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# THE EFFECT OF SOYBEAN OIL SHORTENING AND COTTONSEED OIL SHORTENING ON THE SHELF LIFE OF CRACKERS

ARMY NATICK LABORATORIES

AUGUST 1973

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# THE EFFECT OF SOYBEAN OIL SHORTENING AND COTTONSEED OIL SHORTENING ON THE SHELF LIFE OF CRACKERS

by

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## FOREWORD

Compliance with the current Federal Specification for round crackers requires the use of a high stability cottonseed and/or peanut oil as the shortening component. Increasing cost and unavailability of these vegetable oils led to the undertaking of this project to provide data on the feasibility of using soybean oil as a lower cost replacement.

This work was performed under project No. 728012.12, Production Engineering.

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## ABSTRACT

The effect of hydrogenated soybean oil and cottonseed oil on the rate of development of oxidation of canned ration crackers under prolonged storage at elevated temperatures was investigated. Chemical analyses indicated that the peroxide value and oxygen uptake in the crackers made with soybean oil increased at a higher rate than in those made with cottonseed oil. The profile panel results indicated that crackers prepared with both shortenings were stable for 24 months at 40°F. or 70°F. However, upon storage at 100°F. or 120°F., inappropriate notes (such as oxidized oil) were detected in soybean oil crackers at an earlier stage than in the cottonseed oil crackers. In addition, the intensity of these inappropriate notes increased at a higher rate in the soybean oil crackers as storage time progressed.

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The effect of hydrogenated soybean oil and cottonseed oil on the rate of development of oxidation of canned ration crackers under prolonged storage at elevated temperatures was investigated. Chemical analyses indicated that the peroxide value and oxygen uptake in the crackers made with soybean oil increased at a higher rate than in those made with cottonseed oil. The profile panel results indicated that crackers prepared with both shortenings were stable for 24 months at 40°F. or 70°F. However, upon storage at 100°F. or 120°F., inappropriate notes (such as oxidized oil) were detected in soybean oil crackers at an earlier stage than in the cottonseed oil crackers. In addition, the intensity of these inappropriate notes increased at a higher rate in the soybean oil crackers as storage time progressed.

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## INTRODUCTION

The current military specification for crackers, MIL-C-1324E requires the shortening compound to conform to Type II, Class 2b (high stability cottonseed and/or peanut oil) of Federal Specification EE-S-321c. Due to the scarcity and relative high cost of shortening made from these vegetable oils, and improvement in the production of soybean oil shortening, the feasibility of using the latter as a lower cost substitute was investigated. Horne, et. al. (1948) reported that by increasing the stability of the shortening, the stability of biscuits containing that shortening would increase. Stevens, et. al. (1948) indicated through chemical analyses and sensory evaluations that biscuits prepared with different lots of cottonseed oil and soybean oil having initial A.O.M. (Active Oxygen Method) values ranging from 40 to 283 had a storage life in excess of 24 months at 70°F. Storage data on these same lots at 100°F. was not conclusive.

## EXPERIMENTAL METHODS

Two lots of round crackers were obtained from a commercial source. One lot was prepared with cottonseed oil shortening, complying with the Federal Specification, while the other lot contained soybean oil shortening. The crackers were air packed in No. 2½ cans and stored at 40°, 70°, 100°, and 120°F. for periods up to 2 years.

Chemical analyses of the crackers performed by the Analytical Services Group, Food Chemistry Division included tests for peroxide value, free fatty acid, thiobarbituric acid value, and headspace gas to indicate oxygen uptake. Sensory evaluation was accomplished through the use of a flavor profile panel consisting of D.R. Bellis, S.J. Bishov, L. Levasseur, I.T. Nii, P.A. Prell, Dr. A.R. Rahman, Dr. D.E. Westcott and M. Wolf. The standard profile technique was used in the evaluations (3). The flavor profile panel members (5-6 members per session) reported overall aroma and flavor amplitudes, and defined specific aroma and flavor notes together with their intensities and the order in which perceived. Amplitude is a numerical expression of the overall sensory impression of the aroma and flavor and is correlated with the overall quality of each The intensity scale used by the panel was 0-3 with one-half step increments, and includes a just recognizable or threshold value designated as )(. Aftertaste is the flavor that remains one minute after the sample has been swallowed. The purpose of the sensory tests was to determine the effect of storage on the shelf life of crackers prepared with two shorteninings, specifically by noting the development of oxidized oil notes throughout the storage period.

## RESULTS AND DISCUSSION

Results of chemical analyses on crackers manufactured with both types of vegetable oil shortenings are shown in Table I. Initial Peroxide Value and Free Fatty Acid content of the soybean oil crackers were higher than in the cottonseed oil crackers. Although the Peroxide Value of the soybean oil crackers increased at a faster rate than in the cottonseed oil crackers at all storage temperatures, the increase was more marked at 100°F. and 120°F. as evidenced by Figures 1 and 2.

