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Evaluating the Relationship of Animal Temperament to Carcass Characteristics and Meat Quality

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Abstract: The purpose of this study was to compare meat quality and sensory characteristics of steaks from longissimus dorsi of steers with different temperaments. Calves ($n = 49$; 314kg) were processed and scored for temperament according to Beef Improvement Federation Guidelines and divided into three groups: Docile (D), Restless (*R*) and Nervous-Flighty (NF). Steers were housed with access to pasture then transferred to a research feedlot until harvest and processed with carcass data recorded. Striploins were wet-aged for 14 d before, frozen and were then cut into 2.54 cm steaks, and individually vacuum packed. Instrumental color was measured on thawed and tray overwrapped steaks on d 0, 1, 2, 3, 5, and 7 of simulated retail display. The CIE L*, a*, and b* color values were collected and oxymyoglobin, hue angle and saturation index values were calculated. A 7-member trained sensory panel evaluated steak samples for myofibrillar tenderness, connective tissue amount, overall tenderness, juiciness, and beef flavor intensity. The NF group had reduced ($P < 0.05$) hot carcass weight compared to the other groups. The D and R groups were lighter (L*; $P < 0.05$), and R group yellower (b*; $P < 0.05$) and greater ($P < 0.05$) in hue angle than the other groups. No difference ($P > 0.05$) between groups for redness (a*), saturation index, and oxymyoglobin ratio were observed. Display time affected color with d 0 being redder (a*; $P < 0.05$), yellower (b*; $P < 0.05$), greater ($P < 0.05$) saturation index, and greater ($P < 0.05$) oxymyoglobin ratio than d 7. Steaks from D and R groups were more tender ($P < 0.05$) in myofibrillar tenderness, had less ($P < 0.05$) perceived connective tissue, were overall more tender ($P < 0.05$), and more ($P < 0.05$) juicy than steaks from the NF group. There was no difference ($P > 0.05$) in off-flavor between the temperament groups. Temperament had minimal effect on carcass characteristics except hot carcass weight. Sensory panelists detected differences between temperament groups.

Keywords: color, display, steak, temperament, tenderness
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Introduction

There have been positive strides in animal well-being improvement, but it has not alleviated all the issues surrounding animal well-being and comfort. The industry has evaluated and adopted a number of technologies to enhance animal comfort and well-being. Some of these practices and technologies include animal shade (Mitlöhner et al., 2001; Miltöhner et al., 2002), flooring patterns (Elmore et al., 2015), and sound (Lanier et al., 2000) to name a few. While these have improved animal comfort and well-being, it is still not uncommon to have animals that cannot cope with stress or their environment (Mitlöhner et al., 2002). Much effort has been put forth dealing with extrinsic factors influencing animal well-being, less is known regarding the intrinsic factors affecting animal comfort and well-being.

Docility can impact feedlot profitability and carcass characteristics, and because producers have ranked docility in the same category of similar importance as traits such as calving ease, a number of

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breed associations have begun developing expected progeny differences (EPD) for docility (Northcutt and Bowman, 2010). Behrends et al. (2009) suggests that late life temperament may have little predictive value of performance. Using over 92,000 records, the American Angus Association has begun to evaluate and generate docility EPD's (Northcutt and Bowman, 2010). The association reports that docility is moderate to high in heritability, meaning that improvements in docility and hopefully environmental coping can be improved in as little as one generation. This approach could offer new insights to cattle development in an effort to better cope with stress to enhance meat quality. Therefore, objectives of this study were to evaluate the effect of steer temperament on carcass characteristics and sensory tenderness and flavor of steaks.

Materials and Methods

Cattle and harvest

The study was conducted in accordance with recommendations in the guide for the care and use of laboratory animals of the National Institutes of Health and the protocol (IACUC protocol no. 16018) was approved by the University of Arkansas Animal Care and Use Committee.

