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Oral Dosage with NutroCAL^{TM} (Calcium Propionate) to Enhance Beef Tenderness

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Oral drenching with NutroCAL™ (calcium propionate) prior to slaughter tends to increase muscle calcium and enhance tenderness of beef strip loin steaks.

Summary

Oral dosage of market-weight beef steers with NutroCAL™ (a source of calcium propionate) tends to increase strip loin calcium and enhance tenderness after a 14 to 21 day aging period. No responses were observed in the eye of round or the chuck tender. The time course for serum and muscle calcium response appears to be highly variable and different from calcium chloride drenching.

Introduction

Beef tenderness is one of the most important sensory characteristics to consumers. Concern about the consistency and quality of beef has led to a variety of research strategies to improve beef tenderness. Knowledge of mechanisms by which beef improves in tenderness offers the opportunity to develop strategies to control and enhance the aging process.

Calcium-dependent proteolytic enzymes (calpains) increase the tenderness of beef during aging. Their requirement of calcium for activity offers an opportunity to enhance beef tenderization through elevation of calcium in the body. Prior research has demonstrated that cattle orally administered a solution high in calcium and glucose precursors prior to slaughter have elevated blood calcium and serum glucose. Administration of a gel high in calcium propionate three to six hours prior to slaughter also elevated muscle calcium content, increased calpain activity, and accelerated postmortem aging. Clearly the strategy of manipulating muscle calcium prior to slaughter has potential to enhance product quality.

As a rich source of readily absorbable calcium, NutroCAL™ may be well suited to such an application. The objective of this research was to determine if orally drenching cattle with NutroCAL™ would elevate serum calcium levels, thereby enhancing muscle calcium levels and improving beef tenderness.

Procedure

Market-weight crossbred cattle (n=42) were randomly assigned to one of three treatments: oral drenching with 1 L water, 1 L of 4.27 M calcium chloride, or 2.5 L of NutroCAL™ (300 g/L of H_20) sufficient to deliver 150 g of calcium. Frequent mixing of the solution

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was required to maintain NutroCAL™ in suspension. Drenching occurred within 35-125 minutes of slaughter using a veterinary stomach pump with a flexible metal hose. Cattle were not provided access to water between the time of drenching and slaughter. Blood (50 mL) was obtained at slaughter to document total serum calcium.

Animals were harvested in a traditional fashion. Strip loins, eyes of round, and chuck tenders were obtained 24 hours post-mortem, shipped to the university meat laboratory and aged at 36°F. Two days post-mortem, muscles were cut into portions and samples were obtained for determination of muscle calcium. The muscle portions were vacuum packaged and frozen at periodic intervals (day 2, 5, 7, 14, 21) for the *Longissimus* (strip loin) and the *semitendinosus* (eye of round) muscles and at day 2, 5, and 7 for the chuck tender (*supraspinatus*). Prior to cooking, muscle portions were tempered for 24 hours at 36°F and cut into 1-inch thick steaks. Steaks were thawed for 24 hours and cooked on tabletop electric broilers to 158°F. They were allowed to cool 24 hours at 39°F and then 1/2-inch cores were removed, parallel to the long axis of fiber direction. Cores (6-8 per steak) were sheared using a Warner-Bratzler shear attachment to an Instron Universal Testing Machine.

Atomic absorption spectrophotometry was used to determine calcium content of previously frozen blood serum and frozen, powdered muscle samples. Muscle samples were immersed in glutaraldehyde so sarcomere length could be determined using the laser diffraction method.

Table 1. Least square means for blood serum calcium level, muscle calcium concentration and sarcomere length for strip steaks, eyes of round, and chuck tenders from cattle drenched with calcium chloride or calcium propionate just prior to slaughter.

