2011

Intramuscular Tenderness and Muscle Fiber Orientation of Beef Round Muscles

Lasika S. Senaratne
University of Nebraska-Lincoln

Chris Calkins
University of Nebraska-Lincoln, ccalkins1@unl.edu

Amilton S. de Mello
University of Nebraska-Lincoln, amilton@cabnr.unr.edu

Siroj Pokharel
University of Nebraska-Lincoln

Jeremy B. Hinkle
University of Nebraska-Lincoln

Intramuscular Tenderness and Muscle Fiber Orientation of Beef Round Muscles

Lasika S. Senaratne
Chris R. Calkins
Amilton S. de Mello, Jr.
Siroj Pokharel
Jeremey B. Hinkle[1,2]

Summary

Intramuscular tenderness and muscle fiber orientation variations of beef round m. adductor femoris *(AF), m.* biceps femoris *(BF), m.* semimembranosus *(SM), and m. semitendinosus (ST) were investigated. The first two proximal steaks of long head of BF were more tender than the rest. The tenderness decreased from the middle of the ST muscle to both ends. The anterior sides of the long head BF and ST were tougher than their posterior sides. The first four steaks of the SM were more tender than rest of the muscle. There was a significant tenderness increment from the middle of the AF to its both ends. Based on tenderness values, the first two to four steaks of long head BF, SM, and AF and middle steaks of ST, could be marketed as premium quality steaks.*

Introduction

Since most beef round muscles are large and long, the tenderness varies within the muscles from one end to the other. The knowledge of muscle fiber direction is important during meat fabrication so that muscles can be cut across the grain to improve the tenderness. Muscle fiber directions along the muscles of the beef round have not been documented. Characterization of all muscles in the beef round, based on their intramuscular tenderness and muscle fiber orientation variations, therefore is necessary to apply value-added strategies for the beef round. This study, attempted first to identify tender portions of beef round muscles, m. *adductor femoris* (AF), m. *biceps femoris* (**BF**), *semimembranosus* (**SM**), and m. *semitendinosus* (**ST**) that could be marketed as "premium" round steaks or single muscle steaks based on tenderness, and second determined fabrication specifications for the beef round muscles based on their muscle fiber orientation.

Procedure

Ten of each beef round, top untrimmed (IMPS #168; *NAMP, 2007*), beef round, outside round (IMPS #171B; *NAMP, 2007*), and beef round, eye of round (IMPS #171C; *NAMP, 2007*) were purchased as USDA Choice boxed beef subprimals and aged for 14 days from boxed date. The BF, ST, SM, and AF were fabricated from relevant subprimals. The anterior and distal directions of each muscle were tracked. Crust-frozen muscles were cut into 1-inch-thick steaks from the proximal to distal end, perpendicular to the long axis. Steaks were vacuum packaged and stored at -4ºF.

Thawed steaks were grilled to an internal temperature of 160ºF. Grilled steaks were cooled at 39ºF for 24 hours. A 2 inch-wide region in the middle of grilled BF, SM, and AF was marked from posterior to anterior sides as posterior, middle, and anterior regions (Figure 1b, 3b, and 4b). Grilled ST steaks were horizontally divided into three regions from the medial to lateral as medial, middle, and lateral regions (Figure 2b). Each region of BF, SM, and AF were again subdivided into two sections as medial and lateral (Figure 1b, 3b, and 4b). Medial, middle, and lateral regions of ST steaks were also subdivided into anterior and posterior sections. From each section of a steak, 0.5 inch-diameter cores were prepared parallel to the muscle fiber orientation and sheared on an Instron Universal Testing Machine with a triangular Warner-Bratzler shear attachment. An individual peak Warner-Bratzler shear force (WBSF) for each steak section was used for the statistical analysis. The WBSF values of each section of steaks were calculated and used to construct intramuscular tenderness maps based on a color scheme (white – tender < 8.6 lb); gray – intermediate tender 8.6 – 10.8 lb; and black – though >10.8 lb; Von Seggern et al. *2005 Journal of Animal Science,* pp. 39-51).

Before removing cores, a digital image of muscle fiber orientation on the longitudinal section of the steak was captured using a digital camera (Model # DSC-S730 cyber-shot 7.2 megapixels, SONY Corp., China). The muscle fiber orientation on each digital picture was measured using a protractor, and expressed in degrees horizontally along the long axis of the muscle from the proximal to the distal at every inch. The fiber orientation with the angle was illustrated on a longitudinal section of the muscle along the long axis from the proximal to the distal.

