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FACTORS INFLUENCING VARIATION IN TENDERNESS OF MAJOR BEEF MUSCLES

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INTRODUCTION: Tenderness issues and sources of variation in tenderness of beef retail cuts were apparent in the National Beef Tenderness Survey (Morgan et al., 1991). Identification of the response of individual muscles to postmortem aging is critical to understanding mechanisms and processing methods that should be used to improve the consistency of tenderness in the cooked retail product. Muscles differ in muscle fiber tenderness and response to aging (also identified as proteolytic enzyme activity). Additionally, it is thought, but not documented, that different beef muscles respond to postmortem aging at varying rates. Therefore, the overall objective of this project was to determine beef tenderness and the variation in tenderness of major beef muscles by examining the mechanisms responsible for differences in beef muscle tenderness.

MATERIALS AND METHODS: Beef carcasses (n=30) were obtained from beef steers and heifers of known genetic background and three breed types that are known to vary in beef tenderness characteristics. These cattle (3/4 Brahman (B) x 1/4 Angus (A), 1/4 B x 3/4 A and F_1 Brahman x Angus crosses) were obtained from the research project entitled "Gene Mapping - Mechanisms of Genetic Control of Beef Carcass Merit" that is being conducted at Texas A&M University. The current study did not include all families or high enough numbers to test breed effects, but breed was included in the model as a main effect. The steers were slaughtered at a similar age and fatness. One side of each carcass was electrically stimulated. From each side (stimulated=ES and non-stimulated=NES), seven muscles (Semimembranosus (Sm), Semitendinosus (St), Biceps femoris (Bf), Vastus lateralis (Vl), Gluteus medius (Gm), Longissimuss dorsi (Ld), Triceps brachii (Tb)) were examined. Calpastatin enzyme activity at 24 hours postmortem (Shackelford et al., 1994), sarcomere length (Cross et al., 1981), and Warner-Bratzler shear force were determined as indicators or evaluations of beef tenderness. Tenderness of steaks stored for 0, 14, 28 and 42 days postmortem in refrigerated storage was determined by Warner-Bratzler shear force determinations.

RESULTS AND DISCUSSION: Sarcomere length did not differ between breed crosses ($P > .05$). Electrical stimulation did not affect sarcomere length in the Sm, Bf, Vl, Gm, and Ld muscles, however, for the Tb and St, the ES muscles had longer sarcomere lengths than the NES muscle (Table 1). Tb, ES muscles had the longest sarcomere length, followed by the NES Tb. Muscles that had the shortest sarcomere length were the Vl, Gm, Ld and the NES St. Electrical stimulation did not influence calpastatin activity ($P > .05$); however, there was a breed by muscle interaction for calpastatin activity (Table 2). The Sm, St and Gm muscles from 1/4 B x 3/4 A had lower calpastatin levels than these muscles from the other breed types. The St, Vl and Tb muscles from 1/2 Brahman cattle were higher in calpastatin than these muscles from the other breed types. In the Ld muscle, calpastatin levels were similar across breed crosses. With increased postmortem storage, Warner-Bratzler shear force values decreased (Table 3). However, shear force values decreased to a greater extend in steaks from 1/4 B x 3/4 A. For the muscle by age interaction (Table 3), steaks from the Sm, Tb and Ld decreased in shear force between 2 and 14 days age, whereas shear force declined after 28 days of aging for St and Vl muscles. Steaks from the Bf did not respond to postmortem aging. Shear force values were lowest for steaks from the Tb, Ld and Gm and shear force values decreased with postmortem aging in these muscles. For the ES by muscle interaction (Table 3), ES lowered shear force values for steaks from the Bf and Ld. Steaks from the Sm, St, Vl, Gm and Tb were not affected by ES. Shear force values for steaks from the round (Sm, St, Bf, Vl) were higher than shear force values for steaks from the loin (Ld, Gm) and chuck (Tb), for both ES and NES.

CONCLUSIONS: Increased calpastatin activity may account for high initial toughness and the decreased response to postmortem aging in steaks. Muscles from the round were tougher initially and shear force values decreased only slightly with postmortem aging whereas, muscles from the loin and chuck improved in shear force value with postmortem aging. Electrical stimulation coupled with aging decreased shear force values, particularly for the Ld. Therefore, for cuts that are tough initially, electrical stimulation and postmortem aging improved meat tenderness slightly, but substantial improvements in tenderness were not found.

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Table 1. Least-squares means for sarcomere lengths as influenced by electrical stimulation interaction.