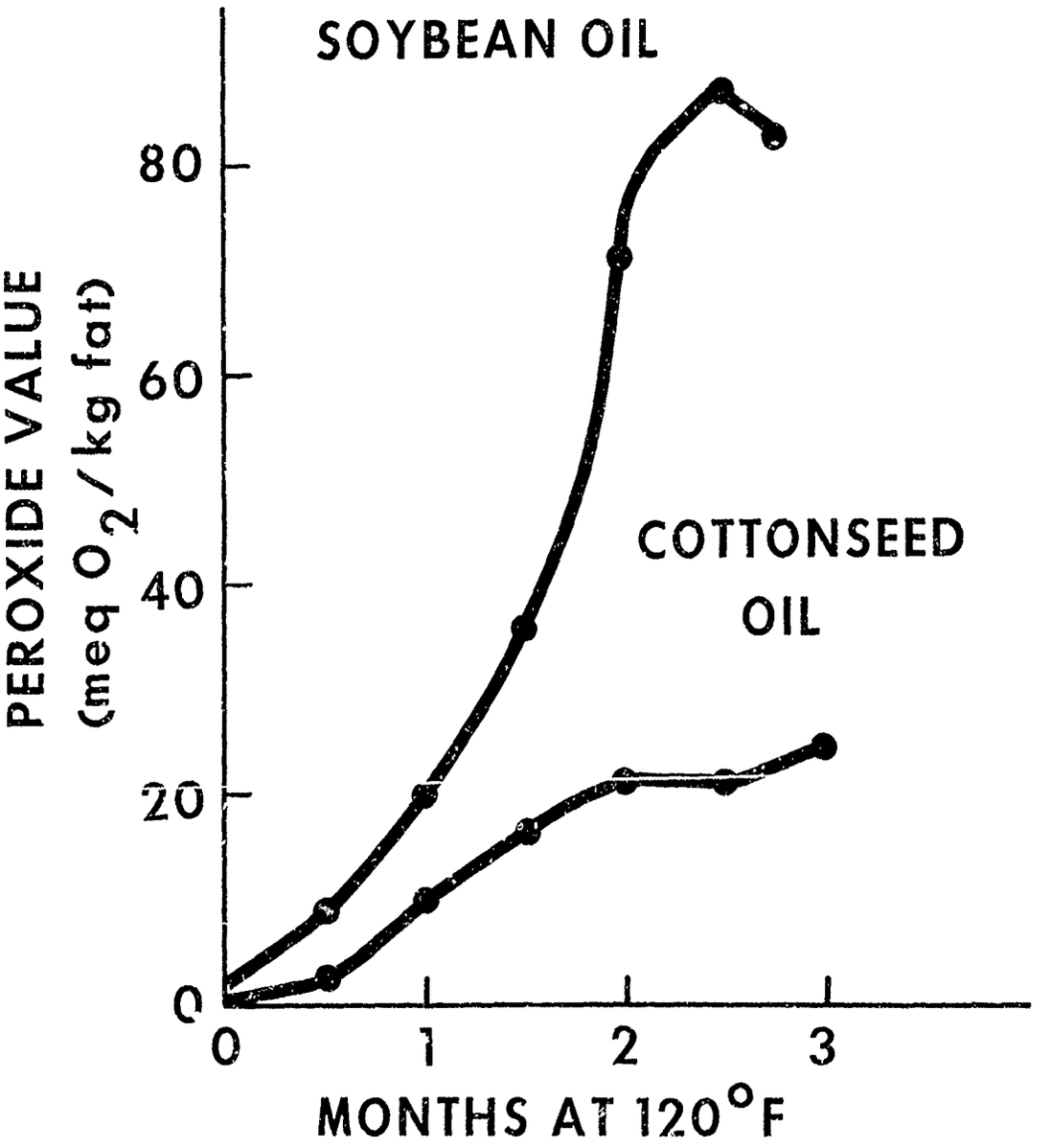



Fig 1 Increase in Peroxide Value of Crackers Stored at 120°F.