Warner-Bratzler shear force values were analyzed by using the ANOVA in GLIMMIX procedure of SAS (version 9.1), with a model including region or steak (from proximal to distal) of BF, ST, SM, and AF muscles. The side differences (anterior *vs* posterior or anterior/posterior *vs* middle, and medial *vs* lateral or medial/lateral *vs* middle) of each muscle steak were determined using the CONTRAST option in SAS. Least square means were calculated for each section using the LSMEANS and mean separation was performed using the DIFF and LINES options of SAS at $P < 0.05$.

Results

The most proximal two steaks of the BF, which were closest to the sirloin/round separation, was the most tender region of the muscle (Figure 1a). The long head of BF had its highest WBSF value in the middle region 4 to 8 inches from the sirloin/round

(Continued on next page)

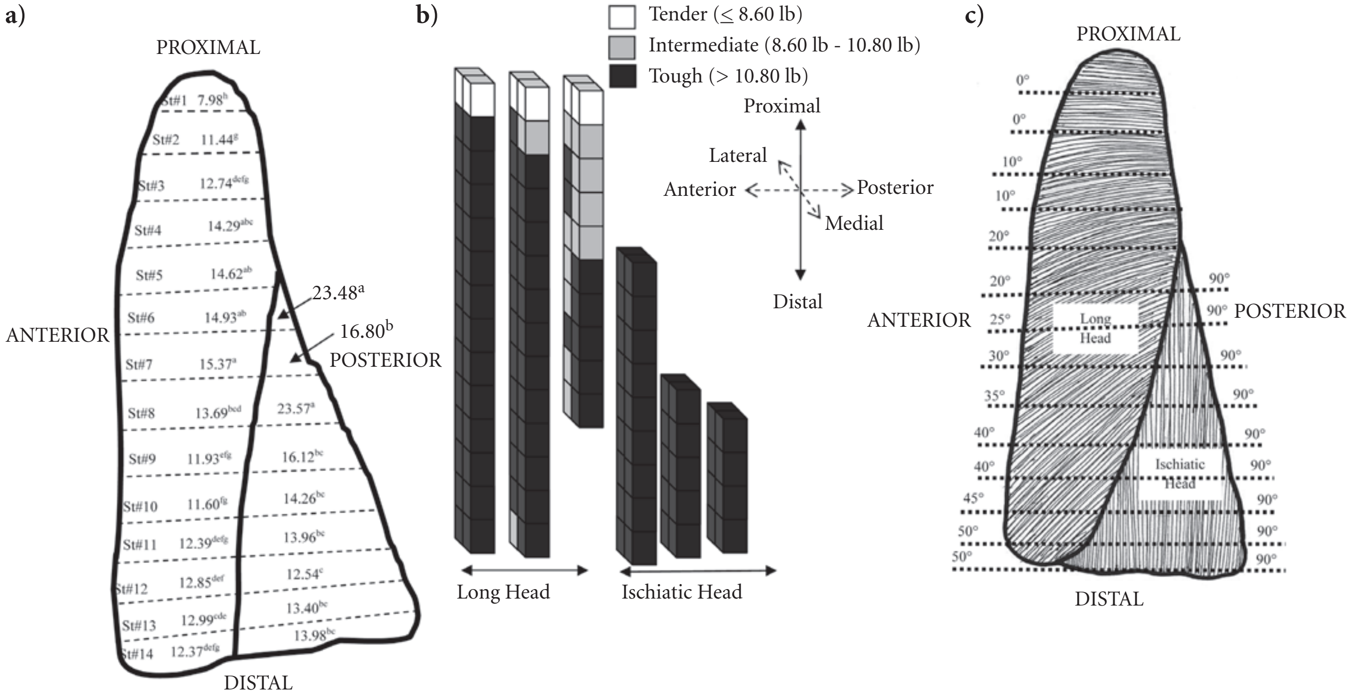

Figure 1. **a. Least square means Warner Bratzler shear force (WBSF) values (lb) of each steak of m. *biceps femoris* long head ($P <0 .0001$) and ischiatic head ($P <.0001$). b. Intramuscular tenderness variation map of m. *biceps femoris* based on WBSF values (lb). c. Intramuscular muscle fiber orientation map of m. *biceps femoris.* [a-h]Within the same figure, means lacking a common superscript were different ($P < 0.05$).**

