Room Odor Evaluation of Oils and Cooking Fats[1]

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ABSTRACT

Panel evaluations have been made of room odors developed by edible oils and cooking fats heated to frying temperatures. Vegetable and mixed fat shortenings, as well as oils of different iodine value and from special processing, were investigated with and without added stabilizers. When silicones were added to frying fats, room odor scores improved markedly. Certain added autoxidative cleavage products had little effect on odor scores at levels where they were detected easily in taste tests. To be discernible in room odors, these additives had to be present at levels ca. 100-fold greater than their taste thresholds. Panel results show that the undesirable frying odors contributed by unhydrogenated soybean oil in mixtures with other oils could be detected readily at 25% levels. As the level of soybean oil was lowered further, the room odor scores of oil mixtures improved perceptibly.

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TABLE I

Room Odor Scores of Vegetable Shortenings

Samples	Scores: Initial heating	Scores: Second heating[a]
All vegetable		
A	5.7	5.9
B	5.7	5.0
C	6.0	5.4
D	7.2	5.4
Mixed fat		
E	5.6	5.1
F	4.4	4.0
G	6.4	6.1

[a]Same fat heated after standing 1 month in the dark at room temperature.

INTRODUCTION

The per capita consumption of fats has increased more than 20% in the past two decades. Almost all of this increase has been in the salad and cooking oil category as is reflected in growing popularity of fried foods, salads and convenience foods. Consumption of fats and oils in 1970 rose to 53 lb per person (1). Both the housewife and the food processor are interested in how fats perform during cooking, and we have attempted to develop a room odor test as one organoleptic means of evaluating cooking fats (2). Methodology of the room odor test has been described and pertinent literature reviewed previously (2). Now further work has been done on all-vegetable and mixed fat shortenings, cooking oils and several minor edible oils. The room odor tests have been compared with other fat quality evaluation methods and the effects of stabilizers, antioxidants and additives on room odor scores have been examined.

METHODS AND MATERIALS

Two comparative room odor tests per panel meeting have been conducted as outlined earlier (2). All vegetable and mixed fat shortenings were commercial products purchased in the local retail market. Peanut, cottonseed, safflower, sunflower, high oleic safflower and partially hydrogenated soybean (hydrogenated-winterized) oils (HWSBO) were purchased as finished salad and cooking oils from various edible oil processors. A southern-grown low-iodine-value refined sunflower oil was obtained from the Southeastern Marketing and Nutrition Research Division, ARS, USDA, at Athens, Ga. The copper-hydrogenated soybean oils, IV 105 and 112, were prepared in the pilot plant and laboratories of the Northern Laboratory.

Tenox-6, purchased from Eastman Chemical Products, Kingsport, Tenn., contains the following antioxidants: butylated hydroxyanisole, butylated hydroxytoluene, propyl gallate and citric acid. The mixture was used at 0.0625 to 0.10% of the oil to give a total active ingredient concentration of ca. 0.02%. Regulations permit the maximum addition of Tenox 6 at 0.077%. Antifoam A, a

TABLE II

Evaluation of Sunflower and Safflower Oils

A. Sunflower Oils

Test	Sunflower normal (IV 140): With[a]	Sig[b]	Without	Sunflower with low iodine value (IV 122): With[a]	Sig[b]	Without
Initial flavor	8.7	*	8.1	7.6	+	7.8
4 Day, 60 C flavor	6.8	**	5.5	6.2	+	6.6
Room odor	6.5	*	5.2	6.2	+	5.4
AOM 8 hr peroxide value (PV)	19		41	7		17

B. Safflower Oils

Test	Normal (IV 143): With[a]	Sig[b]	Without	High oleic (IV 92): With[a]	Sig[b]	Without
Initial flavor	7.7	**	6.0	7.7	*	8.3
Room odor	6.2	*	5.6	6.8	*	5.7
AOM 8 hr PV	18		53	2.4		5.3

[a]With 0.1% (see text) antioxidant mixture (Tenox 6) + 1 ppm silicone.
[b]Sig: + no significance; * significance at 5% level; ** significant at 1% level.

