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Tenderness, Sensory, and Color Attributes of Two Muscles from the Beef Knuckle

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Summary

Twelve USDA Choice and twelve USDA Select quadriceps muscles were fabricated traditionally or the seams it shares with the top and bottom round were separated pre-rigor to test the effect of pre-fabrication on tenderness, sensory, and color. Results from this study indicated treatment had minimal effects on quality attributes. The proximal portions of the knuckle were more tender, lighter in color, and more red when compared to the distal portions, although all were reasonably tender. Pre-fabrication can be conducted without detriment to product quality.

Introduction

The Uniform Retail Meat Identity Standards were developed to standardize meat labeling at the retail sector. Included in the labels are species, primal, and the retail cut name. According to these standards, the knuckle would be labeled as a Beef Round Sirloin Tip Center Roast. The Institutional Meat Purchasing Specifications of the USDA classify the knuckle as originating from the round under current fabrication practices used in the United States. However, if the quadriceps (**QUAD**), which consists of the knuckle and ball tip under current fabrication procedures, is removed prior to the round/loin separation, then the knuckle is classified as being from the sirloin and would be higher in value. If no quality is acceptable for both (tenderness, sensory, and color) knuckles and ball tips, the value of the knuckle could be increased. Additionally, discrepancies in labeling could be resolved.

Pre-fabrication of the knuckle might ease removal of this cut after chilling. If so, removal of the intact knuckle prior to cutting the round would preserve the sirloin designation under current labeling guidelines. Therefore, the objectives of our study were to document intramuscular differences in tenderness and objective color within the two major muscles of the knuckle and determine if separating pre-rigor the natural seams shared by the quadriceps and the top and bottom round pre-rigor altered tenderness and color.

Procedure

Twenty-four animals were selected for this study (12 USDA Choice and 12 USDA Select) from a commercial abbattoir. Right sides were alternatively assigned to the innovative fabrication procedure (**HOT**) while the other side was traditionally fabricated (**COLD**). The HOT treatment was a prerigor separation of the natural seams between the QUAD and the top and bottom round while attachments to the femur were maintained. Following a 2-day chilling period, intact QUAD muscles from both treatments were removed prior to the sirloin/round break, vacuum-packaged, and shipped to the Loeffel Meat Laboratory at the University of Nebraska. After a 7-day aging period, the *M. Rectus femoris* (**REC**) and *M. Vastus lateralis* (**VAL**) were isolated and cut into 1 in steaks from the proximal end of the muscle (Figure 1). Steaks were then allowed to bloom for 1 hour before objective color was measured. Following color measurement, steaks were vacuum-packaged and frozen until sensory and shear force measurements were conducted.

A Hunter Lab® Mini Scan XE Plus colorimeter containing a 1 inch port with a 10° standard observer and illuminant A was used. Three random measurements were taken on each steak, and the mean of the three measurements was reported.

Starting from the proximal end of the QUAD, the 2nd, 4th, and 6th steak were used for sensory analysis. Steaks were cooked to an internal temperature of 158°F on an electric broiler. Internal temperature was monitored with a digital thermometer with a type T thermocouple. Once the internal temperature reached 95°F, the steak was turned once. The steak was then cut into 0.5 in x 0.5 in x 1.0 in cubes and served warm to 6 to 8 panelists, approximately 5 minutes post cooking. Six samples, identified using three-digit codes, were served on each day. Eight-point descriptive attribute scales (Muscle Fiber Tenderness: 1 = extremely tough,

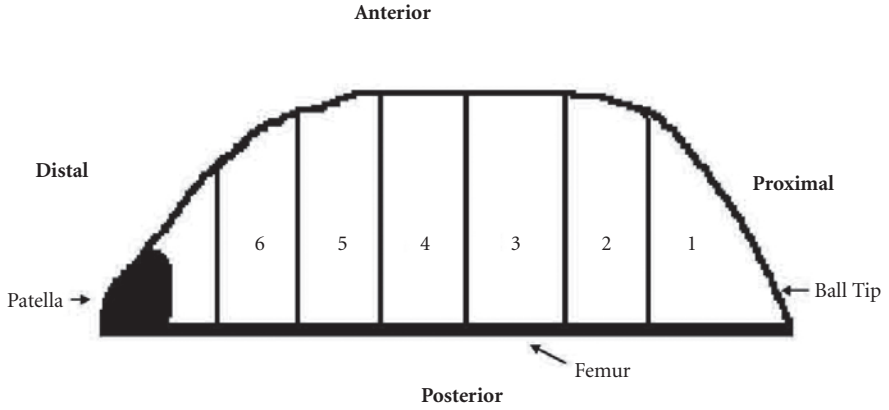

Figure 1. Anatomical directions of the quadriceps muscle.

