gastric motility and retards the evacuation of the food remaining in the stomach.

The experimental findings cited above suggest an explanation for the prolongation of gastric emptying time effected by addition of large quantities of digestible fats to glucose solutions and by the excess fats in "greasy" fried potatoes. Fats are easily separable from both of these meals on contact with gastric juice. Thus, large amounts of free fats may contact the gastric mucosa, or they may be delivered into the small intestines in quantities adequate to inhibit gastric secretory or motor functions.

On the other hand, fat taken in moderate amounts, particularly if it has been incorporated intimately into the food by the proper methods of cooking, may during gastric digestion be separated slowly from the food. Hence, amounts of free fat in the gastric contents or the quantities delivered into the small intestines during the early stages of digestion of these foods may be inadequate to influence gastric function either by direct contact with the stomach or by activation of enterogastrone.

### Summary

1. In eight series of triplicate tests on persons in good health and with normal secretory responses who were fed test meals of foods cooked with fat, the day to day variations in gastric evacuation times ranged from 0 to 30 minutes with an average deviation from the mean of $\pm 17$ minutes.

2. Experiments with meals of foods in which moderate quantities of fats were incorporated intimately by either baking or frying according to good culinary procedure revealed no relationship between the fat contents of the foods and the times required for complete evacuation of the foods from the subjects' stomachs.

3. The experiments indicated a parallelism between the protein contents of the test meals and the gastric evacuation times.

4. No significant differences were observed between the influences of a hydrogenated vegetable fat and of butter upon the rates of evacuation from the subjects' stomachs of meals of potatoes in which these fats had been incorporated intimately by good culinary technic. Within the limits of error of the experimental procedure, French fried and Lyonnaise potatoes containing moderate amounts of fat were evacuated from the stomachs as rapidly as boiled potatoes.

5. Gastric emptying times for meals of doughnuts did not differ significantly from gastric evacuation times for meals of bread and butter supplying equivalent amounts of fat.

6. The addition to a test meal of glucose in water of either hydrogenated vegetable fat or butter fat in amounts equivalent to two-thirds the weight of the glucose retarded the evacuation of the glucose meal from the stomach.

7. Excess fat, added to potatoes by pan-frying in hydrogenated vegetable fat or butter to the extent of making the potatoes "greasy," such as may occur in poor culinary practice, prolonged the emptying time of the stomach beyond the period for boiled potatoes.

8. An explanation has been suggested for this retardation of the emptying of the stomach effected both by digestible fats added to glucose solutions and by foods containing fats in excess of that which is incorporated intimately in these foods by good culinary methods.

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# Stability Test End-Points by Refractive Index

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RECENT runs on the Swift Stability Tester (1) in this laboratory have indicated that highly satisfactory end-points can be established by butyro or refractive index measurements. Thus far the work has been limited to soybean oil (hydrogenated and unhydrogenated), but the method is believed to be generally applicable to the Swift Test.

### Advantages

In a modification of King, Roschen, and Irwin's (1) original method Riemenschneider et al. (2) reduced the number of tubes for each stability test from 3 to 1 by using only 0.2 gms. of oil for each peroxide value (P.V.) determination. This increased the capacity of the standard Swift box from six to 18 determinations. This advantage is retained in the proposed method with the further advantage that sampling can be done in approximately 60 seconds. Rapid sampling results in a minimum of interference with equilibrium conditions in the individual sample and in the box as a whole.

Without sacrificing accuracy, the method proposed here substitutes the relatively simple reading of refractive indices on a Zeiss refractometer for P.V. determinations, thus eliminating the preparation of solutions, weighing, and titrating.

It is evident that a great many tests can be made on one sample without materially reducing its size, enabling more completely defined plots to be drawn.

### Procedure

The refractive index of the original oils and any other desired characteristics are measured and recorded immediately before the start of the test. Duplicate samples (when possible) of the oils to be tested are measured into the aeration test tubes (20 cc.) and

