Effects of Packaging Type and Storage Characteristics and the Effect of Steak Location on Palatability and Color Stability of Center Cut Top Sirloin Aged for Extended Storage Postmortem.

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Postmortem aging has a positive influence on palatability and can influence color stability on top sirloin steaks. However, there is not an appreciable increase in tenderness regardless of packaging type or temperature between the 14 and 42 day aged steaks in this study. Also, anterior and posterior positioning within the muscle had a greater effect on tenderness than dorsal and ventral steak location on the sirloin subprimal.

Summary
A study was conducted to examine the combination of packaging type, temperature and extended aging on palatability and color stability of center-cut sirloin, as well as the effect of steak location on palatability and color stability of center cut beef sirloin steaks. Steaks were aged for 14, 28 or 42 d, in one of two packaging options, DryBag and a traditional vacuum-bag. The parameters studied were Warner-Bratzler shear force (WBSF), color stability, and sensory attributes.

Introduction
The top sirloin steak is an economical alternative to steaks from the short loin or rib, but only a few studies have evaluated it, and none of the studies assessed the lean color stability during retail display and the effects of post mortem aging on retail display (Harris et al., 1992; Savell et al., 1999; King et al., 2009). Aging of fresh beef increases the tenderness and palatability of the product (Gruber et al., 2006; Warner & Kastner, 1992; Miller et al., 1997). There are 2 generally recognized methods of aging: wet aging, storing the beef cuts in highly moisture-impermeable vacuum packages, and dry aging which refers to storing the beef carcass or wholesale cuts without any type of protective packaging, exposing the meat to the cooler conditions (Smith et al., 2008). A third type of packing was used in this project, along with the wet aging method, a dry age bag which is a highly moisture-permeable bag that makes it more tolerant of variable cooler conditions (Ahnstrom et al., 2005).

The impact of steak location on palatability and color stability has been investigated within the rib and short loin (Belew et al., 2003; Wheeler et al., 2007), round (Reuter et al., 2002; Sawyer et al., 2007), and chuck (Bratcher et al., 2005). However, the only known work documenting the impact of sirloin steak location on palatability was by Rhee et al. (2004) which addressed steak location anterior to posterior, but did not address location dorsal to ventral. Purveyors who fabricate center-cut top butts for foodservice cut the subprimal in half anterior to posterior prior to fabricating steaks, but no known publication documents the differences in palatability between the locations.

Materials and Methods
Carcass Collection
Beef carcasses used for subprimal collection were preselected using USDA-AMS instrumentation data to have marbling scores between Slight<sup>50</sup> and Small<sup>50</sup> at the 12<sup>th</sup>/13<sup>th</sup> rib interface. Paired top sirloin butts (IMPS # 184; n = 74) were collected at 24 to 48 h postmortem from 37 commercially slaughtered A-maturity beef carcasses (Table 1). Samples were shipped under refrigeration to the University of Florida Meat Processing Center.

Temperature Variation
One top butt from each pair was held at 32°F for the duration of the postmortem aging period, the other side of each pair was held at 39°F for its duration.

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Packaging and Postmortem Aging
Top sirloin butts (n = 6) were randomly assigned to 1 of 6 packaging × aging combinations, for each storage temperature. Packaging treatments included: DryBag (D), and Traditional vacuum-bag (V). Top butts were allotted to postmortem aging periods of 14, 28, or 42 d. After the assigned postmortem aging period, the biceps femoris or cap muscles were removed leaving the gluteus medius, or top sirloin muscle. The anterior end of the subprimal was then squared and divided in half with a cut anterior to posterior along the sciatic ligament. Muscles were then fabricated into 1 in steaks and utilized for trained sensory, WBSF, and color stability.

Steak Processing
Steaks for color stability were individually placed on a Styrofoam tray containing a Dri-Loc 40 g white meat pad and overwrapped with polyvinylchloride film. Sensory and WBSF steaks were vacuum sealed and frozen until analysis was completed at a later date.

Cooking
Prior to cooking, steaks were thawed for 12-18 h at 40°F. Steaks were cooked on Hamilton Beach™ Indoor/Outdoor Grills preheated for 20 min. Steaks were turned once when the internal temperature reached 95°F and then be allowed to finish cooking until they reach an internal temperature of 160 °F (AMSA, 1995). Internal temperatures were monitored by copper-constantan thermocouples placed in the geometric center of each steak and recorded. Cooking procedures was the same for both sensory and WBSF analysis.

Sensory analysis
Once the steaks reached an internal temperature of 160°F they were cubed and served to panelists while still warm. Panelists evaluated 4 samples per session. The 2 sample cubes were 0.5 in.3 per sample, served in warmed covered containers twice daily in a positive pressure ventilated room with lighting and cubicles designed for objective meat sensory analysis. A 7 to 10 member sensory panel trained according to AMSA sensory evaluation guidelines (AMSA, 1995) evaluated each sample for juiciness, flavor, tenderness, connective tissue, and off-flavor.