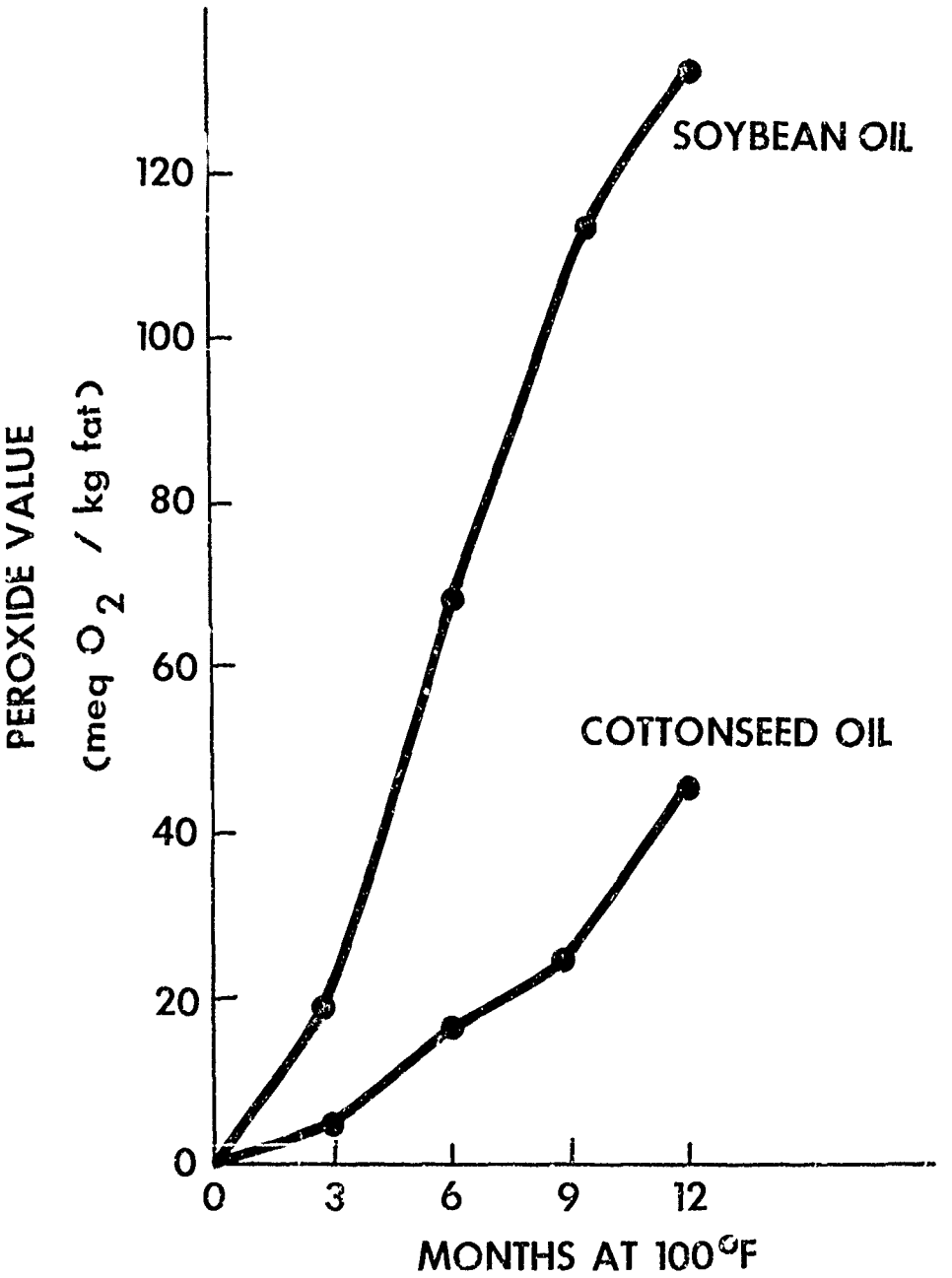



Fig. 2 Increase in Peroxide Value of Crackers Stored at 100°F.

Results of analyses for free fatty acid were inconclusive for both samples. Thiobarbituric acid test results varied for samples stored at 40°F. or 70°F. However, at 100°F. or 120°F., they were higher in soybean oil crackers than in the cottonseed oil crackers.

The percent oxygen in the headspace of the canned crackers was similar for both samples initially and after 2 years storage at 40°F. However, at 70°F., 100°F., or 120°F. the oxygen uptake of the canned soybean oil crackers was greater than that of the canned cottonseed oil crackers as shown by the relative decrease in headspace oxygen (Fig. 3).