Trait	Control (1)	Calcium Chloride (2)	Calcium Propionate (3)	Contrast P-values 1 vs 2	Contrast P-values 1 vs 3
Serum calcium, mg/100 mL	13.25 ± 1.11	15.89 ± 1.11	12.35 ± 1.11	.101	.571
Muscle calcium, µg/g					
Strip steak	28.40 ± 6.09	30.04 ± 5.86	38.11 ± 5.86	.848	.258
Eye of round	6.86 ± .30	6.74 ± .30	6.56 ± .30	.766	.480
Chuck tender	5.24 ± .17	5.64 ± .17	5.49 ± .17	.107	.310
Sarcomere length, µm					
Strip steak	1.84 ± .09	1.80 ± .09	1.87 ± .09	.778	.756
Eye of round	1.70 ± .03	1.69 ± .03	1.71 ± .03	.906	.748
Chuck tender	1.68 ± .07	1.52 ± .07	1.62 ± .07	.114	.511

Table 2. Warner-Bratzler shear force values (lb) of strip steak, eyes of round, and chuck tender steaks from cattle drenched with calcium chloride or calcium propionate just prior to slaughter.

Trait	Control (1)	Calcium Chloride (2)	Calcium Propionate (3)	Contrast P-values 1 vs 2	Contrast P-values 1 vs 3
Strip steak					
2	11.26 ± 0.59	10.79 ± 0.59	11.17 ± 0.59	.583	.909
5	9.16 ± 0.51	9.54 ± 0.51	8.50 ± 0.51	.602	.368
7	9.23 ± 0.44	8.70 ± 0.44	8.26 ± 0.44	.419	.141
14	8.28 ± 0.40	8.41 ± 0.40	7.36 ± 0.40	.811	.105
21	7.25 ± 0.46	7.56 ± 0.46	6.39 ± 0.46	.658	.191
Eye of round					
2	11.23 ± 0.55	10.18 ± 0.55	11.41 ± 0.55	.189	.829
5	9.82 ± 0.37	9.10 ± 0.37	9.82 ± 0.37	.164	.957
7	9.91 ± 0.37	9.63 ± 0.37	10.20 ± 0.37	.584	.590
14	9.36 ± 0.33	9.23 ± 0.33	10.09 ± 0.33	.772	.118
21	9.74 ± 0.42	9.69 ± 0.42	10.64 ± 0.42	.950	.134
Chuck tender					
2	11.83 ± 0.51	12.40 ± 0.51	11.83 ± .0.51	.436	.993
5	10.97 ± 0.62	11.65 ± 0.62	11.41 ± 0.62	.443	.613
7	10.42 ± 0.46	11.39 ± 0.46	11.54 ± 0.46	.148	.088

Results

None of the responses variables were significant for the overall effect of treatment. However, given the initial intent to compare specific treatments, results are presented to gain insight into the trends. The calcium chloride treatment elevated serum calcium levels above the control (P=.101); they were also significantly higher than NutroCAL™ (Table 1). Surprisingly, there was no difference between the NutroCAL™ treatment and the control. Previous research in our laboratory has shown drenching with calcium chloride caused a transient increase in serum calcium — we showed an immediate rise in serum calcium, peaking within 30 - 90 minutes and then rapidly falling off. From these results, one might conclude that the serum calcium response of an animal to an oral dosage of NutroCAL™ follows a different time course.

It is through the elevation of muscle calcium concentration that enhanced enzyme activity (and thus tenderization) would be expected. Table 1 shows the muscle calcium concentration for each of the three treatments and each of the muscles. Several issues are immediately apparent. First, strip loin muscles appear to have about five times more calcium than do the round or chuck muscles that were studied. This trend is consistent with data published in USDA Handbook 8-13 concerning nutrient composition of beef. The reasons for differential calcium concentrations among muscles are not known. Perhaps the transport mechanism is different among the muscles. Perhaps there is greater blood supply and vascularization of the strip loin, thereby offering greater opportunity for calcium to be taken up. At this point, it is not possible

