Influence of quality classification, aging period, blade tenderization, and endpoint cooking temperature on cooking characteristics and tenderness of beef gluteus medius steaks\textsuperscript{1,2}

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ABSTRACT: Top sirloin butts (n = 162) were used to investigate the influence of quality classification, aging period, blade tenderization passes, and endpoint cooking temperature on the tenderness of gluteus medius steaks. Top sirloin butts (gluteus medius) from Select (SEL), Choice (CHO), and Certified Angus Beef (CAB) carcasses were obtained, aged for 7, 14, or 21 d, and either not tenderized or blade tenderized one or two times. Three steaks from each top sirloin butt were randomly selected and assigned to a final endpoint cooking temperature of 65.5, 71.0, or 76.6° C. Cooking characteristics and Warner-Bratzler shear force (WBSF) were analyzed as a split-plot with a $3 \times 3 \times 3$ factorial treatment structure of quality classification, aging period, and tenderization passes in the whole plot and endpoint cooking temperature in the subplot. Sensory panel data for CHO steaks cooked to 70° C were analyzed with a $3 \times 3$ factorial treatment structure of aging period and tenderization passes. Thawing loss was greater ($P < 0.05$) for steaks aged 7 d than those aged 21 d. Cooking loss was greater ($P < 0.05$) for steaks aged for 14 and 21 d than those aged 7 d, and increased ($P < 0.05$) with each increasing endpoint temperature. Each increase in aging period resulted in lower ($P < 0.05$) WBSF values. In addition, steaks blade tenderized two times had lower ($P < 0.05$) WBSF values than steaks blade tenderized once or not at all. Within each quality classification, WBSF values increased ($P < 0.05$) as endpoint cooking temperature increased. When cooked to 71 or 76.6° C, CHO and CAB steaks had lower ($P < 0.05$) WBSF than SEL steaks. Steaks blade tenderized one or two times received higher ($P < 0.05$) sensory panel ratings for myofibrillar and overall tenderness than steaks not blade tenderized. Connective tissue amount and overall tenderness ratings were higher ($P < 0.05$) for steaks aged 21 vs. 7 d. Postmortem aging and blade tenderization of gluteus medius steaks can improve tenderness, as measured by WBSF and sensory panel, without decreasing flavor or juiciness. When cooking to higher endpoint temperatures, higher quality classifications should be selected to minimize toughness due to cooking.

Key Words: Aging, Beef, Meat Quality, Tenderness

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Introduction

Tenderness is the most important factor affecting beef palatability. Consumers can segregate differences in beef tenderness and are willing to pay more for more tender beef (Miller et al., 2001). The challenge is to decrease variation and improve tenderness through multiple ante- and postmortem technologies. Of beef steaks regularly offered on restaurant menus, top sirloin steaks are the toughest and most variable in tenderness (Morgan et al., 1991), but are typically lower in price than most other menu offerings.

Quality grade is relied upon heavily as a predictor of palatability, but has long been questioned for accuracy (Parrish et al., 1973; Jost et al., 1983). Postmortem aging is among the most popular options for improving tenderness (Dransfield, 1994). Endpoint cooking temperature, however, may be the definitive factor in beef tenderness. Parrish et al. (1973) found endpoint temperature was a better predictor of rib steak tenderness than marbling. Blade tenderization is another available technology that has been shown to improve tenderness through muscle tissue disruption (Parrish, 1977). In a survey of North American Meat Processors Association members (George-Evins et al., 1999), 61.8% of meat processors used blade tenderization on the top sirloin.

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butt, and, when used, the average number of passes was 1.6 times (range of one to three passes).

Although each of these technologies has been used to improve tenderness, the effect of the combination and/or different levels of these factors on tenderness merits further investigation. Therefore, the objective of this study was to study the effects of postmortem technology combinations (quality classification, post-mortem aging, blade tenderization, and endpoint cooking temperature) on cooking characteristics and tenderness of gluteus medius steaks from top sirloin butts.