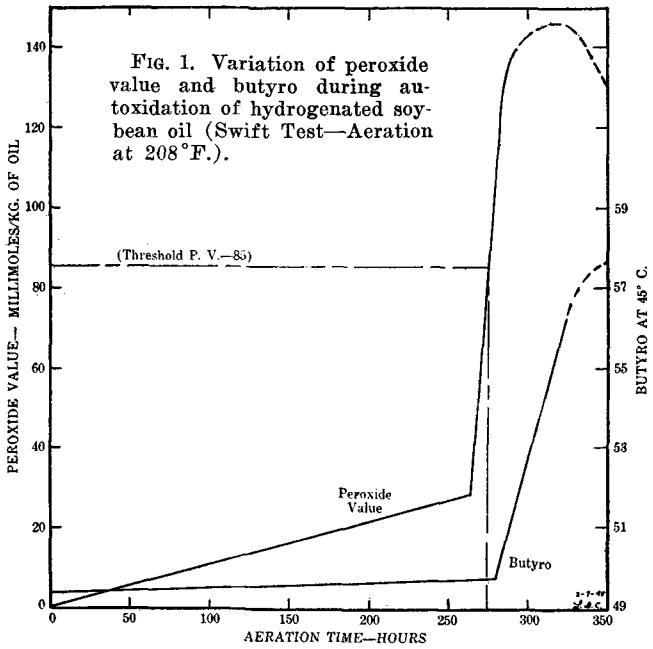


FIG. 1. Variation of peroxide value and butyro during autoxidation of hydrogenated soybean oil (Swift Test—Aeration at 208°F.).

preheated by inserting in boiling water for 15 minutes. They are then transferred to the Swift box which has been allowed ample time to reach equilibrium; aeration is started immediately. Sufficient refractive index measurements are made at arbitrary intervals (depending on the expected keeping qualities of the oils) to insure a satisfactory plot. (At least three before and three after the end-point, except when linear relationships are known to exist, as in the case of hydrogenated soybean oil.)

The readings are made as follows: At the specified time for a given sample the aeration train is broken between the capillary and the test tube; the sample is removed from the box, wrapped in a cloth, and taken to the refractometer; the aeration tube is removed and a few drops of oil transferred to the clean prism; the aeration tube is then reinserted, the sample returned to the box, and aeration resumed. The operation can be performed in just about 60 seconds. The refractive index thus obtained is recorded with the time of sampling. Finally the prism is cleaned in preparation for the next test. When sufficient readings have been taken (including two or more on the part of the curve representing rancidity of the sample), the test is discontinued and the keeping quality determined from the recorded values.

The end-point in the case of the hydrogenated oils is indicated by the sharp break in the plot of butyro vs. aeration time. This can also be determined analytically because of the near-linearity of the two parts of the curve. The end-point in the case of the salad oils is defined as the length of time in which an increase of exactly 1.00 unit over the original butyro has occurred. This is necessarily determined graphically.

TABLE I

Agreement between duplicate samples in which keeping qualities were determined by butyro, and between end-points determined graphically and analytically.

| Oil | Swift Keeping Quality (Hrs. @ 208°F.) | | | "GR" & "AN" Discrepancy | | Discrepancies Between Duplicates | |
|---|---|---|---|---|---|---|---|
| | Graphic Det. "GR" | Analytic Det. "AN" | Average of Duplicates | Hrs. | % (Based on "AN") | Hrs. | % (Based on Ave.) |
| Hydrogenated Oils | | | | | | | |
| 131—1A | 202.0 | 201.6 | 224.0 | 0.4 | 0.20 | 44.8 | 18.2* |
| 131—1B | 248.3 | 246.4 | | 1.9 | 0.77 | | |
| 131—2A | 259.3 | 259.0 | 260.2 | 0.3 | 0.12 | 2.3 | 0.9 |
| 131—2B | 261.1 | 261.3 | | 0.2 | 0.08 | | |
| 131—3A | 266.2 | 266.9 | 267.6 | 0.7 | 0.26 | 1.5 | 0.6 |
| 131—3B | 268.6 | 268.4 | | 0.2 | 0.08 | | |
| 131—4A | 265.7 | 266.7 | 265.0 | 1.0 | 0.38 | 3.5 | 1.4 |
| 131—4B | 262.4 | 263.2 | | 0.8 | 0.30 | | |
| 131—5A | 341.2 | 340.5 | 337.3 | 0.7 | 0.21 | 6.4 | 1.9 |
| 131—5B | 337.8 | 334.1 | | 3.7 | 1.10 | | |
| 131—6A | 487.2 | 487.8 | 473.8 | 0.6 | 0.12 | 28.1 | 5.9 |
| 131—6B | 459.0 | 459.7 | | 0.7 | 0.15 | | |
| 131—7A | ..... | 560.9 | 545.8 | .... | ..... | 30.2 | 5.5 |
| 131—7B | ..... | 530.7 | | .... | ..... | | |
| 131—8A | ..... | 581.5 | 586.2 | .... | ..... | 9.5 | 1.6 |
| 131—8B | ..... | 591.0 | | .... | ..... | | |
| Unhydrogenated Oils | | | | | | | |
| 133—1A | 10.6 | ..... | 10.5 | .... | ..... | 0.2 | 2.0 |
| 133—1B | 10.4 | ..... | | .... | ..... | | |
| 133—2A | 11.7 | ..... | 11.9 | .... | ..... | 0.4 | 3.4 |
| 133—2B | 12.1 | ..... | | .... | ..... | | |
| 133—3A | 12.2 | ..... | 12.2 | .... | ..... | 0.0 | 0.0 |
| 133—3B | 12.2 | ..... | | .... | ..... | | |
| 133—4A | 13.1 | ..... | 13.2 | .... | ..... | 0.3 | 2.3 |
| 133—4B | 13.4 | ..... | | .... | ..... | | |
| 133—5A | 20.1 | ..... | 20.4 | .... | ..... | 0.7 | 3.4 |
| 133—5B | 20.8 | ..... | | .... | ..... | | |
| 133—6A | 33.8 | ..... | 32.1 | .... | ..... | 3.4 | 10.6* |
| 133—6B | 30.4 | ..... | | .... | ..... | | |
| 133—7A | 37.3 | ..... | 37.9 | .... | ..... | 1.2 | 3.2 |
| 133—7B | 38.5 | ..... | | .... | ..... | | |

