Use of 25-Hydroxyvitamin D_3 to Improve Tenderness of Beef from Pasture- and Feedlot-Finished Beef Steers

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Summary and Implications

Pasture- and feedlot-finished beef steers (n = 48) were supplemented with 25-hydroxyvitamin D_3 (25-OH D_3) prior to harvest to investigate effects on beef tenderness. After harvest, the longissimus (LM), semimembranosus (SM), and gracilis (GR) muscles were collected for evaluation. Warner-Bratzler shear force (WBSF) indicated that 25-OH D_3 supplementation prior to harvest did not improve tenderness as compared to the non-supplemented treatment. This result was supported by evaluation of protein degradation, which further indicated that 25-OH D_3 did not increase protein degradation. The lack of tenderness improvement was likely attributable to the finding that 25-OH D_3 supplementation did not increase muscle calium concentrations, so increased proteolysis by the calpains (calcium activated proteolytic enzymes) was not observed.

Introduction

Tenderness has been regarded as the most important beef palatability trait for consumer satisfaction. Inadequate beef tenderness costs the beef industry nearly $72 million a year according to the 2000 National Beef Quality Audit. Furthermore, consumers are becoming more health and/or environmentally conscious and may turn to products that have been raised on pasture. Pasture-finished cattle, however, have been noted to yield less tender beef than feedlot-finished cattle. A novel method to improve beef tenderness involves the use of 25-hydroxyvitamin D_3 (25-OH D_3). Treatment with 25-OH D_3 prior to harvest increases calcium absorption from the digestive tract, increasing plasma calcium concentrations. This increased plasma calcium may then increase the activity of the calpain system of protein breakdown, which requires calcium for activation. Therefore, the objective of this research was to evaluate the effect of 25-OH D_3 on beef tenderness in pasture- and feedlot-finished beef steers.

Materials and Methods

British-breed beef steers (n = 48) averaging 814 lbs. were assigned to one of two diets on April 18th, 2006. A typical feedlot ration containing 10% wet distillers' grain was fed to the steers assigned to the feedlot diet (Table 1). Feedlot steers were housed at the Iowa State University (ISU) Beef Nutrition Farm in Ames, IA in outside lots and fed once daily. The steers assigned to pasture-finishing continuously grazed bromegrass pasture and were supplemented initially with 10 lbs./head daily of a pellet containing dried distillers' grain (Table 2). On July 13, 2006, supplement was increased to 15 lbs./head daily due to decreasing forage availability and quality. Pasture-finished steers also had access to a vitamin/mineral block with Rumensin®. Pasture-finished steers were housed at the Western Research and Demonstration Farm (Castana, IA) and received supplement once daily. All steers were implanted with Component TE-S prior to beginning the study.

After 12 weeks on the respective feeding regimens, ultrasound image evaluation indicated that a number of steers were nearing 0.5 in. of 12th rib fat. At this time, steers were designated to 1 of 3 harvest dates (3 weeks apart) based on estimated 12th rib fat thickness. On d 7 prior to harvest, steers received a bolus of either 0 or 500 mg of 25-OH D_3. Blood was collected at bolus administration and at harvest for analysis of plasma calcium and vitamins. At 24 hours after harvest, individual carcass data were collected, consisting of USDA marbling score, 12th rib fat thickness (used for the preliminary yield grade), ribeye area, hot carcass weight, percentage kidney, pelvic, and heart fat, and final yield grade. Strip loins and inside rounds were collected for analysis of WBSF, calcium and vitamin content, and protein degradation through Western Blotting. Statistical analysis was completed using PROC MIXED of SAS.

Results and Discussion

Weight gain. Steers had similar weights (P = 0.07) upon dietary treatment assignment. Feedlot steers weighed 805 lbs. and pasture steers weighed 825 lbs at the onset of the study. At harvest, feedlot steers were heavier (P = 0.04; 1,285 lbs.) than pasture-finished steers (1,239 lbs). This resulted in significantly greater average daily gain (ADG; P<.001) for the feedlot-finished steers (3.84 lbs./day) than the pasture-finished steers (3.32 lbs./day). Because equal numbers of steers from each diet were not harvested on each harvest date, average days on feed for each diet were calculated. Feedlot steers and pasture-finished steers averaged 132 and 130 days on feed, respectively.

Carcass characteristics. At harvest, pasture-finished steers had significantly less 12th rib fat as well as less kidney, pelvic, and heart fat than did feedlot-finished steers (Table 3). Additionally, pasture-finished steers had lower (P= 0.01) marbling scores (345) than did feedlot-finished steers (390).

Plasma analyses. Plasma analyses indicated that steers supplemented with 500 mg of 25-OH D_3 had increased ($P < 0.05$) plasma calcium (9.85 mg/dL) and 25-OH D_3 (301 ng/ml) at harvest compared to the steers receiving 0 mg (8.91 mg/dL and 61 ng/mL, respectively). The increased 25-OH D_3 and calcium in plasma showed that the treatment was absorbed and effectively increased plasma calcium, as expected. Pasture-finished steers had increased ($P < 0.0001$) plasma concentrations of β-carotene (2217 ng/mL) and vitamin E (3680 ng/mL) than feedlot-finished steers (109 and 1394 ng/mL, respectively). These results were attributable to diet because fresh forage has high concentrations of β-carotene and distillers' grains and wheat middlings in the supplement of the pasture-finished steers had a high vitamin E content.