Materials and Methods

Product Collection

One hundred sixty-two top sirloin beef butts were obtained from a commercial packing facility. Sirloin butts were ordered for qualification into USDA Select (SEL, n = 54), USDA Choice (CHO, n = 54), and the Certified Angus Beef Program (CAB, n = 54; average and high Choice). Sirloin butts were shipped to a commercial fabrication plant and aged at 1°C for 7, 14, or 21 d postmortem. After aging, top sirloin butts were passed through a blade tenderizer (model T7001; Ross Industries Inc., Midland, VA) zero (0×), one (1×), or two (2×) times, with the external fat side down. Plant personnel trimmed and removed the biceps femoris muscle from each top sirloin butt. The gluteus medius muscle was cut into 2.54-cm-thick steaks and individually vacuum-packaged (model M 860, Multivac Inc., Calhoun, Germany). Steaks were frozen for 35 to 40 days at −29°C in a McCall refrigerator and stored at −37°C in a spiral freezer (Meyer Metal Craft, Windsor, MO), transported to the Kansas State University Meat Laboratory, and stored at −29°C until analysis. Top sirloin butt identification was maintained throughout the process.

Warner-Bratzler Shear Force Determination

Three steaks were randomly selected from each top sirloin butt and assigned to one of three endpoint cooking temperatures (65.5, 71.0, or 76.6°C). Endpoint cooking temperatures were selected to approximately represent medium rare, medium, and well-done degrees of doneness. Vacuum seals were broken and steaks were thawed for 24 h at 3°C. Steaks were weighed in the bag with juices, weighed again out of the bag, trimmed of external fat, and weighed again. Percentages of thawing loss for the three steaks from each top sirloin butt were averaged. Steaks were cooked according to an established protocol consistent with AMSA (1995) guidelines in a Blodgett dual-air-flow gas convection oven (model DFG-201; G. S. Blodgett Co., Inc. Burlington, VA) preheated to 163°C. Temperature was monitored by 30-gauge, type-T thermocouples inserted into the geometric center of the steak and attached to a Doric temperature recorder (model 205; Vas Engineering, San Francisco, CA). Cooking time was recorded for each steak. Steaks were cooled at least 30 min, reweighed, and cooking loss percentage was calculated. Steaks were stored overnight at 3°C in a McCall refrigerator (Kolpak Industries Inc., Parsons, TN), and a minimum of six 1.27-cm-diameter cores were taken parallel to the muscle fiber orientation. Cores were sheared perpendicular to the muscle fiber orientation as recommended by AMSA (1995) guidelines using an Instron universal testing machine (model 4201; Instron Corp., Canton, MA) with a Warner-Bratzler shear force (WBSF) attachment with a V-shaped blade (AMSA, 1995). A 50-kg compression load cell with a crosshead speed of 250 mm/min was used.

Sensory Panel Evaluation

One steak from each USDA Choice top sirloin butt (n = 54) was randomly selected for sensory panel evaluation. Due to a large sample size, the mid-quality classification and mid-endpoint cooking temperature were selected to investigate the effect of aging and tenderization passes on sensory traits. Panelists were trained according to AMSA (1995) guidelines. Steaks were thawed and cooked as described for WBSF to an internal temperature of 70°C. Each steak was cut into 1.27-cm × 1.27-cm × thickness of the cooked steak cubes perpendicular to the cut surface. Sensory panel evaluations were conducted in an environmentally controlled (21 ± 1°C, 55 ± 5% relative humidity) room partitioned into booths with a mixture of adjustable red and green lighting that, when combined, was less than 107.64 lumens. One orientation sample was evaluated and discussed at the beginning of each session. For each session, duplicate samples for each of the nine treatments were served warm and evaluated by a six-member panel. The order of presentation was randomized for each panelist within each session. Samples were assessed for six sensory attributes using an eight-point numerical scale evaluated steaks to the nearest 0.5. Sensory traits evaluated were flavor intensity (1 = extremely bland to 8 = extremely intense), juiciness (1 = extremely dry to 8 = extremely juicy), myofibrillar tenderness (1 = extremely tough to 8 = extremely tender), connective tissue amount (1 = abundant to 8 = none), and overall tenderness (1 = extremely tough to 8 = extremely tender).