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Table 1. Treatment by position by location interaction for Warner-Bratzler shear force values of the *M. Rectus femoris*.[ab]

	Treatment, Location					
Position	Cold, Anterior	Cold, Middle	Cold, Posterior	Hot, Anterior	Hot, Middle	Hot, Posterior
1	3.12	3.45	3.57[d]	2.85[d]	2.94[d]	3.22[e]
3	3.14[z]	3.44[z]	3.99[dy]	3.21[dz]	3.21[dz]	4.36[cy]
5	3.34[z]	3.98[y]	4.25[cy]	4.02[cy]	4.17[cy]	3.79[dy]
SEM	0.29	0.32	0.30	0.29	0.37	0.31

[a]Treatment by position by location interaction *P*-value = 0.026
[b]Cold = conventional processing; Hot = pre-fabrication
[cde]Values containing the same superscript within a column do not differ statistically ($P > 0.050$).
[yz]Values containing the same superscript within a row do not differ statistically ($P > 0.050$).

Table 2. Grade by treatment interaction of the *M. Rectus femoris* for the sensory attribute tender.[abc]

Treatment	USDA Choice	USDA Select
Hot	5.63[e]	5.84
Cold	5.91[d]	5.69
SEM	0.14	0.13

[a]Grade by treatment interaction *P*-value = 0.016.
[b]1 = Extremely Tough; 8 = Extremely Tender.
[c]Cold = conventional processing; Hot = pre-fabrication.
[de]Values containing the same superscript within a column do not differ statistically ($P > 0.050$).

Table 3. Grade by position interaction of the *M. Rectus femoris* for the sensory attribute tender.[ab]

Position	USDA Choice	USDA Select
2	6.04[c]	6.26[c]
4	5.72[c]	5.84[d]
6	5.54[d]	5.19[e]
SEM	0.14	0.13

[a]Grade by position interaction *P*-value = 0.050.
[b]1 = Extremely Tough; 8 = Extremely Tender.
[cde]Values containing the same superscript within a column do not differ statistically ($P > 0.050$).

Table 4. Position by location interaction for Warner-Bratzler shear force values of the *M. Vastus lateralis*.[a]

Position	Anterior	Posterior
1	4.33[by]	4.87[bz]
3	5.18[c]	5.10[b]
5	5.58[d]	5.69[c]
SEM	0.25	0.25

[a]Position by location interaction *P*-value = 0.043.
[bcd]Values containing the same superscript within a column do not differ statistically ($P > 0.050$).
[yz]Values containing the same superscript within a row do not differ statistically ($P > 0.050$).

8 = extremely tender; Connective tissue: 1 = abundant, 8 = none; Juiciness: 1 = extremely dry, 8 = extremely juicy; Off-Flavor Intensity: 1 = extreme off-flavor, 8 = no off-flavor) were used.

Beginning with the proximal end of each muscle, the 1st, 3rd, and 5th steaks were used for shear force measurement. After cooking, steaks were covered and allowed to cool at room temperature for 4 hours. Following the cooling period, 6 to 9 (0.5 in diameter) cores were removed parallel to the muscle fibers and core location was recorded. Cores were sheared on an Instron Universal Testing Machine with a Warner-Bratzler shear attachment set at a crosshead speed of 9.84 in/minute and equipped with an 1102 lb load cell.

An analysis of variance (**ANOVA**) using the GLIMMIX procedure of SAS (Version 9.1, Cary, N.C., 2002) was used to analyze the data. When indicated significant by ANOVA ($P \leq 0.050$) main effects (grade, treatment, location, and position) were separated using the LSMEANS, DIFF, and LINES functions, while simple effects of interactions were generated using the LSMEANS, SLICE, and SLICEDIFF functions, respectively.

Results

Warner-Bratzler shear force and sensory analysis

A significant ($P = 0.026$) treatment by position by location interaction for shear force of the REC was noted (Table 1). Regardless of location (anterior to posterior), there were significant ($P < 0.050$) positional (proximal to distal) differences in muscles receiving the HOT treatment. For all HOT-treated muscles, tenderness decreased moving from the proximal to distal position. A similar trend was noted for traditionally fabricated muscles and the posterior location which was closest to the bone. Regardless of treatment or location, there were no tenderness differences between the most proximal positions. However, within position 3 (regardless of treatment), the posterior location of the muscle was the toughest. Within position 5 (most distal) the cold and anterior treatment combination was the most tender. Grade had no effect on shear force values ($P = 0.340$). Generally, all of the shear force values were in the acceptable range.

