Acceptability of Accelerated-Processed Pork

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ABSTRACT

Five market hogs were slaughtered to determine the microbial, organoleptic and appearance differences between accelerated and conventionally processed pork. The left side of each carcass was processed 4 h after slaughter, whereas the right side was fabricated at 24-h postmortem. Microbial sampling was conducted. Appearance and organoleptic characteristics were evaluated. Conventionally processed cuts of pork were rated higher for color and overall appearance than the accelerated-processed cuts until 120 h. Taste panel data revealed no significant difference in tenderness and juiciness between the accelerated and conventionally processed cuts. Differences in microbial load between the two processes after 120 h of storage were negligible; however, the accelerated processed cuts had a higher microbial load than the conventionally processed cuts except at 120 h. No measurable differences were found in the genera of microorganisms among samples from the accelerated and conventional methods. TBA values suggested little difference in rancidity between the two processes. Differences between the accelerated and the conventionally processed samples of pork were not enough to merit the preference of pork from one processing technique over the other method.

The conventional method of handling meat involves chilling the carcass at approximately 0°C for 24 h after dressing. After the chill period, the carcass is normally shipped to its destination or fabricated into primal cuts. It has been suggested that rapid chilling of the carcass results in shortening of muscle fibers, which decreases the tenderness of meat (6, 8, 9). This phenomenon has been termed "cold shortening."

Accelerated processing differs from conventional processing in that the carcass is fabricated into retail cuts before chilling. The ambient temperature at which the carcass is fabricated is 20-25°C. The length of time that the carcass is held at ambient temperature is usually 4-16 h, and depends upon the species and processing method. Some researchers have conducted studies in which the carcass was held at 20°C for 6, 8, or 10 h (7). After this holding period, the retail cuts are then chilled at -1 to +1°C. Since the carcass has undergone rigor mortis before chilling, the effects of "cold shortening" are reduced.

The advantages of accelerated processing of meat over the conventional method of processing have been previously elucidated (5). One of the greatest advantages of the former method is that processing costs may be reduced. Conventional methods of processing require from 2 days to 2 weeks before the finished products reach the retailer. Another potential advantage of accelerated processing is that removing excess fat and bone before chilling would conserve cooler space (6). Since the carcass is subdivided before chilling, refrigeration time can be decreased (6). Reduction of transportation costs by removal of excess fat and bone before shipping is another advantage of accelerated processing and this excess waste can be processed at a central location. In addition to those previously mentioned advantages, meat processed by the accelerated method, if handled properly, is equal in tenderness to the conventionally processed meat (6).

One of the major limitations of accelerated processing is the potential for increased microbial proliferation on the meat surface, thus increasing the likelihood of spoilage or contamination by pathogenic organisms. Very little research has been conducted to determine the size and taxonomy of the microbial population of meat processed by the accelerated method. This investigation was designed to study the feasibility of accelerated processing of the porcine carcass as a feasible alternative to conventional processing. The processing of porcine carcasses to wholesale cuts and/or a finished product before initial chilling has been shown to have various applications in the meat industry.

MATERIALS AND METHODS

Five market hogs from East Texas State University were sacrificed, skinned and otherwise slaughtered conventionally. The left side of the carcass was consistently selected for conventional processing, whereas the right side of the carcass was selected for accelerated processing. The conventionally processed side of the carcass went immediately into refrigerated storage (1°C) after slaughter and dressing. The accelerated-processed side of the carcass was held at room temperature (20-25°C) for 4 h and subsequently fabricated into loin roasts, boneless Boston butt roasts, and ground pork before being packaged in
polyvinyl chloride film and placed in refrigerated storage (1 C). After 24 h of storage at 1 C, the conventionally processed sides were fabricated into the same cuts as the accelerated-processed sides and returned to storage at 1 C. Unseasoned pork was used instead of sausage so that seasonings would not influence the flavor characteristics.

The quantitative and qualitative characteristics which were determined included microbial load, microbial taxonomy, color, overall appearance and rancidity. Color and overall appearance were subjectively evaluated by three raters. Flavor, juiciness and tenderness scores were determined by four trained sensory panel members. Statistical analyses included analysis of variance - both one-way and two-way analysis, correlation and regression analysis and mean separation. All statistical evaluations were done by a CDC Omega 480 unit using procedures available on the SPSS package (J).

**Bacterial characteristics**

The procedure for determining microbial load involved the swab technique and blending and dilution of ground samples. Taxonomy was determined by using procedures of Buchanan and Gibbons (2) and the USDA (19) as guidelines. Sampling for microbial growth was conducted at 0, 4, 24, 48, and 120 h postmortem. Sampling locations were on the dorsal portions of the skinned loin, Boston butt and picnic area of the carcass before fabrication. After fabrication, sampling locations on the loin and Boston butt were adjacent to previous locations, and ground pork samples were randomly taken. The initial isolation and dilution procedure were performed identically for each cut and sampling time, except for ground pork.

