Effect of Deep-Fat Frying on Sunflower Oils

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ABSTRACT

Sunflower seed oils were compared with a commercial oil based upon the oils' tendencies to oxidize after various periods of heating and cooking. Hydrogenated and unhydrogenated sunflower oils and a commercial shortening obtained from a fast-food establishment were used to deep fry 8 lb of raw potatoes daily for six 8-hr days. Samples of oils were taken daily and active oxygen method values determined. A plot of the log of active oxygen method values vs. the time gave a straight line, the slope of which reflects the oxidizability of the oil. The partially hydrogenated northern sunflower oil was much less prone to oxidation after use than the commercial shortening even with its lower initial active oxygen method value.

INTRODUCTION

In recent years a number of studies have demonstrated the acceptability of sunflower seed oil for deep-fat cooking (1-4) and the effects of various antioxidants on its stability (2,4-6). Our previous study (3) showed that partially hydrogenated sunflower seed oil could compete favorably with a commercial cottonseed-corn oil mixture which is used by the potato chip industry. This report compares the oxidative stability measurements for sunflower oils and for a commercial shortening used to fry potatoes.

Since the time required to train a flavor panel properly is considerable and the difficulties with the flavor panel are well known (7-9), chemical methods are being sought to evaluate edible oil quality and stability. Some present methods are the amount of pentane released to the package head space by an oil (10), the active oxygen method (AOM) (11), and the oxygen bomb (12), a method which correlates well with AOM but is faster.

Usually the chemical tests are run on fresh oil, but in this study AOM is used to evaluate an oil's tendency to oxidize after various periods of heating and cooking using northern, southern, and partially hydrogenated sunflower oils and a shortening obtained from a fast-food establishment.

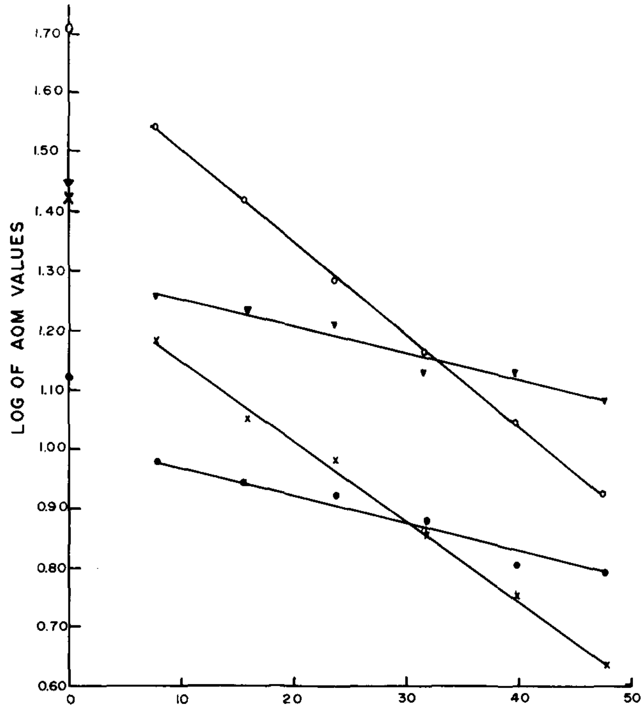

FIG. 1. Change in active oxygen method values with oil use. o = commercial shortening, ▾ hydrogenated northern sunflower oil, X = southern sunflower oil, ● = northern sunflower oil.

MATERIALS AND METHODS

The vegetable oils used in this study were: (a) northern sunflower oil, a commercially refined and deodorized sunflower oil from seed grown in Minnesota; (b) partially hydrogenated northern sunflower oil; (c) southern sunflower oil, a pilot plant refined and deodorized sunflower oil from seed grown in Alabama; and (d) commercial vegetable shortening obtained from a local fast-food establishment. The sunflower oils contained 0.076% Tenox 6 antioxidant and 2 ppm Dow Corning Antifoam A Compound. The commercial shortening was used as received.

The northern and hydrogenated northern sunflower oils contained 0.5% linolenic acid, which was caused by contamination with soybean oil during processing. Some contamination normally occurs in processing of oils during changeover from one oil to another in a commercial operation even though special precautions are taken.

Initially 3 liters of oil were placed in a 4 qt household deep-fat fryer and heated to 180 ± 3 C. The potatoes, purchased from a local market, were peeled, washed, cut, and refrigerated 1 day prior to use. Each day for 6 days, eight 1 lb batches of raw potatoes cut ca. 1/2 in. x 1/2 in. x 4 in. were fried at regular intervals over an 8 hr period. Each 1 lb batch was cooked for 15 min. A total of 48 lb raw potatoes were fried in each oil, and each oil was heated for a total of 48 hr. About 200 ml make-up oil was added at the beginning of each day's run to bring the volume of oil in the fryer to 3 liters. A total of 4 liters of oil were used for each test. At the end of each day's run, a 100 g sample of oil was frozen for chemical evaluation.