* These higher discrepancies are attributed to sample contamination, despite extreme caution exercised in cleaning apparatus. It is evident that these discrepancies would appear even though the end-points were determined by P. V.

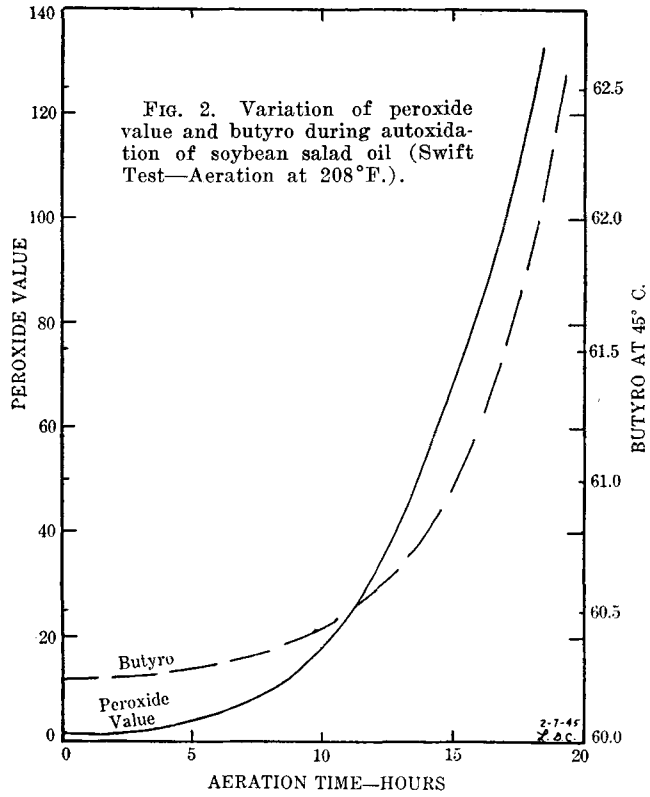


FIG. 2. Variation of peroxide value and butyro during autoxidation of soybean salad oil (Swift Test—Aeration at 208°F.).

## Hydrogenated Soybean Oil

A few extensive Swift tests were run on hydrogenated soybean oils in which several variables (color, FFA, butyro, I.V., T.V., sap. no., and sp. gr.) were measured progressively along with P.V. From these tests the possibility of using butyro as a means of determining the end-point or keeping quality, with its attendant advantages, was immediately apparent. In subsequent tests both butyro and P.V. were measured until the relationship was satisfactorily established, after which P.V. determinations were discontinued.

Figure 1 shows a typical plot of P.V. and butyro vs. aeration time for a hydrogenated soybean oil (I.V. approx. 75). From these curves it is readily apparent that the break in the butyro-time curve corresponds closely to the end-point established by the threshold P.V. of 85 milli-moles of peroxide oxygen per kilogram of oil (the approximate midpoint of the steep segment of the curve). To indicate further the validity of this method it has been observed in all tests to date that no samples exhibited a true rancid odor until after the butyro end-point was reached, after which it was invariably detected.