**Initial isolation and dilution procedure**

Samples of meat were swabbed aseptically within a specified 12.9-cm² area of the sterile swabbing templates. The samples were then diluted and plated according to standard dilution and plating procedures (5) and plates were incubated for 48 h at 25 C. The ground pork samples were prepared by placing 20 g of ground pork in a sterile blender and adding 180 ml of sterile distilled water. The ground pork was blended for 5 min then diluted and plated according to standard dilution and plating procedures (5).

**Procedure for isolation of microorganisms**

Following enumeration of microorganisms, plates were allowed to incubate at room temperature for an additional 48 h to facilitate pigment production. Colonies were then differentiated according to pigment, morphology, size and location. The different organisms were then counted and a count, as total organisms on the plate, was recorded and a percentage taken. Each different colony was introduced into various selective broths and then transferred onto three types of media — Violet Red Bile Agar (VRBA) Pseudomonas Isolation Agar (PIA) and Mannitol Salt Agar (MSA). PIA plates were incubated at room temperature for 24-48 h and MSA and VRBA plates were incubated at 37 C for 24 h. Plates were then checked for growth and pure colonies were obtained from isolated colonies.

**Identification procedure**

The pure cultures were transferred to Trypticase Soy Agar (TSA) and incubated at room temperature for 18-24 h. After incubation, a gram stain was conducted on each isolated colony and the results were recorded. Gram-negative organisms were transferred to TSA agar slants and incubated according to standard procedures (J).

An inoculum from the TSA slant was then used to perform additional identification procedures, using API-10 biochemical strips. Special selective media were used for identification of gram-positive microorganisms. Additional tests conducted to confirm preliminary identification included catalase, oxidase, litmus milk, dextrose, nitrate and urease. Microorganisms were keyed by genera.

**Color and overall appearance characteristics**

Color and overall appearance scores of all samples were evaluated by three raters, and rated by use of 8-point rating scales. Evaluation was based on appearance of all exposed muscles and fat. Rating scale nomenclature was as follows: color (8 = very bright red; 1 = gray or green discoloration) and overall appearance (8 = extremely desirable; 1 = extremely undesirable). The scoring times for the accelerated-processed cuts were 4, 24, 48 and 120 h after slaughter, whereas the conventionally processed cuts were evaluated at 24, 48, and 120 h postmortem.

**Organoleptic characteristics**

Four trained panel members that were screened according to performance during training, evaluated samples for flavor, tenderness and juiciness. Flavor, tenderness and juiciness scores were rated according to the following scale: 8 = extremely desirable; 1 = extremely undesirable. A total of 20 samples (10 conventionally processed cuts and 10 accelerated-processed cuts) of loin chops and ground pork were selected and served at random. The longissimus dorsi was the only muscle evaluated from the loin chops. Each sample was broiled until the internal temperature reached approximately 70 C.

**Rancidity characteristics**

The thiobarbituric acid test was used to determine the oxidative rancidity of ground pork and Boston butt samples. Random samples taken from the ground pork and Boston butt blade slices adjacent to the loin were removed for grinding and subsequent random sampling. A total of six samples were used. Samples were stored for approximately 3 months at -20 C. The Spillman-Fox procedure (16) was used to determine oxidative rancidity. This method for determination of oxidative rancidity is similar to the TBA test.

**RESULTS AND DISCUSSION**

**Color and overall appearance**

No significant (P > 0.05) difference in color and overall appearance existed between cuts. Therefore, differences were due to accelerated processing.

One-way analysis of variance was conducted on the differences in color and overall appearance at the various sampling times. The mean and standard deviation values for color of both the accelerated and conventionally processed cuts are found in Table 1. Multiple range testing between accelerated and conventionally processed cuts was not conducted due to a significant interaction between processing method and storage time.

Accelerated-processed samples at 4 h were brighter colored (P < 0.05) than after storage beyond this time. Mean scores for the other time periods were not significantly different. These results confirmed that the fresher cuts were superior in color. Conventionally processed samples at 120 h were less desirably colored (P < 0.05) than at the other time periods, whereas the mean scores for 24 and 48 h were not different (P > 0.05). The lower scores at 120 h were attributed to the fact that the meat was not as fresh as during the early time periods. When color scores for both accelerated and conventionally processed cuts were combined, mean separation indicated that the mean scores at 4 h were higher (P < 0.05) than for other time periods. Mean scores for the other time periods (24, 48 and 120 h) were not significantly different from each other. This observation suggests that storage time may have more effect on color scores than processing method. The mean and standard deviation values for overall appearance of both accelerated and conventionally processed cuts are presented in Table 2.

