✂ A Comparison of the Stability of Sunflower Oil and Corn Oil[1,2]

A.-S. HUANG[3], **O.A.-L. HSIEH, C.-L. HUANG**[4] and **S.S. CHANG**, Department of Food Science, Cook College, Rutgers, The State University of New Jersey, New Brunswick, NJ 08903

ABSTRACT

The stability of a northern sunflower oil was evaluated against a corn oil. The sunflower oil was tested before and after winterization, as well as with and without the addition of methyl silicone and antioxidants. The corn oil was tested after winterization with and without the addition of methyl silicone and antioxidants. Under normal use conditions at room temperature and 35 C, in the presence of air in the headspace gas, sunflower oil samples developed peroxides more rapidly than corn oil. However, these higher peroxide numbers did not seem to affect their organoleptic scores. Starch chunks, deep-fat fried in corn oil, had better flavor stability than those fried in sunflower oil. The peroxide values of the corn-oil-fried starch chunks were consistently lower than the sunflower-oil-fried starch chunks at various stages of aging. The chemical and physical changes of the corn oil and sunflower oil samples during simulated deep-fat frying were compared. The stability of the corn oil was approximately the same as that of the sunflower oil.

INTRODUCTION

Two of the common vegetable oils suitable for cooking or frying without being hydrogenated are corn oil and sunflower oil. They are preferred over soybean oil and considered premium oils on the world market because they contain practically no linolenic acid which is prone to autoxidation.

Corn oil is produced as a by-product of the corn starch industry. Therefore, its supply is limited by the amount of starch needed. Sunflower oil, which has been widely used in the eastern European countries, has just begun to attract attention and have use in this country. In fact, sunflower seeds are second only to soybeans as an important source of vegetable oil in the world (1-3). Morrison et al. (4) reported that partially hydrogenated northern sunflower oil was much less prone to oxidation in deep-fat frying than the commercial shortening, even with its lower initial active oxygen method value.

The present paper compares the stability of corn oil and sunflower oil under normal use as a salad oil and in frying as a cooking oil.

EXPERIMENTAL

Oil Samples and Storage

The 6 oil samples evaluated in this study were: (1) sunflower oil, not winterized, no additives; (2) sunflower oil, winterized, no additives; (3) sunflower oil, winterized, with 1 ppm of methyl silicone and 0.0625% of Tenox 6 added; (4) corn oil, winterized, no additives; (5) corn oil, winterized, with 1 ppm of methyl silicone and 0.0625% of Tenox 6 added; (6) corn oil, winterized with 5 ppm of methyl silicone and 0.02% of isopropyl citrate added. All samples were equally fresh when packed under nitrogen in clear, uncolored pint-sized bottles and all samples were held at -10 C until used.

The six samples were aged under the following conditions for various periods of time as indicated: (a) room temperature under diffused daylight for 0, 3, 7, 14, 21 and 28 days; (b) room temperature in a box lighted with fluorescent light for 12, 24, 32, 40 and 48 hr; and (c) 35 C in the dark for 7, 14, 21 and 28 days. In order to simulate normal household use, the samples were aged in half-filled, clear, uncolored, pint-sized glass bottles, capped under air. The bottles were each opened at the indicated periods to restore air to the head space. They were then recapped, inverted and returned to the upright position twice before continuing the aging.

Frying of Starch Chunks

A Sears deep-fat fryer (Model 309.6930; 1150W) was used for the deep-fat frying of starch chunks. The starch chunks were made from Ex-prod Starch F4-277 (A.E. Staley Manufacturing Co., Decatur, IL) which had been mixed with 40% of their weight of water in a Hobart Mixer. The mixed, moist Ex-prod starch was extruded through a Hobart grinder (.5 in. diam.) and cut into .5-in. lengths.

Approximately 2 kg of fresh oil was heated to 195 C in a deep-fat fryer. Sixty pieces of moist starch chunks were deep-fat fried for 6 min at 185 ± 5 C. The frying was continuously repeated 10 times in each oil. The fried starch chunks of the last batch from each oil were put into 600-mL beakers, covered with a watch glass and aged in an oven at 60 ± 1.5 C.

