CHANGES IN TBA VALUE OF MEAT UNDER CONTROLLED CONDITIONS

by

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Traditionally, beef and pork which are not strictly fresh have been used to make frankfurters and pork sausage. Such beef and pork show no visible evidence of either protein or fat degradation; however, the fat has deteriorated sufficiently to prevent frankfurters or pork sausage from surviving a year in freezer storage. This deterioration in fat cannot be reliably detected organoleptically. A chemical method (TBA test) of detection has been proven reliable.

The TBA test is an objective measurement of a type of deteriorative change in complex fatty foods which is associated with the appearance of unpleasant flavors and odors. It has a close correlation with the subjective organoleptic evaluation of oxidative rancidity. Its principal function is to eliminate the conflicts of opinion and the senses regarding the existing rancidity condition of the meat fat at the moment of inspection.

The TBA test performs this function by quantitatively determining the amount of oxidation products reacting with thiobarbituric acid to produce a red pigment with a fixed absorption spectrum. The optical density of the TBA--fatty acid reaction pigment is compared spectrophotometrically with the standard absorption curves of varying concentrations of a specific rancidity product, malonaldehyde. The TBA test does not measure the total carbonyls of rancidity, but there is a close correlation between the TBA test value and the ultimate appearance of a rancid odor and flavor in raw or cooked meats. The test method, itself, breaks down intermediate rancidity products which re-enter into the reaction.

The reliability of the TBA test to detect fat degradation which is not organoleptically evident is not questioned. Variations of the methods by which the thiobarbituric acid principle is applied have caused a lack of confidence among the knowledgeable and the naive. The successful use of one or more of the specific methods of applying the thiobarbituric acid (TBA test) principle as a Quality Control technique has proved its value to industry; its successful use as a Quality Assurance technique has yet to prove its value to the Government.

The probability of a successful application of the TBA test principle to Military Procurement would be enhanced by testing frozen samples. The absence of adequate information relating to the testing of frozen samples caused this investigation which was conducted by the University of Missouri, Columbia, under contract DA19-129-AMC-638(W) through funds allocated to the upgrading of Subsistence Specifications. Dr. M. E. Bailey served as
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ABSTRACT

This report summarizes work done to determine the effects of cooler and freezer storage on TBA values of ground uncooked pork and beef and their relationship to pH and percent fat. TBA values of pork were determined by distillation and extraction methods and those of beef were determined by the latter method. The TBA values determined were relatively low during storage from 2 to 7 days at 38°F and from 1 to 7 days at -3°F. There were significant animal differences in beef and pork in TBA values, percent fat and pH. There were significant changes in TBA values due to 38°F storage, pH and percent fat, but changes during freezer-storage were insignificant.
I. INTRODUCTION

The purpose of this research was to determine the effects of chilling and freezing on the production of certain oxidation products in beef and pork as measured by the TBA test.

The thiobarbituric acid (TBA) test has been used successfully by several investigators to measure lipid oxidation during short term storage of cooked meats, but its use as a measure of oxidative change in fresh meat from pork and beef has not been fully explored.

Food technologists have been searching for many years for a chemical index of fresh meat quality as it might change during chilling and frozen storage. Since the TBA test is considered one of the most sensitive tests for oxidative deterioration of fats, it was felt that it might serve as a useful measure of the storage potential of fresh beef and pork.

II. EXPERIMENTAL METHODS AND MATERIALS.

A. Processing of Meat from Animals.

Pork. Carcasses from 5 pigs were studied in these experiments. Three animals were purchased from the University of Missouri Testing Station at weights of 210±10 pounds. The other two animals were obtained from the Missouri Station Swine Farm at approximately the same weight. These animals were slaughtered at the University
of Missouri abattoir and chilled overnight at 38°F. The ham, picnic, Boston Butt and loin from the left side of each carcass were used in these studies. The surface fat and bone of the cuts were removed and the meat cut into approximately 1/2" cubes and mixed thoroughly. The tissue was then divided into 48 portions and packaged in polyethylene bags which were closed to minimize air space and clamped with metal clips.

**Beef.** Forequarters from 5 different cutter grade cows were purchased from a local packer after overnight chilling. The quarters were boned and divested of excess fat and connective tissue. The lean tissue was then ground through a 1/2" plate followed by thorough mixing; it was re-ground through a 1/8" plate and again mixed. Forty-eight one-half pound samples were packaged as described for pork.

### B. Storage of Samples Following Processing.

The following storage conditions were used:

a. Storage at 38±2°F. for a period of 2 to 7 days.

b. Storage at -3±2°F. for a period of 2 to 7 days.

c. Storage at various combinations of the temperatures in a and b for a period of 2 to 14 days.

The design of the storage times is indicated in Table I (Appendix).

Table II is a description of the test load for each individual carcass. Each cycle was essentially completed prior to initiation of the next cycle involving another carcass.
Immediately before analysis, each frozen sample was ground without thawing through a 1/4" plate of a Universal No. 2 hand grinder.

C. Chemical Procedures Used.

**TBA value analyses.** All pork samples were analyzed for TBA value by two methods. The first method was that of Tarladgis et al. (1960). The second was as follows:

Twenty grams of comminuted meat were blended full speed for 1.5 minutes in a chilled stainless steel Waring blender cup with 50 ml of 40°F.-extracting solution containing 20% trichloroacetic acid in 2M phosphoric acid. The resulting slurry was transferred quantitatively to a 100 ml volumetric flask with 40 ml water. The sample was diluted to 100 ml with water and homogenized by shaking. A 50 ml portion was filtered through Whatman #1 filter paper. Five ml of filtrate was transferred to a test tube (15 x 200 mm) followed by 5 ml of TBA reagent (0.005M in distilled water). The tube was stoppered and the solution mixed by inversion and kept in the dark for 15 hours at room temperature (approximately 25°C.). The resulting color was measured at 530 mu in a Beckman DU spectrophotometer.

TBA values of the beef samples were determined by the extraction procedure described above for pork. All TBA values were determined on two different portions of each sample and in turn, two replicate colorimetric analyses were made of each portion.
**pH determinations.** Single pH determinations were made on two different portions of each sample by the official A.O.A.C. procedure (1960).

**Fat determinations.** The quantities of fat were measured on two different portions of each sample by the method of Salwin et al. (1955).

D. **Statistical Analyses.**

Analysis of variance was calculated as outlined in Snedecor (1965). Significance of differences between means was determined by the method of Least Significant Difference (LSD) as used by Le Clery (1957). Correlation coefficients were computed as described in Ezekiel (1950) and linear regression curves were drawn as indicated in Snedecor (1965).

III. RESULTS AND DISCUSSION.

A. **Mean Values for Chemical Constituents.**

Mean values of TBA, pH and fat for the five pork carcasses are listed in Table III. Those for beef are in Table IV. It should be noted that in most series (A thru F), TBA values for unfrozen samples (2C-OF, 3C-OF, 4C-OF, etc.) were higher than those for corresponding fresh samples. This difference was undoubtedly due to the fact that extraction and distillation of the frozen samples was initiated prior to thawing of the samples. Surprisingly, these differences were greater for samples analyzed by distillation.
than those analyzed by extraction. There may be some effect of freezing and thawing on availability of aldehyde in fresh samples. Preliminary study in this laboratory of fresh beef samples indicate that this assumption is true.