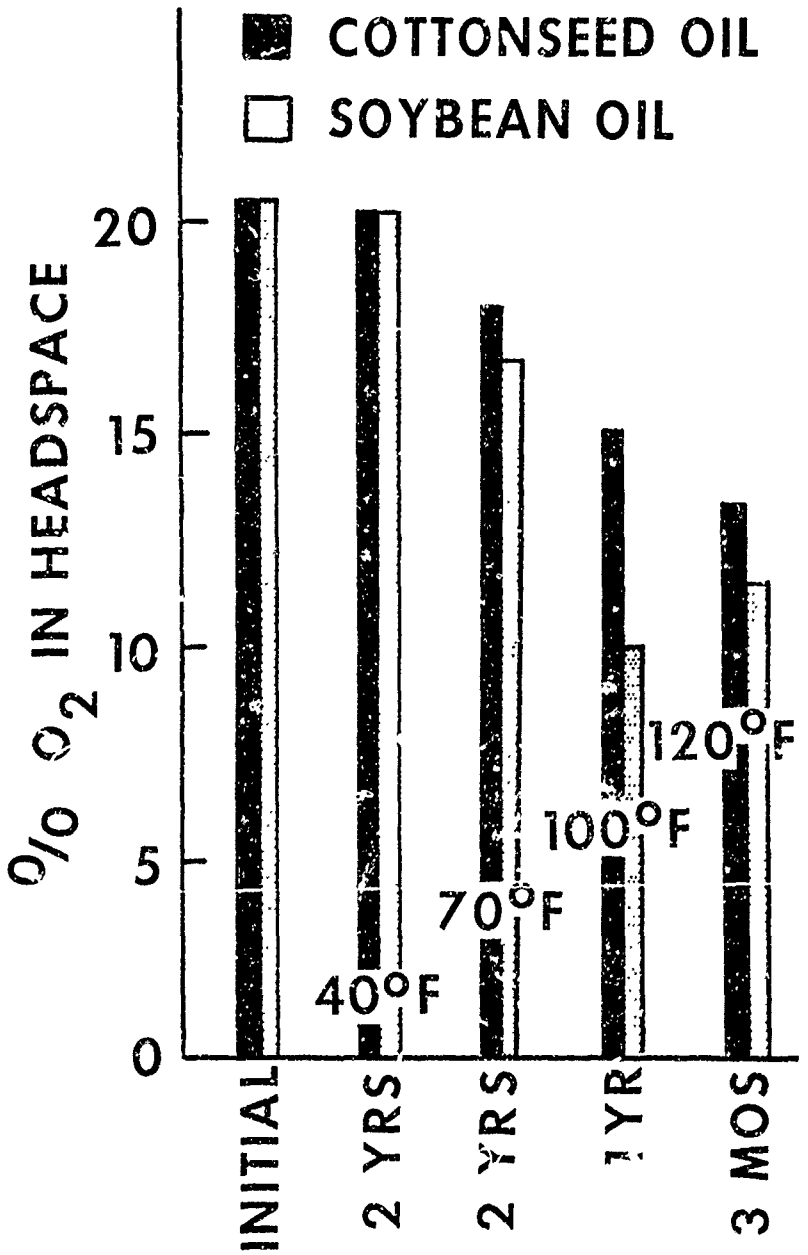



Fig. 3 Decrease in Headspace Oxygen of Canned Crackers

The sensory results of the profile evaluations are shown in Table II for soybean oil crackers and Table III for cottonseed oil crackers. The profile panel results will be discussed separately for aroma, flavor and aftertaste. An off note is considered definitely present at 1 or above.

AROMA. The initial aromas were similar for crackers prepared with either shortening. Amplitude in both types of crackers decreased as oxidized oil and musty stale aromas developed. The order and intensities of the notes were similar at each storage temperature and withdrawal period for the cottonseed oil crackers and the soybean oil crackers, except for the toasted note, the musty stale note and the oxidized oil note.

The toasted note was the fourth note perceived in both types of crackers at an intensity of 1-1½ throughout the study. The intensity was slightly higher in the soybean oil crackers than in the cottonseed oil crackers.

The musty stale note was the first note perceived in both types of crackers throughout the study, except for the soybean oil crackers at 100°F. for 24 months in which the oxidized oil (painty) note was the first and dominant note. In both types of crackers, the musty stale note appeared as a slight but definite note after 1 month at 120°F. Through the remainder of storage at 40°F., the intensity of the musty stale note in both types of crackers was usually very slight. At higher storage temperatures some increase in the intensity of the musty stale note was apparent at each withdrawal period. This note was at a slightly higher intensity at some test intervals in the cottonseed oil crackers than in the soybean oil crackers.

The oxidized oil note was usually the second note perceived in both types of crackers except at low intensities ( )( and ½), where it appeared as the fourth note. As indicated in Figure 4, this note was not detected in either type of crackers initially. Oxidized oil aroma appeared as a definite note (intensity of 1 or higher) in soybean oil crackers stored at 100°F. for 3 months and in cottonseed oil crackers at 12 months. It appeared in both types of crackers stored at 120°F. for 1 month, but was higher in intensity in soybean oil crackers at each time interval. Both types of crackers stored at 40°F. and 70°F. did not develop a definite oxidized oil note (1-slight) until the 18 and 24 month withdrawal period.

FLAVOR. The initial flavors were similar for the crackers produced with either type of shortening. The amplitude in both types of crackers decreased throughout the study with the appearance and increase in intensity of oxidized oil and musty stale notes. The order and the intensities of the notes were similar at each storage temperature and time for both types of crackers, except for the toasted note, the musty stale note and the oxidized oil note.

The toasted note was the fourth note perceived in both types of crackers. The intensity was usually ½ to 1 in the cottonseed oil crackers and 1½ to 2 in the soybean oil crackers throughout the study.

The musty stale note was usually perceived as the sixth note. As the intensity increased, the order of perception changed and the note was perceived sooner. The intensity of the musty stale note in both types of crackers was usually the same; $\frac{1}{2}$ in the 40°F. crackers, 1 in the 70°F. crackers, 1 in the 3 month - 100°F. crackers and $1\frac{1}{2}$ in the 100°F. crackers stored for 6 months or longer.

The oxidized oil note was usually perceived as the tenth note. As the intensity increased, the order of perception changed and the note was perceived sooner. When the intensity of this note had reached $1\frac{1}{2}$ - 2, it was perceived as the first note. As indicated in Figure 5, this note was not a definite off-note in either type of cracker stored at 40°F. or 70°F., since it was usually perceived by less than $\frac{1}{2}$ the panel and never at an intensity beyond $\frac{1}{2}$. At 100°F., oxidized oil was a definite off-note in the soybean oil crackers at 12 months but not in the cottonseed oil crackers until 24 months. The intensity of the oxidized oil note in the soybean oil crackers stored at 100°F. for 24 months was 2, and was characterized as painty.

AFTERTASTE. The definite notes perceived as aftertaste were toasted, musty - stale, salt and oxidized oil. When the oxidized oil note was present at an intensity of 1 or above in the crackers, it was usually perceived as a definite note in the aftertaste.

