Organoleptic and Oxidative Stability of Blends of Soybean and Peanut Oils[1]

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ABSTRACT

A table oil or a salad and cooking oil must serve both as an oil for salad dressings and for cooking potatoes in a deep-fat fryer. Blends of peanut and unhydrogenated soybean oil that have been treated with a metal inactivating agent such as citric acid were scored fairly high by a research taste panel after aging for 4 or 8 days at 60 C. Heating the samples to frying temperature resulted in significantly higher room odor scores for peanut oil than for the blends. Blends of hydrogenated or hydrogenated-winterized soybean oil with peanut oil were generally scored about equal to peanut oil in room odor tests. Potatoes fried in these oils were generally given comparable and not significantly different scores.

INTRODUCTION

During the past 10 years annual exports of soybeans to Europe have increased some 138 million bu. The amount is equivalent to about 1.52 billion lb. of soybean oil. France has taken only a comparatively small amount of the increase--2 million bu, or 1.3%. Table I reports the U.S. exports to Western Europe and two of the individual countries (1,2). There are, of course, a variety of reasons for differences in soybean imports from the U.S. among the European countries. Some of these countries, like the Netherlands, use large amounts of fats and oils in margarine. Others like France use comparatively large amounts of oils in the salad and cooking category and import large quantities of other oilseeds, such as peanuts.

We were asked by the American Soybean Institute and the Foreign Agricultural Service to compare various available types of processed soybean oils and the quality of their mixtures with peanut oil. Soybean oil has been used for years in salad dressings in the U.S. with general acceptance. In 1970 over a billion pounds of soybean oil were used for salad dressings, or about 5 lb. per person (3). Such acceptance for cooking, particularly as an oil for deep fat frying in the home, has not been achieved (4-6). Since the French were reported to use much of their oil for frying, this use was believed to be a critical one. After consultation with members of Market Development, American Soybean Association, the Fats and Oils Branch of Foreign Agricultural Service and representatives of French industry, we undertook studies specifically on the use of blends of soybean and peanut oils for frying potatoes in the home.

This choice was based in part on comparatively high per capita consumption of salad and cooking oils in France as compared to the other Northern European countries such as the Netherlands (1,2). Data are given in Table II. Also, the French in contrast to the Dutch use relatively small amounts of margarine (plus shortening). Our choice was also guided by previous reports on room odor associated with soybean and partially hydrogenated-winterized soybean oil heated in a frying pan (4,5). Some European processors have reported undesirable room odors associated with these oils. We have shown in a recently published report that specially processed soybean oils containing little or no linolenate gave higher scores in aging tests than soybean oils with linolenate contents of 2.0-7.8. Room odor scores and descriptions were included in this report (4). Consequently blends of soybean and peanut oil appeared to be worth investigating since such blends could lower linolenate significantly.

The French laws provide other reasons for testing blends, particularly when peanut oil is high-priced and soybean oil is low-priced. A table oil containing less than 5% linolenate may be labeled a superior oil. Thus mixtures of a soybean oil containing 6-9% linolenate with peanut oil could easily achieve the labeling requirement for table oil, superior grade. In addition if the oil is sold in packages of 5 kg or more, laws permit the inclusion of certain antioxidants up to 0.01% (Frank A. Padovano, Acting Agricultural Attache, American Embassy, Paris, France). Oil sold in small packages may not have additives that have been approved for the larger packages. Consequently the legal restrictions for a cooking oil are considerably different in France than in the United States and this gave us additional reasons for making a study of the blends.

MATERIALS AND METHODS

Representative samples of soybean and peanut oils were obtained. These samples included unhydrogenated soybean salad oil (A), partially hydrogenated but not winterized soybean oil (B), partially hydrogenated-winterized soybean oil (C) and peanut oil (D,E). One sample (D) was obtained from France. The fatty acid analysis of these oils is given in Table III.

