookies and pies, and they successfully substitute 10-20% wheat flour with sunflower meal in bread.

PROPERTIES OF THE OIL

Crude sunflower oil is yellow in color and when refined is very light yellow or pale. The oil has a relatively low level of natural antioxidants (15) and wax esters are present which have their origin in the hull fraction. These esters probably contribute to cloud formation in chilled oil (16,17). Oxygenated fatty acids, which have been identified in sunflower oil, may have an adverse effect on its stability and nutritional properties (18,19). However the role of these components in oil quality has yet to be determined since they appear in the seed generally after prolonged storage (20).

The fatty acid composition of sunflower oil makes it desirable for use as an edible oil. It is relatively low in the saturated fatty acids, palmitic and stearic, and it contains only small amounts of palmitoleic, linolenic, arachidic, behenic and lignoceric acids. The low content of linolenic acid is primarily responsible for its excellent storage qualities. The oleic and linoleic acid composition of sunflower oil is quite variable ranging from 13.9-60.0% for oleic acid and from 29.9-76.4% for linoleic acid (3,4,21-23). These two fatty acids vary inversely with each other.

Table II shows that the oil of seed grown in the northern U.S. and Canada contains about 70% linoleic acid and has a high ratio of polyunsaturated to saturated fatty acids. This makes it desirable as an edible oil in light of evidence linking saturated fats to high blood cholesterol and incidence of heart disease (24). The northern oil has an iodine value of 130-138 and can be classified as a semidrying oil which may be used as an edible or as an industrial product. In contrast sunflower oil from seed produced in the South generally contains 40-50% linoleic acid (Table III) and has an iodine value of 105-121. This indicates that the southern oil would be ideal as an edible oil from the stability and flavor aspects.

The degree of unsaturation of sunflower oil has been found to be largely dependent upon the climatic conditions during the growing season (4,22). However Putt et al. (21) have reported that oil quality is under genetic control, and that breeding for different levels of oleic and linoleic acid is a practical objective.

The effect of environmental temperatures on the fatty acid composition of sunflower seed grown at six locations in the South is shown in Table IV. The oil of sunflowers grown at the warmer locations (southern Georgia, Louisiana and southeast Texas) had a lower linoleic acid, a slightly lower saturated fatty acid and a higher oleic acid content than those grown at the somewhat cooler locations (South Carolina, northern Alabama and central Georgia) (4). Similar results were obtained with sunflower varieties grown at two locations in California (Table II). The oil from seed produced at the warmer location of Five Points, California, had a 16.8% lower linoleic acid content than oil from seed produced in the cooler climate of Davis, California.

The high-oil open pollinated sunflower varieties which were introduced from Russia are higher in oil content than any of the American hybrids (4,22). In Russia a variety is now being grown which has a 52% oil content, and scientists at the Oilseed Research Institute at Krasnodar reportedly are breeding varieties that may have an oil content of 55-60% (25).

On the basis of the limited data available, the total oil content of sunflower seed produced in the cooler climates

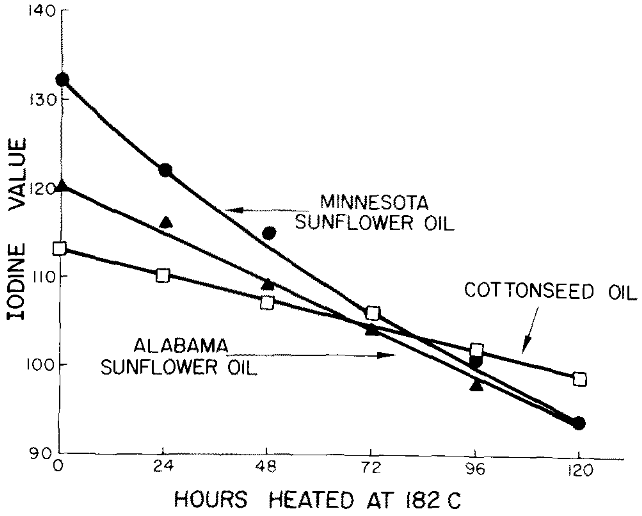

FIG. 3. Change in iodine value of vegetable oils upon heating.

of the North appears to be higher than the oil of seed of similar varieties grown in the South. Earle et al. (3) report a range of 39.7-51.4% oil content for high-oil type varieties grown in northern U.S. and Canada, whereas Robertson et al. (4) report a range of 28.8-44.7% for introductions grown at nine locations in the Cotton Belt. However analysis of the seed from a date of planting study in Alabama (Table V) by Robertson et al. (4) showed that the earlier plantings which had a mean daily temperature of 81.5 F from fertilization to maturity had a 5.5% greater oil content than the later planting which had an average daily temperature of 78.2 F during the same growth period. Canvin (26) has reported that the oil content of sunflower seed produced in temperature controlled growth cabinets increased with increasing temperatures from 50-70 F but then decreased at temperature of 80 F. The effect of climatic conditions on the fatty acid composition of sunflower oil needs further study.

