A Technique for Testing the Reversion Properties of Hydrogenated Soybean Oil Shortenings

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PREVIOUS efforts to measure the heat reversion characteristics of hydrogenated soybean oil in our laboratory have been handicapped by the lack of a convenient and specific organoleptic test which would yield reliable and reproducible evaluations. In order to remedy this situation the work outlined in this paper was carried out.

The psychological aspects of a measurement problem such as this which employs human subjects must not be overlooked. Personal bias may play a greater role than some investigators suspect, and consequently it is important that the test be carefully designed and conducted and the data cautiously interpreted if misleading conclusions are to be avoided. In our opinion, panel tests attacking this problem have lacked specificity and the more carefully conducted ones have been restricted by the necessity for making a single comparison at a time. At the Northern Regional Laboratories (1) where this problem has received close attention, the panel members were able to develop a memory scale against which pairs of samples were scored. We felt that in our laboratories such a program would be difficult to carry out in a manner which would assure the desired degree of objectivity.

For example, in a rather closely knit group the observers are apt to be directly involved in or, at least, conversant with the research or control problems under investigation so that personal bias is likely to play a significant role in the panel vote. Schools of thought are built up and positions have often been taken which are likely to influence the individual decisions. Some investigators have indicated that people closely connected with research programs supplying the test samples are not suitable as panel members for testing the results of their work, but it is often difficult to avoid this situation entirely.

It was thus considered desirable to set up the panel test in such a way that the effect of personal bias was minimized and also to provide a more specific determination for soybean oil reversion. The panel evaluation technique was employed to test the heat reversion characteristics of soybean oil which had been hydrogenated to a shortening consistency, and all unqualified reference to "reversion" in this paper is considered to refer to it as it is reflected in such fat. The general approach, however, is considered to be suitable for any similar organoleptic measurement problem.

From a practical point of view most soybean oil reversion difficulties encountered in the shortening industry have been associated with fat which had been used for frying and was thus exposed to high temperatures for appreciable time intervals during its use. Our investigation revealed that at 140°C. the type of sample we were accustomed to deal with could be satisfactorily reverted in four hours. Under these conditions samples could be treated and evaluated in the same day although it was found practical to store them overnight in a refrigerator for testing on the following day if necessary.

The reverted samples were maintained at 80°C. in a water bath for observation. In order to avoid deterioration due to ultraviolet light, they were protected by Pyrex, low actinic beakers, and covers. When a number of samples were being reverted simultaneously, it was found desirable to avoid interabsorption of odors so that best results were obtained when the individual samples were sufficiently isolated from one another to avoid this source of error.

Careful observation led us to believe that the reversion factor was largely of an aromatic nature and thus would be most effectively tested through the use of the olfactory sense rather than by tasting. Oral observations obtained by tasting are significantly influenced by the olfactory reactions because aromatic components reach that nerve from the mouth as well as through the nose; but significantly lower concentrations of an aromatic agent can be inhaled through the nose than will usually reach the nerve from material in the mouth, and furthermore better control can be exercised on the amount taken in this way. The olfactory nerve and the taste buds rapidly lose their sensitivity and discriminating ability with respect to a specific odor or flavor, especially when subjected to high concentrations or prolonged exposure to it; but, by carefully smelling the samples, loss of sensitivity is usually avoided during the test. If it does occur, a few breaths of fresh air will generally serve to restore it.

Tasting has the advantage of supplying high concentrations of an aroma to the olfactory nerve so that less acute individuals often considered it necessary to taste the samples. Their discriminating powers were generally lost before the usual series of samples was evaluated so that these observers were not capable of rendering reliable decisions. We found that practically all of our effective observers could arrange controls of known concentration in the proper order by smelling alone, and rarely did tasting help any.

On this basis it seemed most appropriate to select the panel for the work by testing their sense of smell. It also seemed quite logical to test the smelling ability of our panel members directly with the type of material to be tested—namely, reverted soybean oil. Accordingly, a series of blends was made from randomly selected samples of hydrogenated soybean oil and cottonseed oil (70-75 I.V.). Five samples ranging from all-soybean oil to all-cottonseed oil in 25% steps were prepared and reverted as described. Prospective panel members, who had first been made acquainted with the reverted soybean odor, were asked to rate the samples in order of increasing reversion odor concentration.