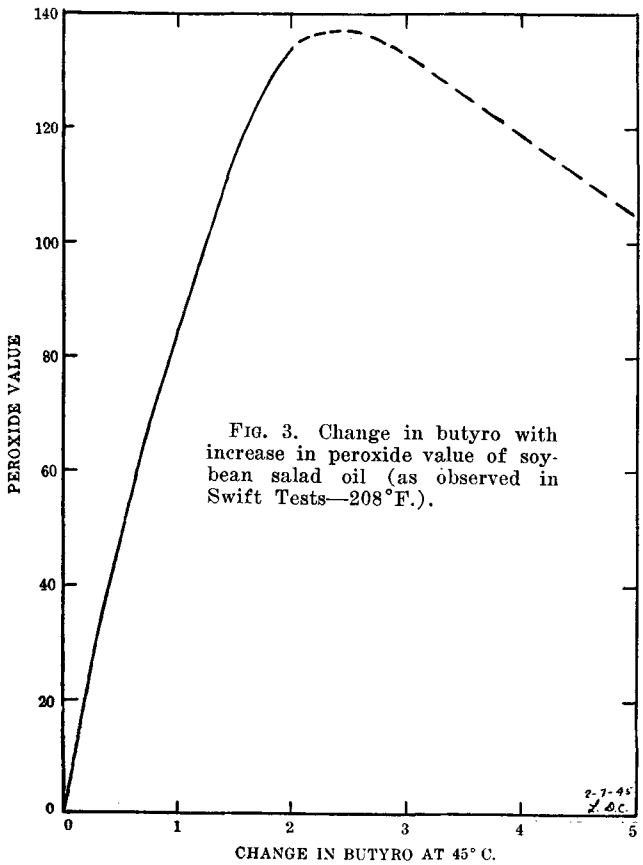


FIG. 3. Change in butyro with increase in peroxide value of soybean salad oil (as observed in Swift Tests—208°F.).

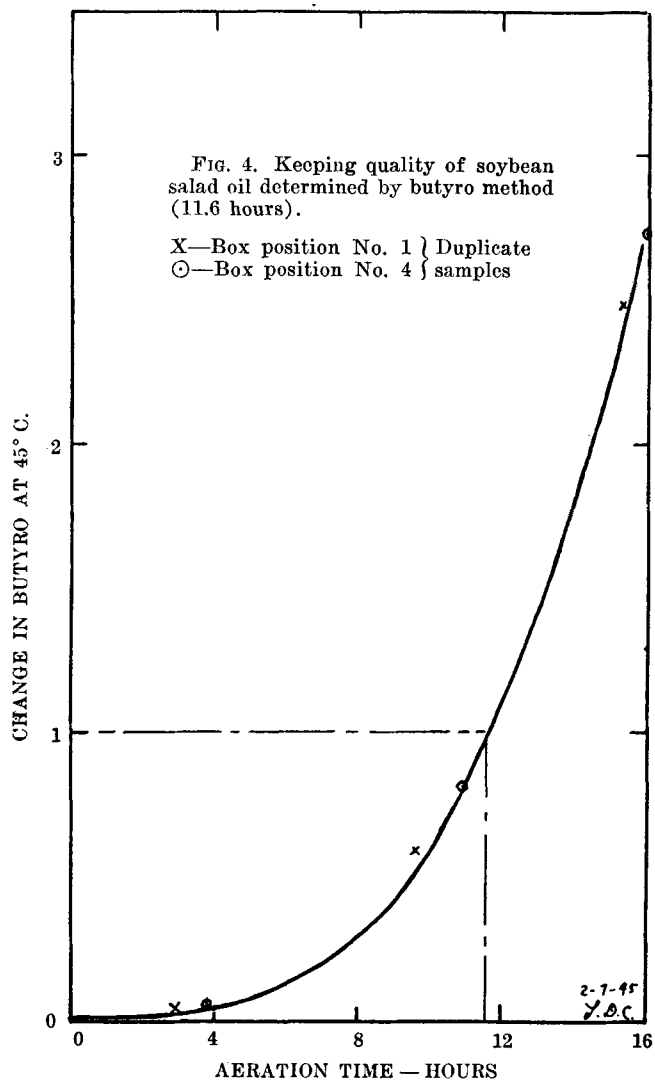


FIG. 4. Keeping quality of soybean salad oil determined by butyro method (11.6 hours).