AOM values, iodine values (IV), and per cent free fatty acids were determined by official AOCS methods (13). Viscosities were measured in centistokes at 70 C (14). Gas chromatographic analyses of the fatty acid methyl esters (15) were made using a Tracor MT220 gas liquid chromatograph equipped with an Infotronics model CRS-101 digital integrator. A 12 ft x 1/4 in. stainless steel column with 10% DEGS on 60-80 mesh Chromosorb W, AW-DMCS was used for the analyses, and the oven was operated at 205 C. Per cent fatty acids were calculated by determining the response factors for the individual methyl esters using standard mixtures of esters purchased from the Hormel Institute. An internal standard was incorporated before the preparation of the methyl esters according to the method of Waltking and Zmachinski (16).

RESULTS AND DISCUSSION

The properties and fatty acid composition of the vegetable oils used in this study are shown in Table I. The commercial shortening had a low IV, 55.2. The northern sunflower oil had IV ca. 135, and hydrogenation produced an oil with IV 109.4.

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TABLE I

Composition and Properties of Oils to be Evaluated

Chemical characteristics	Commercial shortening	Hydrogenated northern sunflower oil	Southern sunflower oil	Northern sunflower oil
Iodine value	55.2	109.4	121.0	134.9
Peroxide value (meq/kg)	1.0	3.5	1.4	3.2
Free fatty acids (as % oleic)	.06	.09	.04	.08
Viscosity (centistokes 70 C)	17.0	15.8	14.2	13.8
Active oxygen method (hr)	50.5	29.2	26.0	13.2
Fatty acid composition %				
14:0	2.6	—	—	—
16:0	25.0	7.2	5.7	6.0
18:0	19.3	5.1	4.1	4.1
18:1	39.7	47.9	37.1	19.1
18:2	7.3	37.0	52.2	69.5
18:3	0.5	0.9[a]	—	0.6[a]
20:0	—		0.2	
22:0	—	0.4	0.6	0.5

[a] These sunflower oils were contaminated slightly with soybean oil and the percentages of 18:3 and 20:0 have been combined.

Often the IV is considered to be a rough indication of relative stability; therefore, the southern sunflower oil (IV = 121) would be expected to have a stability intermediate between the northern (IV = 135) and the hydrogenated (IV = 109) sunflower oils. The AOM values of the fresh oils also support this suggestion.

Table II shows results of chemical analyses of the oils after use. As expected, IVs decreased while the per cent free fatty acids and viscosity increased.

Table III shows the changes in fatty acid composition due to cooking and heating. In the sunflower oils, oleic acid decreased between 1 and 4% and linoleic acid between 8 and 13%, while in the commercial shortening the decrease was ca. 0.3 and 10% for oleic and linoleic, respectively.

The log of the AOM values vs. the number of hr the oil had been heated and used are plotted in Figure 1. The linearity of this plot suggests that the rate of loss of oxidative stability, as measured by the AOM values, is first order or pseudo-first order. Note that each line begins at the 8 hr reading. If the line is extended to 0 hr, this initial AOM falls below the measured AOM for the fresh oil (Table I), indicating that initially rapid oxidation occurs before a constant rate of loss of oxidative stability is reached.

The commercial oil had an initial AOM of 50.5 hr and the hydrogenated sunflower oil an initial AOM of 29.2 hr. This suggests that the hydrogenated sunflower oil would be less stable toward oxidation than the commercial oil. However, the data show that even though the hydrogenated sunflower oil had a lower initial AOM, its stability decreased more slowly than that of the commercial oil. After 32 hr the lines intersect and the AOM values for the hydrogenated sunflower oil are then higher than those for the commercial oil.

AOM values have been correlated with the shelf-life of an oil (17). A product which does not have a high oil content, such as potatoes, will absorb oil on cooking and

