Internal Color and Tenderness of the Semimembranosus Are Affected by Cooking Method and Degree of Doneness

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Story in Brief

Semimembranosus (SM) steaks (n = 360) from USDA Select top/inside rounds aged 0 to 35 d at 35.6°F were used to test the effect of cookery method and internal endpoint temperature on Warner-Batzlpler shear force (WBSF) and cooked beef color. Steaks were cooked to 3 different endpoint temperatures (150, 160, or 170°F) using: 1) an air-impingement oven (IMP); 2) clam-shell griddle (PANI); 3) forced-air convection oven (BLOD); 4) counter-top electric griddles (GRID); and 5) gas-fired, open-hearth char-grill (CHAR). Steaks cooked to 170 and 150°F had the greatest (P < 0.05) and lowest (P < 0.05) cooking loss percentages. Steaks cooked in the PANI had the lowest (P < 0.05) cooking losses, and GRID-cooked steaks had lower (P < 0.05) cooking losses than steaks cooked in BLOD, CHAR or IMP. Shear force (WBSF) values increased with increasing endpoint temperature, and steaks cooked on CHAR had greater (P < 0.05) WBSF values than those cooked in BLOD, GRID, IMP and PANI at 150 and 170°F. Internal color of steaks cooked in the BLOD was lighter (P < 0.05) and less yellow (P < 0.05) than steaks cooked on CHAR, GRID or PANI. Internal color of steaks cooked to 150°F was redder (P < 0.05) and more yellow (P < 0.05) than steaks cooked to 170°F. Obviously, cooking SM steaks to 170°F produced tougher steaks, with less internal red cooked beef color, especially when cooked on CHAR; however, grilling SM steaks on GRID produced the most tender steaks, regardless of endpoint temperature.

Introduction

Cooking method and endpoint temperature/degree of doneness are important factors in determining the overall desirability of beef steaks. Neely et al. (1999) and Behrends et al. (2005) found that consumers in metropolitan cities (Chicago, Houston, Philadelphia, and San Francisco) prefer to grill top round (semi membranosus) steaks to “medium well” or greater degrees of doneness. Moreover, Belk et al. (1993) reported that sensory panel scores for juiciness and tenderness of top round roasts decreased with increasing endpoint temperature.

When cooking beef from “rare” to “very well done,” obvious changes occur to the internal color of cooked meat. Myoglobin is the primary heme pigment responsible for fresh meat color, and, during cooking, myoglobin is denatured to varying degrees, thereby influencing the appearance of meat color (Gracia-Segovia et al., 2006); however, there is limited information concerning the effects of cookery method and/or degree of doneness on internal cooked beef color, especially in top round steaks. Therefore, the objective of this research study was to test the effect of cookery method and internal endpoint temperature on Warner-Batzlpler shear force and cooked beef color of the semimembranosus steaks.

Experimental Procedures

USDA Select inside (top) rounds were aged 0, 7, 14, 21, 28, or 35 d at 35.6°F (10 inside rounds/aging period) to develop a wide range in possible tenderness differences. After the aging period, the adductor and gracilis muscles were removed before six 1-in-thick semimembranosus (SM) steaks (n = 360) were cut from each primal, labeled, vacuum-packaged, and frozen at -22°F for approximately 60 d before cooking. Then, frozen SM steaks were randomly assigned to 1 of 15 treatments in a 3 × 5 factorial arrangement, with 3 endpoint temperatures (150, 160, or 170°F) and 5 cookery methods. Steaks were thawed overnight at 35.6°F, removed from vacuum–packages, and weighed. Steaks were then cooked to their assigned endpoint temperature in/on either: 1) an air-impingement oven (IMP); 2) a clam-shell griddle (PANI); 3) electric, counter-top griddle (GRID); 4) forced-air, convection oven (BLOD); or 5) gas-fired, open-hearth char-grill (CHAR). All cookery methods were preheated to 360°F before cooking, and internal temperature was monitored in steaks cooked in PANI, BLOD, GRID and CHAR by placing copper-constantan thermocouples in the geometric-center of each steak. Additionally, SM steaks cooked in the BLOD, PANI and CHAR were turned when the internal temperatures had reached 95, 100, and 105°F for 150, 160 and 170°F endpoint temperatures, respectively, whereas steaks cooked on GRID were turned every 4 min until reaching the appropriate endpoint temperature. Finally, belt speeds of the IMP were set at 20, 25 and 30 min to produce endpoint temperatures of 150, 160 and 170°F, respectively, and endpoint temperature of IMP-cooked steak was confirmed at the completion of cooking with a hand-held thermometer.