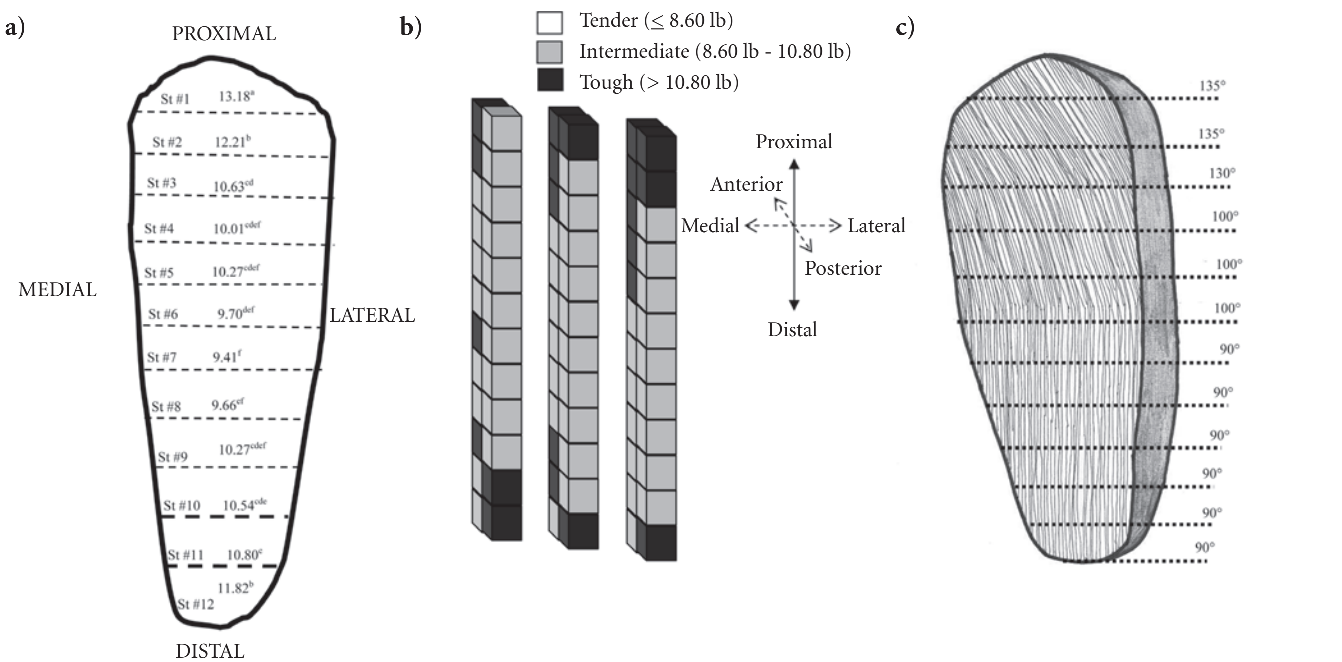

Figure 2. **a. Least square means Warner Bratzler shear force (WBSF) values (lb) of each steak of m. *semitendinosus* ($P < 0 .0001$). b. Intramuscular tenderness variation map of m. *semitendinosus* based on WBSF values (lb). c. Intramuscular muscle fiber orientation map of m. *semitendinosus*. [a-f]Within the same figure, means lacking a common superscript were different ($P < 0.05$).**

separation (steak 4 to 8; Figure 1b) and intermediate shear force values toward the distal end. The lateral side (steak 5, 6, and 8) of the long head of BF was significantly ($P < 0.05$) tougher than the medial side (towards the femur; data not shown). In addition, the anterior and the middle sides of the long head of BF were significantly ($P < 0.05$, data not shown) less tender than the posterior side (steak 1 to 10; Figure 1b). There was no significant ($P > 0.05$) difference in posterior and anterior sides of the ischiatic head of the BF. The WBSF values of this study indicated that the most proximal two steaks of the long head BF were in steak quality. The muscle

