Effect of Packaging Type, Storage Time and Temperature on the Beef Strip Loin and Shoulder Clod Heart Steaks.

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Summary
A study was conducted to examine the combination of packaging type, temperature and extended aging on palatability and color stability of beef strip loins and shoulder clod heart steaks. Steaks from each muscle were aged for 14, 21, 28, 32, 35, or 42 d in one of three packaging options: DryBag®, traditional vacuum-bag, and no bag. The parameters studied were Warner-Bratzler shear force (WBFS), color stability, and sensory attributes. After completion of the study it was determined that steaks held for a shorter duration, 14-21 d had negligible differences in tenderness and palatability to those steaks aged for longer periods.

Introduction
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 two 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 cooler conditions (Smith et al., 2008). A third type of packing was used in this project, a dry age bag which is a highly moisture-permeable bag that makes it more tolerant of variable cooler conditions (Ahnstrom et al., 2005). Many studies have explored the effect of postmortem aging on the quality and palatability of steaks from the rib and short loin, however, most focused on products with Modest or greater marbling. Results from these studies also differ in the magnitude of the differences among the different aging methods for tenderness and palatability (Sitz et al., 2006; Parrish et al., 1991; Laster et al., 2006). Postmortem aging has also been reported to affect the process that determines lean color stability and shelf-life (Ledward, 1985; Feldhusen et al., 1995; Tang et al., 2005, King et al., 2012). The purpose of the study was to determine the best method and aging period to increase palatability and color stability on lower quality subprimals.

Material and Methods
Carcass Collection
Beef carcasses used for subprimal collection were preselected using USDA-AMS instrumentation data to have marbling scores between Slight\(^5\) and Small\(^5\) at the 12\(^{th}/13\(^{th}\) rib interface. Paired beef strip loins (IMPS # 180; n = 48) and paired chuck clod hearts (IMPS # 114E; n = 108) were collected at 24h postmortem from 24 or 54 commercially slaughtered A-maturity beef carcasses, respectively. Samples were shipped under refrigeration to the University of Florida Meat Processing Center.

Temperature Variation
One strip loin (n = 24) and clod heart (n = 54) from each pair were held at 32°F. The other strip loin and clod heart from each pair were held at 38°F.

Strip loins
Each loin (n = 24 per temperature) was separated into 3 equal portions and randomly

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assigned to 1 of 3 packaging treatments during storage. Packaging treatments included: DryBag® (B), traditional vacuum-bag (V), and no packaging (D). Within each loin, the 3 sections were randomly allotted to aging for 21, 32 or 42 d postmortem. After the assigned postmortem aging period, strip loins were fabricated into 1 inch steaks (n = 3) for sensory, WBSF and color stability evaluations respectively.

Chuck clod hearts
Chuck clod hearts (n = 6) were randomly assigned to 1 of 9 packaging × aging combinations, for each storage temperature. Packaging treatments for chuck clod hearts were the same as described for strip loins: B, V, or D and were allotted to postmortem aging periods of 21, 28, or 35 d. After the assigned postmortem aging period, clod hearts were fabricated into 1 inch steaks, the most medial steaks (n = 3) were allocated to sensory, WBSF and color stability evaluations.

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 at -40°F until analysis was completed at a later date.

Cooking
Prior to cooking, steaks were thawed for 12-18 h at 39°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 allowed to finish cooking until they reached 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 6 samples per session for the strips loins and chuck clod hearts. The 2 sample cubes are 0.5 in³ 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 39°F then four to six 0.5 in 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.

Color Stability
Steaks were displayed in a 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 5-d period for each cut and steak

Statistical Analysis
Strip loins were analyzed as a split-plot design with the whole-plot a 2 x 3 factorial representing temperature x aging periods, with packaging treatment as the sub-plot. Clod hearts were analyzed as a split-plot design with the whole-plot a 2 x 2 x 3 factorial design for clod hearts, representing temperature x packaging x aging periods and nested within animal with subprimal as the experimental unit.

Results and Discussion
Saleable yield
Vacuum packaged subprimals of both subprimals had greater saleable yield percentages (P < 0.001) than the other packaging treatments represented. Subprimals stored in B packages did not differ (P > 0.10) from D aged
subprimals for saleable yield percentage. Storage temperature did not affect ($P > 0.70$) the saleable yield percentages of strip loins but, clod hearts aged at 39°F tended ($P = 0.09$) to have greater saleable yield than the same muscles stored at 32°F. For each muscle evaluated, the subprimals fabricated after the shortest postmortem aging period had greater saleable yield percentages ($P \leq 0.05$) than subprimals fabricated after either of the more extended aging periods, which did not differ ($P > 0.10$) data not shown.