Mean values for pH were quite uniform and those for fat were variable as expected.

B. Statistical Differences in TBA Values of Pork Determined by Distillation.

Data from analysis of variance of TBA values of pork by the distillation method are given in Table V. There were significant animal differences in TBA values, there were differences due to cooler and freezer storage, and there was an interaction between cooler time and freezer time.

The mean TBA values determined by distillation during storage of samples for the individual pigs are given in Table VI. These data indicate that the mean TBA value for animal No. 1 was higher than those of the other animals and the mean TBA value for animal No. 4 was significantly higher than that of animal No. 3. Animals No. 1 and No. 4 were obtained from the Missouri Station Swine Farm and the other three from the Missouri Swine Testing Station. This may mean that diet influenced TBA values of these animals.

The effect of cooler storage at 38°F. on TBA values (distillation) of the five pork carcasses is shown in Table VII. The values increased progressively during storage at this temperature. The TBA value of the seven-day sample was significantly higher than
those of the remaining samples and the two-day sample was signifi-
cantly lower than those of the 5, 6 and 7-day samples.

TBA values of the pork carcasses (Table VIII) changed very little during storage at -30°F. The differences between the mean TBA values of the non-frozen samples and those of the frozen samples were discussed previously.

The interaction of storage at 38°F and -30°F. on mean TBA values of pork is shown in Table IX and in Figure 1 (Appendix). There were many significant interactions in TBA values due to storage at the two temperatures. These are easily seen in Figure 1 where the mean TBA values of the 5 pork carcasses for the different cooler times are plotted against days of frozen storage.

There were no significant differences in TBA values during frozen-storage for the individual cooler-storage times. However, there were significant differences between TBA values of frozen samples and those of non-frozen (0°F) samples. These data also indicate that the TBA values of samples stored for 2 days at 38°F were different from those stored for 7 days at this temperature.

C. Statistical Differences in TBA Value of Pork Determined by Extraction.

Data from analysis of variance of TBA values of pork by the extraction method are given in Table X. As in the results from the distillation analysis, there were significant animal differences in TBA values. There were also differences due to cooler
and freezer storage, and there was an interaction between cooler time and freezer time.

The individual effects of animal differences, cooler storage, freezer storage and cooler-freezer interaction on TBA values as determined by the extraction method are shown in Tables XI thru XIII. In general, these results were similar to those for TBA values determined by the distillation method.

The interaction of storage at 38°F and -3°F. on mean TBA values (extraction) of samples from the five pork carcasses is shown in Table XIV and Figure 2. These data indicate that there were significant interactions in TBA values due to storage at the two different temperatures. In general, the changes due to frozen storage were insignificant, but there were significant changes due to cooler storage. The decrease in TBA value of samples between 0 and 1 day storage time was undoubtedly due to extraction of the 0 day samples without prior freezing.

D. Statistical Differences in TBA Value of Beef.

Data from analysis of variance of TBA values of beef are presented in Table XV. There were significant animal differences in TBA values and there were significant differences due to cooler and freezer storage.

The mean TBA values determined by extraction during storage of samples from the individual animals are presented in Table XVI. All values for the different animals are significantly different.
This animal variation may be important in regard to use of the TBA value as an index of quality for this type of animal, although all values for these samples were still quite low.

As with pork, there was a gradual increase in TBA values of beef as storage progressed at 38°F. (Table XVII). After the third day of storage at this temperature, the daily increase in constituents detected by reaction with TBA were significant.

The apparent difference in TBA values during freezer-storage (Table XVIII) was due to inclusion of the sample 0-F which actually was not a frozen sample. Thus, there were no significant changes due to frozen-storage of TBA values in beef. The interaction of cooler and frozen storage of TBA values of beef is shown in Table XIX and Figure 3. There were significant variations in TBA values due to interaction at the two storage temperatures.

E. **Statistical Differences in Fat of Pork and Beef.**

Data from analysis of variance of pork and beef fat are presented in Tables XX and XXI, respectively. There were significant animal differences in fat of both pork and beef. The data also indicate that there were differences in pork due to cooler time and freezer time and differences in beef due to cooler time. There were also significant interactions between cooler time and freezer time for fat from the two species.

F. **Statistical Differences in pH of Pork and Beef.**

Data from analysis of variance of pH of pork and beef are
presented in Tables XXII and XXIII, respectively. There were significant animal differences in pH of both pork and beef. This was surprising due to the uniformity of pH values given in Tables III and IV, but the mean square error terms were extremely low for these analyses. These data reflect the reproducibility of the pH determinations for duplicate samples at each of the storage periods concerned.

There were also significant differences for pH of pork and beef due to freezer time and significant interactions between cooler and freezer time.

G. Correlations Between Two Methods of Determining TBA Values.

Correlations between TBA values determined by the extraction method relative to those determined by the distillation method for pork are shown in Table XXIV. There was considerable variation between the correlations for the individual animals. Higher correlations were obtained between data obtained by the two methods on samples that gave the highest results. The highest correlations among the individual cycles were for animals number one and four. These two animals were the ones obtained from the Missouri Station Swine Farm.

Data from the two methods of determining TBA values might have been more highly related if the TBA values had been of greater magnitude. The correlation was improved by removing values for samples (0-F) which were analyzed unfrozen.
The overall correlation between TBA values as determined by the extraction method relative to those determined by the distillation method for duplicate analyses of two separate portions from 240 individual pork samples (n = 960) was 0.845. The correlation obtained by using the average of the duplicate analyses (n = 480) was 0.846. There was essentially no difference between the two. The overall correlation between TBA values as determined by the two different methods with the (0-F) samples removed was 0.858 (n = 420).

The regression curve of TBA (distillation) with TBA (extraction) of samples involving 960 analyses from five pork carcasses is drawn in Figure 4.

H. Correlation Coefficients Between TBA Values and pH, Fat and Storage Time of Pork.

Extraction method. These correlations for pork are listed in Table XXV. There were significant correlations between TBA values and pH, fat, cooler storage and freezer storage for the individual animals. When data from all 5 animals were pooled, there were significant correlations between TBA values of samples and their pH and cooler storage time. It was apparent from the data concerning TBA values and actual freezer time that these two variables were not related significantly. The significant correlations for the individual cycles between TBA values and freezer time included 0-time storage (0-F) samples but these were not frozen samples. These samples from pork always produced greater
quantities of material that reacted with TBA, but as pointed out previously, this was because the samples were analyzed unfrozen. A corrected correlation involving removal of 0-F samples for the total (420) samples between freezer time and TBA values was -0.024. Correction for individual animal differences by pooling cross products and sum of squares of variables from the individual cycles did not significantly change the correlation results. Simple regression curves for the significant uncorrected correlations between TBA values and pH and cooler time of the compiled data (total) are drawn in Figures 5 and 6, respectively.

