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Adding Value to Low-Quality Beef Muscles through Glycolytic Inhibition in Pre-rigor Muscle

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Adding Value to Low-Quality Beef Muscles through Glycolytic Inhibition in Pre-rigor Muscle

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Pre-rigor injection of specific glycolytic inhibitors may be an effective strategy to enhance tenderness of low-quality beef muscles.

Summary

*Pre-rigor **Semimembranosus, Triceps brachii** and **Supraspinatus** muscles were removed from 10 steers to determine effects of several glycolysis-inhibiting compounds on pH, tenderness and color. Muscles were injected and tumbled with 10% of sodium citrate, sodium fluoride, sodium acetate, or calcium chloride. Sodium citrate and sodium fluoride increased pH values in **Semimembranosus, Triceps brachii** and **Supraspinatus**. Tenderness improved in **Triceps brachii** and **Supraspinatus** with calcium chloride, sodium fluoride and sodium citrate when compared with controls. Color values were not different among treatments. Sodium citrate and sodium fluoride were successful in improving beef tenderness by maintaining a high pH in pre-rigor muscles.*

Introduction

Many beef muscles are low in quality and value because they lack tenderness. Given that the value of the beef chuck and round has dropped 20-30 % over the past 5-6 years, strategies should be developed to enhance tenderness of these low-quality muscles.

Muscle has an ultimate pH near 5.6. Higher muscle pH has been associated with enhanced tenderness, although most high pH meat is also darker in color. The opportunity exists to inhibit glycolysis, the metabolic pathway responsible for production of lactic acid which lowers muscle pH during development of rigor mortis. Our study was conducted to evaluate pre-rigor injection of different compounds for their effects on pH, color and tenderness of low-value beef cuts.

Procedure

Ten steers (22 to 24 months of age, 1,133 to 1,488 pounds live weight) were slaughtered at the University of Nebraska Meat Laboratory. Pre-rigor S*emimembranosus* (from the round), *Triceps brachii* and S*upraspinatus* muscles (from the chuck) were excised from both carcass sides. Muscles were randomly assigned to treatments: sodium citrate (200 mM), sodium fluoride (200 mM), sodium acetate (200 mM), and calcium chloride (300 mM). Control samples remained in the carcass at 40 °F for 24 hours, to simulate commercial conditions. Treatments were identified in a preliminary experiment (1999 Nebraska Beef Report, pp. 77-78). Calcium chloride was compared with the glycolytic inhibitors. At two hours postmortem, each muscle was injected with a volume equal to 8 % of the muscle weight. Each muscle was individually packaged (2 % of solution was added to complete 10 % of muscle weight) and tumbled for 30 min. Samples were taken for analysis three days after injection. Sarcomere length was determined by neon laser diffraction. pH was measured using a pH-meter with a combined glass electrode. A Hunter Lab Mini Scan Plus was used to evaluate color instrumentally for L*, a* and b* values. Water holding capacity was defined as the percentage of muscle weight removed by centrifugation. Meat samples were cooked on a grill to an internal temperature of 158°F. Tenderness was measured by shear force

Table 1. Effect of pre-rigor injection with glycolytic inhibitors in *Triceps brachii* muscles.

Variable	Treatments				
	Control	Calcium Chloride	Sodium Acetate	Sodium Fluoride	Sodium Citrate
L*[e]	28.18	32.15	31.36	28.27	29.56
a*[f]	25.26[a]	23.17[abc]	21.87[bc]	23.83[ab]	21.18[c]
b*[g]	6.50	6.23	6.38	6.39	5.72
WHC[h]	36.66	40.09	36.36	35.27	37.76
Sarcomere length, µm	2.41[a]	1.31[b]	1.53[b]	1.41[b]	1.62[b]
pH	5.28[d]	5.67[b]	5.48[c]	5.92[a]	5.73[b]
Shear force, lb.	12.50[a]	10.69[b]	14.26[a]	11.41[ab]	9.47[b]

[a,b,c,d]means within a row having different superscripts differ (P<.05).
[e]L*= lightness; 100= white, 0= black
[f]a*= redness; -80= green, 100= red
[g]b*= yellowness; -50= blue, 70= yellow
[h]Water Holding Capacity, %

Table 2. Effect of pre-rigor injection with glycolytic inhibitors in *Semimembranosus* muscles.