**Color Stability**

**Strip**

Strip steaks from subprimals aged for 42 d were darker (lower $L^*$ values) on d 0 of retail display than steaks from subprimals aged for 21 or 32 d, which were similar (postmortem aging period × day of retail display; Figure 1). Interestingly, strip steaks from subprimals aged for 42 d became lighter (increasing $L^*$ values) throughout display, compared with steaks from subprimals given 21 or 32 d of aging which tended darker throughout retail display (postmortem aging period × day of retail display; Figure 1). Strip steaks from subprimals stored in V packages had greater ($P \leq 0.03$) subjective color scores than steaks from subprimals given D storage, which did not differ ($P > 0.10$) from subprimals stored in B bags (Table 1). Subprimal packaging type or storage temperature did not affect ($P \geq 0.39$) lightness values of strip steaks during retail display and storage temperature did not affect ($P = 0.99$) subjective color scores during retail display (Table 3).

**Clod hearts**

All clod steaks had similar lightness values at the start of retail display, but steaks from subprimals aged for 35 d trended darker (decreasing $L^*$ values) throughout display, compared with steaks from subprimals given 21 or 28 d of aging which tended lighter throughout retail display (postmortem aging period × day of retail display; Figure 2). Subprimal packaging type did not affect ($P \geq 0.28$) lightness values and storage temperature did not affect ($P \geq 0.20$) redness or yellowness values for clod steaks during retail display (Table 2). As postmortem aging increased, redness and yellowness values of clod steaks during retail display decreased ($P \leq 0.02$) linearly (Table 2).

Clod steaks from subprimals aged for 35 d had lower subjective color scores than steaks from subprimals given shorter postmortem aging periods, resembling results for lightness values and postmortem aging period of clod steaks during retail display.

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

**Strip**

Subprimal packaging type or storage temperature did not affect ($P \geq 0.13$) WBSF values, or trained sensory panel values for juiciness or connective tissue of strip steaks (Table 3). Strip steaks from subprimals stored at 39°F tended ($P = 0.08$) to have greater sensory panel values for tenderness, but panelist also reported greater detection ($P = 0.04$) of undesirable off-flavors compared to steaks from subprimals stored at 32°F (Table 3). Postmortem aging did not affect ($P \geq 0.38$) trained sensory panel values for juiciness, beef flavor, or off-flavor of strip steaks (Table 3). Strip steaks from subprimals aged for 32 d had greater ($P \leq 0.01$) WBSF values than steaks from subprimals aged for 42 d which had the lowest ($P \leq 0.01$) WBSF values of the three aging period. However, steaks from subprimals aged for 21 d had lower ($P \leq 0.01$) WBSF values than steaks aged for 32 d (Table 3). Trained sensory panelist found strip steaks from muscles aged for 42 d were more tender ($P \leq 0.01$) than steaks aged for 21 days and panelists tended ($P = 0.10$) to find less connective tissue as the length of postmortem aging increased (Table 3).

Clod hearts

Subprimal packaging type or storage temperature did not affect ($P \geq 0.23$) trained sensory panel values for juiciness, tenderness, connective tissue or off-flavor of clod steaks (Table 4). Additionally, subprimal packaging type did not affect ($P = 0.63$) trained sensory panel values for beef flavor, however, steaks from subprimals stored at 39°F tended ($P =$
to have greater sensory panel values for beef flavor than steaks from subprimals stored at 32°F (Table 4). Length of postmortem age did not affect \( P \geq 0.25 \) trained sensory panel values for juiciness, beef flavor, tenderness, or connective tissue of clod steaks (Table 7). Trained sensory panelist found clod steaks from muscles aged for 35 d to have more off-flavor \( P < 0.001 \) than steaks aged for 21 or 28 days which did not differ (Table 4).

Clod steaks from subprimals aged for 35 d in V packaging had greater \( P \leq 0.01 \) WBSF values than steaks from any other packaging type \( \times \) days of postmortem aging combination, suggesting that subprimals which were allocated to this particular combination were innately tougher than subprimals allocated to the other combinations (Figure 3).

**Conclusions**

Aging has always been considered the best way to tenderize and enhance the flavor of steaks and this research furthers that fact. It also shows that only a limited number of days are needed to be effective for tenderizing a lower valued cut, such as a clod heart. Strip steaks did become more tender as the length of aging progressed, but the actual difference was marginal. Clod steaks remained nearly the same throughout the aging process, except for the one subgroup which was speculated to simply being innately tougher. Strip steaks aged for 42 days retained its darker color throughout the retail days, but all steaks decreased at approximately the same rate regardless of age. Clod steaks aged for 35 days became significantly darker as retail display progressed.