**Distillation method.** The simple correlations between TBA values as determined by the distillation method and pH, fat and storage time of pork are listed in Table XXVI. There were significant correlations between TBA values and the other variables within samples of the various cycles and for the total samples between TBA values and pH, cooler time and freezer time. The correlation of total samples (n = 420) exclusive of 0-F samples between freezer time and TBA value was -0.004. Correction for individual animal differences by pooling cross products and sums of squares of variables from the individual cycles changed the correlations somewhat. It was thought that this procedure would improve the overall relationships between the variables, but it only improved the correlation between TBA value and cooler time from 0.220 (P>0.05) to 0.254 (P>0.01). The strongest relationship was between TBA value and cooler time. Since the distillation data were similar to that of
the extraction data for pork, regression curves were not drawn of the latter results.

I. Correlation Coefficients Between TBA Values and pH, Fat and Storage Time of Beef.

These data for the TBA values of beef as determined by the extraction method are in Table XXVII. As with pork, when data from the individual animals was considered, the strongest relationship was between TBA values and cooler time but there were also significant correlations between TBA values and fat and between TBA values and freezer time. These were invariably negative indicating that the relationship between fat and TBA value was inverse. The correlation data for the compiled samples showed significant relationships between TBA values and pH, fat and cooler time.

Simple regression curves for the uncorrected correlation data between TBA values and pH, fat and cooler time are drawn in Figures 7, 8 and 9.

J. Coefficients of Multiple Correlations Relating Changes in Cooler Time, Freezer Time, pH and Fat With Changes in TBA Values of Pork and Beef.

The multiple correlations as measures of the combined importance of the several independent variables as related to TBA values
of pork determined by the distillation and extraction methods were respectively 0.416 (n = 420) and 0.437 (n = 420). The respective regression equations were:

\[ \hat{Y} = 1.9352 + 0.0324 \ (CT) - 0.0006 \ (FT) -0.3270 \ (pH) - 0.0014 \ (F) \]
and

\[ \hat{Y} = 1.6460 + 0.0183 \ (CT) + 0.0003 \ (FT) -0.2912 \ (pH) + 0.0027. \]

The multiple correlation between the independent variables as related to TBA values of beef was 0.575 (n = 420).

The regression equation for the beef data was:

\[ \hat{Y} = 1.0786 + 0.0093 \ (CT) + 0.0008 \ (FT) - 0.1598 \ (pH) - 0.0141 \ (F). \]

CT = cooler time.
FT = freezer time.
F = fat.
IV. CONCLUSIONS

The extraction method used in these studies for measuring TBA values of raw meat from pork and beef is useful for routine analysis of constituents involved in this determination. The method is simple and more convenient than the distillation method.

The TBA values obtained for the raw meat studied were generally low, but there were significant variations due to animal differences.

TBA values of beef and pork increased significantly during storage at 38°F., but changes during freezer-storage (-30°F.) were usually insignificant. TBA values determined on unfrozen samples were significantly higher than those of frozen samples when the analyses were initiated prior to thawing.

Even though TBA values of pork and beef were significantly correlated with pH, cooler storage and percent fat, the correlations were quite low and in general accounted for only 5 to 15 percent of the total variation.
SUMMARY

TBA values, pH and percent fat were determined on ground, uncooked portions of five pork and beef carcasses during storage at 38°F and -30°F. Distillation and extraction methods were used to determine TBA values of pork and the extraction method was used for beef. The relationships between the various chemical constituents were determined statistically.

Data obtained by using the two methods for determining TBA values of pork were highly related (r = 0.845, n = 960) and the correlations were greater for samples having the highest TBA values. The TBA values obtained for most of the samples analyzed were low compared to those reported in the literature for cooked meat.

There were significant animal differences in beef and pork in regard to their TBA values, percent fat and pH.

The major changes in TBA values of pork and beef samples occurred during storage at 38°F. There was a gradual significant increase in TBA values during storage of both types of meat at this temperature.

The data also indicated significant differences in TBA values of pork due to freezer (-30°F)-storage and significant interactions due to cooler and freezer storage. The TBA values of beef decreased significantly during storage at -30°F. However, these changes in both beef and pork were apparently due to inclusion of 0-time freezer storage samples in the statistical analyses. These samples were analyzed for TBA values without freezing and the values were significantly higher than those of frozen samples analyzed without previous thawing. Changes in TBA values during actual storage of both pork and beef at -30°F were usually insignificant.

TBA values of some of the individual samples of beef and pork were significantly correlated with pH, fat, cooler time and freezer time. Pooling of data from all five pork carcasses resulted in significant correlations between TBA values and pH and between TBA values and cooler time. Similar results were obtained for beef, and there was also a significant negative correlation between percent fat and TBA values of these samples. In general, these correlations accounted for from 5 to 15 percent of the total variation.

The most outstanding result was that TBA values of both pork and beef increased significantly during storage at 38°F, but the values were still low compared to those most frequently reported in the literature.
V. LITERATURE CITED


VI. APPENDIX
TABLE I

DESIGN OF STORAGE TESTS

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Code:

F = frozen storage at -3±2°F.

C = chilled storage at 38±2°F.

Number = days of chilled or frozen storage.
### TABLE II

DISTRIBUTION OF TEST LOAD

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| Frequency of Tests       | 1 | 2 | 3 | 4 | 5 | 6 | 6 | 6 | 5 | 4 | 3 | 2 | 1 | 48 total |
# TABLE III

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<th>Fat (%)</th>
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<th>Extraction</th>
<th>pH</th>
<th>Fat (%)</th>
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1. Values are means of duplicate analyses of samples from 5 carcasses.

2. F = frozen storage at -3±2°F; C = chilled storage at 38±2°F; Number = days of storage.
TABLE IV
MEAN VALUES$^1$ OF TBA, pH AND FAT OF BEEF

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<th>TBA Value</th>
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<th>Fat (%)</th>
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<td>5.6950</td>
<td>7.1900</td>
</tr>
<tr>
<td>6C-2F</td>
<td>.1384</td>
<td>5.6920</td>
<td>7.1700</td>
</tr>
<tr>
<td>6C-3F</td>
<td>.1640</td>
<td>5.7220</td>
<td>7.2200</td>
</tr>
<tr>
<td>6C-4F</td>
<td>.1315</td>
<td>5.6760</td>
<td>7.1000</td>
</tr>
<tr>
<td>6C-5F</td>
<td>.1367</td>
<td>5.6200</td>
<td>7.1000</td>
</tr>
<tr>
<td>6C-6F</td>
<td>.1433</td>
<td>5.6480</td>
<td>6.8800</td>
</tr>
<tr>
<td>6C-7F</td>
<td>.1514</td>
<td>5.7300</td>
<td>7.3000</td>
</tr>
<tr>
<td>E</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7C-0F</td>
<td>.1684</td>
<td>5.6720</td>
<td>6.9800</td>
</tr>
<tr>
<td>7C-1F</td>
<td>.1430</td>
<td>5.6900</td>
<td>7.0400</td>
</tr>
<tr>
<td>7C-2F</td>
<td>.1557</td>
<td>5.7280</td>
<td>7.1300</td>
</tr>
<tr>
<td>7C-3F</td>
<td>.1558</td>
<td>5.6820</td>
<td>7.2600</td>
</tr>
<tr>
<td>7C-4F</td>
<td>.1455</td>
<td>5.6240</td>
<td>7.0100</td>
</tr>
<tr>
<td>7C-5F</td>
<td>.1543</td>
<td>5.6390</td>
<td>7.3200</td>
</tr>
<tr>
<td>7C-6F</td>
<td>.1538</td>
<td>5.7240</td>
<td>7.3000</td>
</tr>
<tr>
<td>7C-7F</td>
<td>.1463</td>
<td>5.6980</td>
<td>7.2400</td>
</tr>
</tbody>
</table>

1Values are means of duplicate analyses of samples from 5 carcasses.