TABLE III

Comparison of Room Odor and Flavor Scores of Hydrogenated Soybean and Peanut Oil Mixtures

Oil	Room odor	Initial flavor	4 Day 60 C	AOM 8 hr PV
Hydrogenated soybean	5.6	7.4	4.8	27
60:40	6.4	7.5	5.5	24
25:75	6.5	7.4	6.3	15
Peanut[a]	6.3	7.9	6.6	9

[a]Redeodorized in laboratory.

TABLE IV

Comparison of Room Odor Tests for Hydrogenated Soybean Oils

Test	Scores		Definitions		
	Cu-hyd.[a]	Ni-hyd.[a]	OIV and FIV[b]	Cu-hyd.	Ni-hyd.-W
Room odor	6.4	6.0	Hot oil	0.52	0.38
			Rancid	0.43	0.48
			Fishy	0.24	0.43
Initial flavor	8.3	7.8	Bland	0.28	0.28
			Buttery	0.78	0.83
4 Day, 60 C	6.7	6.7	Buttery	0.93	0.80
			Rancid	0.33	0.40
AOM 8 hr PV	2.8	1.0			

[a]Either copper- or nickel-hydrogenated and stabilized with 0.01% antioxidant mixture and 1 ppm silicone.
[b]OIV = odor intensity value; FIV = flavor intensity value.

silicone product made by Dow Corning Corp., Midland, Mich., was used at 1-5 ppm. The additives known to be products of autoxidation were purchased from the Campagnie Products Corp., Croton-on-Hudson, N.Y.

Room odor descriptions designated by panel members as weak, moderate or strong were weighted 1, 2 or 3, and an average odor intensity value (OIV) was calculated (2). It was arbitrarily decided that at least 25% of the panel judges must report a single odor before its presence would be regarded as important. The panel operator must use independent judgment in summarizing reported odors; otherwise the list becomes an almost endless tabulation. The same conditions and essentially the same panel personnel were employed in these studies as in those reported previously (2,3).

RESULTS AND DISCUSSION

Odor studies on six salad-cooking oils indicated that stabilized corn oil had higher initial room odor scores after heating to 192 C than other vegetable oils and that most oils showed no lowering in odor scores on a second heating (2). Almost all room odor scores with unhydrogenated oils were higher on the second heating. Similar tests conducted on a series of shortenings (Table I) indicated that odor scores cover approximately the same range as the cooking oils. Because hydrogenation increases the oxidative stability of shortenings, higher room odor scores might logically be expected for hydrogenated fats. In tests with soybean oil, hydrogenation did give products with higher room odor scores (2). Hydrogenation does not ensure a high room odor score. Selective hydrogenation of a fat, like linseed oil, imparts remarkably good oxidative stability but produces a fat that gives a low room odor score (4). Odor scores for shortenings heated the second time are, in general, lower than scores at initial heating.

Two samples of sunflower oil were evaluated for initial flavor, room odor and autoxidative stability (Table II). Northern grown seed with the higher iodine value oil (IV 140) and the southern grown variety with the lower iodine value (IV 122) were both tested with and without added stabilizers. Significant improvements were shown by the addition of both antioxidant and silicones to the sunflower IV 140 oil. The room odor score of sunflower IV 122 oil was improved by stabilization but not to the same extent as the higher unsaturated oil. Flavor and room odor scores of both sunflower oils were about the same as the scores previously reported for other vegetable oils, such as cottonseed and corn (2).

Safflower oil (IV 143) and high oleic safflower oil (IV 92) were evaluated for room odor and flavor stability with and without added stabilizers (Table II). The more saturated oil had greater oxidative stability and slightly higher room odor scores than the more unsaturated oil. Stabilized high oleic oil received one of the highest room odor scores of all the fats and oils in our room odor investigations. The

TABLE V

Comparison of Room Odor Scores with Heated Flavor Scores

Test	Copper-hyd.		HWSBO[a]		Cottonseed
Initial flavor	7.4	+[b]	7.4	+	8.1
Heated flavor			+		
150 C	5.9	+	6.3	+	6.1
200 C	3.5	**	3.0	**	4.2
			**		
Room odor					
Average	6.0	+	5.9	*	6.7
AOM 8 hr PV	2.0		0.9		2.9

[a]Nickel-hydrogenated-winterized soybean oil.
[b]Significance. See Table II.

