Feeding Supplemental Dietary Vitamin D_3 to Improve Beef Tenderness

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Summary

An experiment was designed to test the hypothesis that short-term oral administration of dietary vitamin D_3 to beef cattle before slaughter would increase beef tenderness through greater calcium-activated protease (calpain) activity in postmortem aged skeletal muscle. Thirty Continental crossbreed steers were allotted randomly to three treatment groups housed in one pen. One group served as a control; two other groups were administered by bolusing with either 5 million or 7.5 million IU of vitamin D_3 daily for nine days. Cattle were slaughtered two days later. Blood samples were collected at the same time daily and at the time of slaughter for the quantification of plasma calcium. The *longissimus lumborum* was excised from each carcass 72 hours postmortem and aged for 3, 7, 14, and 21 days and the semimembranous was excised and aged for 7, 14, and 21 days for subsequent Warner-Bratzler shear force determination and sensory evaluation. Concentrations of calcium in plasma and muscle from cattle treated with 5 million IU of vitamin D_3 were higher ($p < .05$) than those from controls. Strip loin and top round steaks from cattle fed supplemental doses of vitamin D_3 had lower ($p < .05$) Warner-Bratzler shear values at 14 days postmortem than did those from controls.

Introduction

Tenderness is the single most important palatability factor affecting consumer satisfaction. Consequently, ante- and postmortem treatments to improve tenderness are constantly being investigated. Our previous work has demonstrated that tenderization of beef loin steaks is caused by naturally occurring calcium dependent proteases (calpains). Because supplemental dietary vitamin D_3 causes increased calcium concentrations in blood and skeletal muscles, we hypothesized that supplemental vitamin D_3 would increase calcium activated protease activity in bovine muscles during postmortem storage and, thereby, enhance beef tenderness.

Materials and Methods

Thirty cross-bred steers approximately 23 months of age and predominantly of large-frame Continental X British breeds were allotted randomly to three treatment groups: a placebo, 5 million IU of vitamin D_3, and 7.5 million of IU of vitamin D_3. The steers were purchased the previous spring and allotted to pasture in May. At this time, each steer was implanted with Ralgro®. In June, they were placed in drylot and fed Berseem clover as green chop. All 30 steers were started on a high-concentrate finishing diet in October, at which time the steers were implanted again with Revalor®. The finishing diet consisted on dry basis of 78.2% whole shelled corn, 14.2% chopped alfalfa hay, 4.1% soybean meal, and 3.5% of a 40% crude protein liquid supplement.

After two weeks, steers were allotted to the three treatment groups. Starting 10 days before slaughter, steers were bled from the jugular vein by venous puncture into heparinized tubes, and plasma was stored at -18°C for subsequent analysis. Blood samples were collected each morning before bolusing each steer at 24-hour intervals and at slaughter. Also starting 10 days before slaughter, steers were given intraruminally a bolus containing ground corn or ground corn containing the 5 or 7.5 million IU of vitamin D_3 in gelatin capsules before the morning feeding for nine consecutive days. On the morning of day 10, the steers were transported 385 km to a commercial beef packing plant and slaughtered that afternoon. An additional blood sample was obtained from each steer at the packing plant.

Three days after slaughter, carcasses were transported to a beef breaking plant. *Longissimus lumborum* (strip loins) and semimembranous muscle (top round) were placed in Cryovac B620® (Cryovac, Duncan, SC) anaerobic vacuum bags and transported to the Iowa State University Meats Laboratory. For Warner-Bratzler shear and sensory evaluation, strip loin and top round steaks were cut 2.54 cm thick, placed in Cryovac B160® beef bags and wet-aged at 1°C. Both types of steaks were aged 7, 14, and 21 days; strip loin steaks also were aged for 3

days. After aging, steaks were frozen at -20°C until subsequent analyses.

Tenderness was determined on strip loin and top round steaks broiled to 70°C internally. After cooking, six cores were removed from steaks.

