Edible Oil Evaluation by Room Odor Tests: A Preliminary Report[1]

C.D. EVANS, HELEN A. MOSER, G.R. LIST, H.J. DUTTON and J.C. COWAN,
Northern Regional Research Laboratory,[2] Peoria, Illinois 61604

Abstract

Room odors developed on heating edible fats in open vessels were evaluated and characterized by a 20 member odor panel. Edible fats tested were: special soybean salad and cooking oils, hydrogenated soybean oil and some commercial salad and cooking oils. Factors were investigated that affect reliability and reproducibility of the test and the acuity of the panel members. The effects of fry temperature and size of sample were investigated. The method has been applied to a study of hydrogenated and unhydrogenated soybean oil samples.

Introduction

Frying foods in fats and oils is an important part of man's culinary art. Properties of heated fats and oils have been extensively reviewed (1–5). These reviews have been primarily concerned with oxidative and thermal deterioration, toxicity and the biological and metabolic changes that result from heating fats. Artman's (1) extensive and excellent summary covers many phases that affect the question of wholesomeness of heated and used cooking fats. Heating fats and oils in a fry pan to evaluate the quality of competitive products is widely used in control laboratories. Certain soybean oil products suffer in domestic and foreign competition because they develop a "fishy" odor when heated to frying temperatures (6). Two of the authors found the room odor to be the major objection of leading Southern European refiners of soybean oil when it was used as a cooking oil.

The importance of mild and bland odors to the acceptability of many foods is well known. Despite the importance of odors, little information has been published on the modification or improvement of the odor of frying fats. Silicones, when added at a few parts per million, reportedly reduce the oxidation of frying fats (7,8). Rock et al. (9) found silicones effective only under certain conditions, whereas Weinberg and Rubin (10) demonstrated that foam volume decreased substantially under most conditions. They discovered that tocopherol was destroyed as rapidly in the protected as in unprotected shortenings. Bito et al. (11) found hexanol and branched short chain alcohols to be the most effective of 25 antifoam agents tested in frying fats as measured by fat decomposition.

Odor and flavor studies on fats have been primarily concerned with the characterization of volatiles derived from mildly autoxidized fats. Although pan frying is considered to be more drastic than deep fat frying, the overall effects of heating are probably similar. Because of the multiplicity of factors and conditions, any laboratory program developed for testing heated fats will probably be intermediate in severity between the limiting conditions of actual use. Organoleptic and stability tests have not been developed for frying fats; most of the tests normally applied have been developed for salad oils. Many of the organoleptic tests are applied to the final food products and the quality of the fat is obtained indirectly. We have initiated studies to develop a room odor test for the evaluation of cooking oils by applying established taste panel methodology and statistical evaluation to the data obtained directly from heating fats in an isolated room. Preliminary results are presented here.

Methods and Materials

Two large laboratory units, available in a new addition to the Northern Laboratory, enabled us to conduct two comparative room odor tests simultaneously. The layout of a single laboratory unit is shown in Figure 1. The test rooms are essentially identical and situated on either side of the central corridor of the new wing. The volume of each room is 5820 cu ft and the hood exhaust fans have a capacity of 900 cu ft/sec. Theoretically, the air in each room (two hoods per room) should be completely changed every 7 min. There is no recirculation of air in the air-conditioning system. Thus, the room can be cleared of odors in a short time after a test. During a test period the hood doors are closed and a slight positive pressure created within each room. Panel judges enter through three buffer rooms closing each door after entering and walk into the test room to a position at the end of the center bench. The pan of hot oil is 5 ft from the point where the panel member stands while making his odor observations. After recording their reaction to the room odor, the panel member leaves through the same three buffer rooms. This neutral area helps to eliminate residual odors in the nose. The units used for room odor tests might be considered almost ideal for this purpose. They had no background of absorbed odors that might affect the odor testing. We plan to try other arrangements in the near future in hopes that they will serve the same purpose.