2F = frozen storage at -3±2°F.; C = chilled storage at 38±2°F.; number = days of storage.
TABLE V
ANALYSIS OF VARIANCE OF TBA VALUES (DISTILLATION) OF PORK

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>Degrees of Freedom</th>
<th>Mean Square</th>
<th>F</th>
<th>1%</th>
<th>5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>83.1031</td>
<td>959</td>
<td>0.0867</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Cycle¹</td>
<td>20.7230</td>
<td>4</td>
<td>5.1808</td>
<td>112.990</td>
<td>3.36</td>
<td>2.39</td>
</tr>
<tr>
<td>Cooler time²</td>
<td>4.4242</td>
<td>5</td>
<td>0.8848</td>
<td>19.298</td>
<td>3.06</td>
<td>2.23</td>
</tr>
<tr>
<td>Freezer time³</td>
<td>12.6353</td>
<td>7</td>
<td>1.8050</td>
<td>39.368</td>
<td>2.69</td>
<td>2.03</td>
</tr>
<tr>
<td>Cooler time x freezer time</td>
<td>3.6904</td>
<td>35</td>
<td>0.1054</td>
<td>2.299</td>
<td>1.74</td>
<td>1.49</td>
</tr>
<tr>
<td>Error</td>
<td>41.6302</td>
<td>908</td>
<td>0.0458</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

¹ Variation due to animal differences.
² Samples stored at 38±2°F.
³ Samples stored at -3±2°F.
TABLE VI
MEAN\(^1\) TBA VALUES (DISTILLATION) OF PORK

<table>
<thead>
<tr>
<th>Cycle No.</th>
<th>Animal No.</th>
<th>N</th>
<th>Mean(^2) TBA Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>192</td>
<td>0.5338 A</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>192</td>
<td>0.1946 BE</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>192</td>
<td>0.1341 BC</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>192</td>
<td>0.3258 DE</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>192</td>
<td>0.1648 BE</td>
</tr>
</tbody>
</table>

\(^1\) Mean TBA values during cooler and freezer storage of samples from 5 pork carcasses.

\(^2\) Means followed by the same letter are not significantly different (LSD\(^{.05}\) = 0.1918).
### TABLE VII

**EFFECT OF 38°F. STORAGE ON MEAN TBA VALUES (DISTILLATION) OF PORK**

<table>
<thead>
<tr>
<th>Days of Cooler Storage</th>
<th>N</th>
<th>Mean² TBA Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>160</td>
<td>0.1820 A</td>
</tr>
<tr>
<td>3</td>
<td>160</td>
<td>0.2361 BA</td>
</tr>
<tr>
<td>4</td>
<td>160</td>
<td>0.2395 BA</td>
</tr>
<tr>
<td>5</td>
<td>160</td>
<td>0.2680 B</td>
</tr>
<tr>
<td>6</td>
<td>160</td>
<td>0.2973 B</td>
</tr>
<tr>
<td>7</td>
<td>160</td>
<td>0.4007 C</td>
</tr>
</tbody>
</table>

¹Cooler storage was followed by freezer storage from 0 to 7 days.

²Means followed by the same letter are not significantly different (LSD .05 = 0.0165).
### TABLE VIII

**EFFECT OF -3°F.-STORAGE ON MEAN TBA VALUES (DISTILLATION) OF PORK**

<table>
<thead>
<tr>
<th>Days(^1) of Freezer Storage</th>
<th>N</th>
<th>Mean(^2) TBA Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>120</td>
<td>0.5735 A</td>
</tr>
<tr>
<td>1</td>
<td>120</td>
<td>0.2411 B</td>
</tr>
<tr>
<td>2</td>
<td>120</td>
<td>0.2284 B</td>
</tr>
<tr>
<td>3</td>
<td>120</td>
<td>0.2264 B</td>
</tr>
<tr>
<td>4</td>
<td>120</td>
<td>0.2152 B</td>
</tr>
<tr>
<td>5</td>
<td>120</td>
<td>0.2344 B</td>
</tr>
<tr>
<td>6</td>
<td>120</td>
<td>0.2222 B</td>
</tr>
<tr>
<td>7</td>
<td>120</td>
<td>0.2236 B</td>
</tr>
</tbody>
</table>

\(^1\)Samples were stored at 38°F from 2 to 7 days prior to freezer storage.

\(^2\)Means followed by the same letter are not significantly different (LSD\(_{0.05}\) = 0.0654).
### TABLE IX

**INTERACTION**\(^1\) **OF STORAGE AT 38^\circ\text{F.} AND -3^\circ\text{F. ON MEAN}^2\ **TBA VALUES (DISTILLATION) OF PORK**

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>0F</th>
<th>1F</th>
<th>2F</th>
<th>3F</th>
<th>4F</th>
<th>5F</th>
<th>6F</th>
<th>7F</th>
</tr>
</thead>
<tbody>
<tr>
<td>2C</td>
<td>.2836</td>
<td>.2462</td>
<td>.1852</td>
<td>.1271</td>
<td>.1558</td>
<td>.1396</td>
<td>.1315</td>
<td>.1867</td>
</tr>
<tr>
<td>3C</td>
<td>.6688</td>
<td>.1824</td>
<td>.1408</td>
<td>.2060</td>
<td>.1638</td>
<td>.1794</td>
<td>.2065</td>
<td>.1414</td>
</tr>
<tr>
<td>4C</td>
<td>.5222</td>
<td>.1527</td>
<td>.2046</td>
<td>.1838</td>
<td>.1746</td>
<td>.2711</td>
<td>.2267</td>
<td>.1805</td>
</tr>
<tr>
<td>5C</td>
<td>.4582</td>
<td>.2415</td>
<td>.2429</td>
<td>.2613</td>
<td>.2446</td>
<td>.2657</td>
<td>.2191</td>
<td>.2106</td>
</tr>
<tr>
<td>6C</td>
<td>.5749</td>
<td>.2224</td>
<td>.2875</td>
<td>.2780</td>
<td>.2657</td>
<td>.2690</td>
<td>.2499</td>
<td>.2306</td>
</tr>
<tr>
<td>7C</td>
<td>.9332</td>
<td>.4013</td>
<td>.3096</td>
<td>.3021</td>
<td>.2867</td>
<td>.2812</td>
<td>.2995</td>
<td>.3919</td>
</tr>
</tbody>
</table>