Cooking times were recorded for each SM steak cooked, and after a 1-h cooling period at room temperature, steaks were weighed to calculate cooking loss percentages. Then, each steak was sliced perpendicular to the cut surface, and instrumental color (L*, a* and b* values), as well as reflectance values from 400 to 740 nm, was measured immediately after cutting with a Hunter Miniscan XL equipped with a 9-mm aperture and illuminant A.

Immediately after cooked color data collection, six 0.5-inch diameter cores were removed parallel with the muscle fiber orientation, and each core was sheared once with a Warner-Batzlpler shear force (WBSF) device attached to an Instron Universal Testing machine with a 110-lb compression load cell and a crosshead speed of 250 mm/min. The average peak shear force of the 6 cores was used for statistical analyses.

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Data were analyzed as an incomplete block design with inside round (subprimal) as the block and individual SM steak as the experimental unit. Analysis of variance was generated with the mixed model procedure of SAS (SAS Inst., Inc., Cary, N.C.) with cookery method, endpoint temperature, and the 2-way interaction included in the model as fixed effects and subprimal as the random effect in the model. Least squares means were calculated and separated statistically using pair-wise t-tests (PDIFFIG option) when a significant ($P \leq 0.05$) F-test was identified.

**Results and Discussion**

An endpoint temperature by cookery method interaction was found for WBSF ($P < 0.05$) (Figure 1). Steaks cooked to 170°F on the CHAR had the greatest ($P < 0.05$) WBSF of any other endpoint temperature and cookery method combination. Furthermore, SM steaks cooked to 150°F on the CHAR had greater ($P < 0.05$) WBSF than any other cookery method at that temperature. Other than the CHAR, steaks cooked to 150°F were similar ($P > 0.05$) in WBSF regardless of cookery method and lower ($P < 0.05$) than those cooked on the CHAR. Steaks cooked to 170°F in the IMP or PANI had greater ($P < 0.05$) WBSF than those cooked to 160°F in the BLOD, GRID, or PANI, but CHAR steaks were similar ($P > 0.05$) to those cooked in the IMP at 160°F. Within the BLOD, CHAR, and GRID cooking methods, steaks cooked to 150 and 160°F had similar ($P > 0.05$) WBSF, but steaks cooked to 150°F had lower ($P < 0.05$) WBSF than those cooked to 160°F in the IMP and PANI. Steaks cooked to 170°F in the BLOD and CHAR had greater ($P < 0.05$) WBSF than those cooked to 150 or 160°F, but on the GRID and IMP, steaks cooked to 170°F were similar ($P > 0.05$) to those cooked to 150 and 160°F. When cooked on the PANI, the WBSF of steaks cooked to 160 and 170°F were similar ($P > 0.05$) and greater ($P < 0.05$) than those cooked to 150°F. In the IMP, steaks cooked to 160°F had greater ($P < 0.05$) WBSF than those cooked to 150°F, but steaks cooked to 170°F were intermediate ($P > 0.05$).

