Odor Considerations in the Use of Frying Oils[1]

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ABSTRACT

Odors generated into cooking and serving areas during use of oils in pan frying and deep-fat frying are of concern to home and institutional consumers and, in some respects, to industrial users. Odor considerations are factors in the selection of types of oils to be used in both domestic and foreign markets. Comparative techniques have been developed to evaluate room odor characteristics of frying oils. Evaluation research has been done on various oils and cooking fats for room odors developed during frying. Improved odor characteristics contributed by additives to oils have been studied, as well as relationship between the linolenate content of soybean oil and its characteristic room odor. The nature of the volatile constituents which contribute to room odors during frying is the subject of continuing research efforts.

INTRODUCTION

Pan frying and deep fat frying are important methods of food preparation in the home, in institutions, and in industry. Liquid cooking/salad oils constitute a significant amount of the edible oils used in these trade sectors (1) (Fig. 1). Refined and properly deodorized frying fats are, initially, odorless and bland tasting regardless of their source or degree of unsaturation. Different vegetable oils have their own characteristic odors when heated to frying temperatures, and these odors can create problems in the use of the oils. Institutional users have been cautioned that "frying odors should not reach the serving area no matter how bland they may seem. Room odors are not always obvious to persons in the room during frying. The odors become evident when a person leaves the room and returns shortly thereafter. The odor may also seem stronger to people in the next room" (2). While the use of vegetable oils such as cottonseed, peanut, or corn is feasible, soybean oil develops a fishy odor on frying that is highly objectionable. Soybean oil has been used for frying in kitchens with exceptional ventilation to remove odors. To a large extent, hydrogenation (special processing of soybean oil) has minimized the problems of objectionable odors during frying. However, in direct comparisons with other available oils, even hydrogenated soybean oil has been graded inferior as to room odor characteristics (3). The major continuing impediment to the expansion of European markets for soybean oil is unacceptable room odor. Evaluation of various processing alternatives to improve the performance of soybean oil during frying has been the subject of considerable research (4-6).

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ROOM ODOR TESTING TECHNIQUES

A room odor test was developed at the Northern Center and has been applied to various research efforts (4). Two large laboratory units, which were available in a new addition at the Center, were pressed into service to provide two comparative room odor tests simultaneously. The layout of a single laboratory unit is shown in Figure 2. The volume of each room was 5820 cu ft, and the air was completely changed every 7 min through the hoods. The odors were generated from an open pan of hot oil. The panelists, entering through three buffer rooms, assumed a position 5 ft from the pan. After recording their judgment of the oil odors, the panel member exited through the same three buffer rooms. This neutral area helped to eliminate residual odors in the nose on leaving and, when entering, minimized premature exposure to the odors. The score sheet developed for these tests is shown in Figure 3. Each panelist was required to judge the odor on a 10-point scale, ranging from very good-10 to very bad-1. Judges were also asked to describe the odor perceived and to rate it as weak, moderate, or strong. Odor Intensity Values (OIV) were computed equal to the weighted summation (1 for weak, 2 for medium, and 3 for strong) of odor responses divided by the total number of panel judges. OIV limits were 0 and 3, and it was decided that for an odor to be regarded as

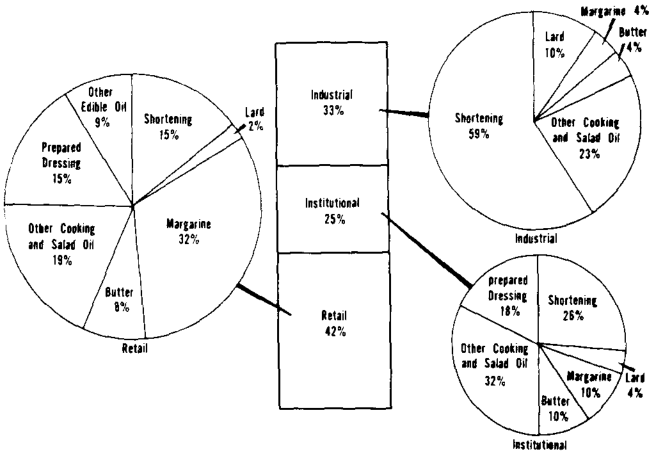

FIG. 1. Edible oil products use by trade sector, 1975 (1).

