Dry-Aging Effects on Palatability of Beef Longissimus Muscle

R.E. Campbell, M.C. Hunt, P. Levis, E. Chambers IV

ABSTRACT: Beef strip loins and short loins were vacuum aged for 7 or 14 d, then these cuts were dry aged for 7, 14, or 21 d. At 2, 9, and 16 d of post-dry-aging vacuum storage, strip steaks were analyzed for sensory, physical, and microbial differences. Controls were vacuum aged for 14 d. Dry aging for 14 and 21 d produced steaks with greater (P < 0.05) dry-aged flavor, tenderness, and juiciness than controls or steaks dry aged for 7 d. Shear forces were lower (P < 0.05) for steaks dry aged for 21 d. Time of vacuum storage before and after dry aging had minimal effects on development of dry-aged flavor attributes.

Key Words: beef, dry aging, flavor, palatability, sensory
starting at the anterior end of the strip loin. Strip loins were repackaged for storage (9 and 16 d at 2 °C) after dry aging. After cutting, the steaks were wrapped in waxed freezer paper, stored overnight, and then evaluated for sensory and physical traits.

### Steak Cookery and Sensory Analysis

Steaks were cooked at 350 °C on an electric grill (No. 8-44; Wells Powerline, Shelbyville, Ind., U.S.A.) for 4 min, then turned, and cooked for an additional 4 min. Steaks then were turned every 2 min until they reached 63 °C (medium rare). Cooking times ranged from 11 to 15 min. Internal steak temperature was measured using a hypodermic probe thermometer (Model 4201, Canton, Mass., U.S.A.) attached to a 25-kg load cell using a Warner-Bratzler shear attachment on an Instron system (Optimas, ver 5.2; Seattle, Wash., U.S.A.).

Cooked steaks were held at 20 °C for approximately 2 min and trimmed so that the center portion of the loin eye (no epimysium muscle) was served to the sensory panel. This center portion was cut into 1 × 1 × 2.5 cm pieces perpendicular to the surfaces that had been on the grill. Four of these pieces were placed randomly into each of 6 plastic cups labeled with the 3-digit code for that steak. Samples were kept warm by placing the cups on tiles preheated to 121 °C and presented to the sensory panel within 3 min of cutting.

The descriptive sensory analysis was conducted at the Sensory Analysis Center at Kansas State Univ. The facility had lighting, temperature, humidity, and noise controls, and the round-table panel room was designed according to the guidelines established by ASTM (1986). The panel was composed of 6 highly trained panelists employed by the Sensory Analysis Center. Each panelist had more than 120 h of intensive training in descriptive sensory principles and method and more than 1000 h of experience in food evaluation. During the orientation period (12 h over 2 wk), panelists as a group defined and then trained to determine 8 parameters (Table 1). Panelists rated each parameter on a 15-point scale and a control that had been wet aged for 14 d, were provided to the panelists to act as anchor points. Additionally, 2 control steaks were served in random order with the aging treatments at each panel session.

### Microbial Analyses

Before strips were cut into steaks, 2 circular samples (2.54 cm in dia and 2 mm in thickness), 1 each from the fat and lean surfaces, were removed aseptically for microbial testing. Both samples from each loin were placed in a sterile stomacher bag with 100 mL sterile peptone water and stomached for 1 min, diluted as necessary, and plated to determine aerobic plate counts, lactic-acid organisms, and *Pseudomonas* spp. (Vanderzant and Splittstoesser 1992).

### Physical Analyses

A 2nd steak from each treatment combination was cooked using procedures described previously. Steaks were weighed before and after cooking, and the percentage of cooking loss was calculated. Length, width, and thickness (at 3 points) also were recorded before and after cooking. Prior to cooking and immediately after, tracings were made of the steaks. The area of each tracing was determined with a video image analysis system (Optimas, ver 5.2; Seattle, Wash., U.S.A.).

