WATER-HOLDING AND COLOR CHARACTERISTICS OF BEEF FROM ELECTRICALLY STIMULATED CARCASSES

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Background

Electrical stimulation has received numerous accolades extolling the benefits associated with beef quality. Initial research indicated that electrical stimulation increased tenderness (Davey et al., 1976; Savell et al., 1977, 1978; Smith et al., 1977), produced brighter, more youthful lean color (Smith et al., 1977; Savell et al., 1978), increased marbling (Savell et al., 1978), and reduced time for aging (Savell et al., 1978). One complaint about the use of electrical stimulation is the apparent increase in the amount of purge in vacuum-packaged beef, especially in cuts from the round. Research by Unruh et al. (1986) and den Hertog-Meischke et al. (1997) indicated that electrical stimulation adversely affected the water-holding properties of beef. In addition, there have been a number of discrepancies in how electrical stimulation affects lean color, especially in the round.

Objectives

The objectives of the present study were to determine the effect of electrical stimulation on the water-holding properties of five bovine muscles and the color characteristics of three bovine muscles.

Methods

Animals. A total of fifteen crossbred steers were slaughtered on three different days (five steers/day) according to standard industry procedures at Texas A&M University. Carcasses were split in half along the mid-saggital plane of the vertebral column. The right sides of the carcasses were electrically stimulated (ES) with 15, 1.8 sec impulses of 500 Volts (AC), 0.5 Amperes, with 1.8 sec between impulses, and the corresponding left sides of the carcasses were utilized as the non-stimulated (NS) controls. Carcasses were placed in a 0 ± 2°C cooler for 48 hr. Carcasses then were moved to a 2 ± 2°C cooler where they were ribbed, and assessed for USDA quality and yield grade factors by qualified personnel from Texas A&M University. Carcasses then were fabricated into primals and subprimals and individual muscles were removed and sliced into 2.54 cm steaks.

pH measurement. Post-mortem pH decline was recorded in the M. triceps brachii, M. longissimus thoracis, and M. semimembranosus, respectively. pH measurements were recorded at 0.5, 3, 6, and 24 hr post-exsanguination. Measurements were collected using a handheld pH meter with a stainless steel "ion sensitive field effect transistor" probe (Model IQ150, IQ Scientific Instruments, Inc., San Diego, CA. USA). The pH meter was calibrated following a two-point calibration procedure before each use.

Color measurement. Muscles were assessed for color differences. M. triceps brachii, M. longissimus thoracis, and M. semimembranosus were fabricated into 2.54 cm steaks, and all muscles were allowed to "bloom" (oxygenate) for at least fifteen minutes. Four color measurements were collected for the M. triceps brachii and M. longissimus thoracis and averaged, respectively. Six color measurements were collected for the M. semimembranosus and averaged, three located towards the superficial and three towards the deep aspects of the muscle, respectively. Color measurements were made using a Minolta Chroma Meter (Model CR-300, Minolta, Inc., Ramsey, NJ, USA). Total color difference (E) from the superficial to the deep portions of the M. semimembranosus were calculated using the following equation: $\Delta E = [(L - L_{ref}) + (a - a_{ref}) + (b - b_{ref})]^{1/2}$. The L, a, and b values from the deep portions were used as the reference values (Francis and Clydesdale, 1975).

Expressible Moisture. Expressible moisture was determined according to the centrifugal method of Jauregui et al. (1981) with the following modifications. Three pieces of 55 mm diameter filter paper (VWRBrand, VWR Scientific Products, West Chester, PA, USA), and one piece of 70 mm diameter filter paper (FisherBrand P5, Fisher Scientific, Pittsburgh, PA, USA) were folded into a funnel shape with the 70 mm filter paper comprising the outside of the funnel. The centrifuged meat sample was reweighed and expressible moisture reported as a percentage of the weight lost from the initial sample. All samples were run in triplicate.

Drip loss. To determine drip loss, muscles were cut into 20 ± 10 g samples and deadlock metal tag fasteners were placed into each sample. Puncture-proof Whirl-Pak bags (1.77 E-04 m^3) (Nasco, Ft. Atkinson, WI, USA) were placed over the samples and partially closed at the top to prevent evaporative loss, and the fasteners were suspended from strings to allow for the samples to drip. Samples were suspended in a 2 ± 2°C cooler. Whirl-Pak bags and fasteners were removed after 3 days, and samples were reweighed. Drip loss was reported as a percentage of the weight lost from the initial sample. All drip loss samples were run in triplicate.

Statistical Analysis. Data were analyzed using the General Linear Model of the Statistical Analysis System (SAS, 1996). Least squares means were generated and separated using the PDIFF function of SAS. An alpha level of $P < 0.05$ was used to determine significance.