Past experience appeared of little value in this work as some individuals who had been grading oil

for many years were frequently unable to arrange the controls in the correct order. Six observers were found who could consistently place these specimens in the proper order. Their subsequent performance in routine tests is demonstrated in the following table showing the number of tests participated in and the proportion of correct decisions:

ROUTINE PERFORMANCE OF TESTED OBSERVERS

Tester	Total No. of Tests	% of Time Correct
1	19	89.5
2	47	76.7
3	70	95.7
4	72	83.4
5	78	93.5
6	38	81.5

Previous experience with similar tests led us to believe that the use of a suitable control in each test, against which any sample in question may be compared, was highly desirable. Such practice lent continuity to the results because all samples were scored against the same control. It was found desirable to replenish our controls periodically, but each new one was compared with the previous one before it was adopted for use.

Some samples did not develop the usual reversion odor and thus could not be legitimately compared with our regular controls. Reconstituted fats and those containing monoglyceride emulsifiers or other addition agents developed such different odors at times that when attempts were made to rate them against our regular controls, no agreement could be obtained among panel members. It was necessary to prepare reconstituted or otherwise comparable controls to test such samples in accordance with our plan. In measurements of this kind it appears important to have a suitable control or scale of controls and to ascertain whether a sample to be tested is comparable; otherwise the score may not be reflecting the true quality of the test sample.

In contemplating our problem it was anticipated that the samples to be evaluated might vary somewhat in reversion intensity and comparisons with a single control would be relatively insensitive so that it was considered desirable to have a scale of controls to compare each sample against. A problem similar to this one in principle was conveniently solved by Dr. Dove (2) in testing the eating quality of many varieties of sweet corn. For our purpose the five controls used to test the odor sensitivity of the panel were found to be eminently suitable.

A set consisting of these five controls and a test sample were reverted and all six specimens were submitted to the panel for a rating. Panel members were simply requested to rate the samples in order of increasing concentration of the reversion odor. To insure objectivity the controls and the sample in question were submitted under code with no *a priori* knowledge about the unknown sample. The reliability of the panel members was conveniently re-established in each test because the probability that all five controls could be placed in the correct order by pure chance is relatively small.

When an observer misplaced the controls, his vote was discarded. In routine practice a single misplacement between adjacent controls was permitted, but where other odors were present a more liberal allowance was necessary. Most of the difficulty normally occurred at the low end of the soybean oil scale with the all-cottonseed and 25% soybean oil controls; but when masking odors were present it was often extremely difficult to detect any real difference between the all-cottonseed oil, 25% soybean oil, and 50% soybean oil controls. This had the effect of limiting the more precise evaluation to those samples of this type which smelled stronger than the 50% soybean oil control. All others necessarily were classed as below the 50% soybean oil control with respect to reversion odor, but no further resolution was possible. Fortunately the subsequent statistical analysis of the data corrects for the variability resulting from the use of improperly rated controls in the sense that unjustified conclusions are avoided.

Panel Record

RATING SUMMARY

Observer		Rating					
		1	2	3	4	5	6
1	VAM	E	F	A	B	D	C
2	WGT	E	F	B	D	A	C
3	WCP	E	A	F	B	D	C
4	SWT	E	F	A	B	D	C
5	FVC	F	A	B	E	C	D
6	EH	E	F	A	B	D	C

SAMPLE CODES

A = 50% SBO
B = 75% SBO
C = SBO
D = WT 180
E = CSO
F = 25% SBO

SCORE CHART

Code	1.27	0.64	0.20	−0.20	−0.64	−1.27	Score
A		1	3		1		.60
B			1	4			− .60
C						5	−6.35
D				1	4		−2.76
E	5						6.35
F		4	1				2.76

ANALYSIS OF VARIANCE

	D.F.	Sum of Squares	Variance	"F"
Samples	5	19.320	3.864	59.17
Error	20	1.305	.0653	
Total	25	20.625		

Sum of Squares for 1 Observer: 6 Classes = 4.1250.