Warner-Bratzler shear force
After cooking, steaks were chilled for 12-18 h at 40°F then four to six 0.5 inch-diameter cores were removed parallel to the longitudinal orientation of the muscle fibers, and each core sheared once perpendicular to the muscle fiber orientation using an a Warner-Bratzler shear head attached to an Instron Universal Testing machine with a cross-head speed of 200 mm/min.

Color Stability
Steaks were displayed in a Hill coffin-style retail case at 35 ± 3 °F for 5-d. Steaks were rotated daily to compensate for uneven temperature and light distribution within the case. Each steak was used for daily visual panel evaluation which included lean color and lean discoloration. Following collection of visual data, Hunter L*, a*, and b* reflectance data was collected for each steak. Two measurements per steak were averaged. Visual and objective color data was collected for a 5d period for each cut and steak.

Statistical Analysis
Data was analyzed as a split-plot design with the whole-plot a 2 x 2 x 3 factorial, representing temperature x packaging x aging periods and nested within animal with subprimal as the experimental unit. The sub-plot was steak location.

Results and Discussion
Saleable yield
Vacuum packaged subprimals had greater saleable yield percentages (P < 0.001) than the other packaging treatments represented. Storage temperature did not affect (P > 0.70) the saleable yield. For each muscle evaluated, the subprimals fabricated after the shortest postmortem aging period had greater saleable yield percentages (P ≤ 0.05) than subprimals.
fabricated after either of the more extended aging periods, which did not differ ($P > 0.10$). Data not shown.

**Color Stability**

Sirloin steaks from subprimals aged for 14 d were lighter (greater $L^*$ values), more red (greater $a^*$ values), and more yellow (greater $b^*$ values) throughout retail display than steaks aged for 28 or 42 d, which were similar throughout display. Interestingly, sirloin steaks from subprimals aged for 42 d had greater subjective color scores than steaks from subprimals aged for 14 or 28 d (data not shown).

Sirloin steaks from subprimals stored in D packages at 39°F were lighter ($P \leq 0.02$; greater $L^*$ values) than steaks from subprimals stored in the same packages at 32°F and lighter ($P \leq 0.02$; greater $L^*$ values) than steaks from subprimals at the same temperature in V packages, at 33.61, 35.58, and 35.51, respectively (subprimal packaging type × storage temperature; $P = 0.01$; data not shown). Subprimal packaging type or storage temperature did not affect ($P \geq 0.61$) redness or yellowness values of sirloin steaks during retail display.

**Warner-Bratzler Shear Force and trained sensory panel**

Subprimal packaging type or storage temperature did not affect ($P \geq 0.29$) WBSF values, or trained sensory panel values for juiciness, beef flavor, or off-flavor of sirloin steaks (Table 2). Additionally, postmortem aging period did not affect ($P \geq 0.29$) trained sensory panel values for juiciness, beef flavor, or off-flavor of sirloin steaks (Table 2). Steaks from subprimals aged for 28 d had greater ($P \leq 0.01$) WBSF values than steaks from subprimals aged for 42 d, but surprisingly steaks from subprimals aged for 14 and 42 d, respectively had similar WBSF values ($P > 0.10$; Table 2). This data shows that only a limited number of postmortem aging days are needed to increase tenderization.

Trained sensory panelists found sirloin steaks from subprimals stored in D packages at 39°F and V packages at 32°F were more tender ($P < 0.05$) than steaks from subprimals stored in V packages at 39°F. Also, trained panelists found less connective tissue ($P < 0.05$) from subprimals stored in D packages at 39°F than V packages at the same temperature, but the opposite was true when subprimals were stored at 39°F where panelists found sirloin steaks from subprimals stored in V packages had less connective tissue ($P < 0.05$) than steaks stored in D packages, data not shown.

**Sirloin steak location**

**Sensory**

Lateral position did not affect ($P \geq 0.69$) trained sensory panel values for juiciness, beef flavor, tenderness, connective tissue or off-flavor of sirloin steaks (Table 3).

**Warner-Bratzler Shear Force**

Anterior and posterior positioning within the muscle had a greater effect on tenderness than dorsal and ventral steak location (Figure 1). Steaks were more tender on d 28 and 42 in those steaks from the dorsal side than from those steaks taken from the ventral side of the muscle. Tenderness was affected by steak location for Warner-Bratzler shear force. Steaks tended to increase in Warner-Bratzler shear force from anterior to posterior location (Figure 2). The variation in tenderness regarding location could result in an increase in the overall profit margin of the top sirloin subprimal.

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**Literature Cited**

Table 1: Characteristics of beef carcasses from which paired top sirloin\(^a\) were used.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of carcasses</td>
<td>37</td>
</tr>
<tr>
<td>Hot carcass wt, lb</td>
<td>654.33 ± 66.14</td>
</tr>
<tr>
<td>12(^{th})-rib fat thickness, in</td>
<td>0.35 ± 0.15</td>
</tr>
<tr>
<td>Longissimus muscle area, in(^2)</td>
<td>12.1 ± 1.2</td>
</tr>
<tr>
<td>USDA Yield grade(^b)</td>
<td>2.5 ± 0.6</td>
</tr>
<tr>
<td>Marbling(^c)</td>
<td>410.8 ± 31.5</td>
</tr>
</tbody>
</table>

\(^a\)Top sirloin (IMPS # 184; n = 74).

