Effects of Electrical Stimulation and Kidney-Pelvic Fat Removal Before Chilling on Microbial Quality of Beef Tenderloins

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ABSTRACT

Twenty-four steers (435-567 kg) were used to study the effects of electrical stimulation (50 V for 120 s) and of kidney-pelvic fat removal before chilling (3-4°C) on microbial populations of beef tenderloins on days 1, 4, and 7 post-mortem. Kidney-pelvic fat was stripped from one side of each carcass; the other side remained intact for later fat removal. On each respective chill-day, kidney-pelvic fat was aseptically removed from intact sides, tenderloins were swabbed at two anatomically referenced locations (3rd and 5th lumbar vertebra) and microbial load was determined. The statistical model for data analysis included the effects of electrical stimulation, chill-day, animal within chill-day X stimulation, fat removal, location, and all main effect interactions. Removal of kidney-pelvic fat before chilling resulted in a significantly higher bacterial load on the surface of exposed tenderloins after 24 h of chill. Electrical stimulation produced significantly lower bacterial counts for fat-intact surfaces on chill-day 7 and for fat-removed surfaces on chill-day 4. Kidney-pelvic fat removal allowed for significantly higher bacterial counts on the tail portion of tenderloins (3rd lumbar vertebra) for surfaces from non-stimulated carcasses than the butt portion (5th lumbar vertebra). Mean bacterial counts from electrically stimulated carcasses at the fifth and third lumbar vertebra locations did not differ (P > 0.10) between fat treatments.

To further improve the efficiency of the boxed beef merchandising systems, removal of kidney, pelvic, and heart fat (KPH) from beef carcasses during slaughter has been proposed as a change in the USDA regulations (3). Such a proposal would eliminate KPH fat content as a factor in beef yield grading. Packers would be permitted to present beef carcasses for grading with KPH fat intact. An important factor to be evaluated is the possibility of an increased bacterial load by the removal of kidney-pelvic fat during the slaughter process and the added exposure to the tenderloin surface during chilling and processing. Application of electrical current to beef carcasses has proven beneficial to many quality characteristics, including microbial quality. Raccach and Henrickson (13) showed that electrical stimulation (ES) of beef carcasses for 15 min extended the lag growth phase of psychrotrophic bacteria population by 2 d. Researchers have suggested the alteration of growth and/or number of bacteria due to ES might be influenced by rapid pH decline (7,11), impairment of bacterial cells (4,14), or actual destruction by proteolytic enzymes (2). Other researchers have found ES to have no influence on the incidence or growth of bacteria (4,8). The objectives of this study were to determine whether kidney-pelvic fat removal before chilling increases surface microbial contamination of beef tenderloins and to determine whether ES affected the microbial load on beef tenderloins.

MATERIALS AND METHODS

Twenty-four crossbred steers (437-567 kg) were randomly divided into groups of six, with each group slaughtered on a separate day. Each slaughter group of six cattle was further randomly divided into electrically stimulated and non-stimulated treatment groups, each with three cattle. On each of the four slaughter days, six cattle were slaughtered in the conventional manner. Immediately following stunning and exsanguination, electrically stimulated carcasses received approximately 50 V of electrical current from the Double "J" "Electro-Stim" unit for 120 s at a pulsation time of 1 s.

Carcasses were split and one side of each carcass was stripped to less than 1% kidney and pelvic fat, resulting in a KP-removed and KP-intact side for each carcass. Beef carcasses were chilled at 3-4°C and randomly chosen for analysis at 1, 4, and 7 d post-mortem.

On chill days 1, 4, and 7, microbial analysis was conducted using the swab method described by Kotula (6) to obtain sur-
face microbial counts. Kidney-pelvic fat was aseptically removed from intact side. A 12-cm² area of tenderloins surface, both fat-intact and fat-removed, was swabbed at two locations referenced anatomically to the fifth lumbar vertebra and the third lumbar vertebra to correspond to the butt and tail portions of the tenderloin. Swabs were placed in 10 ml of 0.1% peptone, packed in ice, and transported to the laboratory for analysis. Four-fold serial dilutions were made in duplicate for each sample using dilution blanks and pipettes. Plates were prepared with sterile plate count agar (Difco) and incubated at 32°C for 48 h. Plates containing between 30 to 300 colonies were counted as the best estimate of surface microbial load. All counts were converted to log₁₀ values before statistical analysis.

All data were subjected to analysis of variance techniques (17). The statistical model included the main effects of stimulation, chill day, animal within (chill-day × stimulation), fat treatment, location, and all possible interactions. Animal (chill-day × stimulation) was a random effect and used as the error term for testing chill-day and stimulation effects.

RESULTS AND DISCUSSION

The least square means for bacterial counts of chill-day × fat treatment interaction are shown in Table 1. On chill-day 1, the log₁₀ mean bacterial count of .39 for KP-fat-intact surfaces was significantly lower than fat removal surface mean count of 1.08. An opposite response was noted on chill-day 7, with fat-removed surfaces having the significantly lower mean count of .92 versus 1.43 for fat-intact surfaces. No significant difference existed on chill-day 4 between KP fat-intact and fat-removed surface counts with mean counts of .90 and 1.01, respectively. Mean bacterial counts for fat-intact surfaces increased (P<.05) over chill-days 1, 4, and 7, while no difference (P>.10) was found in bacterial counts over chill-days 1, 4, and 7 for fat-removal tenderloin surfaces.