## CONCLUSION

Chemical analyses of crackers stored at 40°F. or 70°F. showed that the peroxide value of the soybean oil crackers increased at a faster rate than that of the cottonseed oil crackers. However, the profile panel indicated that both types of crackers were equally stable at 40°F. and 70°F. for 2 years. Thus, the cottonseed oil crackers displayed no advantage compared to the soybean oil crackers after storage for 2 years at 40°F. or 70°F.

Under accelerated storage conditions (120°F.), the soybean oil crackers showed a greater rate of increase in peroxide value than the cottonseed oil crackers. However, the profile panel found both types of crackers reached a definite oxidized oil flavor at $2\frac{1}{2}$ months and an oxidized oil aroma at 1 month. There seems to be no sensory difference in shelf life between the crackers prepared with the 2 types of oil, under accelerated storage conditions for 3 months at 120°F. These results indicate that it is difficult to predict results of a 100°F. storage study from an accelerated storage study at 120°F.

At 100°F., crackers prepared from cottonseed oil showed a lower oxygen uptake and a smaller increase in peroxide value than crackers containing soybean oil. The profile panel indicated a definite oxidized oil flavor in the soybean oil crackers at 12 months of storage. This intensity of oxidized oil was not detected in the cottonseed oil crackers until the end of 24 months of storage. In the soybean oil crackers, the oxidized oil note at an intensity of 2 was characterized as "painty, rancid, linseed" and was typical of soybean oil reversion. During storage at 100°F., the intensity of the oxidized oil

aroma increased at a faster rate than the intensity of the oxidized oil flavor in both types of crackers. A definite oxidized oil aroma was detected at 3 months in soybean oil crackers, but not until 12 months in cottonseed oil crackers. Based on these results and the fact that operational rations are stored for three years and sometimes longer at ambient temperatures (in all parts of the world), the use of soybean oil shortening in crackers is not considered advisable.

Table I - Chemical Analyses of Crackers

| Storage Temp/Time | Peroxide Value meq $O_2$/kg Fat | | Free Fatty Acid as % Oleic Acid | | Thiobarbituric Acid Test as ppm malonaldehyde | | Headspace $O_2$% | |
|---|---|---|---|---|---|---|---|---|
| | C | S | C | S | C | S | C | S |
| Initial | 0.7 | 1.8 | 0.25 | 0.32 | 0.58 | 0.54 | 20.8 | 20.9 |
| 40°/3 Mos. | 1.5 | 2.4 | 0.28 | 0.28 | 0.70 | 0.60 | | |
| 6 | 2.8 | 2.4 | 0.21 | 0.26 | 0.69 | 0.66 | | |
| 9 | 0.0 | 0.0 | 0.20 | 0.23 | 0.66 | 0.62 | | |
| 12 | 1.2 | 5.2 | 0.26 | 0.29 | 0.67 | 0.68 | | |
| 18 | 2.7 | 3.9 | 0.23 | 0.26 | 0.63 | 0.66 | | |
| 24 | 4.0 | 8.5 | 0.35 | 0.32 | 0.55 | 0.56 | 20.3 | 20.4 |
| 70°/3 Mos | 2.1 | 2.8 | 0.29 | 0.37 | 0.60 | 0.60 | | |
| 6 | 3.2 | 6.5 | 0.33 | 0.26 | 0.53 | 0.68 | | |
| 9 | 3.4 | 10.9 | 0.21 | 0.23 | 0.66 | 0.62 | | |
| 12 | 17.3 | 25.1 | 0.26 | 0.30 | 0.76 | 0.81 | | |
| 18 | 10.8 | 38.8 | 0.22 | 0.26 | 0.70 | 0.84 | | |
| 24 | 17.0 | 69.2 | 0.36 | 0.33 | 0.62 | 0.76 | 18.2 | 16.8 |
| 100°/3 Mos | 4.6 | 19.1 | 0.27 | 0.33 | 0.60 | 0.80 | | |
| 6 | 17.0 | 68.2 | 0.22 | 0.28 | 0.76 | 0.86 | | |
| 9 | 23.9 | 109.5 | 0.23 | 0.28 | 0.70 | 1.08 | | |
| 12 | 46.8 | 133.6 | 0.30 | 0.41 | 1.01 | 1.29 | 15.3 | 10.1 |
| 120°/1/2 Mos | 1.7 | 9.3 | 0.29 | 0.36 | 0.57 | 0.61 | | |
| 1 | 5.3 | 20.2 | 0.25 | 0.36 | 0.65 | 0.69 | | |
| 1½ | 8.5 | 35.7 | 0.32 | 0.40 | 0.70 | 0.80 | | |
| 2 | 22.1 | 75.3 | 0.29 | 0.42 | * | * | | |
| 2½ | 20.8 | 86.9 | 0.31 | 0.41 | 0.80 | 1.40 | | |
| 3 | 24.3 | 82.7 | 0.32 | 0.38 | 0.80 | 1.10 | 13.4 | 12.0 |