Cattle were purchased from auction markets and exact age and breed is unknown. Cattle (n = 180) processed for the feedlot were evaluated and scored according to the Beef Improvement Federation Guidelines (Crews et al., 2010) for chute scores by the same technician. Cattle were divided into three groups according to temperament: Docile (1; D), Restless (2; R), and Nervous-Flighty (3 to 4; NF). Incoming cattle were weighed (average of 314 kg) before entering the feedlot and at harvest (average of 609 kg) and average daily gain (ADG) was calculated. Steers were transported (~772 km; 7 to 10 h) without stop to the AgriResearch Center feedlot (Canyon, TX) and consumed the same ration with equal water, and open pens. Cattle were harvested at three different time points (first group n = 16, second group n = 16, third group n = 17) when the average back-fat for the group was visually appraised to be 1.27 cm at the 12th rib. Once the compositional endpoint was reached, steers were transported (~129 km; 1 to 2 h) to the packing plant (USDA Establishment no. 3, Cactus, TX) for harvest. The steers were unloaded and allowed time to rest with access to water for acclimation. Steers were immobilized using a captive bolt stunner. ADG was calculated individually on each animal through the duration of finishing for each of the harvest group. At harvest, hot carcass weight was collected and after a 24-hour chill USDA carcass quality and yield grade factors (back-fat, ribeye area, marbling, maturity, and kidney, pelvic, and heart fat percentage [KPH]) were evaluated and grades were determined. At fabrication, a subset of steers was chosen (all black coats since breed was unknown) and identified to represent steers from each of the 3 docility groups (n;D = 19, R = 18, NF = 12). After a 24-hour chill, striploin section from one side was removed and wet aged for 14 d (Shackelford et al., 2001), labeled and vacuum packaged (20 mmHG) in Cryovac vacuum bags (1cc/m^2 per 24 h) containing bone guard protection, frozen then transported to the University of Arkansas Red Meat Laboratory for further analysis.

Striploins were removed from the bags, 1.27 cm was removed from the anterior end of the striploin, and fabricated via bandsaw into 2.54 cm steaks for evaluation of instrumental color, Warner-Bratzler shear force (WBS), cook loss and sensory tenderness, juiciness and flavor characteristics, respectively. Steaks removed from the posterior end, were assigned to 1 to 2) cook loss and WBS, 3) sensory evaluation, and 4) simulated retail display and color. Frozen steak were individually packaged in Cryovac vacuum bags (1cc/m2 per 24 h) and returned to frozen storage. Steaks were thawed at 4°C overnight before respective evaluation.

Simulated retail display

For simulated retail display 12 steaks were randomly selected from each temperament group placed on polystyrene foam trays (Cryovac Food Packaging and Food Solutions, Ducan, SC) with absorbent pads and overwrapped with poly-vinyl chloride film (14,000 cc/mm^2/24 h per 1 atm; Koch Supplies, Inc., Kansas City, MO). Steaks were displayed in a commercial chest type display case (Tyler Refrigeration Corp. Niles, MI) at 4°C under 1,630 lux of deluxe warm white fluorescent lighting (Phillips Inc., Somset, NJ) at a light source to meat distance of 122 cm.

On d 0, 1, 2, 3, 5, and 7 of simulated retail display, instrumental color was measured using a HunterLab MiniScan XE spectrophotometer, Model 4500L (Hunter Associated Laboratory Inc., Reston, WV). Samples were read using an illuminant A/10° observer and evaluated for CIE (L*, a*, and b*) color values. In addition, reflectance measurements in the visible spectrum from 400 to 700 nm were taken to estimate oxymyoglobin, hue angle and Chroma from calculation (Hunt et al., 2012). Before use, the spectrophotometer was standardized using white tile, black tile, and working standards. Three measurements were taken of each sample and averaged for statistical analysis.

Procedures for WBS were conducted according to the American Meat Science Association guidelines (American Meat Science Association, 2016) for cookery, sensory and instrumental tenderness measurements of fresh meat. Thawed steaks (2.54 cm) were weighed. Steaks were cooked in a Blodgett forced air oven operating at 163°C until an internal temperature of 70°C was achieved. Steaks were allowed to cool to 24°C, reweighed for percent cook loss calculation and cored (1.27 cm) 8 times parallel to the long axis of the muscle fibers using a powered coring device. Each core was sheared using an Instron Universal Testing Machine (Instron, Canton, MA) using a 100 kg compression load cell and a crosshead speed of 250 mm/min. The eight cores evaluated for WBS were averaged for statistical analysis.

Sensory

For sensory panel analysis, seven panelists were selected and trained in one session 1 d before testing according to the American Meat Science Association guidelines (American Meat Science Association, 2016). In the training session, all docility groups were represented. All 7 sensory panelist completed training and all sensory evaluation sessions. During the 4 sensory evaluation sessions 1 sample was used for warmup prior to each session. Steaks were cooked on electric griddles to an internal temperature of 70°C. After orientation, panelists evaluated one 1.27 × 1.27 × 2.54 cm steak sample at a time in individual booths under sodium color neutralizing lights in a randomized order. Myofibrillar tenderness, connective tissue amount, overall tenderness, juiciness, and beef flavor intensity were evaluated on an 8-point scale where 1 = extremely tough, extremely dry, extremely bland or abundant and 8 = extremely tender, extremely juicy, extremely intense, or none. Off-flavor intensity was evaluated on a 5-point scale where 1 = extreme off flavor and 5 = no off flavor.