Simulated Deep-fat Frying

The method of Krishnamurthy et al. (5) was used. Ten viscose cotton balls (Johnson & Johnson, New Brunswick, NJ), each containing 75% of its weight of water, were deep-fat fried for 3 min in ca. 2 kg of oil maintained at 185 ± 5 C in the deep-fat fryer. The frying was done every hour for 6 hr. The oil was cooled to room temperature and kept overnight. When the oil was to be used for frying for more than one day, fresh oil was added to the fryer each morning to replenish the oil absorbed by the cotton balls.

Sensory Evaluation of the Oils and the Fried Starch Chunks

Sensory evaluation was conducted by 7 trained panelists. The samples were evaluated for odor strength, odor preference, flavor strength and flavor preference. A Hedonic scale of 1 to 9 was used for the scoring of both the strength and preference. For strength, 1 indicated the weakest, 5 moderate, and 9 the strongest response. For preference, 1 indicated least liked, 5 neutral, and 9 the most-liked response.

The panel members were seated in individual booths under yellow light so the color of the oils would not influence their judgment. The samples were evaluated at 60 C in glass creamers. In order to maintain the temperature during the evaluation period, the creamers were set in machine-drilled heavy aluminum blocks preheated to 60 C.

---

[1] Paper of the Journal Series, New Jersey Agricultural Experiment Station, Cook College, Rutgers, The State University of New Jersey, New Brunswick, NJ 08903.

[2] Presented at the AOCS meeting, May 1, 1977, New York.

[3] Present address: Standard Brands, Inc., 15 River Road, Wilton, CT 06897.

[4] Present address: Warner Lambert Research Institute, Morris Plains, NJ 07950.

The samples were first sniffed for the odor of the sample and then tasted for its flavor. Tasting was accomplished by cupping 1 or 2 mL of the warm oil on the tongue, sucking air into the mouth a few times and exhaling through the nose with the mouth closed. The mouth was thoroughly rinsed with warm water before tasting another sample.

The fried starch chunks which were kept in beakers covered with watch glasses were also sensory evaluated by the same panel members each day in order to determine the length of time required for samples to develop a definite rancid odor.

Analytical Methods

Peroxide value (PV) was determined by AOCS Official Method Cd-8-53, color was measured as AOCS red values, according to AOCS Official Method Cc 13B-45, and iodine values (IV) were determined by the Wijs method (AOCS Official Method Cd 1-25). Fatty acid composition was determined using the procedure described by Luddy et al. (6). The nonurea adduct-forming esters were determined according to the method of Firestone et al. (7). Viscosity was measured at 37.8 C using a Cannon-Fenske Routine Viscometer (Cannon Instrument Co., State College, PA).

The PV of the residual oil in the fried starch chunks were determined by putting 50 ± 1 g of starch chunks into a 250-mL beaker with 30-mL of glacial acetic acid/chloroform (3:2, v/v). The mixture was swirled, allowed to stand for a minute, and then filtered through Whatman no. 42

TABLE I

Fatty Acid Composition of Oil Samples

Sample identity	Sunflower oil			Corn oil		
Sample number	1	2	3	4	5	6
	Unwinterized; no additives	Winterized; no additives	Winterized; methyl silicone, Tenox 6	Winterized; no additives	Winterized; methyl silicone, Tenox 6	Winterized; methyl silicone, isopropyl citrate
Iodine value	135.6	136.0	136.3	127.4	127.0	126.8
Fatty acid composition (100% basis)						
C-14	T	T	0.1	–	–	–
C-16	6.0	6.7	6.7	11.2	11.3	11.3
C-18	4.4	4.5	4.5	4.5	1.9	1.9
18:1	18.4	17.6	17.7	25.2	25.6	25.6
18:2	70.6	70.7	70.4	61.1	60.6	60.7
18:3	0.1	T	0.2	0.6	0.6	0.5
C-20	T	T	T	–	–	–
C-22	0.5	0.5	0.4	–	–	–
Categorical summary:						
% Polyunsaturates	70.7	70.7	70.6	61.7	61.2	61.2
% Monounsaturates	18.4	17.6	17.7	25.2	25.6	25.6
% Saturates	10.9	11.7	11.7	13.1	13.2	13.2