Muscle vitamins and calcium. Concentrations of 25-OH D_3 in the muscle were increased ($P < 0.0001$) as a result of treatment with 25-OH D_3 compared to controls (7.62 vs. 6.63 ng/g of wet tissue, respectively). Despite increased calcium concentrations in the plasma and increased 25-OH D_3 in the muscle, calcium concentrations in muscle did not increase ($P = 0.52$) as a result of 25-OH D_3 supplementation as was hypothesized. These results may indicate that muscle calcium concentrations are more tightly regulated than plasma calcium.

Pasture-finished steers had increased ($P < 0.0001$) concentrations of vitamin E in the tissue (4.00 μg/g) as compared to feedlot-finished steers (1.22 μg/g). The increased vitamin E content may result in greater shelf-life and color stability for the steaks from pasture-fed steers because of the antioxidant activity of vitamin E.

Warner-Braztler shear force (WBSF). Steaks from steers supplemented with 500 mg of 25-OH D did not have improved WBSF ($P = 0.20$) as compared to those from steers receiving 0 mg, in contrast to our hypothesis. Degradation of troponin-T, a myofibrillar protein, was also not increased by treatment with 25-OH D_3, nor was calpain autolysis impacted. Calpain autolysis was expected to increase because of increased muscle calcium, which was not achieved, and as a result tenderness was not improved. Muscles did differ in WBSF over the aging period (Table 4). The GR showed a progression of improvement from d 3 to 7 to 14. The LM was more tender than the GR, but had no further improvement in tenderness after 7 d of aging. The SM had peak tenderness on d 7, and then increased. It is unclear why this increase occurred, though it may be attributable to increased purge loss in steaks aged 14 d. The LM also showed the greatest protein degradation.

In addition, steaks from pasture- and feedlot-finished steers did not differ in WBSF ($P = 0.44$; 8.51 vs. 8.71 lbs., respectively). Further research is warranted to investigate the effects of supplementation of pasture-finished steers on beef tenderness.

Conclusions. Though pre-harvest supplementation with 25-OH D_3 was effective at increasing plasma 25-OH D_3 and calcium concentrations, it was not effective at increasing muscle calcium concentrations and improving tenderness through enhanced proteolysis. Differences in tissue concentrations of vitamin E may be attributable to distillers' grains and wheat midds in the supplement of the pasture-finished steers, which may improve shelf-life of steaks from those steers because of the antioxidant effects of vitamin E.

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Table 1. Composition of feedlot-finishing diet.

Feed Ingredient	**% of diet, DMB[a]**
Dry rolled corn	72.965%
Wet distillers' grain	10.000%
Corn silage	9.955%
Ground hay – brome	2.500%
Urea	1.474%
Potassium chloride	0.966%
Limestone	0.966%
Salt	0.300%
Vitamin A	0.080%
Trace minerals	0.024%
Rumensin 80	0.020%
Molasses	0.750%
Total	100.000%

[a]DMB = Dry Matter Basis

Table 2. Composition and calculated analysis of a by-product feed mix.

Composition	%
Dried distillers' grain with solubles	50.0
Soy hulls	25.0
Wheat middlings	20.9
Molasses	2.5
Calcium carbonate	1.6
Total	100.0
Calculated Analysis	
Dry matter, %	90.1
Crude protein, %	21.8
Calcium, %	0.94
Phosphorus, %	0.67
NE m	0.91
NE g	0.61
TDN, %	85.9

Table 3. Carcass characteristics of pasture- and feedlot-finished steers.

Carcass Characteristic	Feedlot	Pasture	SEM	P-value
Hot carcass weight, lbs.	768	755	14.7	0.3230
LM area, in.^{2}	13.6	13.1	2.8	0.1746
Fat thickness, in.	0.34^a	0.24^b	0.03	< 0.0001
Kidney, pelvic and heart fat, %	1.83^a	1.64^b	0.06	0.0108
Final yield grade	2.4	2.2	0.2	0.1014
Marbling score [a]	390^a	345^b	31	0.0142
% Choice	54	25		

[a] Marbling score where 300 = Slight ^{00}, 400 = Small ^{00}, 500 = Modest ^{00}.

[bc] Numbers within a row with different superscript letters differ

Table 4. Least squares means of WBSF (kg) of gracilis (GR), longissimus (LM), and semimembranosus (SM) steaks from pasture- and feedlot-finished steers after steaks were aged 3, 7 or 14 d.

	Aging, d			
Muscle	3	7	14	SEM
GR	4.54^{a,y}	4.20^{b,x}	3.73^{c,y}	0.28
LM	4.17^{a,z}	3.30^{b,z}	3.02^{b,z}	
SM	4.52^{a,y}	3.74^{c,y}	4.06^{b,x}	

[abc]Means within a row lacking a common superscript letter are different ($P < 0.05$).

[xyz]Within a trait, means within a column lacking a common superscript letter are different ($P < 0.05$).