C = Cottonseed Oil
S = Soybean Oil
* = Results rejected

Table II - Effect of Storage Conditions on Flavor Profile of Soybean Oil Crackers

| | I | 120°F 1 M | 120°F 1½ M | 120°F 2½ M | 40°F 3 M | 70°F 3 M | 100°F 3 M | 120°F 3 M | 40°F 6 M | 70°F 6 M | 100°F 6 M | 40°F 12 M | 70°F 12 M | 100°F 12 M | 40°F 18 M | 70°F 18 M | 40°F 24 M | 70°F 24 M | 100°F 24 M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AROMA | | | | | | | | | | | | | | | | | | | |
| AMPLITUDE | 1½ | 1 | 1 | 1 | 1½ | 1 | ½ | )( | 1 | 1 | ½ | 1 | 1 | ½ | 1 | 1 | 1½ | 1 | )( |
| MUSTY-STALE | ½ | 1 | 1 | 1 | ½ | 1 | 1 | 1½ | ½ | 1 | 1 | ½ | 1 | 1 | ½ | ½ | ½ | 1 | |
| OXIDIZED OIL | 0 | 1½ | 1½ | 1½ | )( | + | 1 | 2 | + | + | 1 | + | ½ | 2 | )( | 1 | )( | 1 | 3 |
| STARCHY FLOUR | 1½ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| TOASTED | 1 | 1½ | 1½ | 1½ | 1½ | 1½ | 1 | 1½ | 1½ | 1½ | 1 | 1½ | 1½ | 1 | 1½ | 1½ | 1½ | 1½ | |
| SWEET FRAGRANCE | 1 | 1 | 1 | 1 | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | |
| FLAVOR | | | | | | | | | | | | | | | | | | | |
| AMPLITUDE | 1 | 1 | 1 | ½ | 1½ | 1 | 1 | )( | 1½ | 1 | 1 | 1½ | 1 | ½ | 1½ | 1 | 1½ | 1 | )( |
| SWEET | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ |
| SALTY | 1 | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1 | 1½ | 1½ | 1½ | 1 | 1 |
| STARCHY FLOUR | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1 | 1½ | 1½ | 1 | 1½ | 1 | 1½ | 1 | 1 |
| TOASTED | 1½ | 1½ | 2 | 2 | 1½ | 1½ | 1½ | 2 | 1½ | 1½ | 1½ | 1½ | 1½ | 1 | 2 | 2 | 2 | 2 | 1½ |
| SOUR | ½ | ½ | ½ | ½ | ½ | + | ½ | + | ½ | ½ | ½ | ½ | ½ | ½ | ½ | + | ½ | + | ½ |
| MUSTY-STALE | 1 | 1 | 1 | 1½ | ½ | + | 1 | 2 | ½ | 1 | 1½ | ½ | 1 | 1½ | ½ | + | ½ | 1 | 1½ |
| SALIVATING | 1 | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | + | ½ | ½ | ½ |
| BITTER | ½ | ½ | ½ | ½ | ½ | ½ | ½ | 1 | ½ | ½ | ½ | ½ | ½ | ½ | ½ | 1 | ½ | ½ | 1 |
| SODA | ½ | + | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | + | ½ | ½ | ½ | ½ | ½ | ½ | + | |
| OXIDIZED OIL | 0 | + | ½ | 2 | + | + | + | 2 | + | )( | + | + | ½ | 1 | + | ½ | + | + | 2 |
| AFTERTASTE | | | | | | | | | | | | | | | | | | | |
| TOASTED | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| MUSTY-STALE | * | * | * | * | - | - | * | * | * | * | * | * | * | * | - | - | - | * | - |
| SALT | * | * | - | * | * | * | - | - | * | * | * | * | - | - | * | - | * | - | - |
| OXIDIZED OIL | | | | * | - | - | - | * | - | - | - | - | - | * | - | - | - | - | * |

I - initial
M - months

INTENSITIES
0 - not detected
)( - recognition threshold
1 - slight
2 - moderate
3 - strong
+ - note reported by a minority of the panel
* - note reported in aftertaste by majority of the panel.

Table III - Effect of Storage Conditions on Flavor Profile on Cottonseed Oil Crackers