TABLE VI

Room Odor Scores on Continued Frying Tests with Potatoes

Fry no.	Odor score Peanut		Odor score 50:50[a]	Odor descriptions	OIV Peanut	OIV 50:50[a]
0	6.0	*[b]	5.3	Hot oil	0.4	0.3
				Rancid	0.3	0.9
1	6.7	+	6.1	Hot oil	0.4	—
				Rancid	—	0.6
3	7.3	**	6.2	Hot oil	0.2	0.4
				Rancid	—	0.3
				Burnt	—	0.3
6	6.4	+	5.8	Hot oil	0.3	0.4
				Rancid	0.4	0.5
				Burnt	0.5	0.4

[a]50:50 Peanut oil and HWSBO with 0.0625% antioxidant.
[b]Significance, see Table II.

TABLE VII

Effect of Frying Potatoes in Oil vs. Heating Oil Only to Frying Temperatures

Room odor scores (first heating)			
Peanut oil		50 HWSBO[a]/50 peanut oil	
With potatoes	Without potatoes	With potatoes	Without potatoes
7.1	5.9	6.1	4.9
6.1	5.9	6.1	5.3
6.8	6.0		

[a]Commercial sample partially hydrogenated-winterized soybean oil.

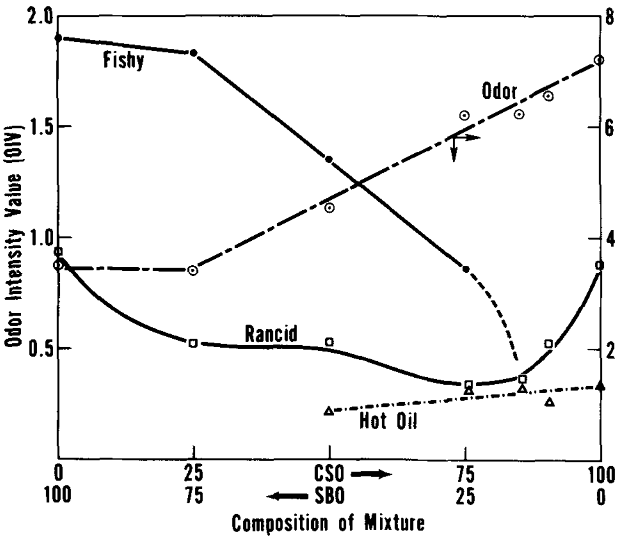

FIG. 1. Room odor scores and odor responses for 0-100% blends of soybean oil (SBO) and cottonseed oil (CSO).

successful use of high-oleic safflower oil for deep fat frying has been reported by Fuller et al. (5). Evidently natural fatty acid glycerides with low polyunsaturation and without positional isomers that result from hydrogenation receive the highest room odor scores.

Comparison with Other Tests

Organoleptic studies on blends of soybean and peanut oil have been reported earlier (6). In Table III room odor scores can be compared to other organoleptic results obtained on blends of soybean and peanut oils. All data were obtained from unstabilized oils. Because the sample of peanut oil had a low initial flavor score, it was redeodorized in the laboratory before tests were run. Oxidative stability decreased with each added increment of hydrogenated soybean oil, but the room odor scores were lower only for the sample of 100% hydrogenated soybean oil. Initial flavors of all oils and mixtures were good and offer no indication of their potential room odor scores or oxidative stability. No correlation was observed between the level of oxidative stability and the quality of the oil as indicated by room odor evaluation. Because linolenic acid has both thermal and oxidative instability, oils high in this acid will show an agreement in the two types of tests.