TABLE II

Peroxide Values of Oil Samples Aged under Different Conditions

Sample identity	Sunflower oil			Corn oil		
Sample number	1	2	3	4	5	6
Conditions	Unwinterized; no additives	Winterized; no additives	Winterized; methyl silicone, Tenox 6	Winterized; no additives	Winterized; methyl silicone, Tenox 6	Winterized; methyl silicone, isopropyl citrate
Room temperature, diffused daylight (days)						
0	0.8	0.8	0.9	1.0	0.9	0.9
3	3.7	4.8	4.3	3.5	3.5	3.4
7	8.5	9.0	8.9	7.3	7.3	6.9
14	12.2	13.0	12.7	8.2	8.5	8.2
21	17.5	16.9	16.6	10.7	11.5	11.4
28	20.8	19.3	19.2	14.6	14.3	13.7
Room temperature, light box (hr)						
0	0.8	0.8	0.9	1.0	0.9	0.9
12	–	–	–	–	–	–
24	4.3	–	4.4	3.5	3.7	3.6
32	4.7	5.2	4.8	3.7	3.9	3.9
40	4.8	5.8	5.4	4.8	4.9	4.6
48	6.9	7.8	6.7	5.4	5.5	5.3
35 C, Dark (days)						
0	0.3	0.8	0.6	1.0	0.9	0.9
7	1.4	10.9	1.7	1.7	1.7	1.6
14	4.0	17.2	2.7	2.5	2.2	2.3
21	11.8	19.8	4.9	2.9	2.5	2.5
28	19.3	22.2	9.9	3.8	3.1	3.2

filter paper. The filtrate was freed of solvent under reduced pressure to obtain the residual oil and its PV was then determined.

RESULTS AND DISCUSSION

Composition of Oil Samples

The fatty acid composition and IV, as well as categorical summary of the fatty acid composition of the 6 oil samples used, are shown in Table I. Winterization only slightly affected the IV of the sunflower oil (135) which was higher than that of corn oil (127). There was no significant difference in fatty acid composition between winterized and unwinterized sunflower oils. The sunflower oil samples contained about 70.6% of linoleic acid, which is typical of sunflowers grown in northern U.S. The samples used in this study were from sunflowers grown in Minnesota. The linoleic acid content of corn oil is 10% less than that of sunflower oil. On the other hand, linolenic acid, which is more prone to autoxidation, was slightly higher in corn oil than in sunflower oil. The sunflower oil contained more polyunsaturated fatty acids, whereas the corn oil contained

TABLE III

Color Values (AOCS red) of Oil Samples Aged under Different Conditions

Sample identity	Sunflower oil			Corn oil		
Sample number	1	2	3	4	5	6
Conditions	Unwinterized; no additives	Winterized; no additives	Winterized; methyl silicone, Tenox 6	Winterized; no additives	Winterized; methyl silicone, Tenox 6	Winterized; methyl silicone, isopropyl citrate
Room temperature, diffused daylight (days)						
0	0.8	1.8	1.1	2.5	2.6	2.6
3	1.0	1.5	1.0	2.6	2.8	2.7
7	0.8	1.3	1.0	3.0	3.0	2.8
14	1.0	1.1	1.0	3.0	2.9	3.0
21	1.0	1.5	1.0	3.5	3.8	3.0
28	0.4	0.9	0.9	3.7	3.7	3.1
Room temperature, light box (hr)						
12	1.2	1.4	1.2	2.8	2.6	2.5
24	1.0	1.6	1.2	3.0	3.0	3.0
32	1.0	1.4	1.2	2.9	2.8	2.6
40	1.0	1.6	1.0	3.0	3.0	3.0
48	0.8	1.3	1.0	2.9	2.9	2.7
35 C, Dark (days)						
7	1.0	1.2	1.0	3.0	2.7	2.7
14	1.0	1.4	1.1	3.5	3.1	3.2
21	1.4	1.6	1.6	5.0	4.0	3.9
28	1.3	1.4	1.0	5.0	4.3	4.1