\(^1\text{LSD}_{.05} = 0.1375.\)

\(^2\text{N} = 20.\)
### TABLE X

**ANALYSIS OF VARIANCE OF TBA VALUES (EXTRACTION) OF PORK**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>Degrees of Freedom</th>
<th>Mean Square</th>
<th>F</th>
<th>1%</th>
<th>5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>17.8658</td>
<td>959</td>
<td>0.0186</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Cycle&lt;sup&gt;1&lt;/sup&gt;</td>
<td>6.9443</td>
<td>4</td>
<td>1.7361</td>
<td>204.970</td>
<td>3.36</td>
<td>2.39</td>
</tr>
<tr>
<td>Cooler time&lt;sup&gt;2&lt;/sup&gt;</td>
<td>1.3777</td>
<td>5</td>
<td>0.2755</td>
<td>32.527</td>
<td>3.06</td>
<td>2.23</td>
</tr>
<tr>
<td>Freezer time&lt;sup&gt;3&lt;/sup&gt;</td>
<td>1.2696</td>
<td>7</td>
<td>0.1814</td>
<td>21.417</td>
<td>2.69</td>
<td>2.03</td>
</tr>
<tr>
<td>Cooler time x</td>
<td>0.5822</td>
<td>35</td>
<td>0.0166</td>
<td>1.960</td>
<td>1.74</td>
<td>1.49</td>
</tr>
<tr>
<td>freezer time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>7.6920</td>
<td>908</td>
<td>0.00847</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

<sup>1</sup> Variations due to animal differences.

<sup>2</sup> Samples stored at 38±2°F.

<sup>3</sup> Samples stored at -3±2°F.
<table>
<thead>
<tr>
<th>Cycle No.</th>
<th>Animal No.</th>
<th>N</th>
<th>Mean TBA Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>192</td>
<td>0.3061 A</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>192</td>
<td>0.1122 B</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>192</td>
<td>0.0827 C</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>192</td>
<td>0.1544 D</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>192</td>
<td>0.0732 C</td>
</tr>
</tbody>
</table>

1Mean TBA values during cooler and freezer storage.

2Means followed by the same letter are not significantly different (LSD .05 = 0.0261).
### TABLE XII

**EFFECT OF 38°F.-STORAGE ON MEAN TBA VALUES (EXTRACTION) OF PORK**

<table>
<thead>
<tr>
<th>Days of Cooler Storage</th>
<th>N</th>
<th>Mean TBA Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>160</td>
<td>0.1032 A</td>
</tr>
<tr>
<td>2</td>
<td>160</td>
<td>0.1019 A</td>
</tr>
<tr>
<td>3</td>
<td>160</td>
<td>0.1324 B</td>
</tr>
<tr>
<td>4</td>
<td>160</td>
<td>0.1560 CB</td>
</tr>
<tr>
<td>5</td>
<td>160</td>
<td>0.1730 C</td>
</tr>
<tr>
<td>6</td>
<td>160</td>
<td>0.2073 D</td>
</tr>
<tr>
<td>7</td>
<td>160</td>
<td></td>
</tr>
</tbody>
</table>

1Cooler storage was followed by freezer storage from 0 to 7 days.

2Means followed by the same letter are not significantly different (LSD .05 = 0.0264).
TABLE XIII
EFFECT OF -3°F.-STORAGE ON MEAN TBA VALUES (EXTRACTION) OF PORK

<table>
<thead>
<tr>
<th>Days of Freezer Storage</th>
<th>N</th>
<th>Mean(^2) TBA Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>120</td>
<td>0.2410 A</td>
</tr>
<tr>
<td>1</td>
<td>120</td>
<td>0.1401 B</td>
</tr>
<tr>
<td>2</td>
<td>120</td>
<td>0.1303 B</td>
</tr>
<tr>
<td>3</td>
<td>120</td>
<td>0.1305 B</td>
</tr>
<tr>
<td>4</td>
<td>120</td>
<td>0.1275 B</td>
</tr>
<tr>
<td>5</td>
<td>120</td>
<td>0.1270 B</td>
</tr>
<tr>
<td>6</td>
<td>120</td>
<td>0.1289 B</td>
</tr>
<tr>
<td>7</td>
<td>120</td>
<td>0.1405 B</td>
</tr>
</tbody>
</table>

\(^1\)Samples were stored at 38°F. from 2 to 7 days prior to freezer storage.

\(^2\)Means followed by the same letter are not significantly different (LSD \(_{.05} = 0.0243\)).
TABLE XIV

INTERACTION$^1$ OF STORAGE AT $38^\circ$ AND $-3^\circ$F. ON MEAN$^2$ TBA VALUES (EXTRACTION) OF SAMPLES FROM FIVE PORK CARCASSES

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>0F</th>
<th>1F</th>
<th>2F</th>
<th>3F</th>
<th>4F</th>
<th>5F</th>
<th>6F</th>
<th>7F</th>
</tr>
</thead>
<tbody>
<tr>
<td>2C</td>
<td>.1417</td>
<td>.1394</td>
<td>.1052</td>
<td>.0911</td>
<td>.0818</td>
<td>.0851</td>
<td>.0818</td>
<td>.0999</td>
</tr>
<tr>
<td>3C</td>
<td>.1336</td>
<td>.0894</td>
<td>.0918</td>
<td>.0946</td>
<td>.0929</td>
<td>.0964</td>
<td>.1150</td>
<td>.1014</td>
</tr>
<tr>
<td>4C</td>
<td>.2098</td>
<td>.1075</td>
<td>.1230</td>
<td>.1289</td>
<td>.1056</td>
<td>.1320</td>
<td>.1318</td>
<td>.1205</td>
</tr>
<tr>
<td>5C</td>
<td>.2567</td>
<td>.1370</td>
<td>.1473</td>
<td>.1273</td>
<td>.1462</td>
<td>.1609</td>
<td>.1394</td>
<td>.1334</td>
</tr>
<tr>
<td>6C</td>
<td>.3292</td>
<td>.1439</td>
<td>.1435</td>
<td>.1636</td>
<td>.1696</td>
<td>.1441</td>
<td>.1327</td>
<td>.1571</td>
</tr>
<tr>
<td>7C</td>
<td>.3751</td>
<td>.2234</td>
<td>.1708</td>
<td>.1777</td>
<td>.1691</td>
<td>.1432</td>
<td>.1725</td>
<td>.2308</td>
</tr>
</tbody>
</table>

$^1_{\text{LSD}} .05 = 0.0591.$

$^2_{N} = 20.$
### TABLE XV

ANALYSIS OF VARIANCE OF TBA VALUES (EXTRACTION) OF BEEF

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Mean Square</th>
<th>F</th>
<th>1%</th>
<th>5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>959</td>
<td>0.0028</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cycle(^1)</td>
<td>4</td>
<td>0.4095</td>
<td>538.816</td>
<td>3.36</td>
<td>2.39</td>
</tr>
<tr>
<td>Cooler time(^2)</td>
<td>5</td>
<td>0.0629</td>
<td>82.763</td>
<td>3.06</td>
<td>2.23</td>
</tr>
<tr>
<td>Freezer time(^3)</td>
<td>7</td>
<td>0.0018</td>
<td>2.368</td>
<td>2.69</td>
<td>2.03</td>
</tr>
<tr>
<td>Cooler time x Freezer time</td>
<td>35</td>
<td>0.0011</td>
<td>1.447</td>
<td>1.74</td>
<td>1.49</td>
</tr>
<tr>
<td>Error</td>
<td>908</td>
<td>0.00076</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^1\)Variation due to animal differences.