To provide an instrumental measurement of tenderness, 6 to 8 cores (1.27 cm in dia) were removed parallel to muscle fibers from each steak 3 h after cooking. Each core was sheared once perpendicular to the fiber direction using a Warner-Bratzler shear attachment on an Instron (Model 4201, Canton, Mass., U.S.A.) with a 25-kg load cell and a cross-head speed of 250 mm/min. Peak force and total energy were averaged for all the cores from each steak.

### Statistical Analyses

The experimental design was 3 replications of a 2 × 3 (vacuum-aging x dry-aging durations) factorial with a split plot on vacuum time post-dry-aging and for sensory data a 2nd split on panelist, with independent controls. There were 3 strip loins in each cell for each replication of the experiment. Using the GLM procedure of SAS (1994), when the model showed significant ($P < 0.05$) treatment differences, mean separation procedures were carried out using the LSD option (SAS 1994).

---

**Table 1—Definitions for sensory evaluation of dry-aged steaks**

<table>
<thead>
<tr>
<th>Sensory Parameter</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Overall aged-beef flavor intensity</td>
<td>A full, blended and sustained, cooked beef flavor that has fewer dominating individual flavor notes. This creates a smooth, balanced impression. Reference: Grilled beef cube steak = 12.0 (grilled until internal temp = 77 °C)</td>
</tr>
<tr>
<td>2. Beef flavor intensity</td>
<td>Amount of beef flavor identity in the sample. Reference: Grilled beef cube steak = 12.0 (grilled until internal temp = 77 °C)</td>
</tr>
<tr>
<td>3. Brown/roasted flavor intensity</td>
<td>A round, full, dark, caramelized aromatic generally associated with beef that has been cooked with dry heat. Measured at its highest point during the initial 10 chews. Reference: Grilled beef cube steak = 10.5 (grilled until internal temp = 77 °C)</td>
</tr>
<tr>
<td>5. Metallic flavor intensity</td>
<td>The impression of a slightly oxidized metal such as iron, copper, and silver spoons. Reference: Dole canned pineapple juice, unsweetened = 6.0</td>
</tr>
<tr>
<td>6. Astringent sensation intensity</td>
<td>The dry puckering mouth feel associated with putting an alum solution in the mouth. References: 0.5% alum solution = 2.5, 0.7% alum solution = 3.5</td>
</tr>
<tr>
<td>7. Tenderness</td>
<td>Ease with which the sample can be cut through with molars on 1st bite. Reference: Sara Lee sliced roast beef = 10.0</td>
</tr>
<tr>
<td>8. Juiciness</td>
<td>The amount of liquid expressed from the sample during the 1st and 2nd chews. Reference: Sara Lee sliced roast beef = 9.0</td>
</tr>
</tbody>
</table>
Dry Aging of Beef . . .

Table 2—Means of sensory scores for flavor traits after dry aging and after vacuum storage following dry aging

<table>
<thead>
<tr>
<th>Dry aging, d</th>
<th>Aged flavor*</th>
<th>Beef flavor*</th>
<th>Brown roasted*</th>
<th>Bloody/Serumy*</th>
<th>Metallic*</th>
<th>Astringent*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (controls)</td>
<td>9.7d</td>
<td>11.4c</td>
<td>10.4d</td>
<td>4.8d</td>
<td>4.9g</td>
<td>3.0</td>
</tr>
<tr>
<td>7</td>
<td>9.7d</td>
<td>11.3c</td>
<td>10.3d</td>
<td>4.9g</td>
<td>4.9g</td>
<td>3.0</td>
</tr>
<tr>
<td>14</td>
<td>10.6d</td>
<td>11.5b</td>
<td>10.6b</td>
<td>4.7c</td>
<td>4.8g</td>
<td>3.0</td>
</tr>
<tr>
<td>21</td>
<td>10.1c</td>
<td>11.5b</td>
<td>10.5c</td>
<td>4.8bc</td>
<td>4.8c</td>
<td>3.0</td>
</tr>
<tr>
<td>LSD</td>
<td>0.25</td>
<td>0.13</td>
<td>0.14</td>
<td>0.13</td>
<td>0.13</td>
<td>0.09</td>
</tr>
</tbody>
</table>

