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EFFECTS OF FEEDING VITAMIN D ON FEED INTAKE, CARCASS CHARACTERISTICS, AND MEAT TENDERNESS OF BEEF STEERS

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Story in Brief

Supplemental vitamin D has been shown to increase tenderness in beef cuts when fed to cattle the final 5 to 10 d prior to harvest. This trial was conducted to examine effects of supplemental vitamin D on dry matter intake, carcass traits, and Warner Bratzler Shear (WBS) force values of three different beef muscles: Strip Loin, Top Sirloin, and Inside Round. Treatments included no vitamin D supplementation or 6 million IU (MIU) vitamin D daily for either 4 or 6 d pre-harvest. Utilizing a completely randomized design, 24 steers (1200 lb) were allocated to treatments (8 pens) and fed a 90% concentrate ration twice daily, with vitamin D fed once daily in a pellet as a percentage of the total ration. At harvest, 3 steaks (1 in thick) were cut from each of the specified muscle groups and aged for 7, 14 and 21 d. Steaks were broiled at 365° F to a final internal temperature of 158° F and shear force values were measured. A significant effect of feeding vitamin D on shear force was detected for Strip Loin and Top Sirloin steaks at 14 and 21 d of postmortem aging. Feeding vitamin D longer (6 vs 4 d) increased tenderness of Strip Loin steaks aged 7 d and of Top Sirloin steaks aged 14 d. As a percentage of total steaks, supplementation with vitamin D decreased the percentage of subprimals that had WBS force of 8.5 lb or greater by 68, 45 and 56% of the controls for Strip Loin, Top Sirloin, and Inside Round steaks, respectively. These data suggest that dietary supplemented vitamin D can improve tenderness of various muscles. However, elevated vitamin D intakes decreased DMI by 14%.

Key Words: Vitamin D, Carcass, Beef, Tenderness

Introduction

Consumers today consider tenderness to be the single most important component in meat quality, which reflects the positive relationship between the price of a cut of meat and its perceived tenderness. Smith et al. (1995) estimated that lack of tenderness in beef cuts costs the beef industry $250 million annually. Lack of uniformity, excessive fatness, and inadequate tenderness were all ranked in the top ten quality concerns in the 1995 National Beef Quality Audit; tenderness was ranked as the second most important beef quality problem. Consumers have demonstrated that they are willing to pay more for meat known to be tender (Boleman et al., 1997). Due to the fact that consumers consider tenderness to be a major factor determining the quality of meat, there is an economic incentive for producing meat that has an improved tenderness rating. One means of improving tenderness in beef cuts is to add supplemental vitamin D (VITD) to the diet shortly before cattle are harvested. Previously Swanek et al. (1997) showed that VITD supplementation will increase tenderness in beef cuts when fed to steers from 5 to 10 d prior to harvest. However, the mechanism by which VITD may increase tenderness is not known. Therefore, our objective in this trial was to examine the effects of VITD, fed for different time intervals, on carcass characteristics of beef steers.

Materials and Methods

Twenty-four crossbred, predominately Angus, steers (1200 lb) were purchased from Hitch Enterprises, Inc. at Guyman, OK, where they had been on feed for approximately 150 d. Upon arrival at the research facilities in Stillwater, OK, steers were allotted into eight pens with three head per pen and randomly assigned to one of three dietary treatments: no VITD supplementation (12 steers) or 6 million IU (MIU) of VITD daily for either 4 or 6 d pre-harvest (6 steers per time interval). Housing consisted of partially covered pens with slatted floors and cement fenceline feedbunks. Automatic waterers were shared by animals in adjacent pens. Steers were fed a 90% concentrate ration (Table 1) twice daily with VITD fed once daily in a pellet as a percentage of the total diet. Cattle were allowed a 12-d adaptation period to the diet before supplementation of VITD began. To ensure that all steers consumed the amount of VITD offered in the diet, DMI was restricted to 90% of mean DMI of the previous 5 d.