\(^2\)Samples stored at 38±2°F.

\(^3\)Samples stored at -3±2°F.
<table>
<thead>
<tr>
<th>Cycle No.</th>
<th>Animal No.</th>
<th>N</th>
<th>Mean TBA Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>192</td>
<td>0.3061 A</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>192</td>
<td>0.1122 B</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>192</td>
<td>0.0827 C</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>192</td>
<td>0.1544 D</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>192</td>
<td>0.0732 E</td>
</tr>
</tbody>
</table>

1 Mean TBA values during cooler and freezer storage.

2 Means followed by the same letter are not significantly different (LSD .05 = 0.0078).
TABLE XVII

EFFECT OF 38°F.-STORAGE ON MEAN TBA VALUES (EXTRACTION) OF BEEF

<table>
<thead>
<tr>
<th>Days of Cooler Storage</th>
<th>N</th>
<th>Mean TBA Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>160</td>
<td>0.1015 A</td>
</tr>
<tr>
<td>3</td>
<td>160</td>
<td>0.1076 A</td>
</tr>
<tr>
<td>4</td>
<td>160</td>
<td>0.1213 B</td>
</tr>
<tr>
<td>5</td>
<td>160</td>
<td>0.1317 C</td>
</tr>
<tr>
<td>6</td>
<td>160</td>
<td>0.1418 D</td>
</tr>
<tr>
<td>7</td>
<td>160</td>
<td>0.1528 E</td>
</tr>
</tbody>
</table>

Cooler storage was followed by freezer storage from 0 to 7 days.

Means followed by the same letter are not significantly different (LSD .05 = 0.0079).
### TABLE XVIII

**EFFECT OF -3°F.-STORAGE ON MEAN TBA VALUES (EXTENSION) OF BEEF**

<table>
<thead>
<tr>
<th>Days of Freezer Storage</th>
<th>N</th>
<th>Mean TBA Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>120</td>
<td>0.1293 A</td>
</tr>
<tr>
<td>1</td>
<td>120</td>
<td>0.1184 B</td>
</tr>
<tr>
<td>2</td>
<td>120</td>
<td>0.1224 B</td>
</tr>
<tr>
<td>3</td>
<td>120</td>
<td>0.1289 B</td>
</tr>
<tr>
<td>4</td>
<td>120</td>
<td>0.1257 B</td>
</tr>
<tr>
<td>5</td>
<td>120</td>
<td>0.1286 B</td>
</tr>
<tr>
<td>6</td>
<td>120</td>
<td>0.1267 B</td>
</tr>
<tr>
<td>7</td>
<td>120</td>
<td>0.1288 B</td>
</tr>
</tbody>
</table>

1. Samples were stored at 38°F. from 2 to 7 days prior to freezer storage.

2. Means followed by the same letter are not significantly different (LSD.05 = 0.0082).
TABLE XIX

INTERACTION\(^1\) OF STORAGE AT 38\(^\circ\) AND -3\(^\circ\)F ON MEAN\(^2\) TBA VALUES (EXTRACTION) OF BEEF

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>0F</th>
<th>1F</th>
<th>2F</th>
<th>3F</th>
<th>4F</th>
<th>5F</th>
<th>6F</th>
<th>7F</th>
</tr>
</thead>
<tbody>
<tr>
<td>2C</td>
<td>.1111</td>
<td>.0983</td>
<td>.0925</td>
<td>.0988</td>
<td>.1048</td>
<td>.1068</td>
<td>.0961</td>
<td>.1033</td>
</tr>
<tr>
<td>3C</td>
<td>.1116</td>
<td>.0968</td>
<td>.0989</td>
<td>.1022</td>
<td>.1096</td>
<td>.1030</td>
<td>.1154</td>
<td>.1234</td>
</tr>
<tr>
<td>4C</td>
<td>.1200</td>
<td>.1101</td>
<td>.1197</td>
<td>.1190</td>
<td>.1301</td>
<td>.1270</td>
<td>.1219</td>
<td>.1224</td>
</tr>
<tr>
<td>5C</td>
<td>.1301</td>
<td>.1276</td>
<td>.1293</td>
<td>.1336</td>
<td>.1331</td>
<td>.1441</td>
<td>.1295</td>
<td>.1260</td>
</tr>
<tr>
<td>6C</td>
<td>.1348</td>
<td>.1344</td>
<td>.1384</td>
<td>.1640</td>
<td>.1315</td>
<td>.1367</td>
<td>.1433</td>
<td>.1514</td>
</tr>
<tr>
<td>7C</td>
<td>.1684</td>
<td>.1430</td>
<td>.1557</td>
<td>.1558</td>
<td>.1455</td>
<td>.1543</td>
<td>.1538</td>
<td>.1463</td>
</tr>
</tbody>
</table>

\(^1\) LSD\(_{.05}\) = 0.0201

\(^2\) \(N = 20\).
TABLE XI

ANALYSIS OF VARIANCE OF PERCENT FAT IN OX

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>Degrees of Freedom</th>
<th>Mean Square</th>
<th>F</th>
<th>Significance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>46.9854</td>
<td>476</td>
<td>0.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cycle 1</td>
<td>5.6352</td>
<td>4</td>
<td>1.43</td>
<td>2.13</td>
<td>3.3</td>
</tr>
<tr>
<td>Co les time 2</td>
<td>2.008</td>
<td>5</td>
<td>0.3298</td>
<td>4.69</td>
<td>3.06</td>
</tr>
<tr>
<td>Freezer time 3</td>
<td>2.893</td>
<td>7</td>
<td>0.21</td>
<td>1.091</td>
<td>2.69</td>
</tr>
<tr>
<td>Cooler time :</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freezer time</td>
<td>8.02</td>
<td>35</td>
<td>0.2242</td>
<td>3.194</td>
<td>1.74</td>
</tr>
<tr>
<td>Error</td>
<td>30.0032</td>
<td>426</td>
<td>0.0712</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Variation due to annual differences.