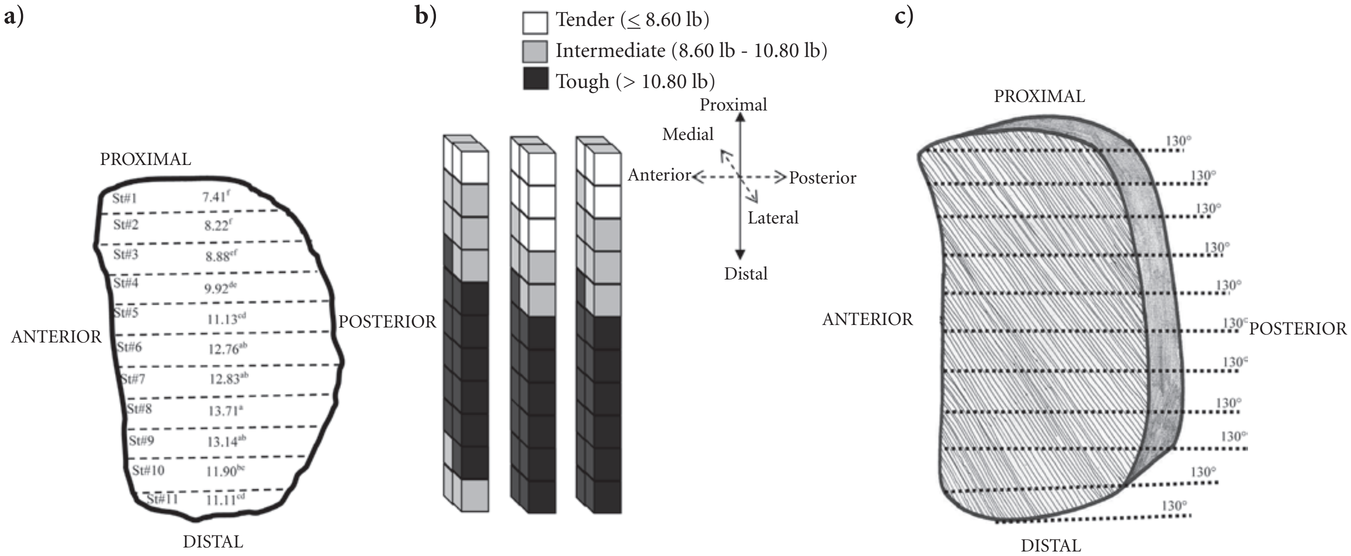

Figure 3. a. Least square means Warner Bratzler shear force (WBSF) values (lb) of each steak of m. *semimembranosus* (*P* < 0 .0001). b. Intramuscular tenderness variation map of m. m. *semimembranosus* **based on WBSF values (lb). c. Intramuscular muscle fiber orientation map of m. *semimembranosus.* [a–f] Within the same figure, means lacking a common superscript were different (*P* < 0.05). The WBSF (lower values – tender; higher values – tough).**