Total Sum of Squares = Sum of Squares for 1 Observer × the total number of observers.

Calculations = 4.125 × 5 = 20.625

$(.60)^2 = .3600$	20.625
$(-.60)^2 = .3600$	19.320
$(-6.35)^2 = 40.3225$	
$(-2.76)^2 = 7.6176$	1.305
$(6.35)^2 = 40.3225$	
$(2.76)^2 = 7.6176$	
$5\overline{)96.6002}$	
19.320	

Significant Difference $= t_{05}\sqrt{2\,Ns^2}$

Significant Difference $= 2.086\sqrt{\frac{.808}{10} \times .0653}$

$= 1.69$

Conclusions: WT 180 rated more beany than the 75% control, but less so than the 100%.

The next important problem concerns the most appropriate way in which to express the panel's composite opinion. The technique developed by Dr. C. I. Bliss (3) for testing consumer preference, with reference to constituents of ice cream, supplied us with a suitable method for treating our panel observations and also for testing the significance of any indicated score differences. The panel ratings obtained were normalized using factors which have been determined by Fisher and Yates (4). The normalizing procedure converts the panel ratings into scores which can be summed and the resulting sums may legitimately be subjected to an analysis of variance. The error variance obtained from the analysis of variance may be used to calculate the required score differences between individual samples in the series to establish significance at any desired probability level. A sample of the panel record sheet which was found useful for filing the data, calculations, and conclusions, is included to exemplify this phase of the work. A more comprehensive treatment of the whole subject may be obtained by studying Dr. Bliss' (2) report and the bibliography he lists. The following method is recommended for determining the reversion properties of shortening containing hydrogenated soybean oil:

Method

Select typical samples of cottonseed oil and soybean oil of appropriate hardness (70-75 I.V.) to serve as controls. Prepare 25%, 50%, and 75% blends of the soybean oil in the cottonseed oil. Weigh 100 grams of each control and the test sample into 400-c.c. Pyrex, low actinic, electrolytic-type beakers and cover if the samples are apt to be exposed to ultraviolet light. Heat the samples to 140°C. as rapidly as possible and maintain at that temperature ± 5°C. for four hours. Remove samples to a hot water bath and when at 80°C. they are ready for observation.

Request the panel members to rate the samples in order of soybean oil reversion odor intensity. Each observer must conduct his examination independently; otherwise, the conclusions to be derived from the panel work may be in error.

It is desirable to cull out the insensitive observers from a small panel by first testing them. Tested observers are not essential to the legitimate use of the statistical technique employed to analyze the data, but if unreliable observers are used in a small panel, such as normally employed in this type of work, the error variance tends to become so great that significance cannot be established between any but the extreme control samples in a series.

The degree of reproducibility normally obtained in the test is demonstrated by the following table showing the scores obtained from four separate runs made upon the same unknown sample. It is quite clear that the reversion odor intensity of the unknown was indicated to be fairly close to that of the 75% control.

REPRODUCIBILITY OF THE PANEL TEST

Test	No. of Observers	Calculated Scores					
		CSO	25% SBO	50% SBO	75% SBO	SBO	Test Sample
1	4	5.08	2.56	.80	−1.24	−5.08	−2.12
2	4	5.08	2.56	.80	−2.31	−4.45	−1.68
3	4	5.08	2.56	.40	−1.24	−4.45	−2.35
4	4	5.08	2.12	1.24	−2.31	−4.01	−2.12

Test	Req. Score Diff.	Conclusion Rel. Reversion Strength
1	.835	75% Control < Unknown < SBO Control
2	1.77	50% Control < Unknown < SBO Control
3	2.00	50% Control < Unknown < SBO Control
4	2.24	50% Control < Unknown = SBO Control

Summary

A technique has been described which was found to yield specific and reproducible evaluations of the reversion properties of shortening samples containing hydrogenated soybean oil. It was shown to be advantageous to conduct the test by smelling rather than by tasting. The use of a control rendered the test specific and by expanding to a series of controls of varying concentrations, it was found possible to increase the discrimination of the test. The statistical method reported by Dr. Bliss (3) was used to analyze the data obtained.

REFERENCES

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