2 Samples stored at 20°F.

3 Samples stored at 0°F.
TABLE XXI
ANALYSIS OF VARIANCE OF PERCENT FAT OF BEEF

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>Degrees of Freedom</th>
<th>Mean Square</th>
<th>F</th>
<th>1%</th>
<th>5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>912.1198</td>
<td>479</td>
<td>1.9042</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Cycle(^1)</td>
<td>881.9224</td>
<td>4</td>
<td>220.4806</td>
<td>3561.880</td>
<td>3.36</td>
<td>2.39</td>
</tr>
<tr>
<td>Cooler time(^2)</td>
<td>0.1267</td>
<td>5</td>
<td>0.0253</td>
<td>0.041</td>
<td>3.06</td>
<td>2.23</td>
</tr>
<tr>
<td>Freezer time(^3)</td>
<td>1.0640</td>
<td>7</td>
<td>0.1520</td>
<td>2.456</td>
<td>2.69</td>
<td>2.03</td>
</tr>
<tr>
<td>Cooler time x Freezer time</td>
<td>3.5081</td>
<td>35</td>
<td>0.1002</td>
<td>1.619</td>
<td>1.74</td>
<td>1.49</td>
</tr>
<tr>
<td>Error</td>
<td>26.4986</td>
<td>428</td>
<td>0.0619</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

\(^1\) Variation due to animal differences.

\(^2\) Samples stored at 38±2°F.

\(^3\) Samples stored at -3±2°F.
TABLE XXII
ANALYSIS OF VARIANCE OF PORK TISSUE pH

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>Degrees of Freedom</th>
<th>Mean Square</th>
<th>F</th>
<th>1%</th>
<th>5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>3.1964</td>
<td>479</td>
<td>0.0677</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Cycle¹</td>
<td>1.2737</td>
<td>4</td>
<td>0.3183</td>
<td>0.458</td>
<td>5.36</td>
<td>2.39</td>
</tr>
<tr>
<td>Cooler time²</td>
<td>0.0272</td>
<td>5</td>
<td>0.0055</td>
<td>1.536</td>
<td>3.06</td>
<td>2.23</td>
</tr>
<tr>
<td>Freezer time³</td>
<td>0.0515</td>
<td>7</td>
<td>0.0074</td>
<td>2.037</td>
<td>2.85</td>
<td>2.03</td>
</tr>
<tr>
<td>Cooler time x freezer time</td>
<td>0.3086</td>
<td>55</td>
<td>0.0033</td>
<td>4.458</td>
<td>1.74</td>
<td>49</td>
</tr>
<tr>
<td>Error</td>
<td>1.9003</td>
<td>428</td>
<td>0.0043</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

¹Variation due to time differences.
²Samples stored at 35±2°F.
³Samples stored at -32±7°F.
**TABLE XXIII**

ANALYSIS OF VARIANCE OF BEEF TISSUE pH

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>Degrees of Freedom</th>
<th>Mean Square</th>
<th>F</th>
<th>1%</th>
<th>5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>3.6314</td>
<td>479</td>
<td>0.0076</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Cycle&lt;sup&gt;1&lt;/sup&gt;</td>
<td>0.5332</td>
<td>4</td>
<td>0.1333</td>
<td>22.593</td>
<td>3.36</td>
<td>2.39</td>
</tr>
<tr>
<td>Cooler time&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.0246</td>
<td>5</td>
<td>0.0049</td>
<td>0.831</td>
<td>3.06</td>
<td>2.23</td>
</tr>
<tr>
<td>Freezer time&lt;sup&gt;3&lt;/sup&gt;</td>
<td>0.0887</td>
<td>7</td>
<td>0.0127</td>
<td>0.152</td>
<td>2.69</td>
<td>2.03</td>
</tr>
<tr>
<td>Cooler time x freezer time</td>
<td>0.4579</td>
<td>35</td>
<td>0.0131</td>
<td>2.220</td>
<td>1.74</td>
<td>1.49</td>
</tr>
<tr>
<td>Error</td>
<td>2.5270</td>
<td>428</td>
<td>0.0059</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

<sup>1</sup>Variation due to animal differences.

<sup>2</sup>Samples stored at 38±2°F.

<sup>3</sup>Samples stored at -3±2°F.
TABLE XXIV

CORRELATIONS BETWEEN TBA VALUES (EXTRACTION) AND TBA VALUES (DISTILLATION) FOR PORK

<table>
<thead>
<tr>
<th>Cycle</th>
<th>N</th>
<th>r</th>
<th>N¹</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>96</td>
<td>0.8110</td>
<td>84</td>
<td>0.8745</td>
</tr>
<tr>
<td>2</td>
<td>96</td>
<td>0.2080</td>
<td>84</td>
<td>0.2533</td>
</tr>
<tr>
<td>3</td>
<td>96</td>
<td>0.3267</td>
<td>84</td>
<td>0.3351</td>
</tr>
<tr>
<td>4</td>
<td>96</td>
<td>0.8530</td>
<td>84</td>
<td>0.7649</td>
</tr>
<tr>
<td>5</td>
<td>96</td>
<td>0.4703</td>
<td>84</td>
<td>0.4945</td>
</tr>
<tr>
<td>Total</td>
<td>480²</td>
<td>0.8458</td>
<td>420</td>
<td>0.8580</td>
</tr>
<tr>
<td>Total</td>
<td>960³</td>
<td>0.8450</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

¹ The twelve samples from each cycle that were not frozen prior to analysis were excluded.

² Involves correlation of the averages of duplicate analyses of two separate portions from 240 pork samples.

³ Involves correlation of two individual analyses of two separate portions from 240 pork samples.
<table>
<thead>
<tr>
<th>Cycle</th>
<th>N</th>
<th>pH</th>
<th>Fat</th>
<th>Cooler Time</th>
<th>Freezer Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>96</td>
<td>-0.383**</td>
<td>0.030</td>
<td>0.549**</td>
<td>-0.369**</td>
</tr>
<tr>
<td>2</td>
<td>96</td>
<td>0.064</td>
<td>0.256*</td>
<td>0.443**</td>
<td>-0.009</td>
</tr>
<tr>
<td>3</td>
<td>96</td>
<td>0.190</td>
<td>0.009</td>
<td>0.332**</td>
<td>-0.448**</td>
</tr>
<tr>
<td>4</td>
<td>96</td>
<td>-0.233*</td>
<td>-0.293**</td>
<td>0.529**</td>
<td>-0.282**</td>
</tr>
<tr>
<td>5</td>
<td>96</td>
<td>0.049</td>
<td>0.096</td>
<td>0.400**</td>
<td>0.198</td>
</tr>
<tr>
<td>Total</td>
<td>480</td>
<td>-0.295**</td>
<td>0.075</td>
<td>0.269**</td>
<td>-0.157</td>
</tr>
<tr>
<td>Total 4</td>
<td>480</td>
<td>-0.139</td>
<td>0.003</td>
<td>0.348**</td>
<td>-0.202</td>
</tr>
</tbody>
</table>

** (P > 0.01)

* (P > 0.05)

