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INFLUENCE OF ANIMAL TEMPERAMENT ON THE TENDERNESS OF BEEF *M. LONGISSIMUS LUMBORUM* STEAKS

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Introduction

Research on human subjects suggests that individuals neurologically respond to stressful stimuli differently (Rosenkranz et al., 2003). Neurological response seemed to be related to variation in the activation of the adrenal axis, which subsequently adversely affected immune response. Clearly, animals, like humans, do not react equally to stressors.

Previous research has indicated strong relationships between animal temperament and stress responsiveness (Curley, Neuendorff, Lewis, Cleere, Welsh, & Randel, 2004). Cattle with more excitable temperaments also had more extensive responses to a CRH challenge. Elevated stress responsiveness has been linked to decreased animal growth and efficiency, as well as reduced immune function.

Voisinet, Grandin, O’Connor, Tatum, and Deesing (1997) reported that a greater percentage of excitable cattle displayed borderline dark cutting lean compared to less temperamental animals. Those investigators also found that steaks from the carcasses of excitable cattle had higher Warner-Bratzler shear force values than those from the carcasses of calmer animals. Additionally, a low-to-moderate relationship has been observed between these measures of temperament and Warner-Bratzler shear force (Vann, Paschal, & Randel, 2004). We hypothesize that animals exhibiting excitable temperament characteristics during common management practices may produce carcasses that possess less merit and consequently, meat that is less tender than animals that exhibit a lesser response.

Objectives

(1) To determine if a relationship exists between the behavioral response of cattle to common management practices and the tenderness of the M. Longissimus lumborum, and (2) To characterize the biological mechanisms by which stress response impacts muscle tenderness of feedlot cattle.

Methodology

Two trials were conducted under typical industry conditions to test the stated hypotheses. Trial 1 consisted of Bonsmara-sired (n = 32) and Angus-sired (n = 49) yearling steers that had been grown on grass prior to entering the feed yard. Forty-eight Angus-sired steers were backgrounded for 40 d post-weaning and then fed for Trial 2. With the exception of data and sample collection as described, these steers were managed identically to other cattle in the feed yard.

In both trials, temperament-indicating traits were measured on the farm before transport to the feed yard, upon arrival at the feed yard, and after approximately 70 d on feed. At each time, exit velocity was measured as the rate at which cattle left the working chute (Burrow, Seifert, & Corbet, 1988). As the animals moved through the facilities during the pre-shipment data collection, chute score (scale of 1 to 5; 1 = calm, no movement; 5 = rearing, twisting, and struggling violently; Grandin, 1993) and pen score (scale of 1 to 5; 1 = not excited by human presence; 5 = excited by human presence, runs over anything in its path; Hammond et al., 1996) were assigned subjectively to each animal. Each time the animals were handled, serum samples were collected via tail venipuncture and subsequently assayed for cortisol concentrations using radio immuno assay (RIA) procedures as an indicator of hypothalamic-pituitary-adrenal axis status (Carroll, Willard, Bruner, McArthur, & Welsh Jr., 1996).

The cattle were fed to a target endpoint determined by the feed yard manager and slaughtered using standard procedures. Days on feed were 120 (Trial 1) and 200 (Trial 2). Carcasses were subjected to high-voltage electrical stimulation immediately before evisceration. Carcasses were chilled for 48 h in a 0°C cooler with intermittent spray chill for 8 h. Muscle pH and temperature decline was monitored during chilling in the caudal portion of the *M. longissimus lumborum*. Due to equipment failure, pH readings were not taken after 12 h on the carcasses in Trial 2. Forty-eight h postmortem, carcasses were ribbed at the 12th-13th rib interface and allowed to bloom for at least 15 min before carcass quality and yield grade characteristics were determined. At this time, CIE L^*, a^*, and b^* values were measured. Following grading, the carcasses were fabricated and the strip loin was removed from the left side of each carcass.