Copper-hydrogenated soybean oils have been previously evaluated (7), and the room odor test has been used to compare the quality of copper-hydrogenated oils with other cooking oils. Tables IV and V contain results for oils stabilized with 0.01% antioxidant and 5 ppm of silicones. Because of the high catalyst selectivity in reducing linolenic acid, the copper-hydrogenated oils compare favorably in room odor and oxidative stability to stabilized cottonseed oil and score higher than nickel-reduced oils. Room odor descriptions tabulated in Table IV show for copper-reduced oils a greater number of hot oil responses, which are desirable responses, and fewer undesirable fishy responses. The initial flavor score is especially good for the copper-reduced oil and indicates the high quality of oil that can be obtained with copper catalyst hydrogenation and good oil processing. In oxidative flavor responses the two oils are equivalent and show the usual bland-buttery flavors and rancid responses that develop on storage.

In Table V room odor scores for copper-hydrogenated oil (IV 105) and two other cooking oils are compared to their heated oil flavor scores. All oils were heated to the specified temperature and allowed to air cool to at least 55 C just before tasting. Flavor scores for each oil dropped considerably when temperature was raised from 150 to 200 C. All oils were about equal when heated to 150 C. After heating to 200 C, cottonseed oil was significantly higher than the hydrogenated oils, and the copper-hydrogenated oil was scored significantly higher in flavor than nickel-hydrogenated soybean oil.

Changes in room odor scores of peanut oil and a 50:50 mixture of HWSBO and peanut with repeated frying tests are presented in Table VI. The oils were heated to the frying temperature of 380 F (192 C) within 20 min. For

TABLE VIII

Effect of Oxidation on Room Odor Scores and Odor Descriptions

Soybean oil PV	Odor score	Odor descriptions[a] Fishy	Rancid	HWSBO PV	Odor score	Odor descriptions[a] Hot oil	Rancid
1.6	3.8	1.4	0.5	00.5	6.3	0.7	0.4[a]
3.2	3.5	2.0	0.7	2.9	5.6	0.7	0.6
7.1	3.4	2.1	0.3[b]	10.3	6.2	0.7	0.3
15.2	3.2	1.3	0.7	15.6	5.1	0.7	0.5

[a]Intensity in terms of OIV.
[b]Less than 25% of panel reported this response.

TABLE IX

Effect of Additives on Room Odor Scores of Cottonseed Oil

Compound	Concentration, ppm	Odor score	Odors, OIV index
cis-4-Heptenal	5	6.0	Rancid 0.3, hot oil 0.2
cis-4-Heptenal	100	5.5	Rancid 0.6, hot oil 0.4
1-Octene-3-ol	25	6.2	Hot oil 0.6, burnt 0.4
1-Octene-3-ol	50	6.5	Hot oil 0.5, rancid 0.4
1-Decyne	25	7.0	Hot oil 0.4, rancid 0.4
1-Decyne	50	6.4	Hot oil 0.5, rancid 0.3
2,4-Decadienal	50	5.8	Rancid 0.5, burnt 0.3
3,4-Decadienal	100	6.5	Rancid 0.6, hot oil 0.4
2,4-Decadienal	200	6.4	Hot oil 0.4, rancid 0.3
2,4-Dodecadienal	100	5.7	Rancid 0.5, fishy 0.3
2,4-Dodecadienal	200	4.3[a]	Rancid 0.6, fishy 0.6
Control cottonseed oil	—	6.4	Hot oil,0.6, rancid 0.4

[a]Significantly different from control.

French fries, 300 g of potato slices were fried continuously for 30 min during odor panel operation. After cooling, the oils were filtered and stored at 3 C until the next day when frying tests were repeated. Frying potatoes in peanut oil or in blends of oils raised odor scores by about one unit above the initial room odor score when only the oil was heated and held at the frying temperature. The intensity (OIV) of rancid and fishy responses when oils were heated alone is higher than when potatoes were fried in the same oils. With peanut oil, the average OIV of two tests for rancid was 0.40, but when potatoes were fried, the OIV's averaged 0.29. When a 50:50 blend of peanut oil and HWSBO was evaluated for room odor, a rancid response of 0.82 was obtained. Upon frying potatoes in this oil, the rancid responses dropped to 0.55 and on the second and third frying to 0.29 and 0.33, respectively. Further evidence of the improvement in room odor scores when potatoes were fried in the oil is given in Table VII.