| | I | 120°F 1 M | 120°F 1½ M | 120°F 2½ M | 40°F 3 M | 70°F 3 M | 100°F 3 M | 120°F 3 M | 40°F 6 M | 70°F 6 M | 100°F 6 M | 40°F 12 M | 70°F 12 M | 100°F 12 M | 40°F 18 M | 70°F 18 M | 40°F 24 M | 70°F 24 M | 100°F 24 M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AROMA | | | | | | | | | | | | | | | | | | | |
| AMPLITUDE | 1½ | 1 | 1 | ½ | 1 | 1 | 1 | ½ | 1½ | 1½ | ½ | 1½ | 1 | ½ | 1½ | 1 | 1½ | 1 | ½ |
| MUSTY-STALE | + | 1 | 1 | 1½ | ½ | 1 | 1 | 1½ | ½ | 1 | 1 | ½ | 1 | 1½ | ½ | 1 | 1 | 1½ | 1½ |
| OXIDIZED OIL | 0 | 1 | 1 | 1½ | )( | + | ½ | 1½ | + | + | ½ | )( | ½ | 1½ | )( | 1 | ½ | 1 | 2 |
| STARCHY FLOUR | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| TOASTED | 1½ | 1½ | 1 | 1 | 1½ | 1½ | 1 | 1½ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| SWEET FRAGRANCE | 1 | 1 | 1 | 1 | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ |
| FLAVOR | | | | | | | | | | | | | | | | | | | |
| AMPLITUDE | 1½ | 1 | 1 | ½ | 1½ | 1 | 1 | ½ | 1½ | 1 | ½ | 1½ | 1 | 1 | 1½ | 1 | 1½ | 1 | ½ |
| SWEET | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ |
| SALTY | 2 | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ |
| STARCH FLOUR | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1 | 1 | 1½ | 1 | 1½ | 1 | 1 |
| TOASTED | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1 | 1½ | 1½ | 1 | 1 | 1½ | 1½ | 1 | 1½ | 1½ | 1½ | 1½ | 1 |
| SOUR | 1 | ½ | ½ | ½ | ½ | + | ½ | ½ | ½ | ½ | ½ | ½ | + | ½ | ½ | + | ½ | + | ½ |
| MUSTY-STALE | 1 | 1 | 1 | 1½ | ½ | 1 | 1 | 2 | ½ | 1 | 1½ | ½ | 1 | 1½ | ½ | 1 | 1 | 1 | 1½ |
| SALIVATING | 1 | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | + |
| BITTER | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ |
| SODA | ½ | + | ½ | 1 | ½ | ½ | ½ | ½ | ½ | ½ | + | ½ | ½ | ½ | ½ | + | ½ | 1 | + |
| OXIDIZED OIL | 0 | 0 | ½ | 1 | + | + | ½ | 1 | + | + | ½ | 0 | + | ½ | + | + | + | ½ | 1 |
| AFTERTASTE | | | | | | | | | | | | | | | | | | | |
| TOASTED | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| MUSTY-STALE | - | * | * | * | * | - | * | * | * | * | * | * | * | * | * | * | * | * | * |
| SALT | * | * | * | * | * | * | - | * | * | * | * | * | * | * | * | * | * | * | - |
| OXIDIZED OIL | - | - | - | * | - | - | | - | - | - | * | - | - | - | - | - | - | - | * |

I - initial
M - months

INTENSITIES
0 - not detected
)( - recognition threshold
1 - slight
2 - moderate
3 - strong
+ - note reported by a minority of the panel
* - note reported in aftertaste by majority of the panel.

Fig. 4 Effect of Storage Conditions on Intensity of Oxidized Oil Aroma of Crackers Prepared with 2 Different Shortenings.