Removal of KP fat before chilling resulted in a higher bacterial load on the surface of exposed tenderloins after 24 h of chill (chill-day 1) compared to tenderloins surfaces with KP fat left intact during chilling. This higher bacterial load could possibly be due to added exposure of the lean surface to atmospheric and environmental contamination. Carcasses with kidney-pelvic fat removed before chilling and processed after a 24-h chill would have a higher initial bacterial count on the wholesale tenderloin than those with KP fat left intact during chilling. Reagan et al. (15) emphasized the importance of a low initial bacterial count on retail cuts to assure higher muscle color scores, increased shelf-life, and ultimate consumer acceptability.

Carcasses chilled and aged for various periods of time present different results. No difference was found on chill-day 4 in the bacterial counts from tenderloin surface with KP fat intact or removed. Carcasses chilled for 7 days had a higher bacterial load on tenderloin surfaces when KP fat was left intact as compared to those with kidney-pelvic fat removed before chilling. The increase in bacterial counts over chill-day 1, 4, and 7 for fat-intact surfaces suggests that the bacteria displayed a short lag phase of growth. The tenderloin surfaces with KP fat re-

TABLE 1. Least squares means for bacterial countsd of chill-day × fat treatment interaction.

<table>
<thead>
<tr>
<th>Fat treatment</th>
<th>Post-mortem chill-day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Intact</td>
<td>.39b</td>
</tr>
<tr>
<td>Removed</td>
<td>1.08</td>
</tr>
</tbody>
</table>

NS = Not significant.

Significance of difference

<table>
<thead>
<tr>
<th>Fat treatment</th>
<th>4</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intact</td>
<td>.89</td>
<td>.97</td>
</tr>
<tr>
<td>Removed</td>
<td>.91</td>
<td>1.89</td>
</tr>
</tbody>
</table>

Significance of difference

<table>
<thead>
<tr>
<th>Fat treatment</th>
<th>4</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intact</td>
<td>.54</td>
<td>.94</td>
</tr>
<tr>
<td>Removed</td>
<td>.24</td>
<td>.85</td>
</tr>
</tbody>
</table>

TABLE 2. Least squares means for bacterial countsd of chill-day × stimulation × fat treatment interaction.

<table>
<thead>
<tr>
<th>Chill-day</th>
<th>Stimulationb</th>
<th>Intact</th>
<th>Removed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ES</td>
<td>.54d</td>
<td>1.23e</td>
</tr>
<tr>
<td></td>
<td>NES</td>
<td>.24d</td>
<td>.94e</td>
</tr>
<tr>
<td>Significance of difference</td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>ES</td>
<td>.89</td>
<td>.54</td>
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<td></td>
<td>NES</td>
<td>.91</td>
<td>1.47</td>
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<tr>
<td>Significance of difference</td>
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<td>P&lt;.005</td>
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<tr>
<td>7</td>
<td>ES</td>
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<td></td>
<td>NES</td>
<td>1.89d</td>
<td>.85e</td>
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<tr>
<td>Significance of difference</td>
<td>P&lt;.005</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>

aLog₁₀ bacterial count per cm² of surface area.
bStimulation treatment: ES (Electrically stimulated), NES (Non-Stimulated).
cProbability that the difference between fat treatments was significant. P>.10 reported as non-significant (NS).
dMeans in the same row bearing different superscripts differ (P<.05).
TABLE 3. Least squares means for bacterial counts<sup>a</sup> of stimulation × fat treatment × location interaction.

<table>
<thead>
<tr>
<th>Chill-day</th>
<th>Stimulation&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Fat treatment</th>
<th>Intact</th>
<th>Removed</th>
</tr>
</thead>
<tbody>
<tr>
<td>5th Lumbar&lt;sup&gt;c&lt;/sup&gt;</td>
<td>ES</td>
<td>.58</td>
<td>.90</td>
<td></td>
</tr>
<tr>
<td>3rd Lumbar&lt;sup&gt;c&lt;/sup&gt;</td>
<td>ES</td>
<td>1.02</td>
<td>.94</td>
<td></td>
</tr>
<tr>
<td>Significance of difference&lt;sup&gt;d&lt;/sup&gt;</td>
<td>NS</td>
<td>NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5th Lumbar vertebral</td>
<td>NES</td>
<td>1.19&lt;sup&gt;d&lt;/sup&gt;</td>
<td>.79&lt;sup&gt;e&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>3rd Lumbar vertebral</td>
<td>NES</td>
<td>.83&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1.38&lt;sup&gt;e&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Significance of difference</td>
<td>NS</td>
<td>P&lt;.0274</td>
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<td></td>
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</tbody>
</table>

<sup>a</sup>Log<sub>10</sub> bacterial count per cm<sup>2</sup> of surface area.

