Project Summary

Mapping of Intramuscular Tenderness and Muscle Fiber Orientation of Muscles in the Beef Round

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Study Completed
May 2009

Funded by The Beef Checkoff
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Background
Tenderness is a major palatability trait that determines the quality of meat. However, beef round muscles are known to be some of the tougher muscles in the beef carcass. Characterization of muscles in the beef round is necessary to evaluate value-added strategies. Although tenderness differences among major muscles of the beef round and their intramuscular tenderness variations have been well identified and reported, the tenderness difference in all the muscles in the beef round are not documented. The knowledge of muscle fiber direction is also important during meat fabrication so that muscles can be cut across the grain to improve tenderness. Muscle fiber directions along the muscles of the beef round have not been documented.

The objectives of this project were to:
1. Map the fiber direction of muscles from the beef round;
2. Construct a detailed tenderness map of the muscles of the beef round;
3. Assess the potential for creating new, smaller cuts from round muscles; and
4. Develop a cutting guide for the beef round.

Methodology
Sample collection
Ten each of beef round top, beef round knuckle peeled, beef round bottom and beef round eye of round were purchased as USDA Choice boxed-beef subprimals and aged for about 14 days from boxed date. The biceps femoris (BF), semitendinosus (ST), semimembranosus (SM), adductor femoris (AF), gracilis (GL), pectineus (PT), sartorius (SR), vastus intermedius (VI), vastus medialis (VM) and vastus lateralis (VL) were fabricated from subprimals. The BF, ST, SM, AF and VL muscles were cut into 2.54 cm-thick steaks from proximal to distal ends perpendicular to the long axis using a band saw. The PT, SR, VM, GL and VI were vacuum-packaged as individual muscles.

Grilling or oven roasting
Whole muscles and steaks were thawed at 4°C for 24 hours. The steaks (BF, ST, VL, SM and AF) and whole muscles (PT, ST, VI, VM and GL) were grilled on a Hamilton Beach Indoor-Outdoor Grill until they reached an internal temperature of 71°C. In addition, the ST and VL muscles were oven-roasted under dry- or moist-heat conditions in a pre-heated oven at 169°C until they reached an internal temperature of 71°C.

Determination of Warner-Bratzler Shear Force and muscle fiber orientation
Grilled or oven-roasted muscles or steaks were cooled at 4°C for 24 hours. After reaching room temperature, the PT, SR, VM and GL were cut into proximal and distal zones and each distal and proximal end was cut into 2.54 cm-thick portions perpendicular to the long axis of the muscle. The BF, ST, SM and VL steaks were divided into posterior, middle and anterior regions. From each region, location-specific cores with 1.27 cm diameter were removed parallel to the muscle fiber arrangement using a drill press. All cores were sheared on an Instron Universal Testing Machine (Model 55R1123, Canton, MA) with a Warner-Bratzler shear attachment. An individual peak Warner-Bratzler shear force (WBSF) for each muscle piece was used for statistical analysis.

The muscle fiber orientation was expressed in degrees horizontally along the long axis of the muscle.
from the proximal to the distal end at every 2.54 cm. Subsequently, the fiber orientation with the angle was illustrated on a longitudinal section of the muscle.

**Statistical Analysis**

Warner-Bratzler shear force values were analyzed by using the GLIMMIX procedure of SAS (version 9.1). Zonal differences were analyzed using CONTRAST statements of SAS. Least square means were calculated for each section using the LSMEANS option of SAS. The mean separation was performed by DIFF and LINES option of SAS at $P < 0.05$.

**Findings**

The mean WBSF values of BF, ST, AF, SM, PT, SR, GL, VI, VM and VL were 5.62, 4.86, 4.18, 4.90, 3.76, 4.44, 4.75, 4.78, 4.24 and 6.53 kg. Von Seggern et al. (2005) classified beef tenderness into three categories: tender ($< 37.76$ N or $< 3.85$ kg WBSF), intermediate ($< 47.96$ N and $> 37.76$ N or $< 4.89$ kg and $> 3.85$ kg WBSF) or tough ($> 4.89$ N or $> 4.89$ kg WBSF). Based on this classification, PT was tender, BF and VL were tough, and VM, VI, SM, GL, SR, AF and ST were intermediate. All muscles had significant tenderness variation from the proximal to the distal end, except VM and GL (Table 1).

The muscle fiber orientation of BF, PT and VI were bipennate, SR and ST were fusiform, and AF, SM, VL, GL and VM were unipennate (Figure 1).

**Implications**

According to the WBSF ratings and muscle fiber orientation, all of these small muscles (PT, SR, VM, GL and VI) could be merchandized as single muscle steaks or medallions. Based on WBSF values, the first 2 to 3 steaks of BF, SM and AF were tender and could be marketed as premium quality steaks. Dry- or moist-heat roasting may tenderize the ST and VL muscles. This information on intramuscular tenderness variation and muscle fiber orientation of muscles in the round could be used in a value-added strategy for the round.

**Table 1. Mean WBSF values (kg) of proximal and distal ends of AF, ST, SM, VL, BF, PT, SR, VM, VI, and GL muscles in the beef round**

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Proximal</th>
<th>Distal</th>
<th>$P$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>m. adductor femoris</td>
<td>4.33$^b$</td>
<td>4.12$^b$</td>
<td>0.01</td>
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<tr>
<td>m. semitendinosus</td>
<td>4.99$^a$</td>
<td>4.73$^b$</td>
<td>0.002</td>
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<td>m. semimembranosus</td>
<td>4.41$^b$</td>
<td>5.65$^a$</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>m. vastus lateralis</td>
<td>5.55$^b$</td>
<td>7.55$^a$</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>m. biceps femoris (anterior head)</td>
<td>5.92</td>
<td>5.32</td>
<td>0.06</td>
</tr>
<tr>
<td>m. biceps femoris (posterior head)</td>
<td>9.07$^a$</td>
<td>6.17$^b$</td>
<td>&lt;.0001</td>
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<tr>
<td>m. pectineus</td>
<td>3.56$^b$</td>
<td>3.96$^a$</td>
<td>0.03</td>
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<tr>
<td>m. sartorius</td>
<td>4.62$^a$</td>
<td>4.25$^b$</td>
<td>0.04</td>
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<tr>
<td>m. vastus medialis</td>
<td>4.08</td>
<td>4.39</td>
<td>0.12</td>
</tr>
<tr>
<td>m. vastus intermedius</td>
<td>4.28$^b$</td>
<td>5.29$^a$</td>
<td>&lt;.0001</td>
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<tr>
<td>m. gracilis</td>
<td>4.66</td>
<td>4.84</td>
<td>0.08</td>
</tr>
</tbody>
</table>

$^{a,b}$Means were significantly different at $P < 0.05$
References

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