Fatty acid analysis was carried out by gas liquid chromatography (GLC) procedures using a flame ionization detector under isothermal conditions at 190 C. A packed 5 ft x 0.25 in. column containing 20% diethylene glycol succinate on 60/80 Chromosorb was used. Although the same identical samples were not used in every test reported herein for the blends, the analytical data for the other soybean and peanut oil samples were not much different.

Oil samples were prepared for evaluation by mixing peanut oils with the proper amount of soybean oil and deodorizing all samples in a laboratory deodorizer with 0.01% citric acid added in the cooling stage (7). The samples were aged and taste panel evaluation was made by procedures previously described (8). Room odor tests were carried out by procedures recently reported on copper-hydrogenated soybean and other oils (4,5). In the present paper additional room odor evaluations were carried out in a similar manner, but potatoes were fried in the oil to simulate actual operation in a kitchen. Potatoes were cut

TABLE I

U.S. Exports of Soybeans to Western Europe, Millions of Bushels

Beginning October	Western Europe	France	Spain
1960	77	3.0	---
1963	93	3.8	1.6
1966	150	2.2	27.0
1968	151	0.3	31.0
1969	215	5.0	36.0

[1]Presented at AOCS Meeting, Houston, May 1971.

[2]Northern Marketing and Nutrition Research Division, ARS, USDA.

TABLE II

Total and Per Capita Consumption of Salad and Cooking Oils, 1000 Metric Tons, Kilograms per Person

Year	Netherlands		France		United States
	Total	Per capita, lb.	Total	Per capita, lb.	Per capita, lb.
1960-1961	23	2.0 (4.4)	362	7.5 (16.5)	4.2 (9.2)
1963-1964	28	2.3 (5.1)	422	8.4 (18.5)	5.4 (11.9)
1966-1967	37	3.0 (6.6)	467	9.0 (19.8)	5.7 (12.6)
1967-1968	38	3.0 (6.6)	490	9.4 (20.7)	6.1 (13.5)

TABLE III

Fatty Acid Analysis of Representative Soybean and Peanut Oils[a]

	Soybean oil			Peanut oil	
	A	B	C	D	E
Palmitic	9	11	10	10	10
Stearic	5	5	4	4	3
Oleic	24	45	45	61	49
Linoleic	54	37	38	20	32
Linolenic	8	3	3	1	2
C_{20}				2	2
C_{22}				2	3

[a]Soybean oils: unhydrogenated, A; partially hydrogenated, B; and partially hydrogenated-winterized, C. Peanut oils: French, D, and American, E, samples.

TABLE IV

Comparison of Unhydrogenated Soybean Oil With Peanut Oil

Condition	Peanut	Soybean	Sig.[a]
Initial flavor score	7.3 (0.0)[b]	7.2 (0.0)	+
Score, 60 C at 4 days	6.6 (1.8)	5.4 (1.5)	**
Score, room odor test	6.6	4.1	**
Hot oil, OIV[c]	1.1	0.8	
Fishy, OIV	0.0	2.2	
Peroxide value, 8 hr, AOM	1.7	4.7	

[a]Significance: +, none at 5% level; *, significant at 5% level; **, significant at 1% level.

[b]Value in parentheses is peroxide value at tasting.

[c]Odor intensity value =

$$\frac{\text{(Weak responses + 2X medium responses + 3X strong responses)}}{\text{Number of tasters}}$$

for the preparation of French fries and were fried in small amounts during a 30 min period when the taste panel was held. Taste panel members were furnished a score sheet that directed them first to one room and then to another for scoring room odor and flavor of fried potatoes. Taster and samples were randomized to avoid any bias caused from testing the samples in the same order by each panel member.

RESULTS AND DISCUSSION

In order to orient our work we undertook direct comparisons of peanut and soybean oils. In trade and consumer tests (6) peanut oil is generally considered a high quality oil. Like all vegetable oils it is subject to autoxidation and its apparent initial quality as found in samples obtained from grocery shelves may not be nearly equal to the quality achieved in the plant at time of manufacture. For example one sample as received had an initial flavor score of 4.5 with a peroxide value of 2.7. After deodorization in the laboratory this oil performed in a fairly satisfactory manner, i.e., it received an initial flavor score of 7.3 and had peroxide value of about 2 after 8 hr in the AOM test. Data in Table IV gave a direct comparison of representative peanut and unhydrogenated soybean oils.