**Literature Cited**

### Table 1. Effect of subprimal packaging type and storage temperature on objective color and subjective color values for strip steaks during 5 d of retail display.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Packaging</th>
<th>Temperature</th>
<th>39°F</th>
<th>32°F</th>
<th>P-value</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>L*</td>
<td>B</td>
<td>V</td>
<td>D</td>
<td>P-value</td>
<td>39°F</td>
<td>32°F</td>
</tr>
<tr>
<td></td>
<td>32.64</td>
<td>33.74</td>
<td>32.73</td>
<td>0.39</td>
<td>33.04</td>
<td>33.03</td>
</tr>
<tr>
<td>Lean color</td>
<td>3.93&lt;sup&gt;d&lt;/sup&gt;</td>
<td>4.67&lt;sup&gt;d&lt;/sup&gt;</td>
<td>3.82&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.05</td>
<td>4.16</td>
<td>4.12</td>
</tr>
</tbody>
</table>

1<sup>B</sup> = DryBag, MacPak, LLC, Wayzata, MN having a water vapor transmission rate of 88.2 oz/in<sup>2</sup>/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 0.02–0.03 oz/25.2 in<sup>2</sup>/24 h at 100°F and 100% relative humidity; D = No packaging.

2<sup>L*</sup> = measure of darkness to lightness (larger value indicates a lighter color); <sup>a*</sup> = a measure of redness (larger value indicates a redder color); <sup>b*</sup> = a measure of yellowness (larger value indicates a more yellow color).

3<sup>1</sup> = Extremely dark red, 2 = Dark red, 3 = Moderately dark red, 4 = Slightly dark red, 5 = Slightly bright cherry red, 6 = Moderately bright cherry red, 7 = Bright cherry red, 8 = Extremely bright cherry red.

d,e<sup>For variables with three treatments, values lacking a common superscript differ (P ≤ 0.03).</sup>

### Table 2. Effect of subprimal packaging type, storage temperature, and days of postmortem age on objective color values for clod steaks during 5 d of retail display.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Packaging</th>
<th>Temperature</th>
<th>39°F</th>
<th>32°F</th>
<th>P-value</th>
<th>21</th>
<th>28</th>
<th>35</th>
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<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>L*</td>
<td>B</td>
<td>V</td>
<td>D</td>
<td>P-value</td>
<td>39°F</td>
<td>32°F</td>
<td>P-value</td>
<td>21</td>
<td>28</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>29.69</td>
<td>30.16</td>
<td>29.48</td>
<td>0.88</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>18.9</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>a*</td>
<td>19.07</td>
<td>18.92</td>
<td>18.55</td>
<td>0.28</td>
<td>18.76</td>
<td>3</td>
<td>0.57</td>
<td>14.51&lt;sup&gt;c&lt;/sup&gt;</td>
<td>12.87&lt;sup&gt;d&lt;/sup&gt;</td>
<td>10.26&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>b*</td>
<td>10.92</td>
<td>10.10</td>
<td>10.85</td>
<td>0.57</td>
<td>10.87</td>
<td>7</td>
<td>0.20</td>
<td>9.91&lt;sup&gt;c&lt;/sup&gt;</td>
<td>9.57&lt;sup&gt;d&lt;/sup&gt;</td>
<td>8.57&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

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2<sup>L*</sup> = measure of darkness to lightness (larger value indicates a lighter color); <sup>a*</sup> = a measure of redness (larger value indicates a redder color); <sup>b*</sup> = a measure of yellowness (larger value indicates a more yellow color).

c,d,e<sup>For variables with three treatments, values lacking a common superscript differ (P ≤ 0.02).</sup>
<table>
<thead>
<tr>
<th>Traits</th>
<th>Packaging¹</th>
<th>Temperature</th>
<th>Postmortem age</th>
<th>SE</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>V</td>
<td>D</td>
<td>P-value</td>
</tr>
<tr>
<td>WBSF, N</td>
<td>32.67</td>
<td>32.84</td>
<td>32.34</td>
<td>0.92</td>
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<tr>
<td>Juiciness²</td>
<td>5.21</td>
<td>5.12</td>
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<td>0.59</td>
</tr>
<tr>
<td>Beef flavor³</td>
<td>5.58</td>
<td>5.43</td>
<td>5.44</td>
<td>0.08</td>
</tr>
<tr>
<td>Tenderness⁴</td>
<td>5.88</td>
<td>5.75</td>
<td>5.74</td>
<td>0.43</td>
</tr>
<tr>
<td>Connective tissue⁵</td>
<td>6.39</td>
<td>6.26</td>
<td>6.37</td>
<td>0.37</td>
</tr>
<tr>
<td>Off-flavor⁶</td>
<td>5.47</td>
<td>5.56</td>
<td>5.33</td>
<td>0.13</td>
</tr>
</tbody>
</table>

¹B = DryBag, MacPak, LLC, Wayzata, MN having a water vapor transmission rate of 88.2oz/in²/24 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 in²/24 h at 100°F and 100% relative humidity; D = No packaging.