TABLE IV

Odor Evaluation of Oil Samples Aged under Different Conditions

Sample identity	Sunflower oil						Corn oil					
Sample number	1		2		3		4		5		6	
	Unwinterized; no additives		Winterized; no additives		Winterized; methyl silicone, Tenox 6		Winterized; no additives		Winterized; methyl silicone, Tenox 6		Winterized; methyl silicone, isopropyl citrate	
Conditions	S	P	S	P	S	P	S	P	S	P	S	P
Room temperature, diffused daylight (days)												
0	–	–	1.5	7.0	2.0	7.0	3.0	6.0	3.0	5.0	–	–
3	2.4	6.3	3.0	5.6	2.6	5.6	3.4	5.1	4.5	4.1	3.8	5.0
21	3.2	5.4	3.2	5.8	2.5	6.5	3.9	4.1	4.9	3.7	4.1	4.7
28	3.0	5.1	2.9	5.7	2.1	6.4	3.3	5.1	4.0	4.5	5.2	3.4
Room temperature, light box (hr)												
24	2.9	5.8	2.8	5.5	3.1	5.6	3.5	5.3	3.3	5.4	3.8	5.1
32	3.0	5.9	2.4	6.6	2.1	6.6	3.4	5.4	3.2	5.4	4.1	4.6
40	2.2	5.7	2.2	6.7	2.1	6.9	3.4	5.2	3.1	5.9	3.1	5.6
48	2.6	6.1	2.5	5.8	2.6	6.2	3.5	4.4	4.1	4.4	4.1	4.7
35 C, Dark (days)												
7	2.8	5.5	3.3	5.1	3.1	5.4	3.2	5.4	4.2	3.9	3.4	4.8
14	3.1	5.4	3.1	5.1	2.1	6.4	2.7	5.8	3.4	5.1	3.4	5.1
28	2.0	6.6	3.7	4.9	3.0	5.4	4.1	5.1	4.0	4.2	3.7	5.1

S = strength; P = preference. Score = 1-9; higher score, stronger odor, more preference.

more monounsaturated acids, and was slightly richer in saturated acids.

Oil Stability under Normal Household Use Conditions

The rate of increase of PV of oil sample aged under different conditions is shown in Table II. In general, sunflower oil developed peroxides more rapidly than corn oil. This was particularly evident when the corresponding samples of sunflower oil (no. 2) and corn oil (no. 4) were compared. Tenox 6 and methyl silicone increased the oxidative stability of sunflower oil at 35 C in the dark. However, at room temperature, under either daylight or fluorescent light, the antioxidant effectiveness was not significant. On the other hand, the methyl silicone and isopropyl citrate did not show significant effectiveness on corn oil during the entire aging process.

Under normal household use conditions, there was no significant change in color for either corn or sunflower oils (Table III). Corn oil had a darker color than sunflower oil.

Sensory evaluation showed that corn oil had a higher odor and flavor strength than sunflower oil (Tables IV and V). In corresponding samples, corn oil (no. 4) was stronger than sunflower oil (no. 2); also corn oil (no. 5) had a stronger odor than sunflower oil (no. 3). The panels also showed a preference for the odor and flavor of sunflower oil over corn oil (Tables IV and V). It should be noted that sunflower oil developed peroxides more rapidly than corn oil (Table II). However, these higher peroxide numbers did not seem to affect their organoleptic scores. These conclusions were significant at a 95% confidence level. Due to the small number of tasters, organoleptic panel scores were calculated by the method "Simplified Statistics for Small-number Observation" described by Dean and Dixon (8).