The pattern for overall appearance scores is similar to that of the color scores except that the convention mean values at all time periods are not different.
TABLE 1. Effects of storage time on muscle color of processed pork.\textsuperscript{a}

<table>
<thead>
<tr>
<th>Processing method</th>
<th>Time (h)</th>
<th>X</th>
<th>S.D.</th>
<th>Accelerated</th>
<th>Conventional</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>6.19\textsuperscript{b}</td>
<td>0.377</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>5.69\textsuperscript{c}</td>
<td>0.295</td>
<td>6.17\textsuperscript{b}</td>
<td>0.183</td>
</tr>
<tr>
<td></td>
<td>48</td>
<td>5.69\textsuperscript{c}</td>
<td>0.388</td>
<td>5.96\textsuperscript{b}</td>
<td>0.305</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>5.48\textsuperscript{c}</td>
<td>0.377</td>
<td>5.63\textsuperscript{c}</td>
<td>0.351</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Means are based on an 8-point scale (8 = extremely desirable; 1 = extremely undesirable).
\textsuperscript{b,c}Means in the same column bearing a common superscript letter are not different (P > 0.05).

TABLE 2. Effects of storage time on overall appearance of processed pork.\textsuperscript{a}

<table>
<thead>
<tr>
<th>Processing method</th>
<th>Time (h)</th>
<th>X</th>
<th>S.D.</th>
<th>Accelerated</th>
<th>Conventional</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>6.22\textsuperscript{b}</td>
<td>0.441</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>5.82\textsuperscript{c}</td>
<td>0.305</td>
<td>6.22\textsuperscript{b}</td>
<td>0.404</td>
</tr>
<tr>
<td></td>
<td>48</td>
<td>5.84\textsuperscript{c}</td>
<td>0.396</td>
<td>6.22\textsuperscript{b}</td>
<td>0.349</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>5.70\textsuperscript{c}</td>
<td>0.423</td>
<td>5.96\textsuperscript{b}</td>
<td>0.309</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Means are based on an 8-point scale (8 = extremely desirable; 1 = extremely undesirable).
\textsuperscript{b,c}Means in the same column bearing a common superscript letter are not different (P > 0.05).

Like the color scores, the overall appearance scores at 4 h are higher (P < 0.05) than after storage. The reason for this may be that at 4 h, the cuts were fresher than at the other time periods. However, mean values at 120 h are numerically lower than for other times. This observation was attributed to reduced freshness at 120 h due to increased dehydration of oxidation.

Organoleptic characteristics

Taste panel data obtained from evaluation of loin roasts and ground pork (Table 3) revealed that no differences (P > 0.05) in tenderness, flavor and juiciness between the two fabrication processes existed. Statistical analysis for determination of differences in tenderness, flavor and juiciness between the loin roasts and ground pork (data not shown) revealed no differences (P > 0.05) between the cuts.

Microbial characteristics

One-way analysis of variance was conducted on the differences in microbial load at various sampling times. At 0-h postmortem for the accelerated side and 0 and 4 h for conventional side, microbial sampling was not used in the statistical evaluation because the data were reduced so that each sample had a value for color, overall appearance and microbial load. Mean values for microbial load of accelerated and conventionally processed cuts are found in Table 4. Mean separation was conducted among the accelerated-processed cuts and among the conventionally processed cuts; however, mean separation between accelerated and conventionally processed cuts was not conducted because there was a significant (P < 0.05) interaction between the two treatments.

At 120 h, the microbial load was higher (P < 0.05) than at the other times for both the accelerated and conventionally processed cuts. This result was attributed to increased storage time permitting additional proliferation of the microbial flora population. These data suggest that storage time has more influence on microbial flora proliferation than processing method.

Results of the taxonomy of the microorganisms isolated from the meat samples are in Table 5. Staphylococcus represented the largest percentage of microorganisms isolated. Other major genera present were Pseudomonas, Neisseria and Bacillus. Miscellaneous microorganisms that were isolated included Acinetobacter, Alcaligenes, Enterobacter, Escherichia coli, Microoccus, Klebsiella, Shigella and yeast.

According to Marriott et al. (11), it is not unusual to have a high percentage of Staphylococcus organisms on meat surfaces. These workers have also found that Pseudomonas microorganisms begin increasing in percentage as temperature decreases. This result is attributed to the psychrotrophic nature of Pseudomonas. Although Neisseria and Bacillus organisms are mesophilic, they are found on meat surfaces due to their ability to withstand temperature fluctuation.