As expected, SM steaks cooked to 150°F had the least ($P < 0.05$) cooking loss, and those cooked to 170°F had the greatest ($P < 0.05$) (Table 1). Steaks cooked on the PANI had the lowest ($P < 0.05$) cooking loss, and those cooked on the GRID had less ($P < 0.05$) cooking loss than those cooked on the BLOD, CHAR, or IMP, which were similar ($P > 0.05$). Cooking SM muscles in the BLOD and GRID and IMP to 170°F took longer ($P < 0.05$) than cooking to 170°F using other cookery methods. In the BLOD, steaks had longer ($P < 0.05$) cooking times to 160°F than other methods, and the steaks took longer ($P < 0.05$) in the IMP to cook to 160°F than on the GRID or PANI (Figure 2). When cooking SM steaks to 150°F, the BLOD had longer ($P < 0.05$) cooking times than the CHAR and GRID, and the IMP was intermediate ($P > 0.05$). The PANI method had the shortest ($P < 0.05$) cooking times at each endpoint temperature. Within the BLOD and IMP cookery methods, cooking SM steaks to 150°F had the shortest ($P < 0.05$) cooking times, and cooking steaks to 170°F had the longest ($P < 0.05$). On the CHAR and GRID, steaks cooked to 150°F had shorter ($P < 0.05$) cooking times than those cooked to 170°F, and steaks cooked to 160°F were intermediate ($P > 0.05$). When cooking on the PANI, cooking time was similar ($P > 0.05$) regardless of end-point temperature.

Endpoint cooking temperature had no effect ($P > 0.067$) on internal lightness ($L^*$ values) (Table 1). Although the differences in $L^*$ were small and inconsequential (total difference less than 2 units), steaks cooked on the BLOD had greater ($P < 0.05$) $L^*$ values than those cooked on the CHAR, GRID, and PANI, and those cooked on the IMP had greater ($P < 0.05$) $L^*$ values than those cooked on the CHAR and PANI. As expected, SM steaks cooked to 150°F were redder ($P < 0.05$; higher a*), and those cooked to 170°F were least red ($P < 0.05$). Cooking method did not affect ($P > 0.05$) redness of SM steaks. Similarly, SM steaks cooked to 150°F had the most yellow ($P < 0.05$) internal color, and those cooked to 170°F were the least yellow ($P < 0.05$). As with $L^*$, the differences in b* due to cookery method were statistically significant but irrelevant. Steaks cooked on the GRID were more yellow ($P < 0.05$) than those cooked on the BLOD, IMP, and PANI, whereas those cooked on the CHAR were more yellow ($P < 0.05$) than those cooked on the BLOD.

**Implications**

Cooking top/inside round (semimembranosus) steaks to 170°F resulted in greater cooking losses and reductions in mechanical measures of tenderness, especially when cooked upon a gas-fired, open-hearth char-grill. And, even though cooking steaks in the clam-shell griddle, where the steak is in contact with the griddle on both sides, greatly reduced cooking times, grilling upon inexpensive electric, counter-top griddles produced the most tender steaks, regardless of endpoint temperature.

**Literature Cited**


**Table 1. Main effects of endpoint temperature and cookery method on characteristics of cooked semimembranosus steaks.**

<table>
<thead>
<tr>
<th>Trait</th>
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<th>Cookery method</th>
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1BLOD = forced-air convection oven; CHAR = gas-fired, open-hearth char-grill; GRID = counter-top electric griddles; IMP = air-impingement oven; and PANI = clam-shell griddle.

2$L^*$ = a measure of darkness to lightness (greater number indicates a lighter color); a* = a measure of redness (greater number indicates a redder color); and b* = a measure of yellowness (greater number indicates a more yellow color).

Within a row and main effect, least squares means lacking common superscript letters differ ($P < 0.05$).
Fig. 1. Interactive effect of cookery method and endpoint temperature on shear force values of *semimembranosus* steaks. Cookery methods were forced-air convection oven (BLOD), open-hearth char-grill (CHAR), counter-top electric griddles (GRID), an air-impingement oven (IMP), and clam-shell griddle (PANI).

Fig. 2. Interactive effect of cookery method and endpoint temperature on cook time of *semimembranosus* steaks. Cookery methods were forced-air convection oven (BLOD), open-hearth char-grill (CHAR), counter-top electric griddles (GRID), an air-impingement oven (IMP), and clam-shell griddle (PANI).