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

³Beef 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.

⁴Tenderness: 1 = extremely tough, 2 = very tough, 3 = moderately tough, 4 = slightly tough, 5 = slightly tender, 6 = moderately tender, 7 = very tender, 8 = extremely tender.

⁵Connective 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.

⁶Off-flavor: 1 = extreme off flavor, 2 = strong off-flavor, 3 = moderate off-flavor, 4 = slight off-flavor, 5 = threshold; barely detected, 6 = none detected.

<sup>b,c,d</sup> For variables with three treatments, values lacking a common superscript differ (P ≤ 0.01).
Table 4. Effect of subprimal packaging type, storage temperature, and days of postmortem age on Warner-Bratzler shear force (WBSF) and trained sensory panel values for clod steaks

<table>
<thead>
<tr>
<th>Traits</th>
<th>Packaging¹</th>
<th>Temperature</th>
<th>Postmortem age</th>
<th>SE</th>
</tr>
</thead>
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<tr>
<td></td>
<td>B</td>
<td>V</td>
<td>D</td>
<td>P-value</td>
</tr>
<tr>
<td>WBSF, N</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>39.3</td>
</tr>
<tr>
<td>Juiciness²</td>
<td>5.2</td>
<td>5.2</td>
<td>5.2</td>
<td>0.99</td>
</tr>
<tr>
<td>Beef flavor³</td>
<td>5.6</td>
<td>5.6</td>
<td>5.5</td>
<td>0.63</td>
</tr>
<tr>
<td>Tenderness⁴</td>
<td>5.5</td>
<td>5.4</td>
<td>5.6</td>
<td>0.23</td>
</tr>
<tr>
<td>Connective tissue⁵</td>
<td>6.1</td>
<td>6.0</td>
<td>6.2</td>
<td>0.24</td>
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<tr>
<td>Off-flavor⁶</td>
<td>5.6</td>
<td>5.5</td>
<td>5.5</td>
<td>0.69</td>
</tr>
</tbody>
</table>

¹B = DryBag, MacPak, LLC, Wayzata, MN having a water vapor transmission rate of 88.2 oz/in²/24 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 0.02–0.03 oz/25.2 in²/24 h at 100°F and 100% relative humidity; D = No packaging.

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

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⁶Off-flavor: 1= extreme off-flavor, 2= strong off-flavor, 3= moderate off-flavor, 4= slight off-flavor, 5= threshold; barely detected, 6= none detected.

₪₫ For variables with three treatments, values lacking a common superscript differ (P < 0.001).
Figure 1: Interactive effect of days of postmortem age and day of retail display on lightness (L*) values ($P < 0.001$), redness (a*) values ($P < 0.001$), yellowness (b*) values ($P < 0.001$), and subjective lean color scores $^a$ ($P = 0.06$) of strip steaks.

1 = Extremely dark red, 2 = Dark red, 3 = Moderately dark red, 4 = Slightly dark red, 5 = Slightly bright cherry red, 6 = Moderately bright cherry red, 7 = Bright cherry red, 8 = Extremely bright cherry red.
Figure 2. Interactive effect of days of postmortem age and day of retail display on subjective lean color score values (P = 0.02) of clod steaks.
1 = Extremely dark red, 2 = Dark red, 3 = Moderately dark red, 4 = Slightly dark red, 5 = Slightly bright cherry red, 6 = Moderately bright cherry red, 7 = Bright cherry red, 8 = Extremely bright cherry red.
Figure 3. Interactive effect of subprimal packaging type\textsuperscript{d} and days of postmortem age on Warner-Bratzler shear force values ($P = 0.01$) of clod steaks.
\textsuperscript{a, b, c}Values with different letters differ ($P < 0.05$).
\textsuperscript{d}B = DryBag, MacPak, LLC, Wayzata, MN having a water vapor transmission rate of 88.2oz/in\textsuperscript{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\textsuperscript{2}/24 h at 100°F and 100\% relative humidity; D = No packaging.