Vacuum storage after dry aging, d

<table>
<thead>
<tr>
<th></th>
<th>Aged flavor*</th>
<th>Beef flavor*</th>
<th>Brown roasted*</th>
<th>Bloody/Serumy*</th>
<th>Metallic*</th>
<th>Astringent*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (controls)</td>
<td>9.7d</td>
<td>10.4c</td>
<td>10.4c</td>
<td>4.8c</td>
<td>4.9</td>
<td>3.0</td>
</tr>
<tr>
<td>2</td>
<td>9.8d</td>
<td>11.4c</td>
<td>10.3d</td>
<td>5.0b</td>
<td>4.9</td>
<td>3.0</td>
</tr>
<tr>
<td>9</td>
<td>10.5c</td>
<td>11.6b</td>
<td>10.6c</td>
<td>4.8</td>
<td>4.8</td>
<td>3.0</td>
</tr>
<tr>
<td>16</td>
<td>10.0c</td>
<td>11.5bc</td>
<td>10.5c</td>
<td>4.8c</td>
<td>4.8</td>
<td>3.0</td>
</tr>
<tr>
<td>LSD</td>
<td>0.25</td>
<td>0.13</td>
<td>0.14</td>
<td>0.13</td>
<td>0.13</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Dry Aging

Dry-aging time had significant effects on all sensory attributes, except for astringent (Table 2). Dry aging for 14 or 21 d increased (P < 0.05) dry-aged flavor compared to 7 d of dry aging and no dry aging (control), which were similar (P > 0.05). This agrees with Diles and others (1994), Hodges and others (1974), and Warren and Kastner (1992), who reported dry aging produced desirable flavor changes. However, Davis and others (1975), Minks and Stringer (1972), and Savell and others (1978) found no differences or a decrease in palatability attributes, other than tenderness, during vacuum aging. This may have been because of the marbling levels of the product studied. Hodges and others (1974) indicated high-quality grade product (USDA Choice) improved in flavor attributes, whereas lower quality grade product (USDA Good) did not. In the present study, strip steaks from product aged 21 d had less (P < 0.05) overall dry-aged flavor than steaks from product aged 14 d. However, the 21-d dry-aged product had the lumbar vertebra attached, so the lower flavor level may have been because of the reduced lean surface area exposed to air.

Beef flavor and the brown roasted aromatics followed the trend observed with overall aged flavor; steaks dry aged for 14 and 21 d generally had higher (P < 0.05) levels of these flavor attributes, while the controls and the steaks dry aged for 7 d had lower scores (Table 2). For flavor attributes considered negative (bloody/serumy and metallic), the 14-d dry-aged products had lower (P < 0.05) scores than the 7-d dry-aged steaks, and the 21-d dry-aged steaks were similar to the 14-d dry-aged steaks. Astringent flavor was not affected (P > 0.05) by aging treatments. In general, these results agree with those of Warren and Kastner (1992).

Tenderness was lowest (P < 0.05) for the control steaks (14-d vacuum aged), and dry aging for 7 and 14 d significantly increased tenderness over the controls. Dry aging for 21 d produced steaks similar (P > 0.05) in tenderness to steaks dry aged for 14 d. Instron shear force was lower (P < 0.05) for steaks dry aged for 21 d compared to other treatments (Table 3). Controls and 7- and 14-d dry-aged steaks had similar (P > 0.05) shear forces. The continuing improvement in tenderness with aging by either method (vacuum or dry) beyond 14 d contrasts with reports reviewed by Jeremiah (1978) who found no significant improvements in tenderness after 11 or 14 d (Culp and others 1973; Smith and others 1979). The control and 7-d dry-aged products had the lowest (P < 0.05) juiciness scores; steak dry aged for 14 d were intermediate, and steaks dry aged 21 d had the highest (P < 0.05) scores. Savell and others (1978) also reported improved juiciness with aging. Explanations for increased juiciness with age might be that the meat has lost water-holding capacity and thus releases more juices as the meat is chewed, or that the...
Dry Aging of Beef . . .