Results and Discussion

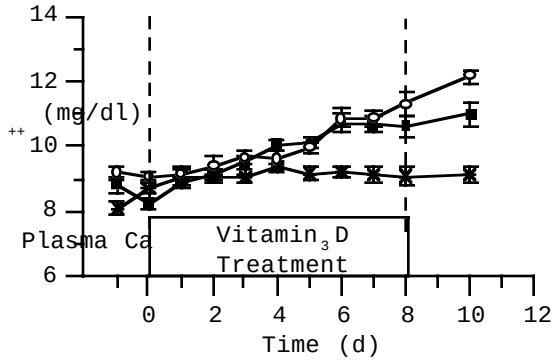
Our results indicate that feeding supplemental dietary vitamin D_3 does increase plasma and muscle calcium concentration. As shown in Figure 1, steers fed no supplemental vitamin D_3 maintained a uniform calcium concentration throughout the pre-slaughter period. The two groups fed supplemental vitamin D_3 had higher concentrations ($p < .05$) of plasma calcium from day 5 to day 8. On day 10 (time of slaughter), both of the treatment groups and the control groups had significantly different ($p < .05$) plasma calcium concentrations. Strip loin steaks that had been postmortem-aged 14 days from the cattle administered 5 million IU of vitamin D_3 had higher ($p < .10$) concentrations of total muscle calcium than did steaks from controls or cattle treated with 7.5 million IU of vitamin D_3 (Figure 2).

Although shear force data demonstrate that supplemental vitamin D_3 improved steak tenderness at all postmortem aging times, the maximal improvement was noted for those steaks postmortem-aged for 14 days. Strip loin and top round steaks postmortem-aged for 14 days from steers orally administered vitamin D_3 preceding slaughter had significantly lower Warner-Bratzler shear values ($p < .05$) than those of controls. Moreover, the 5 million IU dose per day was equally effective to the 7.5 million IU dose per day in improving beef steak tenderness.

Implications

Feeding 5 million IU of vitamin D_3 per day for ten days before slaughter could be implemented easily in a commercial feedlot system and offer a cost effective way of producing tender strip loin and top round steaks within 14 days postmortem. Therefore, antemortem feeding of supplemental vitamin D_3 is an effective, easy, and inexpensive way to improve beef tenderness before slaughter and potentially increase consumer acceptance of beef. It could also be used in a value-based marketing system.

Figure 1. Effect on plasma calcium concentration of orally administering 0, 5, or 7.5 million IUs of supplemental vitamin D_3 daily for nine days. Steers were slaughtered on day ten. Data are means ± S.E. for ten steers.



X = Control
= 5 million IUs
O - 7.5 million IUs

Figure 2. Effect on skeletal muscle (14 days postmortem) calcium concentration of orally administering 0, 5.0, 7.5 million IUs of supplemental vitamin D3 daily for nine days. Data are means ± S.E. for ten steers

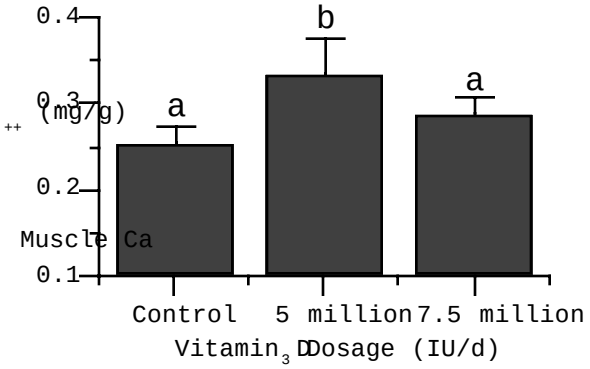


Table 1. Effect of supplemental dietary vitamin D_3 on Warner-Bratzler shear force of strip loin and top round steaks at various postmortem aging times.

	Vitamin D_3 Treatments						
Steak/	Control		5 million IU/d		7.5 million IU/d		
	Shear force, kg	S.E.	Shear force, kg	S.E.	Shear force, kg	S.E.	P>F
Strip loin steak							
Aging time (d)							
3	3.58	.17	3.11	.18	3.17	.15	.1638
7	3.32	.09	3.20	.19	2.89	.16	.1873
14	3.25[a]	.09	2.80[b]	.08	2.78[b]	.14	.0015
21	3.38	.11	2.90	.17	3.02	.13	.1071
Mean	3.38[a]	.12	3.00[b]	.16	2.97[b]	.15	.0001
Top round steak							
Aging time (d)							
7	3.97	.23	3.56	.20	3.32	.17	.0685
14	3.91[a]	.15	3.37[b]	.14	3.37[b]	.15	.0366
21	3.74	.10	3.32	.17	3.56	.16	.1973
Mean	3.87	.16	3.42	.17	3.42	.16	.0003

[ab]Means in the same row with a common superscript or no superscript are similar (P > .05).