A 150 to 600 ml sample of oil was heated in an electric all-aluminum sauce-fry pan of 19 cm diameter and 10 cm deep (Sunbeam Model No. RS-3) at the location shown in Figure 1. The temperature of the pan (1150 watt internal cast heater) was controlled by a glass-enclosed thermistor probe (2.5 sec time constant) and by an electronic relay controller. The temperature was held to within ± 2 F of any desired setting. The heating cycle for 300 ml of oil was on for 15 sec and off for 70 sec. Temperature was recorded by means of a thermocouple. Both the thermistor and the thermocouple were immersed in the oil and touched the bottom of the pan. No attempt was made to embed the controls within the metal of the pan and by such means obtained a more rapid response and closer control of temperature. A temperature of 380 F, which is considerably below the smoke point of most refined vegetable oils, was selected as typical for frying.

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[2] No. Market. Nutr. Res. Div., ARS, USDA.

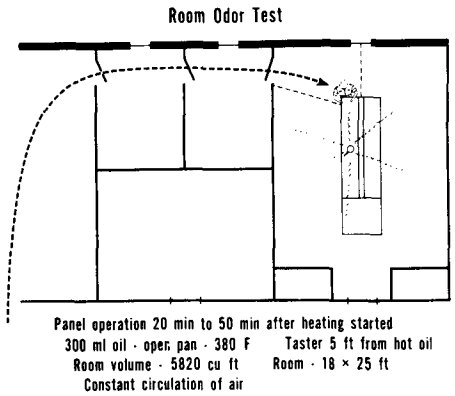

FIG. 1. Arrangement of laboratory unit used for odor test showing entrance rooms, test room, panel member and fry pan.

The score sheet and statistical analysis used in these tests (Fig. 2) is similar to that used for our oil evaluations (12–14). The 20 panel members were experienced in oil evaluation and were allowed free choice in describing room odors. Score sheets were numbered 1 and 2 sequentially. As the panel members reported they were given the next numbered sheet, thus randomizing the order of presentation and eliminating the bias of first position. Since the randomizing of samples could result in error of scoring by the panel member, red pencils were placed in the room where sample 1 was graded and green pencils in the room where sample 2 was scored. Thus, the person analyzing results could easily detect an error made by a panel member.

The oils employed in this report include edible soybean salad oil with a linolenate content of 8% (S_1); a specially prepared hydrogenated soybean salad and cooking oil with a linolenate content of 1.2% and an IV of 107 (S_2); a specially prepared hydrogenated soybean cooking oil with a linolenate content of 1.2% and an IV of 109 (S_3); and commercial samples of hydrogenated-winterized soybean oil (HWSBO), olive, corn, safflower and peanut oils. Soybean oils S_1 through S_3 were not stabilized with antioxidants and antifoam agents.

Room odor descriptions reported by the panel judges were quantitized and normalized by computing

Name_____ Date_____

Please indicate the score by placing a check mark (√) in the space opposite the proper value for odor

		Sample 1 Odor	Sample 2 Odor
Very Good	10		
Good	9		
	8		
Fair	7		
	6		
Poor	5		
	4		
Bad	3		
	2		
Very Bad	1		

Please indicate intensities of odors by placing check marks opposite the proper odor.
(√) Weak: (√√) Moderate: (√√√) Strong

Odor	Sample 1	Sample 2

FIG. 2. Example of score sheet; more spaces usually allowed for description of the odor.

TABLE I

Effect of Oil Volume on Room Odor Tests

Volume. ml	Scores[a]	
150 vs. 150	5.6	5.4
150 vs. 300	5.9	5.2
300 vs. 300	6.3	6.0
300 vs. 600	5.8	6.3
600 vs. 150	6.2	5.9
600 vs. 300	6.5	5.9
600 vs. 600	6.9	6.5

[a] Differences not statistically significant at the 5% level.

an odor intensity value (OIV). The value equals the weighted summation (1 for weak, 2 for medium and 3 for strong) of the odor responses divided by the total number of panel judges. Thus, OIV limits are 0 and 3. It was arbitrarily decided that at least 25% of the panel judges must report a single odor before its presence is regarded as being important in our judgment.