Statistical analysis

Live animal-finishing data as well as cook loss and WBS data were analyzed as a completely randomized design with docility score as the main effect. Pearson correlation coefficients were obtained for chute score and carcass characteristics. Instrumental color and retail display data were analyzed as a completely randomized design with treatments in a 3 × 6 factorial arrangement with temperament group, display day serving as the main effects in the model. Sensory panel data was analyzed as a completely randomized design with docility score serving as the main effect. Panelist and session were treated as random effects. The MIXED procedure of SAS (SAS Inst. Inc., Cary, NC) was used to analyze variance and LS means were generated for significant main effects and separated using the PDIFF option of SAS.

Table 1. Temperament effect on live, carcass, cook loss and shear characteristics

	Temperament group		
Attribute	Docile (1)	Restless (2)	Nervous-Flighty (3–4)
n	19	18	12
Incoming wt, kg	314 ± 14.3	314 ± 14.3	314 ± 14.5
Average daily gain, kg	1.54 ± 0.20	1.60 ± 0.20	1.45 ± 0.20
Final body wt, kg	613 ± 11.1	617 ± 10.8	588 ± 13.8
Hot carcass wt, kg	367 ± 6.3^{a}	377 ± 6.1^{a}	345 ± 7.6^{b}
Back-fat, cm	1.33 ± 0.11	1.51 ± 0.11	1.15 ± 0.14
Ribeye area, cm^2	88.2 ± 2.3	92.9 ± 2.3	83.8 ± 2.9
KPH[1], %	2.0 ± 0.3	2.0 ± 0.3	2.0 ± 0.4
Yield grade	3.0 ± 0.16	3.0 ± 0.16	2.8 ± 0.20
Marbling score	413 ± 20.0	413 ± 20.0	380 ± 25.2
Dressing percent	60.7 ± 1.0	61.0 ± 1.0	58.7 ± 1.2
Cook Loss, %	22.5 ± 1.1	22.0 ± 1.3	23.5 ± 1.6
WBS[2], kg force	3.8 ± 0.17	3.6 ± 0.16	3.7 ± 0.20

^{a,b}Means ± SEM (standard error of mean) within row with different superscripts differ ($P < 0.05$).

[1] Kidney, pelvic, and heart fat.

[2] Warner-Bratzler shear force.

Results and Discussion

Carcass characteristics

The cattle in temperament groups were similar in incoming weight ($P = 0.99$), final body weight ($P = 0.24$) and ADG ($P = 0.36$; Table 1). Previous studies have determined that cattle with slower exit velocities have increased weight gain than those with faster exit velocities (Voisinet et al., 1997b; Burrow and Dillon, 1997; Petherick et al., 2002; Müller and von Keyserlingk, 2006; Café et al., 2011) and calm cattle have increased live weights compared to temperamental cattle (Fordyce et al., 1985). Petherick et al. (2003) reported a negative correlation between exit velocity and average daily gain and similarly, Hoppe et al. (2010) reported negative correlations between chute score and flight speed score with average daily gain. Both the Docile and Restless group had heavier ($P < 0.01$) hot carcasses compared to the Nervous-Flighty group (Table 1). All carcass in the temperament groups had similar characteristics in back-fat ($P = 0.11$), yield grade ($P = 0.61$), marbling score ($P = 0.54$),

Table 2. Effect of temperament on color attributes of steaks

	Temperament group		
Attribute	Docile (1)	Restless (2)	Nervous-Flighty (3–4)
n	12	12	12
L*[1]	37.5 ± 1.4^{a}	38.3 ± 1.4^{a}	33.9 ± 1.4^{b}
a*[1]	16.0 ± 0.6	16.4 ± 0.6	16.4 ± 0.6
b*[1]	17.1 ± 0.3^{b}	17.9 ± 0.3^{a}	17.0 ± 0.3^{b}
Oxymyoglobin ratio[2]	2.1 ± 0.2	2.2 ± 0.2	2.3 ± 0.2
Hue angle[3]	47.8 ± 0.9^{ab}	48.6 ± 0.9^{a}	46.9 ± 0.9^{b}
Chroma[4]	23.5 ± 0.6	24.4 ± 0.6	23.7 ± 0.6

[a,b] Means ± SEM (standard error of mean) within row with different superscripts differ ($P < 0.05$).