The results of this test suggested that the differences in responses between soybean and peanut oils might make it easy for a trained taste panel to recognize blends of soybean and peanut oil. The taste panel did find significant differences in flavor scores of samples aged at 60 C for 4 days and in the room odor tests. However we believed that we should undertake some direct comparison of blends of unhydrogenated soybean and peanut oil.

Samples of soybean, peanut, and blends of 25% soybean (25-soy) and 60% soybean (60-soy) and peanut oil were prepared by mixing and deodorizing with citric acid added

TABLE V

Taste Panel Evaluation of Blends of Peanut and Unhydrogenated Soybean Oil[a]

Treatment	Peanut[b]	25-Soy	60-Soy	Soybean
Score, aged 4 days, 60 C	6.6 (1.8)	5.9 (1.2)	6.3 (1.2)	5.4 (1.5)
Score, aged 8 days, 60 C	6.0 (9.4) +	6.0 (9.4) +	5.3 (10.3)	4.6 (7.1)
Score, heat test, 170 C	5.3 (3.3) +	4.7 (3.1)	3.8 (2.9) +	3.2 (2.1)
	5.4 (3.7)			3.2 (2.0)
Flavor responses, FIV				
Rancid	0.8	0.9	0.9	0.9
Painty		0.6	0.6	0.8
Grassy		0.5	0.3	0.6

[a]For key, see Table IV.

[b]French origin.

TABLE VI

Comparison of Blends of Unhydrogenated Soybean and Peanut Oils in Room Odor Test

Treatment	Peanut	25-Soy	60-Soy	Soybean	Sig.[a]
Room odor scores	6.5	4.9			**
	6.6		4.2		**
	6.3			3.8	**
		5.7	5.1		+
		5.9		4.1	**
			5.8	4.9	*
Room odor responses, OIV[a]					
Hot oil	1.0	0.7	0.7	0.6	
Fishy	0.1	0.7	1.0	1.5	

[a]Sig. and OIV, see Table IV.

during the cooling stage. Initial flavor scores were 7.2 and 7.3; initial flavor intensity values (FIV—see Tables IV and V) were predominantly buttery at 0.6-0.8 and the peroxide values in the AOM test after 8 hr were 4.6-5.3. Thus the initial quality of these oils may be considered to be good and about equal. The oils were aged for 4 and 8 days at 60 C, or heated to 170 C and cooled to 55 C before tasting. Results of the aging and heat tests at 60 C are given in Table V. The 25-soy blend performed almost equal to the peanut oil in these tests.

Although the 25-soy blend of unhydrogenated soybean and peanut oil had scored higher than 60-soy blend and soybean samples, the pattern of flavor responses for 25-soy from sample heated at 170 C was similar to 60-soy and the all-soybean samples. Room odor tests confirmed that at least some samples of 25-soy blend of good quality unhydrogenated soybean oil could impart odors not associated with peanut oil. These odors cause our taste panel to give the 25-soy, as well as 60-soy, significantly lower scores than peanut oil. Data are reported in Table VI. Consequently we undertook studies with blends of hydrogenated and hydrogenated-winterized soybean oil.