Results and Discussion

A great many factors influence the result of any odor test. The physical conditions of temperature and volume of oil used were studied. Other factors, largely physiological, such as the acuity and variability of a judge and reproducibility of odor scores and OIV's were also considered.

Three volumes, 150, 300 and 600 ml, of a specially prepared soybean oil (S_2) were investigated and results indicated that volume did appear to have some effect on panel scores and odor descriptions. Table I shows that in all tests, differences were not significant at the 5% level between these volumes for a sample of specially prepared hydrogenated soybean oil (S_2).

Odor descriptions changed with increased amounts of oil. The predominant odor recorded for the 600 ml sample was hot oil with an average OIV of 0.59. This value decreased to 0.50 for the 300 ml sample and 0.46 for the 150 ml sample. Rancidity was highest (OIV 0.53) in the 150 ml sample, decreased (OIV 0.39) in the 300 ml sample but was negligible in the 600 ml sample.

The effect of temperatures of 365, 380 and 395 F on odor was investigated for three different oils. Table II shows that in most tests, oils heated at 365 F had higher odor scores than did oils heated at 380 and 395 F. One discrepancy indicates that further investigations might be needed, but the data clearly point out that temperature of heating is one of the important factors in odor development. The three soybean oils showed about the same change in response to increasing temperatures, but the actual scoring levels are different because of hydrogenation, added antioxidants and stabilizers.

Data relating to the reproducibility of odor scores

TABLE II

Effect of Frying Temperature on Room Odor Scores

Sample	Scores 365 F	380 F	395 F	Significance[a]
Soybean salad oil (S_1)	5.4	4.1		*
		4.7	4.5	+
	5.4		4.7	+
Special soybean oil (S_2) (unstabilized but hydrogenated)	6.0	5.9		+
		5.8	6.2	*
	6.4		5.3	**
Commercial HWSBO[b] (stabilized)	7.4	6.4		**
		7.5	7.1	+
	7.4		6.7	**

[a] Symbols: +, no significance; *, significant at 5% level; **, significant at 1% level.
[b] Hydrogenated-winterized soybean oil.

TABLE III

Reproducibility of Room Odor Scores and Odor Intensity Values (OIV)

Sample	No. of tests	Average score	OIV		
			Rancid	Hot oil	Fishy
Commercial HWSBO[a]					
Sample 1	8	6.3 ± 0.38[b]	0.35 ± 0.15	0.55 ± 0.14	0.33 ± 0.14
Range		5.8 to 6.8	0.15 to 0.61	0.38 to 0.79	0.10 to 0.44
Sample 2	6	6.7 ± 0.80	0.35 ± 0.17	0.40 ± 0.13	0.36 ± 0.23
Range		5.7 to 7.7	0.16 to 0.61	0.26 to 0.56	0.11 to 0.67
Soybean salad oil (S_1)					
Sample 1	4	4.0 ± 0.41	0.55 ± 0.22	.....	1.2 ± 0.33
Range		3.6 to 4.5	0.32 to 0.82	.....	0.94 to 1.7
Sample 2	4	4.5 ± 0.28	0.56 ± 0.29	0.34 ± 0.21	1.2 ± 0.13
Range		4.1 to 4.7	0.38 to 1.0	0.11 to 0.61	1.0 to 1.3
Special soybean oil (S_2) (unstabilized but hydrogenated)	12	6.0 ± 0.37	0.37 ± 0.19	0.53 ± 0.20	.....
Range		5.2 to 6.8	0.05 to 0.82	0.26 to 0.88	.....

[a] Hydrogenated-winterized soybean oil.
[b] Standard deviation.

and OIVs are given in Table III. Two commercial samples of HWSBO with eight and six replications, gave similar results although sample 1 had a much lower standard deviation. The OIVs for rancid, hot oil and fishy responses are very similar. Two unhydrogenated soybean oils each with four replications gave lower scores as would be expected. Again the agreement in scoring and odor description is good.

