January 2006

Alternative Enhancement Strategies for Beef Muscles

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Summary

USDA Select grade semitendinosus (eye of round) muscles from 12 cattle were used for controls (non-enhanced); salt and phosphate enhanced; water enhanced, or enhanced by addition of 10% of a solution containing 1, 3, or 5% sodium citrate to evaluate the effect of citrate on meat tenderness. Shear force and trained taste panel ratings were not different, ($P > 0.05$) between controls and citrate-treated muscles. Less than half of the enhancement solution was retained by the muscle. Perhaps the high connective tissue content of the semitendinosus or poor retention of the enhancement solution contributed to these results, which are in conflict with our previous research using other muscles.

Introduction

A wholesome, full-flavored, consistently tender piece of beef is of the utmost importance to consumers when a beef purchase is made. Consumers are willing to pay a premium for meat that is guaranteed tender. Treatments to improve tenderness of chuck and round muscles would add value to the whole carcass.

Previous research in our laboratory indicated beef chucks injected prerigor with water were less tender than control samples while those injected prerigor with 200 and 400 mM sodium citrate, a glycolytic inhibitor, improved tenderness over the controls. This earlier research focused on prerigor beef muscles. Thus, the current study was conducted to determine the effect of a postrigor injection of sodium citrate on beef muscle tenderness.

Procedure

Meat

Select-grade semitendinosus muscles from 12 cattle were obtained and assigned randomly to one of four replications. Muscles in each replication were then split in half and assigned randomly to one of six treatments: 1) untreated, 2) enhanced by addition of 10% of muscle weight with water, 3) enhanced by addition of 10% of muscle weight with a solution containing water, 0.3% salt and 0.3% phosphate solution, 4) enhanced by addition of 10% of muscle weight with a solution containing water and 1.0% sodium citrate solution 5) enhanced by addition of 10% of muscle weight with a solution containing water and 3.0% sodium citrate solution, 6) enhanced by addition of 10% of muscle weight with solution containing water and 5.0% sodium citrate solution. Injection of water and solution was done by hand throughout the semitendinosus using a single-needle ham injection unit. Once injected, the muscles were vacuum packed and tumbled for 20 minutes. After allowing 24 hours for enhancement equilibration, muscles were removed from their package and weighed to determine the percentage pick-up of the enhancement. The semitendinosus muscles were cut in half and randomly assigned an aging period of 1 or 7 days. After aging at 38°F postinjection, three 1-inch thick steaks were removed in succession from each muscle and frozen. The first (counting from the cut surface) was designated for Warner-Bratzler shear force determination and the second and third were delegated for trained panel evaluation of tenderness, connective tissue, juiciness, and off-flavor intensity.

Warner-Bratzler Shear Force

A 1-inch thick steak from each muscle was broiled on a tabletop broiler to a final internal temperature of 160°F. Temperature was monitored at the geometric center of each steak using a thermocouple thermometer. Cooked steaks were chilled 24 hours at 38°F, and then eight cores (1/2 inch in diameter) were removed parallel to the muscle fiber orientation. Cores were sheared once each on an Instron Universal Testing Machine with a Warner-Bratzler attachment and a 250 mm/min crosshead speed.

Objective Color

A 1-inch thick steak from each muscle was cut and allowed to oxygenate (bloom) for 1 hour. Objective color [L* (measure of lightness), a* (measure of red), and b* (measure of yellow)] was measured with Illuminant D65 using a Hunter Lab Mini Scan XE Plus colorimeter with a 1-inch port.

Trained Taste Panel

A 1-inch thick steak from each muscle was broiled on a tabletop broiler to a final internal temperature of 160°F. Temperature was monitored at the geometric center of each steak using a thermocouple thermometer. Steaks were then cut into 0.5 in x 0.5 in portions and placed in a double boiler to maintain temperature. The panel was specifically trained for evaluating tenderness, connective tissue, and juiciness. The panel was also asked to note any off-flavors, if present. The panelists received six randomly-assigned samples a day, plus an initial "warm-up" sample to begin each panel.

Statistical Analysis

Data were analyzed using the GLM procedures of SAS in a 6 x 2 factorial randomized complete block design.

Table 1. Effect of treatments on shear force values (lb), and sensory traits.[a]

Treatment	WBSF[b]	Juiciness	Tenderness	Connective Tissue	Saltiness	Off-Flavor Intensity
Control	8.66	4.97	6.02	5.25	5.69	5.53
Control with water	7.92	5.11	6.16	5.48	5.89	6.05
0.3% Salt/ 0.3% phosphate	8.17	5.22	6.17	5.49	5.66	5.89
1% Sodium citrate	8.97	5.09	6.03	5.00	6.04	5.92
3% Sodium citrate	8.95	5.05	5.97	5.02	5.85	5.83
5% Sodium citrate	8.02	5.19	6.25	5.39	6.07	5.94
SEM	0.43	0.19	0.17	0.22	0.19	0.18

[a]Evaluated on 8-point rating scale where 1= extremely dry, extremely tough, extreme amount of connective tissue, extremely salty, and extremely off-flavored and 8 = extremely juicy, extremely tender, no connective tissue, no salt, no off-flavor.
[b]Warner-Bratzler Shear Force.