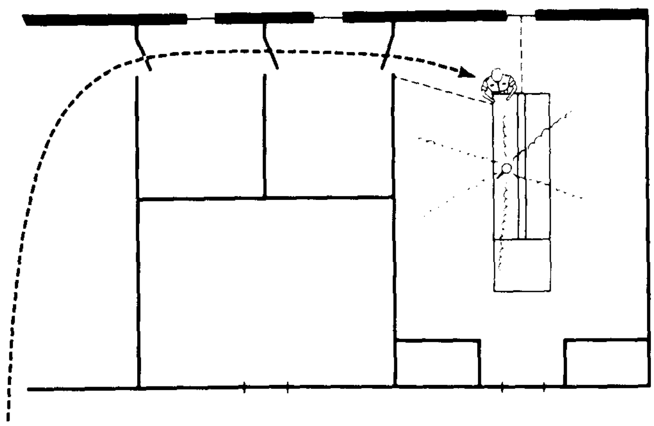

FIG. 2. Arrangement of laboratory unit used for odor test showing entrance rooms, test room, panel member, and fry pan (4).

Name____________________Date____________

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

		Sample 1	Sample 2
		Odor	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. 3. Example of score sheet; more spaces usually allowed for description of odor (4).

important to the evaluation of the oil, at least 25% of the panel judges had to report its presence. A fishy response in the room odor test was associated with the linolenate content of soybean oil. More than 75% of the panelists gave this response. Painty responses, commonly encountered in flavor tests of autoxidized oils, were seldom encountered in room odor tests.

The influence of the volume of oil used on the result of the odor test was investigated using three volumes, 150, 300 and 600 ml, of soybean oil, which had been hydrogenated but not further stabilized (4). The results, shown in Table I, indicated that although volume did appear to have some effect, differences were not significant at the 5% level. Temperature studies indicated that odor scores decreased as the temperature was increased from 365 F to 380 F and 395 F. Standard operating conditions were selected as 300 ml of oil heated to a temperature of 380 C.

APPLICATIONS OF ROOM ODOR TESTS

Additives to soybean oil were evaluated as shown in Table II (4). The importance and effectiveness of stabilizers was clearly indicated. An antioxidant mixture (Tenox 6) and an antifoam agent (Dow Silicone A) were added, both separately and to the same oil sample. Addition of the antioxidant without the antifoam agent improved the room odor score and the score was further improved when both additives were present. Use of the antifoam agent alone improved the score as well as when both agents were present. Although 5 ppm silicone was used in this test, other tests showed that silicone added at a level of 1 ppm was effective in improving room odor scores. Again, the fishy odor response was the dominant description perceived by the panelists.

The room odor test method was used to evaluate locally purchased cooking and salad oils (Table III) (4). Corn oil received the highest scores on the initial room odor test and

TABLE I

Effect of Oil Volume on Room Odor Scores (4)

Volume, ml	Scores		Sig.[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]+ denotes no statistical significance.

TABLE II

Effect of Additives[a] on Unhydrogenated Soybean Oil (4)

Parameter	Original	+ Additives	+ Silicone	Sig.[b]
Room odor score	3.9		4.9	**
		4.5	5.5	**
Odor intensity values				
Hot oil	0.4	0.5	0.5	
Rancid	0.7	0.5	0.4	
Fishy	0.9	1.3	0.6	

[a]Citric acid, BHA, BHT, propyl gallate.
[b]**Denotes significance at 1% confidence level.

TABLE III

Room Odor Scores for Chemical Salad and Cooking Oils (4)

Oil	Average scores	
	First heating	Second heating[a]
Corn	6.4	6.7
Cottonseed	5.7	6.0
Olive	4.0	4.3
Peanut	4.8	6.3
Hyd-wint. SBO	5.8	6.2
Vegetable	5.6	5.6
Safflower	6.0	6.3

[a]Same oil heated after staying 1 week in dark at room temperature.

TABLE IV

Composition of Soybean Oils (Wt. %) (6)

Fatty acid	Unhydrogenated oil (SBO)	Nickel-reduced oil (NiHSBO)	Copper chromite-reduced oil (CuHSBO)
$C_{16:0}$	11	11	12
$C_{18:0}$	4	5	4
$C_{18:1}$	23	43	42
$C_{18:2}$	54	39	43
$C_{18:3}$	8	3	0.4
Calc. IV	134	111	111