1 Different animals.

2 Storage at 38±2°F.

3 Storage at -3±2°F.

4 Effect of individual animal differences removed by pooling data from individual cycles.
### TABLE XXVI

**CORRELATIONS BETWEEN TBA VALUES (DISTILLATION) AND pH, FAT AND STORAGE TIME OF PORK**

<table>
<thead>
<tr>
<th>Cycle¹</th>
<th>N</th>
<th>pH</th>
<th>Fat</th>
<th>Cooler Time²</th>
<th>Freezer Time³</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>96</td>
<td>0.436**</td>
<td>-0.124</td>
<td>0.397**</td>
<td>-0.462**</td>
</tr>
<tr>
<td>2</td>
<td>96</td>
<td>0.156</td>
<td>-0.136</td>
<td>0.279**</td>
<td>-0.281**</td>
</tr>
<tr>
<td>3</td>
<td>96</td>
<td>0.032</td>
<td>-0.195</td>
<td>0.126</td>
<td>-0.240**</td>
</tr>
<tr>
<td>4</td>
<td>96</td>
<td>-0.283**</td>
<td>-0.260**</td>
<td>0.324**</td>
<td>-0.281**</td>
</tr>
<tr>
<td>5</td>
<td>96</td>
<td>0.031</td>
<td>-0.006</td>
<td>0.648**</td>
<td>0.026</td>
</tr>
<tr>
<td>Total</td>
<td>480</td>
<td>-0.254*</td>
<td>-0.052</td>
<td>0.220*</td>
<td>-0.236*</td>
</tr>
<tr>
<td>Total⁴</td>
<td>480</td>
<td>-0.171</td>
<td>-0.105</td>
<td>0.254**</td>
<td>-0.272</td>
</tr>
</tbody>
</table>

**(P>0.01)**

*(P>0.05)*

¹Different animals.

²Storage at 38±2°F.

³Storage at -3±2°F.

⁴Effect of individual animal differences removed by pooling data from individual cycles.
### TABLE XXVII

**Correlations Between TBA Values (Extraction) and pH, Fat and Storage Time of Beef**

<table>
<thead>
<tr>
<th>Cycle&lt;sup&gt;1&lt;/sup&gt;</th>
<th>N</th>
<th>pH</th>
<th>Fat</th>
<th>Cooler Time&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Freezer Time&lt;sup&gt;3&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>96</td>
<td>0.183</td>
<td>0.008</td>
<td>0.278**</td>
<td>0.131</td>
</tr>
<tr>
<td>2</td>
<td>96</td>
<td>0.040</td>
<td>-0.080</td>
<td>0.620**</td>
<td>0.040</td>
</tr>
<tr>
<td>3</td>
<td>96</td>
<td>-0.019</td>
<td>-0.296**</td>
<td>0.144</td>
<td>-0.396**</td>
</tr>
<tr>
<td>4</td>
<td>96</td>
<td>-0.098</td>
<td>0.245*</td>
<td>0.611**</td>
<td>0.075</td>
</tr>
<tr>
<td>5</td>
<td>96</td>
<td>-0.111</td>
<td>-0.251*</td>
<td>0.850**</td>
<td>0.040</td>
</tr>
<tr>
<td>Total</td>
<td>480</td>
<td>-0.245*</td>
<td>-0.384**</td>
<td>0.332**</td>
<td>-0.002</td>
</tr>
<tr>
<td>Total&lt;sup&gt;4&lt;/sup&gt;</td>
<td>480</td>
<td>-0.030</td>
<td>-0.065</td>
<td>0.743**</td>
<td>-0.041</td>
</tr>
</tbody>
</table>

***(P>0.01)***  
***(P>0.05)***  

<sup>1</sup>Different animals.  
<sup>2</sup>Storage at 38±2°F.  
<sup>3</sup>Storage at -3±2°F.  
<sup>4</sup>Effect of individual animal differences removed by pooling data from individual cycles.
Figure 1
EFFECT OF -2° F. STORAGE ON MEAN TRA VALUES (DISTILLATION)
OF PORK FOLLOWING CHILLING AT 38° F.

Legend
- - - - 2 Days Storage at 38° F.
- - - - 3 Days Storage at 38° F.
- - - - 4 Days Storage at 38° F.
- - - - 5 Days Storage at 38° F.
- - - - 6 Days Storage at 38° F.
- - - - 7 Days Storage at 38° F.

LSD .05 = 0.1375

TRA VALUE

DAYS OF STORAGE
Figure 3
EFFECT OF -3°F. STORAGE ON MEAN TBA VALUES (EXTRACTION) OF BEEF FOLLOWING CHILLING AT 38°F.

Legend

- - - - - - - - - 2 Days Storage at 38°F.
- - - - - - - - - 3 Days Storage at 38°F.
- - - - - - - - - 4 Days Storage at 38°F.
- - - - - - - - - 5 Days Storage at 38°F.
- - - - - - - - - 6 Days Storage at 38°F.
- - - - - - - - - 7 Days Storage at 38°F.

LSD .05 = 0.0201
Figure 4
SIMPLE REGRESSION OF TBA VALUES (DISTILLATION) WITH TBA VALUES (EXTRACTION) OF PORK

\[ Y = 0.0358 + 0.3917X \]

\[ r = 0.845 \]

\[ n = 960 \]
FIGURE 5
SIMPLE REGRESSION OF TBA VALUES (EXTRACTION) WITH pH OF PORK

\[ y = 2.923 - 0.492x \]
\[ r = -0.295 \]
\[ n = 400 \]
Figure 6
SIMPLE REGRESSION OF TBA VALUES (EXTRACTION) WITH
38°F.-STORAGE OF PORK

\[ Y = 0.0442 + 0.0216X \]
\[ r = 0.269 \]
\[ n = 480 \]
Figure 7

SIMPLE REGRESSION OF TMA VALUES (EXTRACTION)

Y = 0.9122 - 0.11 X

r = -0.245

0 0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4 2.7 3.0

Y = 3.36, 3.48, 3.60, 3.72, 3.84, 4.16, 4.48, 4.80, 5.12, 5.50

TMA VALUE

0.0 0.1 0.2 0.3

0.6 0.7 0.8 0.9 1.0
Figure 8
SIMPLE REGRESSION OF TBA VALUES (EXTRACTION)
WITH PERCENT FAT OF BEEF

\[ Y = 0.218 - 0.014 X \]

\[ r = 0.384 \]

\[ n = 480 \]
Figure 9
SIMPLE REGRESSION OF TBA (EXTRACTION) WITH 38°F.-STORAGE OF BEEF

\[ Y = 0.0762 + 0.00929 X \]

\[ r = 0.322 \]

\[ n = 480 \]
### Abstract

This report summarized work done to determine the effects of cooler and freezer storage on TBA values of ground uncooked pork and beef and their relationship to pH and percent fat. TBA values of pork were determined by distillation and extraction methods and those of beef were determined by the latter method. The TBA values determined were relatively low during storage from 2 to 7 days at 30°F and from 1 to 7 days at -30°F. There were significant animal differences in beef and pork in TBA values, percent fat and pH. There were significant changes in TBA values due to 30°F - storage, pH and percent fat, but changes during freeze-storage were insignificant.
Determination
Oxidation
Sea
Steel
Thiobarbituric acid (TBA)
Tests
Raw
Storage
Cooling
Pressing
Ph
\( n \)

<table>
<thead>
<tr>
<th>Determination</th>
<th>Oxidation</th>
<th>Sea</th>
<th>Steel</th>
<th>Thiobarbituric acid (TBA)</th>
<th>Tests</th>
<th>Raw</th>
<th>Storage</th>
<th>Cooling</th>
<th>Pressing</th>
<th>Ph</th>
<th>( n )</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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