FLAVOR AND STABILITY STUDIES ON SUNFLOWER OIL

Sunflower oil is finding acceptance as a cooking fat for potato chip frying. Evans and Shaw (27) conducted a 20 hr potato chip frying test to compare northern produced sunflower oil with a mixture of 70% cottonseed and 30% corn oil which is a standard potato chip frying oil. The flavor evaluation of potato chips stored at room temperature is shown in Table VI. Potato chips fried in sunflower oil and stored at room temperature generally received the higher flavor scores of each evaluation by the taste panel. Also the color of the chips fried in sunflower oil was equal to that of the chips fried in the cottonseed-corn oil mixture.

Sunflower oil produced in the southern part of the U.S. which has a lower content of linoleic acid and lower iodine value should have better keeping qualities and stability characteristics than oils with higher linoleic acid content. To investigate this relationship we have undertaken a study to compare the effect of deep-fat frying conditions on sunflower oil produced in Alabama and Minnesota with cottonseed oil.

The vegetable oils used in the study were refined and deodorized and contained no antioxidants. The composition and properties of the oils are shown in Table VII. Approximately 3.5 liters of each vegetable oil were heated at 182 C ±4 C with a minimum amount of stirring in a 5 qt household deep-fat fryer. The oils were heated for a period of 8 hr during single time intervals and allowed to cool to room temperature overnight. This heating and cooling cycle

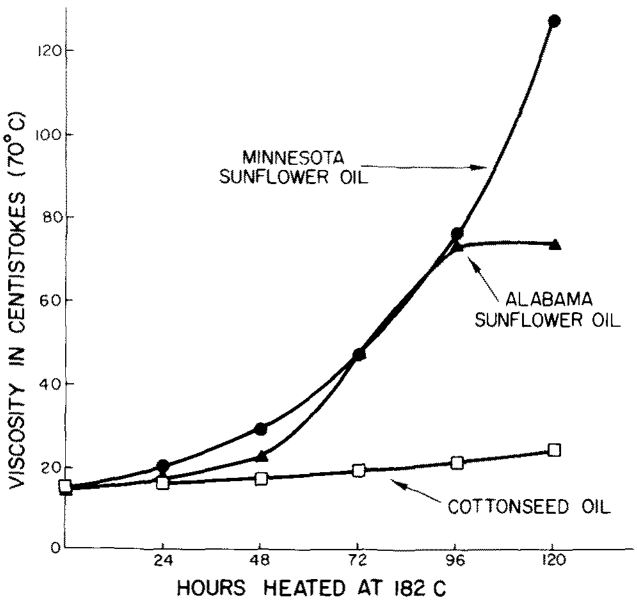

FIG. 4. Change in viscosity of vegetable oils upon heating.

was repeated until the oil was subjected to a total of 120 hr of actual heating. The data obtained are shown in Figures 1-4.

As expected the free fatty acids, color and viscosity increased and the iodine value and linoleic acid content of the oils decreased. In each of the oils there was only a small increase in free fatty acid concentration. The color of the cottonseed oil changed very little (as measured by absorbance at 400 nm), but the color of both sunflower oils changed from a pale yellow to a dark brown color during the heating. The color of the Minnesota sunflower oil increased sharply after 48 hr of heating and the Alabama oil after about 72 hr of heating. The iodine value of the sunflower oils decreased to about 94 indicating a substantial decrease in unsaturation.

There was only a small change in the viscosity of the cottonseed oil, whereas the viscosity of the sunflower oils increased rapidly after 60 hr of heating. The viscosity curve for the Alabama oil appeared to be following the Minnesota oil to a higher viscosity; however at the end of the heating the Minnesota sunflower oil was more viscous than the Alabama sunflower oil. The apparent tendency for the Alabama oil to be less viscous than the Minnesota oil upon heating was not confirmed because we didn't have another sample of Alabama sunflower oil. Since Rock and Roth (28) have shown a direct relation between viscosity and the amount of non-urea-adducting fatty acids, this increase in viscosity of the sunflower oils is probably due to a greater amount of polymerization.