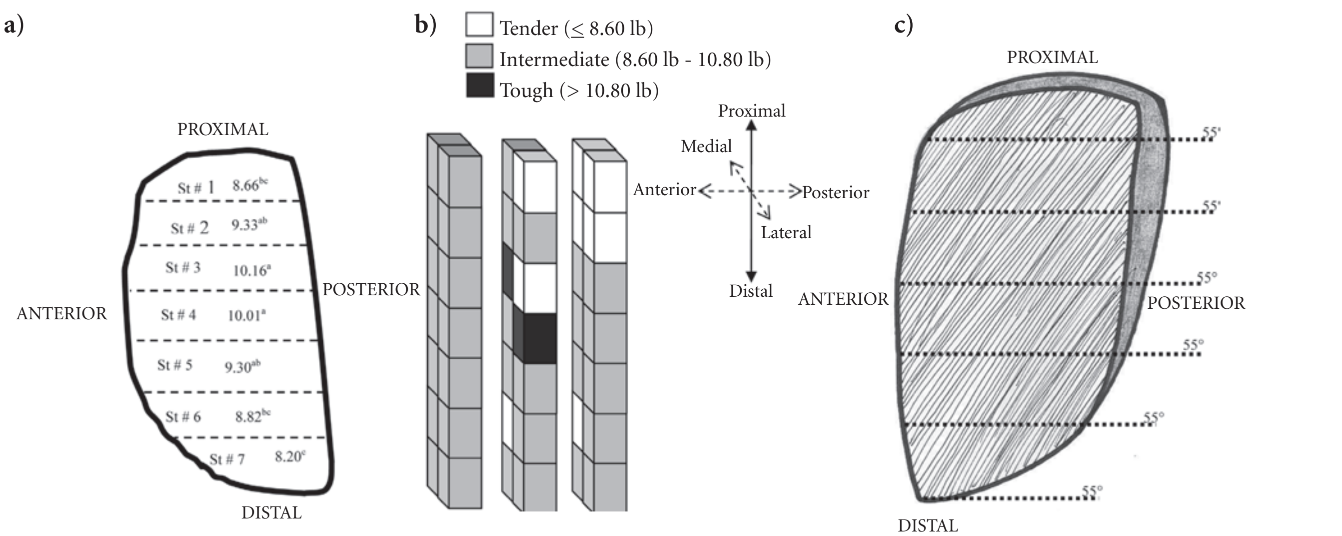

Figure 4. a. Least square means Warner Bratzler shear force (WBSF) values (lb) of each steak of m. *adductor femoris* (*P* = 0.002). b. Intramuscular tenderness variation map of m. m. *adductor femoris* based on WBSF values (lb). c. Intramuscular muscle fiber orientation map of m. *adductor femoris.* [a–c] Within the same figure, means lacking a common superscript were different (*P* < 0.05).

fiber orientation of BF was bipennate (Figure 1c). At the sirloin/round separation region (steak 1 to 4) of the BF long head had more horizontal fiber orientation than the rest of the muscle (Figure 1c). Then, the degrees of inclination of muscle fibers of the long head BF were gradually more angular to the horizontal axis of the muscle. There was no variation of muscle fiber orientation in the ischiatic head of BF from the proximal to the distal. Muscle fibers of the ischiatic head of BF were parallel to the long axis of the muscle.

There was significant (*P* < .0001) tenderness variation in the ST from the proximal to the distal (Figure 2a). The tenderness of the ST decreased from middle of the muscle to both ends (the proximal and the distal). The medial side (steak 2 to 4) of the ST was significantly (*P* < 0.05) more tender than the lateral side. The posterior side of the ST was significantly (*P* < 0.05; Figure 2b) more tender than the anterior side of the muscle up to 9 inches from the proximal end. The middle side of the ST did not (*P* > 0.05) differ in tenderness from the medial or lateral side of the muscle, except for the first 2 inches from the proximal end. The muscle fiber orientation of the ST was fusiform (Figure 2c). Tenderness mapping data suggests cutting the muscle into steaks perpendicular to the long axis of the muscle from the proximal to

(Continued on next page)

the distal and selling middle tender steaks as "premium" to the rest.

The proximal end of the SM muscle up to 4 inches (steak 1 – 3) had significantly ($P < 0.05$) lower shear force values than the rest of the SM muscle (Figure 3a). The lateral side (steak 7 -8; Figure 3b) of the SM was less tender ($P < 0.05$) than the medial. There was no ($P < 0.05$) tenderness variation between the posterior and anterior sides of the muscle. The muscle fiber angle of the SM is 130° to the horizontal axis of the muscle along the muscle from proximal to distal making unipennate fiber orientation (Figure 3c). The most proximal steaks (steak 1 – 3 or 5) were in steak quality compared to the rest; therefore, the five proximal steaks could be marketed as SM "premium" steaks and the rest could be sold as regular SM steaks or as a roast.

The proximal and distal ends (steak 1, 6, and 7) of the AF were more tender than the center part of the muscle (Figure 4a). Overall tenderness variations between medial and lateral sides or posterior and anterior sides were not significant ($P > 0.05$). The fiber arrangement of the AF was unipennate (Figure 4c). Tenderness and muscle fiber orientation maps of the study propose that the first two proximal and three distal steaks could be sold as "premium" AF steaks and the rest as regular steaks.

A clear intramuscular tenderness variation in the beef round muscles based on different anatomical orientations is present. The first few steaks of large beef round muscles (BF, SM, and AF and the middle steaks of ST) are more tender and could be sold at a premium compared to other steaks from the same muscles. Intramuscular tenderness and muscle fiber orientation of the beef round muscle provide a complete guide for individual muscle fabrication, which would be needed by the meat industry for development of innovative meat cuts for optimum eating quality, and by academia for research purposes.

---

[1]Lasika S. Senaratne, graduate student; Chris R. Calkins, professor; Amilton S. de Mello Jr., graduate student; Jeremey B. Hinkle, graduate student; Siroj Pokharel, graduate student, University of Nebraska–Lincoln Department of Animal Science.

[2]This project was funded, in part, by the Beef Checkoff and the Nebraska Beef Council.

(Continued on next page)