Correlation evaluation

Table 6 presents the correlation coefficients among three variables for all cuts of both accelerated and conventionally processed pork to show the relationship between color, overall appearance and microbial load. Color was highly correlated with overall appearance for both the accelerated and conventionally processed cuts.
This relationship is to be expected because as color deteriorates, overall appearance declines. There were also negative correlations between color and microbial load. As microbial flora proliferated, their use of oxygen on the meat surface and excretion of by-products of metabolism increased color degradation. The same is true for overall appearance, whereas when microbial load increased, overall appearance deteriorated. Variation of tenderness, flavor and juiciness scores was so small that meaningful correlations could not be developed. To determine the relationship between microbial load and color and overall appearance, regression analysis was performed to develop a prediction equation for conventionally processed pork:

\[ Y' = a + b_1 x_1 + b_2 x_2 \]

where

- \( y = \) microbial load,
- \( a = \) intercept coefficient = 10.767,
- \( b_1 = \) color coefficient = 0.530,
- \( b_2 = \) overall appearance coefficient = 0.182.

A prediction equation for the accelerated-processed regression analysis was

\[ Y = a + b_1 x_1 + b_2 x_2 \]

where

- \( a = \) intercept coefficient = 7.889,
- \( b_1 = \) color coefficient = 0.136,
- \( b_2 = \) overall appearance coefficient = 0.078.

The multiple Rs for the accelerated-processed side for color and overall appearance were not significant. This suggests that other variables that were not measured also contributed to the change in microbial load. The multiple R for the conventional side for overall appearance was also insignificant (\( P > 0.05 \)). However, the multiple R for the conventional side for color was significant. Thus, 16.7% of the variation in microbial load can be attributed to changes in color scores.

### Rancidity

The results of the TBA tests (Table 7) revealed that the TBA values were all numerically close. Tarladgis et al. (18) found a TBA number of 0.1-0.2 to be the threshold for oxidized odor detection with the distillation method. These samples were within this threshold range. This result may be due to the frozen samples being stored for approximately 60 days. These data suggest that accelerated processing had no consistent effect on development of oxidative rancidity.

### CONCLUSIONS

Results of this study suggested the following conclusions:

1. Conventionally processed cuts were slightly superior in color and overall appearance to the accelerated processed cuts until 120-h postmortem.

2. No difference (\( P > 0.05 \)) in tenderness, juiciness and flavor scores existed between the accelerated and conventionally processed cuts.

3. No significant differences in microbial load may be anticipated between the two fabrication processes after 120 h of storage; however, the accelerated-processed cuts had a higher microbial load than the conventionally processed cuts before 120 h.

4. The microbial population of the accelerated-processed samples does not pose a public health threat at 120 h because no significant difference in microbial load or noticeable difference in the microbial population existed between the two fabrication methods.

5. TBA values reveal that there was little difference in rancidity between the two fabrication processes.

6. From a consumer standpoint, there was not enough difference between the accelerated-processed cuts and the conventionally processed samples of pork to merit preference of meat from one processing technique over the other method.

### REFERENCES


**TABLE 5. Microbial taxonomy of processed pork.**

<table>
<thead>
<tr>
<th>Microorganisms</th>
<th>Percentage 0 h</th>
<th>4 h</th>
<th>24 h</th>
<th>48 h</th>
<th>120 h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staphylococcus</td>
<td>66</td>
<td>88</td>
<td>75</td>
<td>88</td>
<td>66</td>
</tr>
<tr>
<td>Pseudomonas</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Neisseria</td>
<td>10</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bacillus</td>
<td>24</td>
<td>4</td>
<td>0</td>
<td>12</td>
<td>32</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>0</td>
<td>2</td>
<td>11</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

**TABLE 6. Correlation coefficients between color, overall appearance, and microbial load.**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Overall appearance</th>
<th>Microbial load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>0.710</td>
<td>-0.191</td>
</tr>
<tr>
<td>Overall appearance</td>
<td>-0.174</td>
<td>-0.174</td>
</tr>
<tr>
<td>Microbial load</td>
<td>-0.174</td>
<td>-0.174</td>
</tr>
</tbody>
</table>

**TABLE 7. Mean values from thiobarbituric acid analysis.**

<table>
<thead>
<tr>
<th>Cut</th>
<th>Processing method</th>
<th>TBA value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boston butt</td>
<td>Accelerated</td>
<td>0.134</td>
</tr>
<tr>
<td>Boston butt</td>
<td>Conventional</td>
<td>0.133</td>
</tr>
<tr>
<td>Ground pork</td>
<td>Accelerated</td>
<td>0.281</td>
</tr>
<tr>
<td>Ground pork</td>
<td>Conventional</td>
<td>0.181</td>
</tr>
</tbody>
</table>

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Figure 2. Neutral sugar profile of the hemicellulose (Hemi) extract in corn bran. Ara = arabinose; Xyl = xylose; Mn = mannose; Ga = galactose; Glu = glucose.

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REFERENCES


Marriott, Poetker, Garcia, and Lee, con't from p. 759