\(^b\)Calculated according to USDA-AMS, 1997.

\(^c\)300 to 399 = Slight; 400 to 499 = Small; 500 to 599 = Modest.

Table 2. Effect of subprimal packaging type, storage temperature, and days of postmortem age on Warner-Bratzler shear force (WBSF) and trained sensory panel values for sirloin steaks

<table>
<thead>
<tr>
<th>Trait</th>
<th>Packaging(^d)</th>
<th>Temperature</th>
<th>Postmortem age, d</th>
<th>P-value</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D</td>
<td>V</td>
<td>39°F</td>
<td>32°F</td>
<td>14</td>
</tr>
<tr>
<td>WBSF, N</td>
<td>38.0</td>
<td>38.0</td>
<td>0.99</td>
<td>0.85</td>
<td>38.2(^d)</td>
</tr>
<tr>
<td>Juiciness(^2)</td>
<td>4.9</td>
<td>4.9</td>
<td>0.93</td>
<td>0.73</td>
<td>4.8</td>
</tr>
<tr>
<td>Beef flavor(^3)</td>
<td>5.6</td>
<td>5.6</td>
<td>0.82</td>
<td>0.57</td>
<td>5.5</td>
</tr>
<tr>
<td>Off-flavor(^4)</td>
<td>5.6</td>
<td>5.7</td>
<td>0.43</td>
<td>0.29</td>
<td>5.7</td>
</tr>
</tbody>
</table>

\(^d\)For variables postmortem age, values lacking a common superscript differ (P ≤ 0.01).

\(^1\)D = DryBag, MacPak, LLC, Wayzata, MN having a water vapor transmission rate of 2500 g/m\(^2\)/24 h at 100.4°F and 50% relative humidity, V= Traditional vacuum-bag (V; 8600-14EL, Cryovac-Sealed Air Corporation, Duncan, SC) having a water transmission rate of 0.02–0.03oz/25.2 in\(^2\)/24 h at 100°F and 100% relative humidity

\(^2\)Juiciness: 1 = extremely dry, 2 = very dry, 3 = moderately dry, 4 = slightly dry, 5 = slightly juicy, 6 = moderately juicy, 7 = very juicy, 8 = extremely juicy.

\(^3\)Beef flavor: 1 = extremely bland, 2 = very bland, 3 = moderately bland, 4 = slightly bland, 5 = slightly intense, 6 = moderately intense, 7 = very intense, 8 = extremely intense.

\(^4\)Off-flavor: 1 = extreme off flavor, 2 = strong off-flavor, 3 = moderate off-flavor, 4 = slight off-flavor, 5 = threshold; barely detected, 6 = none detected.
Table 3. Effect of lateral position on trained sensory panel values of sirloin steaks

<table>
<thead>
<tr>
<th>Traits</th>
<th>Lateral position</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dorsal</td>
<td>Ventral</td>
</tr>
<tr>
<td>Juiciness</td>
<td>4.9 ± 0.10</td>
<td>4.9 ± 0.10</td>
</tr>
<tr>
<td>Beef flavor</td>
<td>5.6 ± 0.06</td>
<td>5.6 ± 0.06</td>
</tr>
<tr>
<td>Tenderness</td>
<td>5.2 ± 0.10</td>
<td>5.2 ± 0.10</td>
</tr>
<tr>
<td>Connective tissue</td>
<td>6.0 ± 0.10</td>
<td>6.0 ± 0.10</td>
</tr>
<tr>
<td>Off flavor</td>
<td>5.7 ± 0.04</td>
<td>5.7 ± 0.04</td>
</tr>
</tbody>
</table>

1Juiciness: 1 = extremely dry, 2 = very dry, 3 = moderately dry, 4 = slightly dry, 5 = slightly juicy, 6 = moderately juicy, 7 = very juicy, 8 = extremely juicy.
2Beef flavor: 1 = extremely bland, 2 = very bland, 3 = moderately bland, 4 = slightly bland, 5 = slightly intense 6 = moderately intense, 7 = very intense 8 = extremely intense.
3Tenderness: 1 = extremely tough, 2 = very tough, 3 = moderately tough, 4 = slightly tough, 5 = slightly tender 6 = moderately tender, 7 = very tender, 8 = extremely tender.
4Connective tissue: 1 = abundant amount, 2 = moderately abundant, 3 = slightly abundant, 4 = moderate amount, 5 = slight amount, 6 = traces amount, 7 = practically none, 8 = none detected.
5Off flavor: 1 = extreme off flavor, 2 = strong off-flavor, 3 = moderate off-flavor, 4 = slight off-flavor, 5 = threshold; barely detected, 6 = none detected.

Figure 1: Interactive effect of lateral position and days of postmortem age on Warner-Bratzler shear force values (P < 0.001) of sirloin steaks.

ab, b, c values with different letters differ (P < 0.05).
Figure 2: Interactive effect of cranial/caudal position and days of postmortem age on Warner-Bratzler shear force values ($P = 0.04$) of sirloin steaks.