Table 2. Pump percentage and 24 hour enhancement retention.

Treatment	Pump percentage	Solution retention percentage[a]
Control	0.00	0.00
Control with water	10.23	29.43
0.3% Salt/0.3% phosphate	10.10	27.54
1% Sodium citrate	10.10	41.15
3% Sodium citrate	10.03	37.95
5% Sodium citrate	10.00	38.11
Standard Error	0.04	6.58

[a] Means after 24 hours.

Table 3. Percentage of panelists detecting the presence of specific off-flavor notes.

Treatment	Liver	Sour	Metallic	Bitter	Oxidized	Rancid
Control	6.94	31.94	8.33	4.17	1.39	5.56
Control with water	0.00	31.94	11.11	0.00	4.17	0.00
0.3% Salt/ 0.3% phosphate	2.78	33.33	9.72	0.00	4.17	1.39
1% Sodium citrate	0.00	34.72	6.94	0.00	5.56	0.00
3% Sodium citrate	4.17	27.78	11.11	2.78	1.39	2.78
5% Sodium citrate	5.56	25.00	8.33	5.56	5.56	0.00
SEM	2.70	4.07	3.01	1.68	1.91	1.63

The model included the main effects of replication, treatment, aging, and treatment x aging.

Results

There were no differences due to aging time or aging by treatment for any of the traits measured ($P > 0.05$). Connective tissue shows little if any response to aging. It's likely the high connective tissue and elastin content of the semitendinosus account for this lack of aging effect.

Panelists were unable to detect any differences among the treatments in juiciness, tenderness, connective tissue amount, saltiness, or off-flavor intensity (Table 1). Similarly, no differences were found using the Warner-Bratzler shear, an objective measure of tenderness. One challenge in this study was the inability of the semitendinosus to retain the solutions which were added. Less than 42% of the solution was retained for any treatment (Table 2). This could account for the lack of effect. Traditional enhancement solutions contain salt and phosphate. Even this treatment in the present study failed to induce any changes in the muscle.

In previous research (Perversi et al., *2002 Beef Report,* pp. 85-87), prerigor injection of sodium citrate was shown to significantly enhance tenderness in other muscles. Results of the present study suggest the lack of response to sodium citrate may be attributed to the loss of the solution from the muscle, the high connective tissue content of the muscle studied, and/or the addition of sodium citrate postrigor rather than prerigor.

It was hypothesized that the sodium citrate solutions might impart a salty sensation, but that proved not to be the case (Table 1). Additionally, the addition of citrate did not contribute to specific problematic off-flavors (Table 3). Further, there were no effects of sodium citrate on pH or color measures, when compared to the untreated control (Table 4). Semitendinosus muscles injected with water or a solution containing salt and phosphate were lighter in color (higher L*) and less red (lower a*). There were no effects on the yellowness scale (b*). Previous speculation was that postrigor injection with sodium citrate may increase pH and ionic strength of muscles to a level where increased solubilization of myofibrillar proteins occurs, there by enhancing tenderness and the ability of the muscle to retain added water. This hypothesis did not hold true in this study.

Implications

Sodium citrate was not effective in changing the sensory properties of semitendinosus muscles. The lack

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of response may be attributed to the loss of the solution from the muscle, the high connective tissue content of the muscle studied, and/or the addition of sodium citrate postrigor rather than prerigor. Additional research is needed to clarify these issues.

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Table 4. Effect of treatments on pH and color.

Treatment	pH	L*[c]	a*[d]	b*[e]
Control	5.56	45.45[b]	22.82[a]	24.95
Control with water	5.54	49.02[a]	20.90[b]	24.26
0.3% Salt/ 0.3% phosphate	5.55	48.15[a]	20.26[b]	24.18
1% Sodium citrate	5.56	43.85[b]	22.36[a]	24.39
3% Sodium citrate	5.57	44.75[b]	22.50[a]	24.40
5% Sodium citrate	5.59	43.42[b]	23.46[a]	24.72
SEM	0.01	0.79	0.52	0.35

[a,b]Within a column, means without a common superscript letter differ ($P < 0.05$).
[c]L*= Lightness.
[d]a*= Redness.
[e]b*= Yellowness.