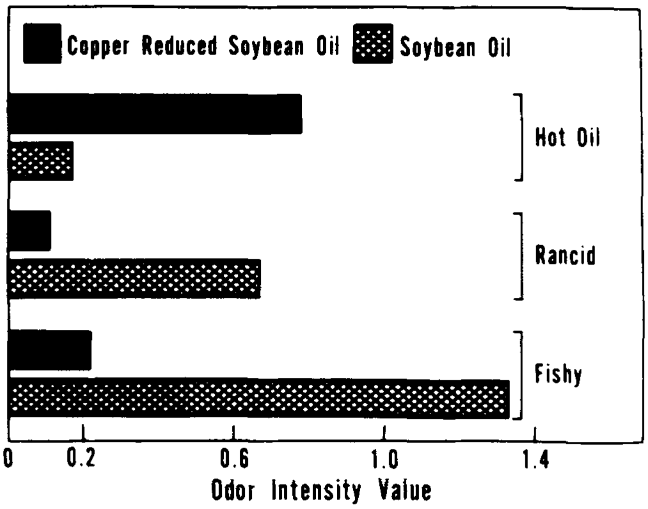

FIG. 4. Odor responses measured by odor intensity values of soybean oils. Oils heated to 193 C in a fry pan and room odors described (8).

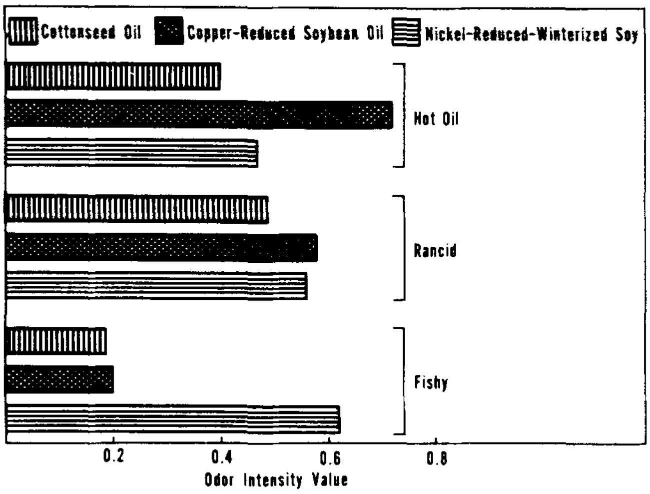

FIG. 5. Odor responses as measured by odor intensity values of cottonseed and hydrogenated soybean oils. Oils heated to 193 C in a fry pan and room odors described (8).

also after a second heating. The low score given to olive oil odors was attributed to unfamiliarity of the panelists with the typically sweet, strong odor, which was unchanged by heating. Peanut oils were found to be quite variable in both flavor and room odor tests. The higher room odor score received on the second heating by peanut and the other oils was an indication that the odor was not strongly dependent on oxidation of the oil and that odor volatiles may be considerably modified by heat and oxidation before they diffuse from the fry pan into the atmosphere.

Concurrent research at the Northern Center resulted in

TABLE V

Comparison of Blends of Peanut Oil and Hydrogenated Soybean Oil (Room Odor Evaluations) (3)

Peanut	25% Soy	60% Soy	Soybean	Sig.[a]
5.4	5.1			+
5.4		4.7		+
	5.7	5.4		+
	6.5		5.7	**
		5.6	5.5	+

[a]+ Denotes no statistical significance; ** significance at 1% confidence level.

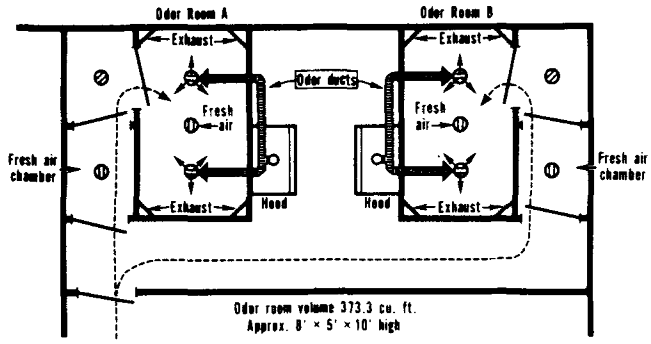

FIG. 6. Newly constructed room odor test facilities.