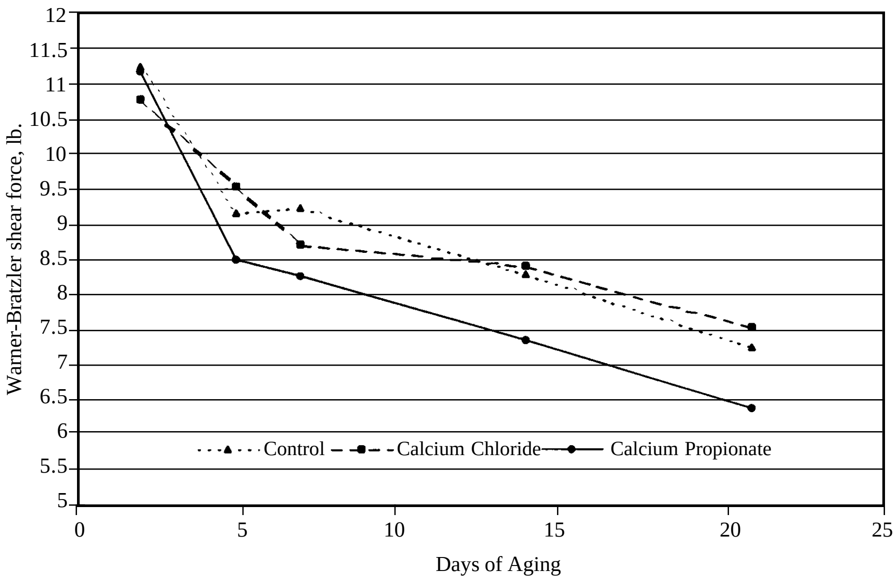

Figure 1. Warner-Bratzler shear force (WBS) values over time for longissimus muscle from steers treated with calcium chloride or calcium propionate prior to slaughter.

to say with certainty that the extra calcium within the muscle is actually within the muscle cell, rather than within the extracellular space.

The second obvious trend is the numerically higher value (by about 25%) for muscle calcium in the strip loins from cattle drenched with NutroCAL™. There was large animal-to-animal variation in muscle calcium levels, especially within the NutroCAL™-drenched animals. It would be useful to understand the reason for this variation. It does appear there is something within NutroCAL™ that seems to facilitate muscle calcium uptake, but it is difficult to determine from these data if it is time sensitive, as was observed with serum calcium. Perhaps the reason serum calcium levels were lower for the NutroCAL™ treatment is because that calcium was being subsequently incorporated into the strip loin muscle.

Shear force (tenderness) measurements taken during the postmortem aging of steaks from each of the three muscles are presented in Table 2. Again the animal-to-animal variation meant that the trends were not consistent enough to be significant. Nevertheless, there is a clear trend for strip steaks from animals treated with NutroCAL™ to be more tender, particularly after aging. To better view this relationship, the data for strip steaks are plotted in Figure 1. This trend is consistent with the hypothesis that elevated muscle calcium would increase proteolysis, which would occur during aging. Further evidence for this was obtained by correlating muscle calcium content to response to aging (the change in shear force from day 2 to day 14) across all treatments combined. The correlation was .47 overall ($P < 0.05$), suggesting muscles with more calcium experience a greater improvement in shear force than muscles with low levels of calcium.

There was one treatment effect for shear force of the chuck tender on day 7 (Table 2). Differences in the eye of round were observed only after 21 days of aging and do not favor the NutroCAL™ treatment. Given the failure of any of the treatments to elevate calcium concentration within either of these two muscles, these differences can be considered inconsequential.

One concern was that elevation of muscle calcium would support contraction of muscle during the rigor process, thereby reducing tenderness. Table 1 shows that there were no differences in sarcomere length among the treatments, suggesting that this strategy to enhance tenderness is not detrimental to muscle shortening.

Conclusions

Taken together, the results from this research suggest that drenching with NutroCAL™ tends to increase calcium content in the strip loin, with a resulting tendency for enhanced tenderness, especially with aging. No trends were observed for the muscles that were studied from the chuck and the round. These data suggest subtle differences in calcium localization and concentration may influence tenderness, and drenching with NutroCAL™ can influence these factors.

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