[1] L* is a measurement of darkness to lightness (greater L* values indicate a lighter color); a* is a measurement of redness (greater a* values indicate a redder color); and b* is a measurement of yellowness (greater b* values indicate a more yellow color).

[2] Oxymyoglobin ratio = 630nm/580nm.

[3] Hue angle = [arctangent(b*/a*)].

[4] Chroma = (a*2+b*2)0.5.

dressing percent ($P = 0.30$), and KPH ($P = 0.77$). The percentage of carcasses that graded choice or better for the Docile, Restless and Nervous-Flighty groups were 32, 28, and 33%, respectively. Similarly, King et al. (2006), also reported that temperament categories did not affect carcass characteristics. However, Hall et al. (2011) reported that cattle with faster rate of exit velocity (excitable) had larger REA. None of the correlations between chute score and carcass characteristics were greater than 0.20, similar to what Hall et al. (2011) reported with exit velocity.

There was no difference between temperament groups for cook loss ($P = 0.76$) and WBS force ($P = 0.54$) between temperament groups. Hall et al. (2011) reported that calves with slower exiting velocity had lower WBS. Voisinet et al. (1997a) reported that more excitable cattle have increased WBS and Boles et al. (2015) also reported that animals with fast exit speed had steaks with higher shear force values compared to shear force values from medium and slow exit speeds.

Simulated retail display

For simulated retail display, there was no interaction between temperament groups and display days for L*, a*, b*, oxymyoglobin ratio, hue angle and chroma. Steaks from the Docile and Restless groups were lighter (greater L*; $P < 0.01$) than steaks from the Nervous-Flighty group (Table 2). Steaks from all temperament groups were similar in redness (a*; $P = 0.61$). The Restless group steaks were more yellow ($P < 0.001$) in color than steaks from the Docile and Nervous-Flighty group. There was no difference ($P = 0.22$) between temperament groups in oxymyoglobin ratio. Temperament group had an effect ($P < 0.04$) on hue angle with steaks from the Restless group being greater than the Nervous-Flighty with Docile group being intermediate. The restless group had a larger shift from an orange hue to a yellow hue than the Nervous-Flighty group. There was no difference ($P = 0.16$) in Chroma between the temperament groups. King et al. (2006) found no differences between temperament categories for CIE L*, a*, and b*. Higher a* and b* color values were found to be associated with lower WBS force values with correlation values of –0.24 and –0.38 respectively (Wulf et al., 1997).

Color is used as an indicator of freshness by consumers and will make a no-purchase decision when metmyoglobin reaches 30 to 40% of total surface pigments (Greene et al., 1971). Lightness of steaks were similar ($P = 0.56$) between all display days of simulated retail display (Table 3). Steaks were reddest ($P < 0.01$)

Table 3. Effect of display days on color attributes of steaks after 14 d of aging

	Display days					
Attribute	0	1	2	3	5	7
n	36	36	36	36	36	36
L*[1]	36.3 ± 1.4	36.2 ± 1.4	36.5 ± 1.4	37.0 ± 1.4	37.0 ± 1.4	36.2 ± 1.4
a*[1]	22.1 ± 0.7^{a}	19.2 ± 0.7^{b}	16.9 ± 0.7^{c}	14.4 ± 0.7^{d}	12.0 ± 0.7^{e}	13.1 ± 0.7^{e}
b*[1]	19.6 ± 0.3^{a}	17.9 ± 0.3^{b}	17.3 ± 0.3^{b}	16.7 ± 0.3^{c}	16.4 ± 0.3^{c}	16.4 ± 0.3^{c}
Oxymyoglobin ratio[2]	3.7 ± 0.2^{a}	2.8 ± 0.2^{b}	2.2 ± 0.2^{c}	1.7 ± 0.2^{d}	1.4 ± 0.2^{e}	1.5 ± 0.2^{de}
Hue angle[3]	42.0 ± 1.0^{e}	43.3 ± 1.0^{e}	45.9 ± 1.0^{d}	49.6 ± 1.0^{c}	54.1 ± 1.0^{a}	51.8 ± 1.0^{b}
Chroma[4]	29.5 ± 0.7^{a}	26.2 ± 0.7^{b}	24.2 ± 0.7^{c}	22.0 ± 0.7^{d}	20.3 ± 0.7^{e}	21.1 ± 0.7^{de}

[a-e] Means ± SEM (standard error of mean) within row with different superscripts differ ($P < 0.05$).