Statistical Analyses

Thawing loss was analyzed with a $3 \times 3 \times 3$ factorial treatment structure consisting of quality classification, aging period, and blade tenderization passes using the GLM procedure of SAS (SAS Inst., Inc., Cary, NC). Cooking loss, cooking time, and WBSF were analyzed as a split-plot design using the MIXED model procedure of SAS. The whole plot (top sirloin butt) comprised a $3 \times 3 \times 3$ factorial treatment structure consisting of quality classification, aging period, and blade tenderization passes. The subplot consisted of internal endpoint tem-
temperature. Fixed effects included quality classification, aging period, blade tenderization passes, and internal endpoint temperature, whereas top sirloin butt was considered to be the random effect. The differences among whole plot effects were tested using the top sirloin butt within quality classification × aging period × and blade tenderization passes as the error term. Sensory panel data were analyzed with a 3 × 3 factorial treatment structure of aging period and blade tenderization passes using the GLM procedure, and sensory panel sessions served as blocks. All interaction and main effect means for all analyses were separated using the LSD procedure when the respective F-tests were significant (P < 0.05).

Results and Discussion

Cookery Characteristics

No interactions (P > 0.05) were observed for thawing loss, cooking loss, and cooking time (min/100 g). Percentage of thawing and cooking losses were similar (P > 0.05) among all quality classifications and blade tenderization treatments (Table 1). In contrast to current results, Savell et al. (1977) reported that steaks blade tenderized 1x had a lower cooking loss percent than those not tenderized. Steaks aged 7 d had higher (P < 0.05) thawing loss percents than steaks aged 21 d. Steaks aged 14 and 21 d had higher (P < 0.05) cooking loss percents than those aged 7 d. Cooking time was faster (P < 0.05) for CHO and CAB steaks than SEL steaks. In contrast, Luchak et al. (1998) found no difference in cooking time when comparing Choice and Select steaks. Additionally, cooking time was similar (P > 0.05) for all postmortem aging periods and blade tenderization passes. In contrast, Savell et al. (1977) reported shorter cooking times for steaks blade tenderized 1x compared with nontenderized controls.

Increasing internal endpoint temperature increased cooking time and cooking losses (P < 0.05; Table 2). Cooking losses were 22.5 and 38.7% greater, and cooking times were 25.3 and 47.5% longer, for steaks cooked to 71.0 and 76.6°C, respectively, than steaks cooked to 65.5°C. Similarly, Luchak et al. (1998) also found increasing internal endpoint temperatures for gluteus medius steaks resulted in longer cooking times and greater cooking losses.

Warner-Bratzler Shear Force

There was a quality classification × endpoint cooking temperature interaction (P = 0.05) for WBSF (Table 3); however, no other interactions (P > 0.05) were observed for WBSF. Within each quality classification, WBSF values increased (P > 0.05) as endpoint temperature increased. In agreement, Lorenzen et al. (2003) found that WBSF for top sirloin steaks increased when cooking to higher in internal endpoint temperatures. For steaks cooked to 65.5°C (approximately medium-rare degree of doneness), WBSF values were similar (P > 0.05) for all quality classifications. For steaks cooked to 71.0 and 76.6°C (approximately medium and well-done degrees of doneness, respectively), CHO and CAB steaks had lower (P < 0.05) WBSF values than SEL steaks. Lorenzen et al. (2003) concluded that WBSF of top sirloin steaks was lower for Choice steaks than Select steaks when cooked to endpoint temperatures above 65°C, and top sirloin steaks were more influenced

Table 1. Influence of quality classification, postmortem aging, and blade tenderization on cooking characteristics and Warner-Bratzler shear force (WBSF) of gluteus medius steaks

<table>
<thead>
<tr>
<th>Trait</th>
<th>Quality classificationa</th>
<th>Postmortem age, d</th>
<th>Blade tenderizationb</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of top sirloin butts</td>
<td>SEL  CHO  CAB</td>
<td>7  14  21</td>
<td>0x  1x  2x</td>
</tr>
<tr>
<td>Thawing loss, %</td>
<td>1.96  1.84  1.70</td>
<td>2.17f  1.82f  1.52g</td>
<td>2.01  1.90  1.59</td>
</tr>
<tr>
<td>Cooking loss, %</td>
<td>30.8  30.4  30.8</td>
<td>29.8f  31.3f  30.9g</td>
<td>30.5  30.7  30.8</td>
</tr>
<tr>
<td>Cooking time, min/100 g</td>
<td>12.8d  12.1e  11.9e</td>
<td>12.0  12.5  12.4</td>
<td>12.2  12.4  12.3</td>
</tr>
<tr>
<td>WBSF, kgf</td>
<td>—  —  —</td>
<td>3.96f  3.64f  3.47h</td>
<td>3.87f  3.76i  3.43j</td>
</tr>
</tbody>
</table>