<sup>b</sup>Stimulation Treatment: ES (Electrically stimulated), NES (Non-Stimulated).

<sup>c</sup>5th Lumbar vertebral refers to butt portion of tenderloin. 3rd lumbar vertebral refers to tail portion of tenderloin.

<sup>d</sup>Means in the same row bearing different superscripts differ (p<.05).

<sup>e</sup>Probability that the difference between stimulation treatments was significant. P>.10 reported as non-significant (NS).

On chill-day 1, electrically stimulated and non-stimulated carcasses with KP fat-intact had tenderloin surface mean bacterial counts that were significantly lower than fat-removed surface counts. The log<sub>10</sub> mean count of 0.54 for electrically stimulated surfaces of the fat-intact treatment was significantly lower than the fat-removed log<sub>10</sub> mean count of 1.23. Non-stimulated treatment log<sub>10</sub> mean count for fat-intact surfaces was 0.24, significantly lower than 0.94, the mean count for fat-removed surfaces. No difference (P>.10) was found between stimulation treatment for fat-intact or fat-removed surfaces.

On chill-day 4, removal of fat had no effect on bacterial counts irrespective of electrical stimulation. Bacterial counts on fat-intact tenderloins from electrically stimulated (0.89) and non-stimulated (0.91) carcasses did not differ significantly. Counts from electrically stimulated fat-removed surfaces were significantly lower (P<.005) with a log<sub>10</sub> mean count of 0.54 versus a mean count of 1.47 for non-stimulated carcasses with fat removed.

On chill-day 7, non-stimulated carcasses with kidney-pelvic fat removed had a significantly lower mean log<sub>10</sub> surface bacterial count of 0.85 versus a mean count of 1.89 for fat-intact surfaces. Surface bacterial counts from electrically stimulated carcasses did not differ (P>.10). Electrically stimulated, fat-intact surface log<sub>10</sub> mean count of 0.97 was lower (P<.005) than non-stimulated fat-intact surface mean count of 1.89, while no difference was found for fat-removed surface counts between electrically stimulated and non-stimulated treatments, 0.99 and 0.85, respectively.

These data suggest that for tenderloin surfaces with kidney fat present, bacterial counts increase at a more rapid rate for non-stimulated carcasses. These bacteria may possibly have entered the logarithmic phase of growth much sooner than those bacteria on electrically stimulated carcasses, or the lag phase may have been extended for bacteria on tenderloin surfaces from electrically stimulated carcasses. Raccach and Henrickson (13) reported that electrical stimulation of beef carcasses caused the lag phase of the psychrotrophic bacterial population to increase by 2 d. Riley et al. (16) found a lower bacterial count on meat from electrically stimulated carcasses versus non-stimulated ones. They attributed the occurrence to the negative effect electrical stimulation had on either the viability of bacterial cells or on the meat as a growth medium by fast reduction in pH value.

No trend was observed in the rate of bacterial growth on surfaces from which fat has been removed. The variability shown in these counts may have been a result of excessive contamination during slaughter and chilling on the fat-removed surface of tenderloins.

Bacterial mean counts from electrically stimulated carcasses at the fifth and third lumbar vertebral locations did not differ (P>.10) between fat treatments (Table 3). At the fifth lumbar vertebral, non-stimulated fat-intact surfaces had a slightly higher log<sub>10</sub> mean bacterial count of 1.19 compared to 0.79, while an opposite response was noted at the third lumbar vertebral. Non-stimulated fat-intact surfaces had a significantly lower log<sub>10</sub> bacterial count of 0.83 versus 1.38 for non-stimulated fat-removed surfaces. Electrical stimulation produced a lower (P<.022) mean bacterial count of 0.58 for fat-intact surfaces when compared to the non-stimulated, fat-intact mean bacterial count of 1.19.

It was hypothesized at the onset of this study, that if fat removal from the tenderloin surface before chilling should cause a higher microbial load, there possibly would be more contamination on the tail portion of the tenderloin than on the butt portion. More exposure to possible contamination was thought to be a probable causative factor. The protected fat-intact surfaces showed no difference in location for both stimulation treatments. Also, no difference was observed between locations for fat removed surfaces of electrically stimulated carcasses, possibly due to stimulation benefits. However, these were higher bacterial counts on the tail position (3rd lumbar vertebral) for surfaces from non-stimulated carcasses than the butt portion (5th lumbar vertebral).

It can be concluded that no one main effect acted independently to significantly change the surface bacterial load of beef tenderloins. Bacterial counts obtained in this study were lower than those obtained by Nottingham (12), who concluded that under good hygienic conditions, external aerobic surface bacterial counts of beef carcasses should be between 10<sup>2</sup> and 10<sup>4</sup> organisms per cm<sup>2</sup>. However, Ingram and Roberts (5) reported that counts would be lower in the body cavity than on the external surface of carcasses. Nonetheless, with such low bacterial counts, the removal of kidney-pelvic fat before chilling resulted in no substantial contamination problems for beef tenderloins through 7 d of chilling.
REFERENCES


Rayman et al., con't. from p. 88

REFERENCES


Jeremiah, con't. from p. 109