Oil Stability of Deep-fat Fried Starch Chunks

The starch chunks, deep-fat fried in the corn oil samples, based on the Schaal Oven Test results, had better flavor stability than those fried in the sunflower oil samples (Table VI). The corn-oil-fried starch chunks were not rancid after 10 days at 60 C, whereas the sunflower-oil-fried samples had developed rancid odors within 10 days.

The PV of residual oil in starch chunks (Table VI) appeared to agree with the results of the sensory evaluations. The corn-oil-fried starch chunks had lower PV both

TABLE V

Flavor Evaluation of Oil Samples Aged under Different Conditions

Sample identity	Sunflower oil						Corn oil					
Sample number	1		2		3		4		5		6	
	Unwinterized; no additives		Winterized; no additives		Winterized; methyl silicone, Tenox 6		Winterized; no additives		Winterized; methyl silicone, Tenox 6		Winterized; methyl silicone, isopropyl citrate	
Conditions	S	P	S	P	S	P	S	P	S	P	S	P
Room temperature, diffused daylight (days)												
0	–	–	2.0	8.0	2.0	7.5	3.0	7.0	3.0	6.0	–	–
3	3.6	5.0	4.5	5.0	4.4	5.2	5.1	4.5	5.8	3.6	4.0	4.6
21	5.4	4.2	4.6	4.4	4.6	4.6	5.6	3.5	5.6	3.4	6.0	3.0
28	4.3	4.6	4.5	4.9	4.7	5.5	5.5	4.0	5.6	4.2	6.1	3.1
Room temperature, light box (hr)												
24	3.9	5.4	4.0	5.7	4.4	5.1	4.8	4.6	4.6	5.1	5.1	4.9
32	4.1	4.6	4.1	4.9	3.6	5.4	4.7	4.1	5.4	3.7	5.5	3.6
40	4.9	4.2	3.4	5.4	4.0	4.9	5.6	3.8	4.7	4.1	5.5	3.5
48	4.1	5.4	4.1	5.5	4.5	4.9	5.5	4.8	5.4	3.9	5.3	3.9
35 C, Dark (days)												
7	3.9	4.9	4.6	4.6	4.0	5.4	4.9	4.2	5.6	3.2	4.3	4.0
14	4.2	5.1	4.6	4.9	4.3	5.4	5.1	4.8	5.5	4.6	4.8	4.5
28	3.9	5.4	4.7	5.0	4.6	5.2	5.9	4.1	5.4	3.9	5.2	3.7

S = strength; P = preference. Score = 1-9; higher score, stronger flavor, more preference.

TABLE VI

Flavor Stability of Starch Chunks Deep-Fat Fried in Various Oils

Sample identity	Sunflower oil			Corn oil		
Sample number	1	2	3	4	5	6
	Unwinterized; no additives	Winterized; no additives	Winterized; methyl silicone, Tenox 6	Winterized; no additives	Winterized; methyl silicone, Tenox 6	Winterized; methyl silicone, isopropyl citrate
Days became rancid at 60 C	7	5	9	>10	>10	>10
Peroxide value						
After frying	5.1	10.4	3.2	3.9	1.7	1.4
After 1 day at 60 C	14.1	21.7	6.9	2.6	1.5	2.2
At time of rancidity	184.2	253.8	100.9	71.6	38.6	60.2