Treatment[a]	Sarcomere length, µm
Semimembranosus by ES	1.85^{cd}
Semitendinosus by ES	1.83^{de}
Biceps femoris by ES	1.76^{g}
Vastus lateralis by ES	1.79^{fg}
Gluteus medius by ES	1.79^{efg}
Longissimus dorsi by ES	1.75^{g}
Triceps brachii by ES	2.04^{b}
Semimembranosus by NES	1.84^{def}
Semitendinosus by NES	1.78^{g}
Biceps femoris by NES	1.78^{g}
Vastus lateralis by NES	1.78^{g}
Gluteus medius by NES	1.77^{g}
Longissimus dorsi by NES	1.79^{efg}
Triceps brachii by NES	1.90^{c}
Residual Standard Deviation	.10

[a]ES=electrically stimulated; NES=not electrically stimulated.
[bcdefg] Means in same column with different superscripts differ ($P < .05$)

Table 2. Least-squares means for calpastatin activity as influenced by breed by muscle interaction.

Treatment	Calpastatin activity per gm
1/4 Brahman x 3/4 Angus by Sm	1.52^{fg}
1/2 Brahman x 1/2 Angus by Sm	1.93^{def}
3/4 Brahman x 1/4 Angus by Sm	2.20^{cd}
1/4 Brahman x 3/4 Angus by St	2.08^{cde}
1/2 Brahman x 1/2 Angus by St	2.80^{b}
3/4 Brahman x 1/4 Angus by St	2.17^{cd}
1/4 Brahman x 3/4 Angus by Bf	1.53^{fg}
1/2 Brahman x 1/2 Angus by Bf	1.71^{efg}
3/4 Brahman x 1/4 Angus by Bf	1.95^{def}
1/4 Brahman x 3/4 Angus by Vl	2.18^{cd}
1/2 Brahman x 1/2 Angus by Vl	2.88^{b}
3/4 Brahman x 1/4 Angus by Vl	2.15^{cd}
1/4 Brahman x 3/4 Angus by Gm	1.44^{g}
1/2 Brahman x 1/2 Angus by Gm	1.91^{def}
3/4 Brahman x 1/4 Angus by Gm	2.02^{cde}
1/4 Brahman x 3/4 Angus by Ld	1.81^{defg}
1/2 Brahman x 1/2 Angus by Ld	2.19^{cd}
3/4 Brahman x 1/4 Angus by Ld	1.96^{de}
1/4 Brahman x 3/4 Angus by Tb	2.44^{bc}
1/2 Brahman x 1/2 Angus by Tb	3.59^{a}
3/4 Brahman x 1/4 Angus by Tb	2.17^{cd}
Residual Standard Deviation	.70

[abcdefg] Means in the same column with different superscripts differ ($P < .05$)

Table 3. Least-squares means for Warner-Bratzler shear force as influenced by breed, electrical stimulation, and muscle.

Treatment	Warner-Bratzler shear force, kg			
	Day 2	Day 14	Day 28	Day 42
Breed				
1/4 B x 3/4 A	4.17^{bc}	4.02^{c}	3.72^{d}	3.36^{e}
1/2 B x 1/2 A	4.57^{a}	4.12^{bc}	3.91^{cd}	4.02^{c}
3/4 B x 1/4 A	4.38^{ab}	4.09^{c}	3.98^{cd}	3.96^{cd}
Muscle				
Semimembranosus	4.43^{defgh}	4.01^{ijk}	3.87^{jkl}	3.87^{jkl}
Semitendinosus	4.72^{bcde}	4.36^{efghi}	4.14^{hij}	4.11^{hij}
Biceps femoris	4.75^{bcd}	5.14^{a}	4.81^{abc}	4.93^{ab}
Vastus lateralis	4.64^{bcdef}	4.50^{cdefg}	4.24^{ghi}	4.05^{ijk}
Gluteus medius	3.59^{lmn}	3.33^{nop}	3.07^{pq}	2.92^{q}
Longissimus dorsi	4.31^{fghi}	3.73^{klm}	3.49^{mno}	3.22^{opq}
Triceps brachii	4.18^{ghij}	3.49^{mno}	3.49^{mno}	3.37^{mnop}
RSD	1.00	1.00	1.00	1.00

[abcdefghijklmnopq] Means within main effect and across aging periods with different superscripts differ ($P < .05$).

Table 4. Least-squares means for Warner-Bratzler shear force for muscle by electrical stimulation interaction.

Treatment	Shear force, kg
Sm by ES	4.03^{de}
St by ES	4.26^{cd}
Bf by ES	4.78^{b}
Vl by ES	4.26^{cd}
Gm by ES	3.19^{h}
Ld by ES	3.39^{gh}
Tb by ES	3.59^{fg}
Sm by NES	4.05^{de}
St by NES	4.40^{c}
Bf by NES	5.04^{a}
Vl by NES	4.46^{c}
Gm by NES	3.26^{h}
Ld by NES	3.99^{e}
Tb by NES	3.68^{f}
RSD	1.00

[abcdefgh] Means in the same column with different superscipts differ ($P < .05$).