X—Box position No. 1 } Duplicate
⊙—Box position No. 4 } samples

Since the institution of this method keeping qualities have been determined both graphically and analytically. Table I shows the agreement attainable by the two methods and the discrepancies observed between the keeping qualities of duplicate samples when using the method proposed. It is felt that the agreement between duplicates is at least as accurate as can be obtained by the P.V. method.

### Unhydrogenated Soybean Oil

Stability tests on soybean salad oil failed to give the sharp break in P.V.- and butyro-time curves shown (Figure 1) for hydrogenated oils. Rancid odor developed gradually with no readily detectable initial appearance. Figure 2 shows typical P.V. and butyro-time curves for a soybean salad oil.

To establish an arbitrary end-point all previous data on this type of oil was combined in a plot of P.V. vs. butyro change (Figure 3). It was found that a smooth curve was obtained up to the point where the P.V. hit a maximum at about 140 units. From this curve it was found that a butyro change of 1.00 unit corresponded to a P.V. of 85 (the threshold P.V. arbitrarily established for this type of oil in previous runs). Thus by plotting butyro change vs. time for any stability test, the end-point could be established at a butyro change of exactly 1.00 unit. Because of the non-linear nature of the curves determinations of keeping qualities had to be made graphically. Since all samples were run in duplicate, a series of readings from one end of the Swift box to the other gave alternate points for duplicate samples. These were plotted and a mean curve drawn through them to establish the end-point. Figure 4 is the curve for one set of duplicates, showing the type of graph obtained and the method of establishing the end-point.

### Accuracy

The degree of accuracy of the method is shown in Table I. From the examination of Figure 4 it is apparent that an error of 0.1 butyro unit (specified maximum for production control work in this laboratory) is equivalent to 0.35 hours, or about 3% of the keeping quality in the case of the particular oil shown. To attain this degree of accuracy, using a refractometer, the reading would have to be reproducible within 0.0001 of a unit. Actually, considerably greater accuracy than this is possible, especially on the easily read Zeiss butyrometer.

### Summary

A method is proposed for determining the end-points in the Swift Stability Test by refractive index, which increases the capacity of the Swift box to 18 individual tests and yields well defined curves. The simplicity and accuracy of the method are such as to make it a convenient tool in this test which is rapidly gaining acceptance as a standard. The method is particularly useful in extensive tests using one type of substrate throughout.

### Note

An apparent disadvantage of this test is that a correlation must be made between butyro and P.V. for each general type of oil to be tested, to establish a suitable end-point. However, since the test would be run by P.V. anyway, little time is required to measure the butyro of each sample and thus establish the relationship for the type of oil under consideration.

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# Spectrophotometric Estimation of Soybean Oil in Admixture With Cottonseed and Peanut Oils[1]

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IT is customary in southern cotton oil mills to process various oilseeds, including soybeans and peanuts, in the same equipment as is used for processing cottonseed. This practice necessarily provides numerous opportunities for one type of oil to become contaminated with another. In one such instance a tank car containing a mixture of cottonseed and soybean oil was shipped to a refiner and was used in the production of shortening without due allowance being made for the unsuspected presence of soybean oil in the original oil. There is always a possibility of accidental, and sometimes unavoidable, contamination from incomplete draining and cleaning the oil troughs, settling tanks, pipe lines, and other processing and handling equipment during conversion from one oilseed to another. Because of the possibility of accidental admixture of soybean with cottonseed and peanut oils and as a means for checking the composition of intentional blending of such oils, a method for estimating the percentage of soybean oil in such admixtures is desirable.

Cottonseed oil may be detected by the Halphen test and peanut oil by its content of higher saturated fatty acids. However, the composition of soybean oil is such that it does not permit its detection or estimation by distinctive color tests or by ordinary chemical methods, especially if it is present in only small proportions. The most distinctive characteristic of soybean oil is its content of linolenic acid which is present to the extent of about 7% in commercial lots. This acid has not been found in cottonseed or peanut oil.

The spectrophotometric measurement of the small but measurable ultraviolet absorption of the triene conjugation, produced by alkali isomerization of linolenic acid or soybean oil, appeared to be the most promising method for the determination of the presence of this oil in mixtures of cottonseed and peanut oils. Mitchell, Kraybill, and Zscheile (4) have described the use of such measurements to determine quantitatively the linolenic and linoleic acid content of various oils. The present authors have established a correlation between the spectrophotometrically measured optical densities of triene conjugation produced by alkali isomerization and the percentage composition of binary oil mixtures. This correlation

[1] Presented before The American Oil Chemists' Society, New Orleans, Louisiana, May 10-12, 1944.

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