Sensory analysis revealed a significant ($P = 0.016$) grade by treatment interaction and grade by position ($P = 0.050$) interaction for sensory tenderness (Tables 2 and 3). Within each treatment, there were no differences among USDA grades ($P \geq 0.286$). Moreover, there were no differences ($P = 0.161$) between treatments among USDA Select muscles. However, within USDA Choice muscles, the COLD treatment required slightly more force to shear

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(0.62 lb), but was significantly more tender when compared to the HOT treatment ($P = 0.021$). Regardless of position, there were no significant grade effects ($P \geq 0.136$). Within each USDA grade, tenderness significantly decreased proximally to distally ($P \leq 0.027$) which likely corresponds to the significant ($P < 0.001$) increase in connective tissue amount moving from the proximal to distal aspect. Off-flavor intensity was lower in the distal aspect ($P = 0.001$), while juiciness was not affected by grade, treatment, position, or location.

Neither grade ($P = 0.227$) nor treatment ($P = 0.289$) had an effect on the shear force values of the VAL. However, a significant ($P = 0.043$) position by location interaction was observed (Table 4). Within position 1 (most proximal), the anterior portion of the VAL was significantly ($P = 0.003$) more tender when compared to the posterior aspect. No location differences were observed within position 3 and 5 ($P \geq 0.508$). Within both the anterior and posterior location, tenderness decreased moving from the proximal to the distal aspect of the VAL.

Sensory analysis revealed similar findings in which tenderness significantly ($P < 0.001$) decreased moving from the proximal to distal portion of the muscle. A significant ($P = 0.040$) grade by treatment by position interaction for connective tissue amount was observed. Within all treatment and grade combinations (except Choice and COLD), connective tissue amount increased moving from the proximal to the distal aspect of the VAL. Within position 4, more connective tissue was detected in the COLD treatment (regardless of grade) when compared to the HOT treatment. Juiciness was not affected by grade ($P = 0.219$), but a significant ($P = 0.045$) treatment by position interaction was observed. No positional differences were noted among the COLD treatment, but within the HOT treatment, juiciness decreased when moving from the proximal towards the distal aspect of the VAL. Additionally, off-flavor intensity was highest in the distal position of the SIDE. The tenderness and sensory properties of the VAL were generally less desirable than the REC.

CIE colorspace values

M. Rectus femoris. Grade, treatment, and position significantly ($P < 0.001$) affected L* (lightness) values of the REC. For all grade and treatment combinations, muscles were darker when moving towards the distal portion. Within positions 2, 3, and 4, USDA Select muscles that received the HOT treatment were significantly darker when compared to USDA Select muscle receiving the COLD treatment. Among USDA Choice steaks and all positions, no significant treatment differences were observed. A significant ($P = 0.021$) grade by treatment effect for a* (redness) values was observed. Within both the HOT and COLD treatments, USDA Choice steaks were numerically ($P = 0.161$) redder when compared to USDA Select steaks. However, within the USDA Choice grade, the HOT-treated steaks were numerically redder; while the COLD treated steaks were numerically redder among select steaks. No grade or treatment effects were observed for b* (yellowness) values.

M. Vastus lateralis. The proximal aspect of the SIDE was significantly darker, redder and more yellow in color ($P < 0.001$). The distal portion of the SIDE was the lightest and least red and yellow. Grade and treatment also affected L* values as indicated by a significant ($P < 0.001$) interaction. There were no treatment differences among USDA Choice steaks, but USDA Select steaks that received the HOT treatment were significantly darker ($P < 0.001$). Additionally, the HOT treatment tended ($P = 0.068$) to be less red and significantly ($P = 0.001$) less yellow.

Implications

Results from this study indicate that while the distal portions of the REC and VAL statistically have greater WBSF and sensory tenderness values when compared to the proximal positions, the distal portion of the REC and VAL are still relatively tender. Therefore, these portions of the knuckle could be fabricated as sirloin which would increase the value of the beef carcass. Pre-fabrication has few negative effects on tenderness and color.

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[1]Blaine E. Jenschke, research technician; Brittni J. Swedberg, former student worker; and Chris R. Calkins, professor, Animal Science, Lincoln.

[2] This project was funded in part by beef and veal producers and importers through their $1-per-head checkoff and was produced for the Cattlemen's Beef Board and state beef councils by the National Cattlemen's Beef Association.

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