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Color stability and tenderness variations within the *gluteus medius* from beef top sirloin butts

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ABSTRACT

Beef top sirloin butts (n = 48) from USDA quality grade (QG; upper 2/3 US Choice vs. US Select) and yield grade categories (YG; 1 and 2 vs. 4 and 5) were aged 14 days, GM steaks were cut, with 2 steaks removed from the anterior (ANT), middle (MID) and posterior (POST) sections of the GM. One steak from each section was cut into lateral (LAT), central (CENT) and medial (MED) portions, packaged aerobically, and displayed for 7 days, whereas the second steaks were cooked to 71 °C for WBSF. Top Choice-steaks were redder and more yellow ($P < 0.05$) than Select steaks during display. Cooking losses were greatest ($P < 0.05$) in the MED, and least ($P < 0.05$) in the CENT, portions of GM steaks. Neither QG nor YG category affected WBSF, but differences within the GM were found for ($P < 0.05$) WBSF. Results of this experiment indicate tenderness and color stability gradients exist within the GM.

1. Introduction

Beef top sirloin steaks are one of the most popular steaks served in restaurants (Harris, Miller, Savell, Cross, & Ringer, 1992), as well as purchased at retail outlets (National Cattlemen's Beef Association, 2005), across the United States. Beef top sirloin steaks are typically marketed at lower prices compared to the other steaks from the loin and rib primals (Harris et al., 1992) because of palatability inconsistencies, especially in cooked beef tenderness. Even though the variation in tenderness for top sirloin steaks has been reduced (Brooks, Belew, Griffin, Gwartney, Hale, Henning, Johnson, Morgan, Parrish, Reagan and Savell, 2000; Morgan, Savell, Hale, Miller, Griffin, Cross and Shackelford, 1991), research has reported similar (Belew, Brooks, McKenna, & Savell, 2003; McKeith, DeVol, Miles, Bechtel, & Carr, 1985; Shackelford, Wheeler, & Koohmaraie, 1995; Voges, Mason, Brooks, Delmore, Griffin, Hale, Henning, Johnson, Lorenzen, Maddock, Miller, Morgan, Baird, Gwartney and Savell, 2007) or greater shear force values (Harris et al., 1992; Rhee, Wheeler, Shackelford, & Koohmaraie, 2004), along with lower tenderness ratings (Carmack, Kastner, Dikeman, Schwenke, & Garcia Zepeda, 1995; Harris et al., 1992; McKeith et al., 1985; Neely, Lorenzen, Miller, Tatum, Wise, Taylor, Buyck, Reagan and Savell, 1998; Rhee et al., 2004; Shackelford et al., 1995), when compared to beef top loin and/or ribeye steaks. Even though Rhee et al. (2004) reported that shear force values from the *gluteus medius* muscle (GM) did not differ between steaks removed from the anterior and posterior of top sirloin steaks, little is known about the tenderness gradient, if any, within the GM.

A number of studies have shown that the beef GM also has color stability issues (Hood, 1980; O'Keefe & Hood, 1982). Based on metmyoglobin formation and discoloration rates over five days of simulated retail display, McKenna, Mies, Baird, Pfeiffer, Ellebracht and Savell (2005) classified the GM as an "intermediate" color-stable muscle when compared to other muscles. Research on the beef *semimembranosus* – also classified as an "intermediate" color stable muscle – demonstrated considerable within-muscle variation in fresh color measured within 30 min of steak fabrication (Lee, Yancey, Apple, Sawyer, & Baublits, 2008) and across seven days of simulated retail display (Sawyer, Baublits, Apple, Meullenet, Johnson and Alpers, 2007). Yet, the limited work on color development and stability on the GM has not examined the existence of lateral and/or longitudinal color variations. Therefore, objectives of this study were to investigate the interactive effect of USDA quality and yield grades on instrumental color and shear force variations within the GM.

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2. Materials and methods

2.1. Top sirloin butt selection and fabrication

Beef top sirloin butts (IMPS #184) were selected at a large commercial slaughter facility based on USDA quality grade (upper 2/3, or top, USDA Choice ["modest" and "moderate" degrees of marbling] or USDA Select ["slight" degree of marbling]) and USDA yield grade (yield grades 1 and 2 or 4 and 5). Individually-identified top sirloin butts (n = 48) from left carcass sides were captured during fabrication, vacuum-packaged, and transported under refrigeration to the University of Arkansas Red-Meat Abattoir for further processing.

Top sirloin butts were allowed to age at 2 °C for 14 days from the box date before removal from vacuum-sealed packages. Depth of the subcutaneous fat opposite the center of the *biceps femoris* (rump fat) was measured with a metal ruler prior to removal of the *biceps femoris* and all overlying subcutaneous fat, as well as the *gluteus intermedius* and *gluteus profundus*. Then, beginning at the posterior end of the resulting *gluteus medius* (GM), eight 2.54-cm-thick steaks were hand-cut: 1) first and second steaks designated as posterior (POST) steaks; 2) third steak was discarded; 3) fourth and fifth steaks designated at middle (MID) steaks; 4) sixth steak was discarded; and 5) seventh and eighth steaks were designated as anterior (ANT) steaks (Fig. 1A). One steak from each location pair was randomly chosen, identified, vacuum-packaged in a 3 mil standard barrier nylon/polyethylene pouch, and frozen approximately 6 weeks at −20 °C for Warner–Bratzler shear force (WBSF) determination.