[1] L* is a measurement of darkness to lightness (greater L* values indicate a lighter color); a* is a measurement of redness (greater a* values indicate a redder color); and b* is a measurement of yellowness (greater b* values indicate a more yellow color).

[2] Oxymyoglibin ratio = 630nm/580nm.

[3] Hue angle = [arctangent(b*/a*)].

[4] Chroma = (a*2+b*2)0.5.

on display d 0 followed by display d 1, 2, and 3 with display d 5 and 7 being the least red. Steaks were yellowest ($P < 0.01$) on display d 0 with steaks from display d 3, 5, and 7 being the least yellow and steaks from display d 1 and 2 being intermediate. There was a difference ($P < 0.01$) in oxymyoglobin ratio between display days for steaks with steaks having a higher oxymyoglobin ratio on display d 0 and the a lower oxymyoglobin ratio on display d 5 followed by display d 7. Hue angle was greatest ($P < 0.01$) on display d 5 followed by display d 7 and the lowest hue angle on display 0. Steaks were the most vivid (Chroma; $P < 0.01$) on display d 0 and the least vivid on display d 5 and 7.

Sensory

For myofibrillar tenderness, connective tissue, overall tenderness, and juiciness the steaks from the Docile and Restless group were more tender ($P < 0.01$), had less connective tissue ($P < 0.01$), were overall more tender ($P < 0.01$), and juicier ($P < 0.01$) than steaks from the Nervous- Flighty group (Table 4). Although WBS force was not different among temperament groups, sensory panelists were able to detect differences between the Docile and Restless groups versus the Nervous-Flighty group. A possible explanation for this is that WBS force is an instrumental estimation of tenderness. Shear force has been found to not accurately reflect differences among different muscles in overall tenderness (Shackelford et al., 1995). Various other research has shown that temperament decreases instrumental tenderness (Fordyce et al., 1988; Voisinet et al., 1997a; Burrow and Dillon, 1997; King et al., 2006; Café et al., 2011). Steaks from the restless group had a stronger ($P < 0.05$) beef flavor than steaks from the Nervous-Flighty group with steaks from the Docile group being similar to both groups. There was no difference ($P = 0.37$) in off-flavors between the temperament groups. Carpenter et al. (2001) suggested that once a consumer purchases beef, regardless of color at the time of purchase, consumer eating satisfaction at home will only depend on tenderness, juiciness, and flavor.

Table 4. Effect of temperament on sensory attributes of steaks

	Temperament Group		
Attribute	Docile (1)	Restless (2)	Nervous-Flighty (3–4)
Myofibrillar tenderness[1]	6.7 ± 0.4^{a}	6.2 ± 0.3^{a}	5.2 ± 0.3^{b}
Connective tissue[1]	6.5 ± 0.3^{a}	6.6 ± 0.3^{a}	5.8 ± 0.3^{b}
Overall tenderness[1]	6.4 ± 0.3^{a}	6.2 ± 0.3^{a}	5.3 ± 0.3^{b}
Juiciness[1]	6.0 ± 0.4^{a}	5.6 ± 0.4^{a}	4.9 ± 0.4^{b}
Beef flavor[1]	6.6 ± 0.3^{ab}	6.9 ± 0.3^{a}	6.5 ± 0.3^{b}
Off flavor[2]	4.7 ± 0.1	4.8 ± 0.1	4.7 ± 0.1

[a,b] Means ± SEM (standard error of mean) within row with different superscripts differ ($P < 0.05$).

[1] Where 1 = extremely tough, extremely dry, extremely bland or abundant and 8 = extremely tender, extremely juicy, extremely intense, or none.

[2] Where 1 = extreme off flavor and 5 = no off flavor.

Therefore, steer temperament had little effect on carcass characteristics, with the exception of hot carcass weight. Although WBS force was not different between the temperament groups, sensory panelists were able to detect differences between the temperament groups. Sensory panelists found steaks from the Docile and Restless groups to be more tender in myofibrillar and overall tenderness, have less perception of connective tissue and to be juicier than the Nervous-Flighty group. However, sensory panelists found the Docile and Restless groups to be similar in myofibrillar and overall tenderness, perception of connective tissue, juiciness, and beef flavor. Therefore, it appears temperament can impact sensory characteristics of beef.

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