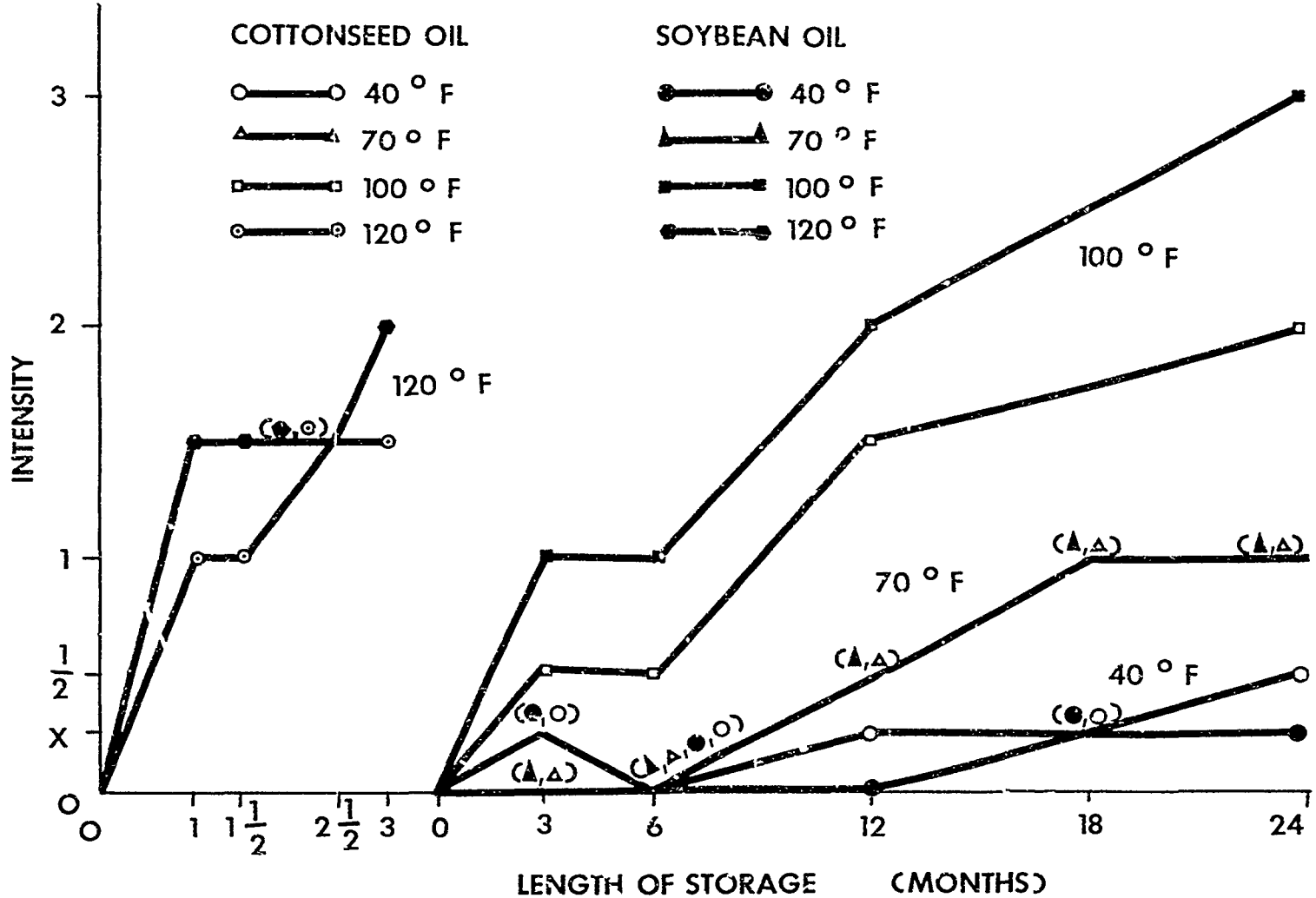
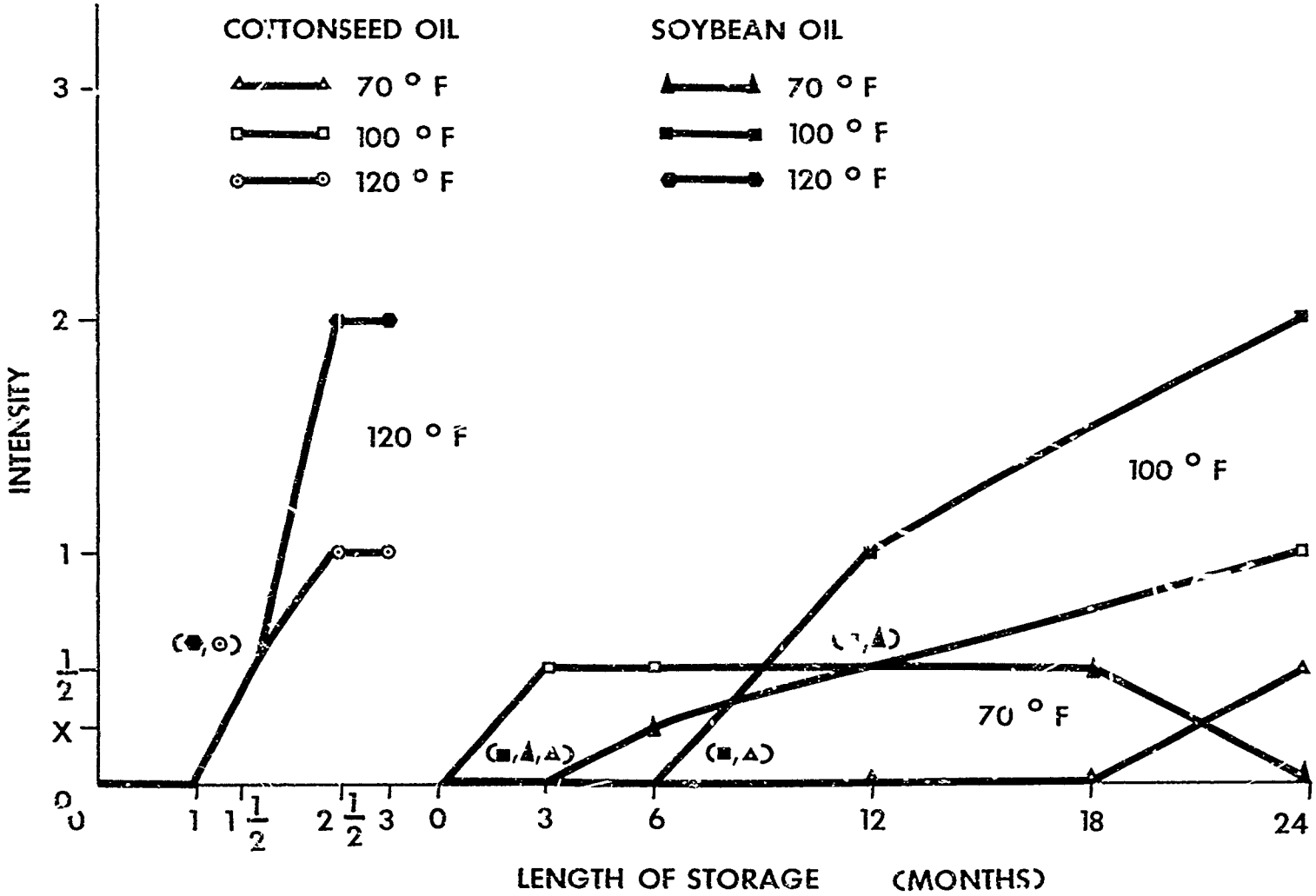


Fig. 5 Effect of Storage Conditions on Intensity of Oxidized Oil Flavor of Crackers Prepared with 2 Different Shortenings



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