TABLE VII

Deterioration of Oil Samples Used for Simulated Frying

Sample identity	Sunflower oil			Corn oil		
Sample number	1	2	3	4	5	6
Analyses	Unwinterized; no additives	Winterized; no additives	Winterized; methyl silicone, Tenox 6	Winterized; no additives	Winterized; methyl silicone, Tenox 6	Winterized; methyl silicone, isopropyl citrate
Iodine value (Wijs)						
0 days	134.6	134.5	135.3	126.6	127.0	127.5
1 ↓	134.3	132.8	135.3	126.0	126.4	127.0
5	130.6	124.5	131.2	122.1	124.4	125.0
Viscosity, centistokes 37.8 C (100 F)						
0 days	33.4	33.9	33.8	35.2	35.3	35.3
1 ↓	34.8	38.5	35.1	37.0	36.2	36.2
5	39.8	60.2	39.6	45.6	39.3	39.2
NUAFE (%)						
0 days	1.4	1.4	1.6	1.5	1.6	1.5
1 ↓	3.7	5.1	3.5	6.7	1.9	3.2
5	6.2	9.5	3.7	8.4	2.7	3.5
PV (meq/kg)						
0 days	0.5	1.0	0.9	1.1	0.8	1.1
1 ↓	2.1	7.2	2.3	1.4	1.3	1.6
5	1.8	6.6	1.8	2.5	1.4	1.4
Colors, AOCS red						
0 days	0.8	1.8	1.1	2.5	2.6	2.6
1 ↓	1.0	2.5	1.7	5.5	6.4	4.3
5	5.3	13.0	3.6	12.5	7.5	9.0

immediately after frying and after aging at 60 C for one day. The PV of corn-oil-fried starch chunks at the time of the onset of rancidity were lower than samples fried in sunflower oil. The addition of antioxidants appeared to improve the stability of the fried chunks. This is obvious when sunflower oil no. 2 was compared to no. 3, as well as when corn oil no. 4 was compared to no. 5.

Stability of Oil Samples Used for Simulated Frying

The deterioration of fats and oils under simulated frying conditions was demonstrated by changes in their chemical and physical properties (Table VII). The IV of both sunflower and corn oils decreased during simulated deep-fat frying. There was an insignificant drop after 1 day of frying. After 5 days of frying, the sunflower oil dropped ca. 4 units *with or without additives*, except for sample 2, which was probably an inferior oil. For corn oil, the drop was 4 units without additives and 2.5 units with additives. There was a steady increase in nonurea adduct-forming (NUAFE) esters during the simulated frying. Additives distinctly decreased the formation of NUAFE. However, with the use of additives, corn oil was as, or more stable than sunflower oil. The viscosity of both corn and sunflower oils increased during simulated frying. At the end of 5 days, sunflower oil had an increase of ca. 6 centistokes with and without additives (except sample 2 which was probably an inferior oil); corn oil had an increase of 10 without additives and 4 with additives. The additives therefore appeared more effective for corn oil than for sunflower oil. This was confirmed by the decrease in IV.

As expected, PV was low immediately after simulated frying. Since the hydroperoxides of lipids are known to be heat-labile, the low initial PV in the fried oil is not necessarily an indication that only a small quantity of hydroperoxides were formed; rather, it indicated that, under simulated frying conditions, hydroperoxides formed and decomposed continuously.

There was an increase in color during the simulated frying for both corn and sunflower oils. Corn oil was darker than sunflower oil when fresh. After being used for simulated frying, the difference was intensified. The addition of antioxidants and methyl silicone significantly decreased darkening during frying.

It should be noted that sample 2 showed an exceptionally large increase in viscosity, NUAFE, PV and color, as well as a decrease in IV during simulated frying (Table VII). The reason is difficult to ascertain.

ACKNOWLEDGMENT

Part of Project No. 10503, supported by the New Jersey Agricultural Experiment Station.

REFERENCES

1. Langstraat, A., JAOCS 53:242 (1976).
2. Industry News, Ibid. 57:264A (1980).
3. From Washington, Ibid. 58:22A (1981).
4. Morrison, W.H., J.A. Robertson and D. Burdick, Ibid. 50:440 (1973).
5. Krishnamurthy, R.G., Ph.D. Thesis, Food Science Department, Rutgers University, New Brunswick, NJ, 1965.
6. Luddy, F.E., R.A. Barford and R.W. Riemenschneider, JAOCS 37:447 (1960).
7. Firestone, D., S. Neshein and W. Horwitz, Ibid. 44:405 (1961).
8. Dean, R.B., and W.J. Dixon, Anal. Chem. 4:636 (1951).

[Received November 13, 1980]