Results and discussion

M. triceps brachii ($P < 0.05$), *M. longissimus thoracis* ($P = 0.055$), and *M. semimembranosus* ($P < 0.05$), from ES carcasses had lower pH's than NS carcasses at 0.5 hr. No difference in pH of the *M. triceps brachii* were observed at 3, 6, and 24 hr. Both *M. longissimus thoracis*, and *M. semimembranosus* from ES carcasses had lower pH's at 3 hr post-mortem than NS carcasses ($P < 0.05$), however, no differences were observed at 6 or 24 hr.

The ES treatment did not affect the color of the lean of beef carcasses. Table 1 shows Hunter L, a, and b values within the same muscles between stimulation treatments. There were no differences in color between ES and NS muscles, nor were there any consistent trends. *M. longissimus thoracis* from ES carcasses had slightly higher Hunter L, a, and b values compared to NS *M. longissimus thoracis* ($P > 0.05$). ES treatments inconsistently affected Hunter L, a, and b values of *M. semimembranosus*. This is probably related to the amount of variability between the deep and superficial aspects of this muscle and thus were analyzed independently.

Table 2 shows the Hunter L, a, and b values for the superficial and deep portions of the *M. semimembranosus*. ES did not affect the Hunter L, a, or b values within the deep or superficial sections. There were stark differences between the superficial and deep portions of the *M. semimembranosus*. The superficial portion of the *M. semimembranosus* had lower L, a, and b values indicating the outside portion was darker, and less red in color than the interior portion of the muscle. The color difference can probably be attributed to the rapid temperature decline on the outside of the round as compared to the slower temperature decline on the inside of the round. The Hunter L, a, and b values from the deep and superficial portions of ES and NS carcasses were used to determine total change in color from the deep to the superficial portions to determine if complaints related to color were actually a result of a greater color gradient rather than an actual change in color. *M. semimembranosus* from ES carcasses had less change in color from the deep to superficial portion, but total color change was not significantly different between ES (E = 6.96, SEM = 0.86) and NS (E = 8.56, SEM = 0.86) carcasses.

Table 3 shows the percentage drip loss and expressible moisture values between ES and NS beef muscles. There were no observed differences in drip loss between ES muscles and NS muscles. Most ES muscles did have slightly higher (but not significant) percentage drip loss with the M. longissimus thoracis being the exception. Additionally, muscles from the round had much higher drip losses. The percentage of expressible moisture did not differ between ES and NS muscles.

Conclusions

Under the parameters used in this study, electrical stimulation of beef carcasses did not adversely affect the color or water-holding properties of individual muscles evaluated in this study. Electrical stimulation parameters (e.g., voltage, amperage, duration, etc.) and chilling parameters (e.g., temperature, air velocity, carcass size, carcass spacing, etc.) play important roles in pH and temperature declines, which could influence water-holding capacity and lean color characteristics if different parameters are used in research or commercial settings.

Pertinent literature

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Table 1. Least squares means of Hunter L, a, and b values for muscles of non-stimulated and electrically stimulated beef carcasses.

	L			a			b		
Muscle	NS	ES	SEM[a]	NS	ES	SEM[a]	NS	ES	SEM[a]
M. triceps brachii	38.11	37.55	0.382	16.65	15.11	0.432	5.28	5.00	0.249
M. longissimus thoracis	36.73	37.32	0.441	13.48	14.59	0.592	4.73	5.29	0.274
M. semimembranosus	39.72	38.02	0.625	19.19	19.82	0.785	7.15	7.10	0.380

[a]SEM is the standard error of the least squares means.

Table 2. Least squares means of Hunter L, a, and b values within *M. semimembranosus* from non-stimulated and electrically stimulated beef carcasses.

M. semimembranosus	L	a	b
NS - Superficial	41.38[a]	21.37[a]	8.24[a]
NS - Deep	38.05[b]	17.01[b]	6.06[b]
ES - Superficial	38.78	20.57	7.43
ES - Deep	37.25	19.07	6.77
SEM[c]	0.86	1.04	0.50

[a,b] Least squares mean values within the same column and stimulation treatment with different superscripts differ significantly ($P<0.05$).

[c] SEM is the standard error of the least squares means.

Table 3. Comparison of least squares means of drip loss, and expressible moisture for muscles of non-stimulated and electrically stimulated carcasses.

	Drip loss (%)			Expressible moisture (%)		
Muscle	NS	ES	SEM[a]	NS	ES	SEM
M. triceps brachii	4.76	6.16	0.71	38.90	38.24	1.72
M. longissimus thoracis	7.82	5.61	1.39	37.68	34.80	2.00
M. semimembranosus	9.3	10.14	0.78	40.61	41.25	1.25
M. gluteobiceps	9.48	9.10	1.79	40.73	40.21	1.39
M. serratus ventralis	6.13	6.19	0.93	40.41	38.86	1.52

[a]SEM is the pooled standard error of the least squares means.