TABLE II

Effects of Frying on Oils

Evaluations	Oil use (hr)						
	0	8	16	24	32	40	48
Commercial shortening							
IV[a]	55.2	52.6	52.4	52.1	52.2	52.0	51.0
FFA[b]	0.06	0.08	0.10	0.18	0.33	0.46	0.61
Viscosity[c]	17.0	17.2	17.3	17.5	17.7	17.8	18.0
AOM[d]	50.5	34.0	26.2	19.6	14.5	11.0	8.3
Partially hydrogenated northern sunflower oil							
IV	109.4	105.7	108.7	105.8	104.7	104.0	105.0
FFA	0.09	0.09	0.15	0.18	0.26	0.41	0.53
Viscosity	15.8	16.1	16.4	16.6	16.9	17.4	17.7
AOM	29.2	18.1	17.1	16.0	13.5	13.3	12.2
Southern sunflower oil							
IV	121.0	117.7	115.6	117.5	117.8	111.0	112.3
FFA	0.04	0.05	0.11	0.18	0.26	0.31	0.38
Viscosity	14.2	14.4	14.8	15.2	15.9	16.8	18.2
AOM	26.0	15.3	11.3	9.7	7.1	5.6	4.3
Northern sunflower oil							
IV	134.9	133.9	132.0	132.7	131.2	130.0	129.4
FFA	0.08	0.09	0.14	0.20	0.23	0.34	0.35
Viscosity	13.8	14.1	14.5	14.8	15.3	15.7	18.2
AOM	13.2	9.5	8.7	8.4	7.7	6.4	6.1

[a] Iodine value.

[b] % free fatty acids as oleic.

[c] Viscosity (centistokes at 70 C).

[d] Active oxygen method values in hr.

TABLE III

Effects of Frying on Fatty Acid Composition

	Fatty acid composition (Wt%)							
Oil use (hr)	14:0	16:0	18:0	18:1	18:2	18:3	20:0	22:0
Commercial shortening								
0	2.6	25.0	19.3	39.7	7.3	0.5	---	---
16	2.5	23.0	17.8	38.4	6.9	0.3	---	---
32	2.6	24.0	18.2	39.1	6.6	0.4	---	---
48	2.6	24.4	19.0	39.6	6.4	0.3	---	---
Partially hydrogenated northern sunflower oil								
0	---	7.2	5.1	47.9	37.0	0.9[a]		0.4
16	---	7.2	6.0	50.0	36.7	1.0		0.4
32	---	6.9	5.6	48.1	34.7	0.5		0.4
48	---	7.1	5.7	47.4	33.9	0.7		0.4
Southern sunflower oil								
0	---	5.7	4.1	37.1	52.2	---	0.2	0.6
16	---	5.7	4.1	37.8	51.2	---	0.2	0.7
32	---	5.7	4.1	35.9	47.5	---	0.3	0.7
48	---	5.8	3.9	35.9	45.6	---	0.5	0.7
Northern sunflower oil								
0	---	6.0	4.1	19.1	69.5	0.6[a]		0.5
16	---	6.0	3.9	19.5	68.6	0.5		0.5
32	---	5.9	3.8	19.0	66.0	0.7		0.5
48	---	5.8	3.7	18.6	63.0	0.2		0.4

[a] These sunflower oils were contaminated slightly with soybean oil and the percentages of 18:3 and 20:0 have been combined.

would have a shelf-life proportional to the AOM of the oil used for cooking. Unpublished work shows a relation between the peroxide values for the oil absorbed by a product and the AOM values of the cooking oil.

Comparison of the rates of oxidizability shows that the commercial oil deteriorates 3 times as fast as the hydrogenated sunflower oil. The change in iodine values, viscosity, per cent free fatty acids, and fatty acid composition do not indicate this difference in rates of deterioration. This would suggest that oxidative stability cannot be reliably detected using these tests. However, the rate of decrease of the AOM values points out a difference in oxidative stability that would not otherwise be readily apparent. Since the oxidation products are contributors to off-flavor development, the desirability of one oil over another might be decided using this technique, particularly when storage of the fried product is required.

Earlier work (14), based on results from heated-oil studies in which oils with no antioxidants were used, suggests that southern sunflower oil would be slightly more stable than northern oil. Since the oils were open to the atmosphere and heated without containing a food product, this heated-oil study would be similar to an accelerated shelf-life study. Cooking a product in the oil should affect the oil differently than simply heating since the steam produced during cooking carries off many volatile compounds (16,18,19) and produces a blanket of water vapor protecting the oil from oxygen (16,19). These phenomena would tend to protect the oil from oxidation and off-flavor development and thus extend its useful life.

The southern sunflower oil used in this study deteriorated faster than the northern and hydrogenated northern oil, but at ca. the same rate as the commercial shortening. Based on the fatty acid distribution, which is intermediate between the northern and hydrogenated northern sunflower oils, this rate of deterioration was unexpected. If hydrogenation raises the overall oxidative stability of an oil, as in the case of the northern sunflower oil (Fig. 1), without increasing its tendency to oxidize, one might expect that hydrogenation would increase the oxidative stability of the southern oil to a point where it would be comparable to the commercial oil.

Since the factors affecting oil deterioration are different for heating and cooking (19), the present procedure should represent the way an oil is used and should indicate an oil's oxidative stability under actual cooking conditions.

ACKNOWLEDGMENT

J.K. Thomas provided analytical assistance.

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[Received January 26, 1973]