At 72 h postmortem, the strip loins were sliced into 2.54-cm steaks, which were assigned to laboratory analyses. Calpastatin activity was determined at 72 h postmortem by the protocol of Koohmaraie, Shackelford, Wheeler, Lonergan, and Doumit (1995). Sarcomere length was measured by the method of Cross, West, and Dutson (1981). Additional steaks were randomly assigned to be aged for 3, 7, 14, or 21 d and used for Warner-Bratzler shear force determination using the method of McKenna, King, and Savell (2004).

Cattle were segmented into temperament groups based on a temperament index value calculated as the sum of the pre-shipment exit velocity and pen score divided by 2. Cattle with temperament index values more than 1 standard deviation higher or lower than the mean of their contemporary group were included in the Excitable and Calm groups, respectively. The Intermediate group consisted of animals with temperament index values within 1 standard deviation of the mean. Temperament groups were compared using analysis of variance with the PROC MIXED procedure of SAS (SAS Institute, Cary, NC).

Results & Discussion

Table 1. Least-squares means for temperament indicating traits of yearling-fed steers segmented into groups according to temperament traits measured before shipment to the feeding facility (Trial 1)

	Temperament classification				
Trait	Calm	Intermediate	Excitable	RMSE	*P* > F
n	15	50	16		
Pre-shipment temperament index[a]	1.75c	2.98b	4.20a	0.31	<0.001
Pre-shipment exit velocity (m/s)	1.45c	2.67b	3.47a	0.37	<0.001
Pre-shipment pen score	1.07c	2.56b	3.47a	0.65	<0.001
Pre-shipment chute score	0.68c	1.12b	1.50a	0.50	0.01
Pre-shipment cortisol (ng/mL)	11.92b	12.02b	16.13a	26.86	0.02
Arrival exit velocity	1.30c	2.05b	2.89a	0.74	<0.001
Arrival cortisol (ng/mL)	10.48	12.46	13.20	52.64	0.55
Mid-point exit velocity	1.23c	1.86b	2.75a	0.64	<0.001
Mid-point cortisol (ng/mL)	8.82	12.10	13.50	37.34	0.09
Final cortisol (ng/mL)	9.85	10.90	11.69	32.96	0.67

[a] Temperament index = (exit velocity + pen score)/2.

Least-squares means within a row with different letters (a-c) differ ($P < 0.05$).

These cattle were segmented into temperament categories based on exit velocity and pen scores taken before the cattle were transported to the feedlot. Because of this classification, all temperament-indicating variables differed ($P < 0.05$) between the classifications (Table 1). These differences were maintained in subsequent exit velocity measurements, although the magnitude of the differences diminished somewhat as the animals grew larger. This is likely due to a combination of the larger cattle having more difficulty moving through the facility and adaptation with increasing experience to being handled. Serum cortisol was higher ($P < 0.05$) in the Excitable cattle than the other groups at the pre-shipment sampling. Though no differences were observed in later samplings, the Excitable cattle had numerically higher means for cortisol concentration at each sampling.

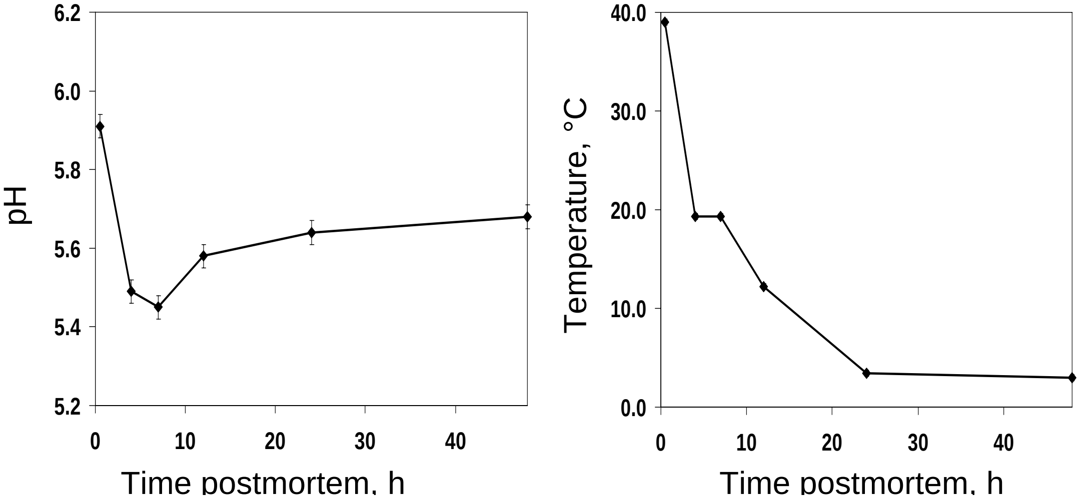

Figure 1. Muscle pH and temperature decline of the *M. longissimus lumborum* of beef carcasses during the chilling process (Trial 1)