Blends of Peanut with Hydrogenated Soybean Oil

A direct comparison between peanut oil and hydrogenated soybean oil showed us that partially hydrogenated or

TABLE VII

Comparisons of Blends of Peanut and Hydrogenated Soybean Oil[a]

Treatment	Peanut	25-Soy	60-Soy	Soybean	Sig.
Initial flavor score	7.8 (0.0)	8.2 (0.0)	8.4 (0.0)	8.4 (0.0)	+
Score (60 C—4 days)	7.5 (0.9)	7.4 (0.9)	7.4 (0.7)	7.0 (0.8)	+
Score (60 C—8 days)	6.9 (6.0)			5.4 (2.7)	**
	7.1 (6.5)		6.0 (4.9)		**
	6.7 (5.5)	6.7 (5.5)			+
Room odor scores	5.4	5.1			+
	6.6	5.9			*
	5.4		4.7		+
	4.9			4.8	+
	6.5			5.3	*
		5.7	5.4		+
		6.5		5.7	**
		7.1		5.6	**
			5.6	5.5	+
Room odor response, OIV[a]					
Rancid	0.6	0.4	0.6	0.6	
Hot oil	0.7	0.3	0.7	0.6	

[a]For key, see Table IV.

TABLE VIII

Room Odor Scores in Frying Tests with Blends of Peanut Oil With Hydrogenated and Hydrogenated-winterized Soybean Oil

Soybean oil	Fry number	Peanut	25-Soy	Sig.[a]
Hydrogenated	1	5.5	5.6	+
	2 1st test	6.8	6.7	+
	5 1st test	7.1	6.2	*
	6 1st test	6.5	6.1	+
	Range, lst test	5.5-7.5	5.6-6.7	
	Range, 2nd test	6.0-7.1	5.8-6.9	
	6th Fry, 2nd test	6.6	5.8	**
Hydrogenated-winterized	1	6.0	6.3	+
	2	5.9	5.9	+
	5	6.6	5.3	**
	6	6.4	5.8	+
	Range	5.9-6.6	5.3-6.3	

[a]For key, see Table IV.

TABLE IX

Room Odor Responses in Frying Tests With Blends of Peanut Oil With Hydrogenated and Hydrogenated-winterized Soybean Oils

Soybean oil	Responses	Peanut	25-Soy
Hydrogenated soybean oil	Hot oil	0.5	0.4
	Rancid	0.3	0.5
Hydrogenated-winterized soybean oil	Hot oil	0.4	0.2
	Rancid	0.4	0.4

possibly partially hydrogenated-winterized soybean oil might prove more useful in blends than unhydrogenated oil. The flavor scores initially and after aging 4 days at 60 C for peanut and hydrogenated soybean oils were not significantly different, but significant differences were found after aging 8 days at 60 C. Some significant differences were found in room odor scores and differences were obtained in the odor intensity value (OIV) tests, with fishy and rancid responses being higher for the hydrogenated soybean oil. We undertook room odor studies on blends of peanut and hydrogenated soybean and later with hydrogenated-winterized soybean oil. Only a few significant differences were found among the blends and soybean oil; the peanut oil generally was scored higher than the blends but not significantly so. Room odor scores for 25-soy blend with peanut oil were very nearly equal to the score given to peanut oil. Representative data are given in Table VII.

Since "proof of the pudding" is usually in the eating, we attempted the evaluation of these blends for frying potatoes. In this evaluation we had our taste panel score room odor as well as the flavor of the fried potatoes. Tests were run with blends of both hydrogenated and hydrogenated-winterized soybean oil with peanut oil. The comparisons were made by running daily tests for 6 days, in which two oils were compared against one another. In the first test, 25-soy was compared with peanut oil and the results on room odor test are given in Table VIII. A significant difference in room odor scores was found in the fifth fry in the first series of six fries and in the sixth fry in the second series. In a third series with hydrogenated-winterized soybean oil, a significant difference was again found in the fifth fry. The peanut oil usually was scored higher in these room odor tests but not in every test. Odor responses obtained with these frying tests are given in Table IX. The soybean samples appear to give more rancid than hot oil responses. Fishy responses are very small with values reported generally less than 0.1 but they may be a factor in the slightly higher scores given for peanut oil.

The potatoes from frying operations with 25-soy blend (hydrogenated) and peanut oils were scored from 7.0 to 7.8 and 6.8 to 8.0, respectively, with no significant differences. With 25-soy blend (hydrogenated-winterized) and peanut oil the flavor scores for the potatoes ranged from 6.3 to 7.1 for the blend and 5.9 to 7.2 for peanut oil. In the first fry only, the potatoes from the 25-soy blend were scored significantly higher.