Odor descriptions in Tables VI and VIII are typical for frying fats. A few panel members became familiar with the heated odor of peanut oil and could distinguish it from the blends. Since no makeup oils were added, these tests were terminated after 6-10 fryings. In these tests peanut oil was generally cited as superior to the blends.

Changes in room odor scores and odor descriptions for blends of soybean oil and cottonseed oil are plotted in Figure 1. The low odor scores and the high fishy responses of soybean oil appear to result from linolenic acid. The responsiveness of the panel to odors and sensitivity to fishiness is indicated by the progressive change of scores. Plotting of data against composition indicates that little difference can be detected between 80% and 100% soybean oil in this blend. When soybean oil constitutes less than 25% of the blend, changes in composition are detected by the odor panel. At these levels of soybean oil, a rise in the lines depicting rancid responses and the odor scores is observed, as well as a drop in fishy responses. Soybean oil used in this experiment contained 7.7% linolenic acid, and it can be inferred that odor differences can be detected at levels of less than 1% linolenic acid.

Oxidation Effect on Room Odor

It was previously pointed out that room odor score is increased more by antifoam agents, such as methyl silicone, than by antioxidants, such as butylated hydroxyanisole (2). Thus prior oxidation may not be a major factor in scoring room odors. Table VIII contains data on soybean oil and HWSBO that have been deliberately oxidized to four different peroxide levels and then evaluated for room odor scores and odor descriptions. Although odor scores decreased slightly with increased peroxide value, the effect is far from pronounced, and odor descriptions did not change with the degree of oxidation. Fishy and rancid responses predominated the odor descriptions for soybean oil, regardless of whether or not it had been oxidized before the heat test. HWSBO after oxidation for 2 days (PV 10.3) had almost the identical score and odor descriptions as when it was tested as fresh oil. The negligible change in room odor intensity or character after oxidation and the slight change observed on repeated heatings would indicate that prior oxidation, as measured by peroxide value, does not have much direct effect on room odor.

In Table IX a number of chemicals that have been reported as oxidative breakdown products of fats (8-10) have been added to bland cottonseed oil in order to check room odor responses. *cis*-4-Heptenal reportedly imparts a creamy flavor (8) or a fishy flavor (9) to oils. The detection of *cis*-4-heptenal in oxidized soybean oil has been questioned by Meijboom et al. (10). The flavor detection threshold of *cis*-4-heptenal as determined at the Northern Laboratory is ca. 0.007 ppm in cottonseed oil. Added to frying oil at levels of 5 and 100 ppm, this aldehyde lowered the room odor score slightly but not significantly. The odor responses are quite similar to those observed routinely for the cottonseed oil control. 1-Octene-3-ol and 1-decyne are known flavor components that develop in oxidized fats (11,12), and both have exceedingly low flavor thresholds (13). When these materials are added at levels far above their thresholds, they do not impart a particular odor to heated fats, and odor scores are not significantly different from the control.

Long chain aliphatic dienals have been characterized as possessing a deep-fried or oily odor of heated or frying fats (14,15). When added at levels of 50-200 ppm to the frying fat, 2,4-decadienal did not alter or intensify the odor descriptions or lower the odor scores. When added at high levels of 100 and 200 ppm, 2,4-dodecadienal imparted a fishy response and at the higher level caused a significant lowering of the odor score.

Information gained from these room odor studies would indicate that polyunsaturated fats (linolenic oils) are the least stable and that high oleic oils are the most stable among edible vegetable oils. Partial hydrogenation of polyunsaturated fats does not necessarily result in high room odor scores, a condition which is in contrast to the apparent high degree of oxidative stability that is conferred to these same fats. Indications are that the various unsaturated isomers formed during hydrogenation give different volatile odors from the natural unsaturated fatty acids. Since hydrogenation moves unsaturation, this result would be expected. Considerable oxidation may be achieved during frying or heating at 192 C to give comparatively large amounts of volatiles needed to impart off-odors to the room.

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