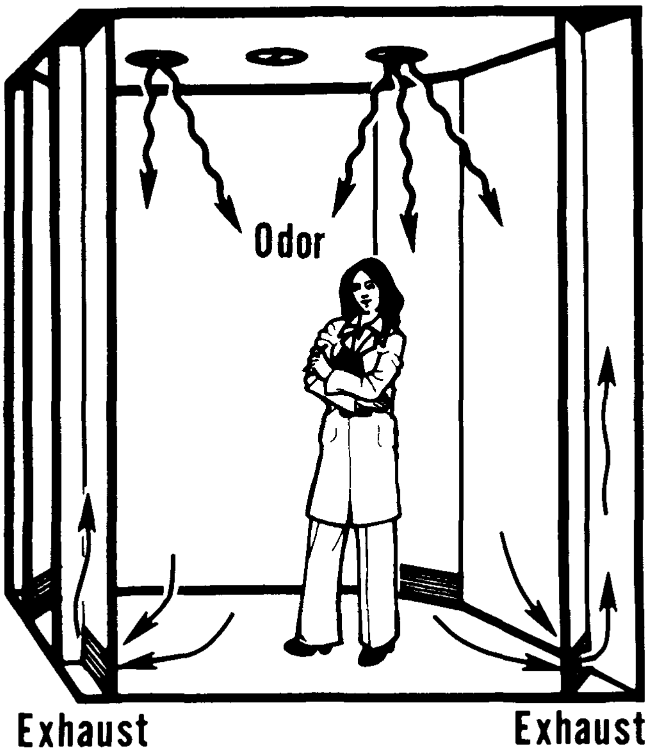

FIG. 7. Odor room air flow.

the discovery of copper chromite catalysts having high selectivity for the reduction of linolenic acid (7). Liquid cooking oils prepared with this selective catalyst had linolenic acid contents of less than 1.0% at iodine values that were higher than commercial oils having 3-4% linolenic acid (Table IV) (6). Early tests demonstrated that these oils with low linolenic acid content were more stable than the original oil. This was also indicated by direct comparisons in the room odor test (Fig. 4) (8). The copper-reduced oil was high in hot oil responses and low in rancid and fishy responses, which are the predominant objectionable odors with unhydrogenated soybean oil. Copper-reduced oil was further evaluated by comparison with cottonseed oil and nickel-reduced winterized soybean oil in room odor tests (8). Each of the oils contained 0.1% Tenox 6 and 5 ppm methyl silicone. Scores for cottonseed oil were significantly higher than the nickel-reduced oil, but not significantly above the copper-reduced oil. The latter scored higher than the nickel-reduced oil, but not significantly. With the copper-reduced oil, hot oil and rancid responses were greater than the low fishy responses (Fig. 5).

Results were the same with cottonseed oil, but none of these responses were as high as with copper-reduced oil. Fishy responses were the highest recorded for the nickel-

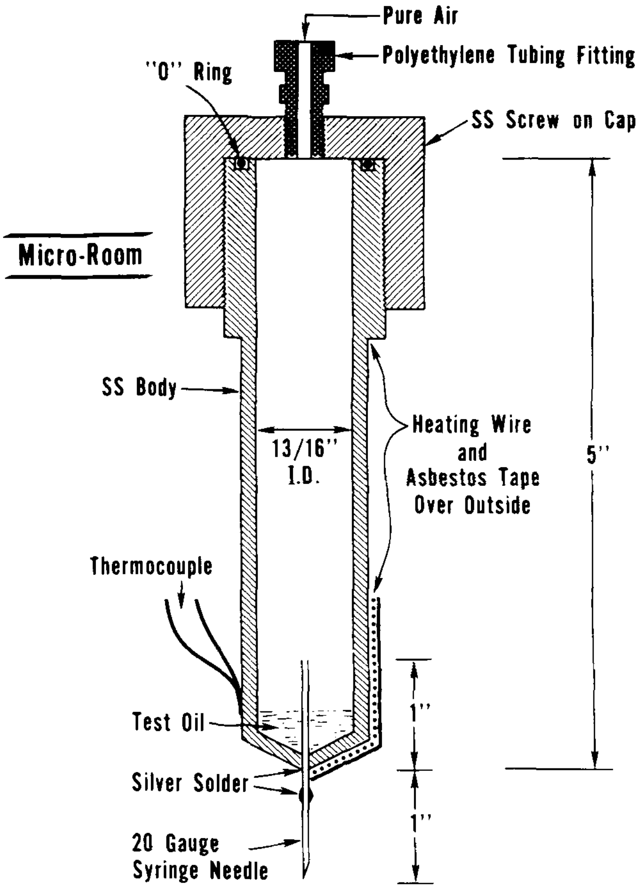

FIG. 8. Stainless steel reactor designed to simulate deep fat frying conditions (10).