The effect of heating on the linoleic acid content of the vegetable oils is shown in Table VIII. The fatty acid composition was determined by gas liquid chromatography area normalization. Since the saturated fatty acids are relatively stable to heating, any increase in saturated fatty acids must be compensated for by a decrease in acids more prone to thermal decomposition. Kilgore (29) assumed the saturated fatty acid composition to be constant throughout heating and recalculated the values obtained for oleic and linoleic acids using a correction factor, the ratio of saturated fatty acids before and after heating. Using this approach to estimate the linoleic acid concentration in the heated oils, the linoleic acid content (Table VIII) of the Alabama oil decreased 47.0% and the Minnesota oil 54.4%, whereas the linoleic acid of the cottonseed oil decreased by only 10.5%. The uncorrected values, calculated by area per cent, are shown for comparison. The results indicate that cottonseed oil is more stable to intermittent heating than the sunflower oils. The southern oil appears to be slightly more stable than the northern oil, but not by as much as would be expected from the fatty acid composition of the two oils. These studies are being continued to further assess the stability of southern produced sunflower oil.

ACKNOWLEDGMENT

R.E. Beal, N. Market. Nutr. Res. Div., Peoria, Ill., refined and deodorized the Alabama sunflower oil.

REFERENCES

1. Hurt, E.F., "Sunflower for Food, Fodder and Fertility," Faber and Faber Ltd., London, 1948, p. 135.
2. Robinson, R.G., F.K. Johnson and O.C. Soine, "The Sunflower Crop in Minnesota," Extension Bulletin 299, Agricultural Extension Service, University of Minnesota, St. Paul, 1967.
3. Earle, F.R., C.H. Vanetten, T.F. Clark and I.A. Wolff, JAOCS 45:876 (1968).
4. Robertson, J.A., J.K. Thomas and Donald Burdick, J. Food Sci. 36:873 (1971).
5. Minnesota Crop and Livestock Reporting Service, Minnesota Department of Agriculture and USDA Statistical Service, July 12, 1971.
6. Gandy, D.E., The Cotton Gin and Oil Mill Press 72(5):8 (1971).
7. "Agricultural Research," USDA, ARS, Vol. 19, No. 12, June 1971, p. 3.
8. Smith, K.J., Feedstuffs 40(23):20 (1968).
9. Clandinin, D.R., in "Processed Plant Protein Foodstuffs," Edited by A.M. Altschul, Academic Press, Inc., New York, 1958, p. 557.
10. Waldroup, P.W., C.M. Hillard and R.J. Mitchell, Ibid. 42(43):41 (1970).
11. Milic, B., S. Stojanovic, N. Vucurevic and M. Turcic, J. Sci. Food Agr. 19:108 (1968).
12. Pomenta, J.V., and E.E. Burns, J. Food Sci. 36:490 (1971).
13. Cater, C.M., S. Gheyasuddin, K.F. Mattil and B.M. Colvin, Fourth International Sunflower Conference, Proceedings, Memphis, Tennessee, June 1970, p. 91.
14. Talley, L.D., B.J.C. Brummett and E.E. Burns, Ibid. Memphis, Tennessee, June 1970, p. 110.
15. Slover, H.T., Lipids 6:291 (1971).
16. Kleiman, R., F.R. Earle and I.A. Wolff, JAOCS 46:505 (1969).
17. Hlavacek, H.J., "Sunflower Oil as a Salad and Cooking Oil," 18th Cottonseed Processing Clinic, New Orleans, Louisiana, February 196, p. 96.
18. Mikolajczak, K.L., R.M. Friedinger, C.R. Smith, Jr. and I.A. Wolff, Lipids 3:489 (1968).
19. Morris, L.J., R.T. Holman and K. Fontell, JAOCS 37:323 (1960).
20. Mikolajczak, K.L., C.R. Smith, Jr., and I.A. Wolff, Ibid. 47:24 (1970).
21. Putt, E.D., B.M. Craig and R.B. Carson, Ibid. 46:126 (1969).
22. Kinman, M.L., and F.R. Earle, Crop Sci. 4:417 (1964).
23. Cummins, D.G., J.E. Marion, J.P. Craigmiles and R.E. Burns, JAOCS 44:581 (1967).
24. Vergroessen, A.J., Fourth International Sunflower Converence, Proceedings, Memphis, Tennessee, June 1970, p. 219.
25. Euler, R.S., The Cotton Gin and Oil Mill Press 72(15):12 (1971).
26. Canvin, D.T., Canadian J. Bot. 43:63 (1965).
27. Evans, C.D., and R. Shaw, Third International Sunflower Conference, Proceedings, Crookston, Minnesota, August 1968, p. 101.
28. Rock, S.P., and H. Roth, JAOCS 43:116 (1966).
29. Kilgore, L.T., Ibid. 41:496 (1964).

[Received February 29, 1972]