With 50-soy (hydrogenated) blends greater differences were found in room odor scores. Significantly higher scores were reported for peanut oil on the fourth and fifth fry in one test and on the third fry in the second test. Potatoes were evaluated in only one series of six fries and no significant differences were found. The potatoes from the 50-soy blend were scored 6.7-7.8 whereas the potatoes from the peanut oil were scored 6.9-7.6. In room odor tests with 50-soy (hydrogenated-winterized), peanut oil was scored significantly higher in the third through sixth fry. Potatoes from the same fryings were scored from 5.8 to 7.5 for the 50-soy and 5.6 to 7.5 for peanut oil. Significant differences were found in these tests: Potatoes fried in 50-soy were rated higher in second fry and potatoes fried in peanut higher in the first and fifth fries.

TABLE X

Effect of Additives on Oil Quality, Hydrogenated Soybean Oil

Test	With additives[a]	Without additives	Sig.[b]
Initial flavor score	7.7 (0.0)	8.0 (0.0)	+
Room odor test	7.4	5.7	**
OIV			
Heated oil	0.65	0.55	
Rancid	0.2	0.6	
Fishy	---	0.25	

[a]Tenox 6 at 0.1% and methyl silicone (Antifoam A) at 5 ppm.
[b]For key, see Table IV.

Blends of 25 and 50% hydrogenated soybean with peanut oil were cooled in a refrigerator at 15 C (59 F) to determine how they might perform at such temperatures. The 25-soy blend remained clear for 30 hr and a few crystals formed at the bottom after 46 hr but did not increase much after 214 hr. The 50-soy blend developed a thin layer of crystals on the bottom of the storage bottle at 22 hr and had a slight precipitate after 214 hr. Peanut oil remained clear. A test with a second peanut oil showed a slight cloudiness that slowly settled to the bottom. Apparently at the level of hydrogenated soybean oil used in these experiments, a very small amount of cloudiness would appear in the blends before it would appear in peanut oil. The earlier appearance of this cloudiness could be avoided by use of hydrogenated-winterized soybean oil if it were deemed necessary.

Our findings with a research taste panel suggest that companies who wish to replace peanut oil in part with soybean oil in their marketing of a table oil should proceed carefully. For use as a salad oil only, both reported and unreported data show that our taste panel generally scored peanut oil higher than soybean oil or the mixtures. The score for peanut oil was not significantly higher after 4 days at 60 C but the differences in the scores became more significant after 8 days at 60 C. These differences would probably not be any major obstacle in the marketing of soybean oil. Differences in odors produced when the oils are repeatedly heated to frying temperatures need to be considered as important. Without stabilizers such as antifoam agents and antioxidants, the blend of 50% hydrogenated-winterized soybean with peanut oil was scored significantly lower in room odor after the second fry. Consumer tests with blends containing 25 and 50% hydrogenated-winterized soybean oil with and without stabilizers might be desirable. Changes in food laws do occur and the French could improve the stability of their soybean oil blends by inclusion of additives. Although we have not made a study of the effect of stabilizers on the blends of peanut and soybean oils, these stabilizers do help improve room odor scores for soybean oil. In a test with a hydrogenated soybean oil a significant improvement in room odor was achieved as shown in Table X. There was a substantial reduction in rancid and fishy responses. Tenox 6 and methyl silicone (Antifoam A) at about 0.1% and 5 ppm, respectively, were used as additives.

Hydrogenated-unwinterized soybean oil in a 25% mixture should also be considered. Its cloud point may be too high to receive favorable consideration but this blend gave room odor scores in frying tests that were generally not significantly below peanut oil.

ACKNOWLEDGMENTS

C. Randolph, American Soybean Institute, H. Akers, Foreign Agriculture Service, and B. Lesieur, Lesieur-Cotelle, provided information and advice concerning French laws and French use of salad and cooking oils.

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[Received June 14, 1971]