Twelve tests on a special unstabilized soybean oil showed excellent agreement in scoring and room odor description. The absence of fishy responses is noteworthy and in contrast to the high response in soybean oil and the lower response in HWSBO.

Judge Attributes

The accuracy and reproducibility of panel scores and descriptions are no better than the reliability of the individual judge. The numerical score given to an odor by individuals with a common background is an integrated, composite value based on training and memory. It is fairly reproducible and is within an agreed numerical system of notation. Judges may, however, lack the essential common background to agree on the type and character of an odor. The individual's experience with food and environment primarily determines the area of his odor descriptions. Panelists with varied backgrounds are constantly trying to describe odors in terms of their experience and the array of terms is sometimes confusing. In the development of this room odor test, free choice was allowed to see if any individuals had the acuity to distinguish oils in respect to their composition, physical properties, processing treatments, or seed source. Olive oil was consistently identified by an appreciable number of judges because of the odor of the hot oil. With training, judges might identify some other oils, but such recognition may depend on the extent of refining of the oil.

A fishy response in the room odor test is usually associated with linolenate content of soybean oil. Tests conducted early in the development of the method indicated that more than 75% of the panel gave this particular response. In comparing odor testing with flavor testing, painty responses, commonly encountered in flavor tests of autoxidized oils, were seldom encountered in room odor tests. Terms used in describing soybean oil flavors are being used more and more by the odor panel. These terms include painty, fishy, beany and grassy. Up to 35 descriptive terms have been used by the 20 member panel to describe the room odors developed by hot oil samples. This number of terms may be unmanageable and attempts are being made to characterize odor in fewer categories.

The reproducibility of a representative sampling of the individual's odor scores for soybean oil and for a commercial HWSBO is shown in Table IV. The standard deviation was calculated from five or more replicates and indicates only the variation of the individual observed measurements. It has no relation to high or low scoring by an individual. Judges who are able to consistently give the same or nearly the same scores to replicate samples will have a proportionally lower standard deviation than a judge who scores samples high at one session and low at the next.

Judge A shows consistency in grading soybean oil while Judge H shows great variation in his scoring of the same oil. In judging HWSBO, Judge A does poorly. Judges E and F are about as consistent in scoring one oil as they are in scoring the other. The data also show that there was considerable difference of opinion concerning the quality of these two samples. The range of 2.0 to 6.0 for the soybean oil and 5.0 to 8.5 for HWSBO shows need for training to evaluate odor. Such training should lead to better agreement in scoring and odor descriptions.

Some Applications of Room Odor Tests

To test this preliminary method of evaluating room odors, several experiments were conducted. It was decided to use 300 ml of oil and a temperature of 380 F in all tests. Oils were held at that temperature for 20 min previous to the 30 min period allowed for judging. These choices were based on our experience with the test and the size of research sample readily prepared in our facilities for use in room odor plus other tests.

The effects of additives in soybean oil (S_1) and a specially prepared stabilized hydrogenated sample (S_3) are shown in Table V. The importance and effectiveness of stabilizers are clearly delineated here. An antioxidant mixture (Tenox 6) and an antifoam agent (Dow Silicone A) were added, and equivalent results were observed in both samples. Addition of the antioxidant without the antifoam agent improved

TABLE IV

Scoring Level and Reproducibility of Individual Panel Judges

Judge	Soybean oil, S_2	HWSBO[a] (commercial)
A	2.8 ± 0.4[b]	5.4 ± 1.4
B	5.0 ± 0.82	7.9 ± 1.1
C	4.3 ± 1.2	6.8 ± 0.84
D	5.2 ± 0.84	6.2 ± 0.98
E	6.0 ± 0.89	8.5 ± 0.84
F	5.0 ± 1.3	7.3 ± 1.3
G	3.8 ± 1.1	5.1 ± 2.0
H	3.7 ± 1.5	5.6 ± 0.97
I	2.0 ± 0.63	5.0 ± 3.2

[a] Hydrogenated-winterized soybean oil.
[b] Standard deviation.