The remaining steak from each location pair was further divided into three equal length intra-steak portions, designated as lateral (LAT), central (CENT) and medial (MED) portions (Fig. 1B). An approximately 2-g sample of GM was removed from each portion for pH measurement before steak portions were placed onto polystyrene foam trays (with absorbent pads) and over-wrapped with an oxygen-permeable, PVC film (OTR = 14,000 cc O_2/m^2/24 h/atm; Koch Supplies Inc., Kansas City, MO, USA). Subsequently, individually-packaged steak portions were placed in open-topped, coffin-chest display cases (model LMG12; Tyler Refrigeration Corp., Niles, MI, USA) maintained at an average temperature of 2.5 °C, and displayed under continuous lighting (1,600 lx of deluxe, warm-white fluorescent lighting [bulb type F40T12, 40-W; Philips Inc., Somerset, NJ, USA]) for seven days. Temperature was monitored with an EV_2 temperature logger (Comark Instruments, Inc., Beaverton, OR), and steaks were rotated daily.

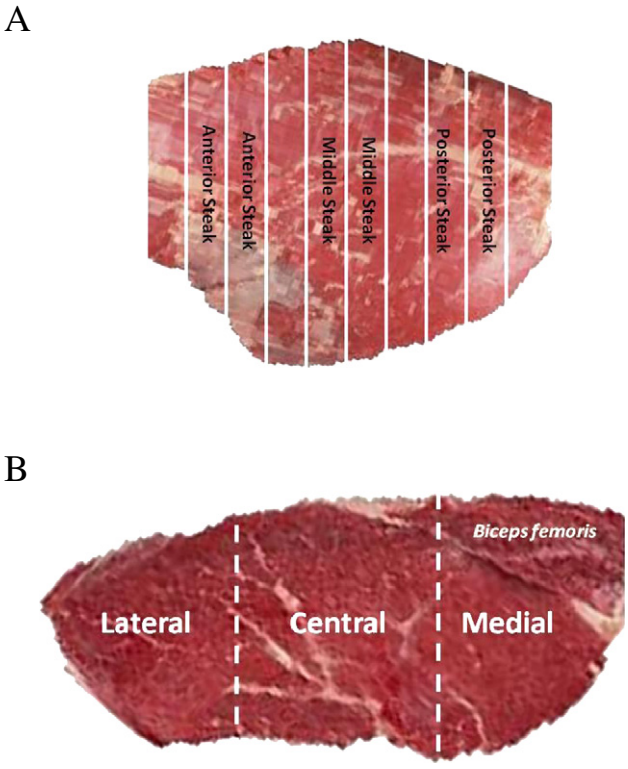

Fig. 1. Diagram of (A) *gluteus medius* steak fabrication and (B) within-steak positions.

2.2. Muscle pH

The 2 g of GM removed from each steak prior to packaging were homogenized in 20 ml of distilled, deionized water, and pH of the homogenate was measured with a pH meter (UP-10; Denver Instruments, Denver, CO, USA) equipped with a temperature-compensating, combination pH electrode. The pH meter was calibrated to both pH 4.0 and 7.0 before measuring GM pH.

2.3. Instrumental color measurement

Instrumental color readings of steak portions (n = 432) were measured daily during the seven-day simulated retail display period using a Hunter MiniScan XE (45/0-L; Hunter Associates Laboratory, Inc., Reston, VA, USA) calibrated against a standard white tile and black glass each day immediately before data collection. The L*, a* and b* values of each steak portion in display were determined from the average of three readings on the cut surface using illuminant A, a 2.54-cm aperture, and a 10° standard observer. Chroma (C*), or saturation index, $\left(\sqrt{a*^2 + b*^2}\right)$ and hue angle ($\tan^{-1}[b^* / a^*]$) were also calculated for each steak portion daily (AMSA, 1991). In addition, reflectance values were simultaneously measured at 10-nm intervals from 400 to 700 nm.

2.4. Warner–Bratzler shear force determinations

Steaks from the ANT, MID, and POST of each GM were allowed to thaw for 16 h in a 4 °C commercial refrigerator before removal from vacuum-packages, and identified with heat-resistant tags. Then, steaks were cut into LAT, CENT, and MED within-steak sections, weighed and oriented on the belt of a gas-fired, air-impingement oven (Lincoln Impinger; Food Service Products, Inc., Ft. Wayne, IN, USA). The oven was preheated to 165 °C, with the belt speed set at 25 min to produce the desired endpoint temperature of 71 °C. Endpoint temperature of each cooked steak was confirmed at the completion of cooking with a digital, hand-held thermometer (KM28; Comark Instruments, Inc., Beaverton, OR, USA). Cooked steaks were allowed to cool to room temperature before weighing, and the difference between the pre-cooked and cooked steak weights was used to calculate cooking loss percentages. Subsequently, cooked steaks were wrapped in an oxygen-permeable, PVC film and chilled overnight in a 4 °C commercial refrigerator before six 1.27-cm-diameter cores were removed parallel to the muscle fiber orientation from each steak. Each core was then sheared once through the center with a V-shaped WBSF device attached to an Instron Universal Testing Machine (Instron Corp., Canton, MA, USA) equipped with a 50-kg load cell and set at a crosshead speed of 200 mm/min. The peak WBSF of the six cores within each steak location was averaged before statistical analyses.

2.5. Statistical analyses

Carcass data from which the top sirloin butts (BUTT) originated were analyzed using the mixed models procedure of SAS (SAS Inst., Inc., Cary, NC, USA), with quality grade (QG) and yield grade (YG) categories, as well as the QG × YG interaction, included in the model as fixed effects. The experiment was conducted as a split–split plot design, with QG and YG as the whole plot, steak location within the