Variable	Treatments				
	Control	Calcium Chloride	Sodium Acetate	Sodium Fluoride	Sodium Citrate
L*[e]	29.15	29.44	32.06	27.06	30.18
a*[f]	27.57[a]	24.88[ab]	20.99[b]	22.48[b]	21.38[b]
b*[g]	7.10	6.58	5.86	5.99	5.85
WHC[h]	36.54	41.71	39.35	38.22	41.99
Sarcomere length, µm	1.81[a]	1.48[c]	1.73[ab]	1.52[bc]	1.72[ab]
pH	5.24[d]	5.60[c]	5.38[d]	6.00[a]	5.81[b]
Shear force, lb.	14.65	12.74	14.59	12.45	11.70

[a,b,c,d]means within a row having different superscripts differ (P<.05).
[e]L*= lightness; 100= white, 0= black
[f]a*= redness; -80= green, 100= red
[g]b*= yellowness; -50= blue, 70= yellow
[h]Water Holding Capacity, %

Table 3. Effect of pre-rigor injection with glycolytic inhibitors in *Supraspinatus* muscles.

Variable	Treatments				
	Control	Calcium Chloride	Sodium Acetate	Sodium Fluoride	Sodium Citrate
L*[d]	28.99	30.86	33.68	28.21	30.51
a*[e]	24.19	24.27	21.67	16.66	20.87
b*[f]	6.26	3.38	6.16	5.41	5.59
WHC[g]	40.03	36.71	35.94	34.19	32.72
Sarcomere length, µm	2.13[a]	1.30[c]	1.43[bc]	1.58[b]	1.46[bc]
pH	5.45[c]	5.54[c]	5.64[c]	6.14[a]	5.86[b]
Shear force, lb.	14.85[ab]	12.10[c]	16.73[a]	13.51[bc]	11.15[c]

[a,b,c]means within a row having different superscripts differ (P<.05).
[d]L*= lightness; 100= white, 0= black
[e]a*= redness; -80= green, 100= red
[f]b*= yellowness; -50= blue, 70= yellow
[g]Water Holding Capacity, %

using the Instron Universal Testing Machine. Data were analyzed by one-way analysis of variance. Means were separated using the least significant difference procedure.

Results

Sodium citrate and sodium fluoride showed (P<.05) the highest pH values in T*riceps brachii* (Table 1), in *Semimembranosus* (Table 2) and in *Supraspinatus* muscles (Table 3).

Shear force values decreased in *Triceps brachii* samples (P<.05) treated with calcium chloride (10.69 lb), sodium fluoride (11.41 lb) and sodium citrate (9.47 lb) compared with control (12.50 lb). In *Supraspinatus*, calcium chloride and sodium citrate also caused a significant (P<.05) decline in shear force (12.10 and 11.15 lb., respectively) compared to control (14.85 lb.). The same trend was observed in *Semimembranosus* muscle, but these differences were not significant (P>.05).

Sarcomeres lengths, an indicator of the contraction state of the muscle, were shorter with calcium chloride, sodium fluoride, sodium acetate and sodium citrate (1.31, 1.41, 1.53 and 1.62 µm, respectively) than the control (2.41 µm) in *Triceps brachii*. Pre-rigor excised muscles are more susceptible to shortening because there is no skeletal restraint. Treated S*upraspinatus and Semimembranosus* muscles also showed sarcomere shortening.

The higher pH and lower shear force of the samples with sodium fluoride and sodium citrate in comparison with the control showed high pH favors tenderness in meat. Even though sodium fluoride and sodium citrate increased pH in all muscles studied, which could indicate glycolytic inhibition occurred, water-holding capacity was not affected by treatments (P>.05).

Hunter color L* (lightness) and b* values (yellowness) were not different among treatments (P>.05). However, treated *Semimembranosus* and *Triceps brachii* muscles had less red color (lower a* values) than the control (P<.05). This result could indicate that brine injection affected color intensity of meat.

Sodium citrate and sodium fluoride were successful in improving beef tenderness, without detriment to lean color, by maintaining a high pH in pre-rigor muscles. Pre-rigor injection of specific glycolytic inhibitors may be an effective strategy to increase value of low-quality beef muscles.

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