TABLE V

Effect of Stabilizers on Room Odor Scores

Additive	Soybean salad oil, S1 8.0% linolenate				Special soybean oil, S3 1.2% linolenate			
	AOM[a]	Score	Response	OIV[b]	AOM	Score	Response	OIV
None	64	3.9	Fishy	0.6	25	5.7	Rancid	0.6
			Hot oil	0.6			Hot oil	0.6
			Rancid	0.4			Fishy	0.3
Antioxidant mixture 0.1%	2.5	4.5	Fishy	1.3	2.2	6.5	Hot oil	0.7
			Hot oil	0.5			Fishy	0.2
			Rancid	0.5				
Silicone (5 ppm)	60	5.5	Fishy	0.6	11	7.1	Hot oil	0.6
			Rancid	0.4			Fishy	0.2
			Hot oil	0.4				

[a] Peroxide value after 8 hr under AOM (active oxygen method) conditions.
[b] Odor intensity value.

room odor scores for both oils but the antifoam agent alone, added at 5 ppm, markedly improved the odor scores of both samples. Surprisingly, samples containing the mixture of antioxidants plus the antifoam agent were no better (data not shown) than the samples containing silicone alone. Other tests with only 1 ppm of silicone have shown this level to be effective in improving room odor scores. Table V also shows the peroxide values developed in an 8 hr active oxygen method (AOM) for samples containing antioxidant and silicone. In this test most of the stabilizing activity can be attributed to the antioxidant and none to the added silicone. Oil stabilizers (antioxidants, metal chelating agents and antifoam agents) are not usually effective at concentrations of only a few parts per million. However, Marcuse and Fredriksson (15) and Olcott et al. (16) have reported antioxidants under special conditions to be active at extremely low concentration levels of 2 and 5 ppb, respectively.

Table V also shows that reduction of linolenate content from 8% to 1.2% lowers the fishy responses as measured by OIVs. Thus, the fishy response of soybean oil was substantially reduced by hydrogenation.

This room odor method was also used to evaluate locally purchased cooking and salad oils and the results are given in Table VI. Corn oil received the highest scores on the initial room odor test and after a second heating.

Olive oil odors scored low probably because the members were unfamiliar with the rather sweet, strong, but typical, olive oil odor that was not unduly changed by heating. The rather low score given the room odor of peanut oil and its marked improvement on the second heating is somewhat surprising and not easily explained. A number of peanut oils purchased in local markets have not received good initial flavor scores. One lot had an initial flavor score of 4.5, another lot 6.3, but after redeodorization in the laboratory both of these oils were given a flavor score of 7.3. The higher room odor score received on the second heating by all oils attest to the concept that the odor is not strongly dependent on oxidation and that odor volatiles may be considerably modified by heat and oxidation before they diffuse very far from the fry pan into the atmosphere. Only corn and the HWSBO listed in Table VI had added antioxidants and antifoam agents.

TABLE VI

Room Odor Scores for Commercial Salad and Cooking Oils

Oil	Average scores	
	1st Heating	2nd Heating[b]
Corn	6.4	6.7
Cottonseed	5.7	6.0
Olive	4.0	4.3
Peanut	4.8	6.3
HWSBO[a]	5.8	6.2
Safflower	6.0	6.3

[a] Hydrogenated-winterized soybean oil.
[b] Same sample heated after standing one week in dark at room temperature.

This preliminary study has developed information that provides a basis for further work and study of the room odor problem. It has shown us that taste panel methodology can be adapted to conducting room odor tests. Odors are markedly different between heated fats and autoxidized fats and experienced panel members will have no difficulty in differentiating between them. Individual members show considerable variation in scoring but panel odor scores are reproducible. Significant differences can be shown between soybean oil and the nonlinolenate edible oils. Fishy responses are associated with linolenate content since oils with low linolenate gave much lower OIVs for fishy responses than do higher linolenate oils. A silicone was shown by the room odor test to be effective in improving the odor of frying fats. The addition of an antioxidant to frying fats had no effect on room odor scores.

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