aSEL = USDA Select, CHO = USDA Choice, and CAB = Certified Angus Beef. b0x = not blade tenderized; 1x = blade tenderized one time; 2x = blade tenderized two times. cQuality classification × endpoint cooking temperature interaction (Table 3). dWithin a row and quality classification, means that do not have a common superscript letter differ (P < 0.05). eWithin a row and postmortem age, means that do not have a common superscript letter differ (P < 0.05). fWithin a row and blade tenderization, means that do not have a common superscript letter differ (P < 0.05).

Table 2. Influence of endpoint cooking temperature on cooking characteristics of gluteus medius steaks

<table>
<thead>
<tr>
<th>Trait</th>
<th>Endpoint cooking temperature, °C</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of steaks</td>
<td>162</td>
<td>162</td>
</tr>
<tr>
<td>Cooking loss, %</td>
<td>25.3a</td>
<td>31.0b</td>
</tr>
<tr>
<td>Cooking time, min/100 g</td>
<td>9.9a</td>
<td>12.4b</td>
</tr>
</tbody>
</table>

a,bWithin a row, means that do not have a common superscript letter differ (P < 0.05).
by degree of doneness than top loin or top round steaks. Wulf et al. (1996) found that shear force was lowest between a medium rare and medium degree of doneness, and increased rapidly as degree of doneness increased to well done (approximately 75°C). Unfortunately, consumers consistently cook top sirloin steaks well done or to higher degrees of doneness (Savell et al., 1999); therefore, consumers should choose sirloin steaks with higher quality classifications to ensure greater tenderness when cooking to a higher degree of doneness. Results of the present study suggest that higher quality classifications (higher i.m. fat) provide some protection against toughening due to increased cooking temperature.

Gluteus medius steaks aged 21 d had lower (more tender, $P < 0.05$) WBSF values than those aged 14 and 7 d (Table 1). Steaks aged 14 d had lower ($P < 0.05$) WBSF values than steaks aged 7 d. In contrast, other researchers failed to detect an improvement in WBSF when gluteus medius steaks were aged (Savell et al., 1982; Harris et al., 1992). Harris et al. (1992) attributed this lack of shear force decline to the higher content of connective tissue (not degraded during aging) compared with top loin steaks; however, they found overall tenderness scores were improved for top sirloin steaks aged 21 vs. 7 d. Harris et al. (1992) found myofibrillar and overall tenderness scores were improved for top sirloin steaks aged 28 and 35 d compared with steaks aged 21 d or less. Steaks blade tenderized $2 \times$ had lower ($P < 0.05$) WBSF values than those blade tenderized $0 \times$ and $1 \times$. Savell et al. (1977) reported that gluteus medius steaks needed to be blade tenderized only once to lower WBSF values compared with nontendered controls. Our results suggest that blade tenderization and postmortem aging can effectively lower WBSF values. Thus, to maximize tenderness of gluteus medius steaks, gluteus medius steaks should be aged for at least 21 d and blade tenderized $2 \times$.

**Sensory Panel**

No interactions ($P > 0.05$) were observed for any sensory panel traits. Sensory panel ratings for flavor and juiciness were similar ($P > 0.05$) for all postmortem aging and blade tenderization treatments (Table 4). Myofibrillar tenderness ratings also did not differ ($P > 0.05$) for all postmortem aging treatments; however, connective tissue amount and overall tenderness ratings were higher and more desirable ($P < 0.05$) for steaks aged 21 vs. 7 d. Harris et al. (1992) found myofibrillar and overall tenderness scores were improved for top sirloin steaks aged 28 and 35 d compared with steaks aged 21 d or less. These authors reported an overall improvement in the amount of connective tissue detected by sensory panelists at 28 and 35 d of age; however, greater variability in connective tissue scores were noted when compared to other sensory traits. Furthermore, Savell et al. (1982) reported no effect of aging on sensory panel flavor, juiciness, or connective tissue amount; however, they did report improved ratings for myofibrillar tenderness and overall tenderness in steaks aged 18 d compared to those aged 4 d.