The muscle pH and temperature decline for these carcasses during chilling are presented in Figure 1. The pH decline was extremely rapid and had reached a minimum value by 7 h postmortem, which was lower than the values typically seen in muscle. During the next 40 h, the pH increased to a point normally observed in postmortem muscle. Neither pH nor muscle temperature differed between temperament groups during chilling (Table 2).

None of the carcass yield or quality grade characteristics differed between temperament groups. The temperament group × aging interaction was not significant for Warner-Bratzler shear force in this trial. However, aging resulted in considerable improvements in tenderness (data not shown). Steaks from cattle in the Excitable group produced Warner-Bratzler shear force values that were higher ($P < 0.05$) than the Calm or Intermediate groups, which did not differ. Despite this tenderness difference, sarcomere length, calpastatin activity, and color values were not affected.

Table 2. Least-squares means for carcass traits of yearling-fed steers segmented into groups according to temperament traits measured before shipment to the feeding facility (Trial 1)

	Temperament classification				
Trait	Calm	Intermediate	Excitable	RMSE	*P* > F
pH	5.62	5.66	5.60	0.04	0.10
Temperature, °C	17.4	17.53	17.68	0.19	0.43
*L**	42.49	43.23	43.74	6.13	0.38
*a**	31.81	31.75	31.74	1.24	0.98
*b**	23.30	23.48	23.24	1.99	0.81
Sarcomere length, µm	1.86	1.84	1.82	0.001	0.37
Calpastatin activity	1.01	0.99	0.94	0.25	0.92
Warner-Bratzler shear force, kg	2.88b	2.97b	3.34a	0.53	0.01

Least-squares means within a row with different letters (a-c) differ ($P < 0.05$)

The cattle in Trial 2 were segmented into temperament categories in the same manner as Trial 1, and differences in temperament measurements taken before shipment to the feedlot were similar to those in Trial 1 (Table 3). Similarly, the differences between the temperament groups diminished as the animals aged, though this trend was more pronounced than in Trial 1. Serum cortisol concentrations did not differ between groups; however, the means for excitable cattle were consistently higher numerically than those for the intermediate and calm groups.

Table 3. Least-squares means for temperament indicating traits of calf-fed steers segmented into groups according to temperament traits measured before shipment to the feeding facility (Trial 2)

	Temperament classification				
Trait	Calm	Intermediate	Excitable	RMSE	*P* > F
n	7	33	9		
Pre-shipment temperament index[a]	1.33c	2.48b	4.02a	0.22	<0.001
Pre-shipment exit velocity (m/s)	1.23c	2.49b	4.15a	0.42	<0.001
Pre-shipment pen score	1.43c	2.48b	3.89a	0.67	<0.001
Pre-shipment chute score	1.57	1.54	2.22	0.64	0.08
Pre-shipment cortisol (ng/mL)	7.24	9.77	10.57	20.18	0.31
Arrival exit velocity	2.10b	2.54b	3.13a	0.62	0.04
Arrival cortisol (ng/mL)	9.75	10.95	13.94	39.25	0.35
Mid-point exit velocity	2.31	2.44	2.87	0.41	0.15
Mid-point cortisol (ng/mL)	13.31	15.17	19.25	37.32	0.13
Final cortisol (ng/mL)	15.68	16.10	18.31	45.47	0.65

[a] Temperament index = (exit velocity + pen score)/2.

Least-squares means within a row with different letters (a-c) differ (*P* < 0.05).