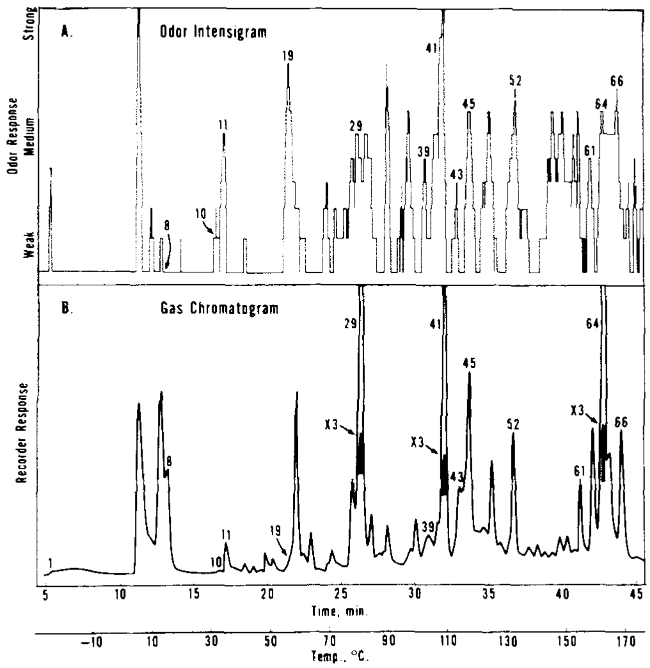

FIG. 9. (A) Odor intensigram or odor intensities of correspondingly numbered peaks shown in B. (B) Chromatogram of volatiles from soybean oil heated at 193 C, collection for 10 min (10).

reduced oil. As much as 5.2% to 6% linoleic acid isomers are formed during reduction of soybean oil with copper catalysts (9). While the fishy response has been all but eliminated with these oils, another objectionable odor, attributed to these isomers, has been perceived in European room odor tests of copper-reduced soy oils. This odor, described as hydrogenated, continues to be a concern in the expansion of soybean oil markets in Europe. A recent consumer use test conducted in Southern Europe showed that the low linolenic acid oils were still unacceptable in this market. Peanut oil was compared with copper-reduced soybean oil, and responses showed a 21% rejection of the latter oil compared to a 3% rejection of the former (Private communication).

The traditional oil in the Southern European countries is peanut, and the possibility of formulating peanut oil-soybean oil blends that would have acceptable room odor scores was explored (Table V) (3). The score for the 25% soy/75% peanut blend was significantly better than that of the hydrogenated soybean oil and very nearly equal to that of peanut oil in a direct comparison test. Subsequent evaluations using such blends for frying potatoes showed that the 25 soy/peanut blend scored significantly lower than peanut oil only in the fifth fry in a series of six consecutive frys. A 50 soy/peanut blend was scored significantly lower during the third fry.

CURRENT ROOM ODOR FACILITIES

The production of a more stable soybean oil for use as a cooking oil remains a research objective important to both domestic and foreign markets. Due to space requirements at the Northern Center, the room odor facilities described above are no longer available. However, drawing on the experience acquired during the research reviewed here, new facilities for room odor evaluation have been constructed (Fig. 6). Two 5 ft x 8 ft x 10 ft odor rooms are available, each with two small entry chambers to avoid premature exposure to odors. The chambers are at a positive pressure relative to the odor rooms, with all air exhausted at floor level. Odors are generated in all-glass fry pans located in hoods exterior to the rooms. Odors are pumpted into the rooms for evaluation by the judges (Fig. 7). These new facilities must be tested, and procedures must be standardized before oil can be evaluated.

INTENSIOMETRIC EVALUATIONS

Concurrently with the research to evaluate oils by room odor tests, we have pursued intensiometric evaluations of odor volatiles using gas chromatography-mass spectrometry (GC-MS) combined with olfactory description of the eluted compounds (10). This technique utilizes a microroom (Fig. 8), which has roughly one-millionth the volume of a home kitchen, to generate heated oil odors and deliver them directly to a GC column. High purity dry air continually swept odors generated from 1-5 ml of oil heated at 193 C in the microroom onto the GC column held at -60 C. Effluent from the column was split three ways: to the FID, the mass spectrometer, and the atmosphere for olfactory sensing. Thus, an instrumental identification of the volatile compounds was combined with a sensory evaluation of their odor. At the exit port of the GC, a judge sniffed the effluent. When an odor was detected, its intensity was indicated on an auxiliary chart recorder using a voltagle dividing resistor taped with a 10-position switch, which controlled the recorder pen's deflection. The number of positions the switch was turned was an indication of the intensity of odor detected. The description of the odor was written on the chart paper and, since both the main GC and auxiliary recorders had the same chart speed, correlation of odor descriptions and GC peaks was easily accomplished. A typical odor intensigram with its GC curve is presented in Figure 9, for odor volatiles generated from 1 ml of soybean oil. Correspondingly numbered odor intensity and GC peaks are shown, and a comparison indicates that olfactory and FID responses differ for the same compounds. This technique has likewise been applied to the characterization of odors generated by heating tristearin (11), triolein (12), and trilinolein (13).

Nondegradative intensiometric analysis of volatiles from fats and oils is the subject of current developmental research using high performance liquid chromatography techniques.

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