Steaks blade tenderized $1 \times$ and $2 \times$ had higher ($P < 0.05$) myofibrillar and overall tenderness scores than steaks not blade tenderized. All blade tenderization treatments (zero, one, or two passes) had similar ($P > 0.05$) ratings for connective tissue amount, flavor, and

<table>
<thead>
<tr>
<th>Quality classification</th>
<th>Endpoint cooking temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>65.5°C</td>
</tr>
<tr>
<td></td>
<td>71.0°C</td>
</tr>
<tr>
<td></td>
<td>76.6°C</td>
</tr>
<tr>
<td>SEL</td>
<td>3.29b</td>
</tr>
<tr>
<td>CHO</td>
<td>3.25b</td>
</tr>
<tr>
<td>CAB</td>
<td>3.14b</td>
</tr>
</tbody>
</table>

$^a$SEL = USDA Select, CHO = USDA Choice, and CAB = Certified Angus Beef.

$^{b,c,d,e,f}$Means that do not have a common superscript letter differ ($P < 0.05$).

**Table 4.** Influence of postmortem aging time and blade tenderization on sensory panel traits of U.S. Choice gluteus medius steaks

<table>
<thead>
<tr>
<th>Trait$^b$</th>
<th>Postmortem age</th>
<th>Blade tenderization$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7 d</td>
<td>14 d</td>
</tr>
<tr>
<td>No. of steaks</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Flavor</td>
<td>5.7</td>
<td>5.8</td>
</tr>
<tr>
<td>Juiciness</td>
<td>5.1</td>
<td>5.3</td>
</tr>
<tr>
<td>Myofibrillar tenderness</td>
<td>4.7</td>
<td>5.2</td>
</tr>
<tr>
<td>Connective tissue amount</td>
<td>5.7$^e$</td>
<td>6.1$^{cd}$</td>
</tr>
<tr>
<td>Overall tenderness</td>
<td>4.8$^e$</td>
<td>5.2$^{cd}$</td>
</tr>
</tbody>
</table>

$^a0 \times$ = not blade tenderized; $1 \times$ = blade tenderized one time; $2 \times$ = blade tenderized two times.

$^b$Sensory traits were evaluated on an 8-point scale; (flavor: 1 = extremely bland to 8 = extremely intense; juiciness: 1 = extremely dry to 8 = extremely juicy; myofibrillar and overall tenderness: 1 = extremely tough to 8 = extremely tender; connective tissue amount: 1 = abundant to 8 = none).

$^c,d,e,f$Within a row and postmortem age, means that do not have a common superscript letter differ ($P < 0.05$).

$^c$Within a row and blade tenderization, means that do not have a common superscript letter differ ($P < 0.05$).
juiciness. Savell et al. (1982) also reported no effects of blade tenderization on sensory panel flavor or juiciness, and improved ratings for myofibrillar tenderness, connective tissue amount, and overall tenderness for top sirloin butt steaks. However, Savell et al. (1977) found that LM steaks were less juicy after blade tenderization.

Results of the present study indicate that aging gluteus medius steaks for 21 d will increase tenderness compared with aging for 7 d, and that blade tenderizing either 1× or 2× will increase tenderness with no decrease in flavor or juiciness. Sensory panel results were confirmed by our WBSF results and suggest that either postmortem aging or blade tenderization improved tenderness in gluteus medius steaks and these methods can be used together to further improve tenderness.

Implications

Increasing the degree of doneness in sirloin (gluteus medius) steaks lowers tenderness; thus, selecting steaks with higher quality classifications (USDA Choice or Certified Angus Beef) resulted in greater tenderness when steaks were cooked to higher degrees of doneness. Furthermore, tenderness of sirloin steaks can be improved with extended postmortem aging or blade tenderization, regardless of degree of doneness. Additional enhanced tenderness can be obtained when using extended postmortem aging followed by blade tenderization.

Literature Cited