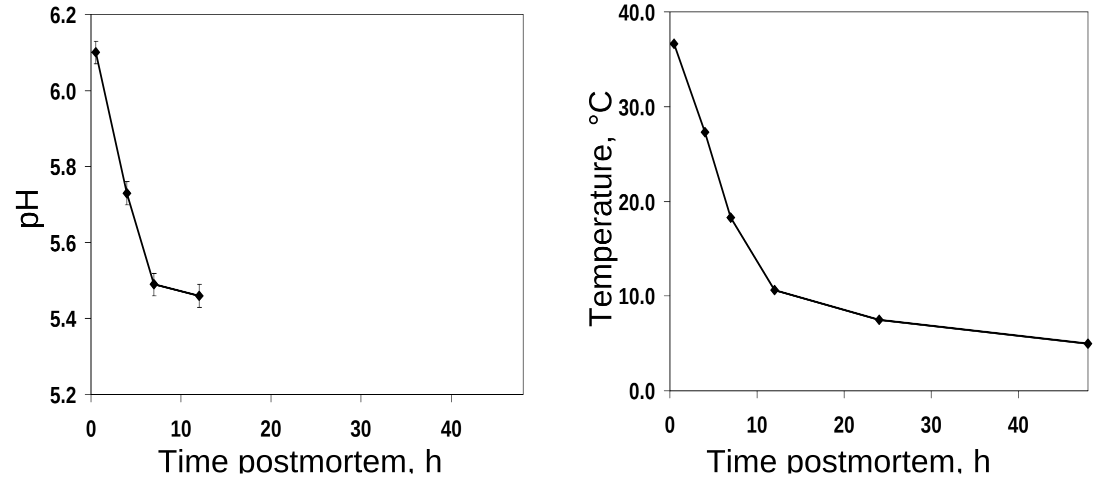

Figure 2. Muscle pH and temperature decline of the *M. longissimus lumborum* of beef carcasses during the chilling process (Trial 2).

Figure 2 presents the pH and temperature decline curves for the *M. longissimus lumborum* in these carcasses. These curves indicate that these carcasses mirrored the rapid pH and temperature declines observed in Trial 1. However, it is unknown if the buffering phenomenon observed in Trial 2 occurred in this trial because these readings were not taken due to equipment failure. Once again, neither pH nor temperature during chilling was affected by temperament.

Table 4. Least-squares means for carcass traits of calf-fed steers segmented into groups according to temperament traits measured before shipment to the feeding facility (Trial 2)

	Temperament classification				
Trait	Calm	Intermediate	Excitable	RMSE	*P* > F
pH	5.73	5.70	5.65	0.03	0.25
Temperature, °C	16.08	16.00	16.07	0.18	0.74
*L**	48.04	48.75	47.34	5.55	0.27
*a**	31.25	30.38	31.07	1.65	0.15
*b**	22.87	22.18	22.68	2.30	0.44
Sarcomere length, μm	1.79	1.79	1.77	0.003	0.65
Calpastatin activity	0.86	1.15	0.97	0.32	0.41
Warner-Bratzler shear force, kg	2.91	3.04	2.86	0.31	0.62

Least-squares means within a row with different letters (a-c) differ ($P < 0.05$).

Carcass characteristics were not affected by temperament grouping in these steers. Once again, aging improved the tenderness of steaks in this trial (data not shown). In contrast to Trial 1, temperament group did not affect Warner-Bratzler shear force. Perhaps the effects of temperament group on tenderness were related to time on feed, as these cattle were fed much longer than the cattle in Trial 1 (200 versus 120 d). It should be noted that the Warner-Bratzler shear force values for all temperament groups in both trials are very tender. This may be due, in part, to electrical stimulation, which has been consistently reported to improve tenderness. As observed in Trial 1, temperament had no effect on color values, sarcomere length, and calpastatin activity.

Conclusions

Measures of animal temperament appeared to rank animals consistently, and differences observed between temperament groups before shipment to the feedlot remained throughout the feeding period. Temperament affected tenderness in the yearling-fed cattle, but not in the calf-fed cattle. Based on these data, it is not clear what mechanism mediates these tenderness differences, but it appears that time on feed may play a role.

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