Vacuum Storage After Dry Aging

Post-drying storage also contributed to aged flavor (Table 2). Generally, flavor peaked for all dry-aged treatments at 9 d of post-drying storage and then decreased at d 16. Beef and brown-roasted flavors peaked at 9 d after drying, although they did not differ statistically from scores for steaks stored for 16 d. Bloody/serumy flavors peaked at 2 d after drying and then decreased (P < 0.05) at 9 and 16 d. Vacuum storage after dry aging did not affect (P > 0.05) metallic or astringent flavors.

Tenderness improved (P < 0.05) during post-drying storage (Table 3). Steaks stored for 9 and 16 d after dry aging were most tender; those stored for 2 d were intermediate, and the control steaks were least tender. Juiciness was not affected by post-drying storage, however, at all post-drying times, juiciness was higher (P < 0.05) for all dry-aged steaks than for control steaks. Storage after dry aging had no effects (P > 0.05) on shear force (Table 3); cooking time; and changes in length, thickness, width, and area after cooking (data not shown).

Microbial Growth

Compared to controls, all of the dry-aged steaks had higher (P < 0.05) aerobic plate counts (Table 4). Duration of dry aging did not affect (P > 0.05) aerobic counts. This lack of response to dry-aging time may have been because of growth inhibition caused by surface drying and storage temperatures low enough to retard growth. As expected, counts of anaerobic lactic-acid bacteria increased during storage of vacuum-packaged, dry-aged product (Table 4). At 2 d of storage after dry aging, the counts for all dry-aged strips were lower than those for controls. Counts of other organisms (aerobics and *Pseudomonas*) were low (< log 5) and too variable to show any trend due to storage after dry aging.

Conclusions

Clearly, dry aging for a minimum of 14 d increases some flavor attributes in high-quality beef that are not typically associated with vacuum-aged beef. Tenderness and juiciness also improved during dry aging. The development of palatability attributes can be sufficient to offset the expense incurred due to dry aging. The mechanism that imparts the flavor changes in the presence of air and drying conditions is still not well elucidated. Vacuum storage for up to 14 d before and 16 d after dry aging did not have major affects on palatability changes imparted by dry aging. This means purveyors who want to dry age their products can still achieve the flavor changes associated with dry aging beef that was previously vacuum packaged. Further, since vacuum packaging after dry aging does not impair the flavor attributes of dry-aged beef, the product can be repackaged after dry aging for storage, transport, and inventory control for the end user. Costs associated with dry aging have to be evaluated against the benefits of enhancing certain flavors.

Table 4—Microbial counts at dry-aging times and at vacuum-storage times after dry aging

<table>
<thead>
<tr>
<th>Storage after dry aging, d</th>
<th>Aerobic count (log 10)</th>
<th>Lactics (log 10)</th>
<th>Pseudomonas (log 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (control)</td>
<td>1.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.8&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>7</td>
<td>3.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.8&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>14</td>
<td>3.9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.2&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>21</td>
<td>3.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.3&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>0.73</td>
<td></td>
<td>0.49</td>
<td>2.21</td>
</tr>
</tbody>
</table>

<sup>a-b</sup> Means within a column with a different superscript letter are different (P < 0.05).

<sup>c</sup> Controls were vacuum packaged for 14 days.

References


Ma. 2000/05/39

Contribution No. 99-435-J from the Kansas Agricultural Experiment Station.

Authors Campbell and Hunt are with the Dept. of Animal Sciences and Industry, Kansas State Univ., Manhattan, KS 66506. Author Chambers is with the Dept. of Human Nutrition, Kansas State Univ., Manhattan, KS 66506. Author Levis is with the Pillsbury Technology Center, 330 Univ. Ave. SE, Minneapolis, MN 55414-2198. Direct correspondence to M.C. Hunt (E-mail: Hhunt@oznet.ksu.edu).