All steers were harvested using an approved humane technique at the Food and Agriculture Processing Center at Oklahoma State University. Following a 48-h postmortem chill (36° F), carcasses were ribbed and USDA quality and yield grades were recorded for each carcass. After aging the carcass for 7 d, the Strip Loin (SL), Top Sirloin (TS), and Inside Round (IR) muscles were fabricated from the left side of each carcass. Three 1 in thick steaks were fabricated from each of the three subprimals and individually vacuum packaged. These steaks were aged at 36° F for 7, 14 and 21 d, at which time they were frozen at -20° F. The steaks aged 7 d were immediately frozen after the steaks were fabricated. Steaks from these subprimals were used later for WBS force determination. Steaks were later thawed for 24 h at 36° F and broiled on an impingement oven to an internal temperature of 158° F. After cooling to room temperature, six to eight 0.5-in diameter cores were obtained from each steak and shear force values were determined; these values were averaged within steak and used as a single measurement.

Statistical Analysis. Shear force values, DMI and carcass traits were analyzed as a completely randomized design using the general linear model procedure of SAS (1985). Treatment sums of squares were separated using orthogonal contrasts that compared control vs VITD-fed animals and duration of feeding of VITD (4 vs 6 d).

Results and Discussion

DMI was held constant for all three treatments during the supplementation of VITD. Although DMI was restricted (90% of ad libitum) during the time of supplementation with VITD in this trial, DMI was still decreased. This was detected on d 4 for cattle receiving 6 MIU for 4 d of VITD (11.7% decrease) and on d 5 for cattle receiving 6 MIU for 6 d (13.9% decrease) as shown in Figure 1.

Carcass characteristics are presented in Table 2. Carcass weights ($P<.05$) and live weights ($P<.07$) were decreased for those cattle that received VITD compared with the control. Although these results are significant, it is hard to justify them since live weight change data from the start of the trial was not obtained. Preliminary yield grade was lower ($P<.05$) for cattle receiving vitamin D than for those that received VITD longer (6 vs 4 d). Although the decreased DMI associated with feeding VITD might explain these differences in carcass weight and yield grade, feed withdrawal for 24 h has not been associated with such drastic effects on carcass measurements. Though muscle glycogen mobilization might decrease carcass water content and weight in a short time, such short-term effects on yield grade are very surprising. Whether these carcass differences can be attributed to VITD feeding or to random chance is not yet certain. No such effects were noted previously by Swanek et al. (1997), although intake was restricted more in this study.

Tenderness, as evaluated by WBS force (Table 3), after 7 d of aging of SL steaks was improved more ($P<.0001$) by feeding VITD for 6 d than by feeding it for 4 d. For meat aged 14 or 21 d, tenderness was improved ($P<.02$) in steaks from steers receiving VITD supplements; however, no differences ($P>.05$) were noted between VITD treatments (4 vs 6 d). For TS (Table 4) steaks, no differences were detected after 7 d of aging, but at 14 and 21 d, shear force was reduced ($P<.04$) for steaks from steers receiving VITD supplements. After 14 d of aging, tenderness was improved more ($P<.03$) by feeding VITD for 6 d than for 4 d. For the IR (Table 3) aged 7 d, WBS force was reduced ($P<.03$) by VITD supplementation but no responses were detected with longer aging times.

Ideally, steaks should have shear forces under 8.5 lb to be considered "very tender." Percentage of steaks within subprimals by treatment group >8.5 lb after 7, 14, or 21 d of postmortem aging is indicated in Table 3. After 7 d of postmortem aging, approximately 50% of all control cuts failed to meet the shear force threshold compared with 17, 26, and 23% for steers supplemented with 6 MIU for 6 d for the SL, TS, and IR, respectively. Extending the postmortem aging time for either 14 or 21 d for SL and IR negated any advantages observed from VITD supplementation; only for TS did extended aging time have the effect of increasing tenderness. These results indicate that improvements in mean shear force can be attributed primarily to reduction in shear force of the toughest steaks and would suggest that the greatest improvements might be expected with breeds of cattle that produce less tender steaks. Surprisingly, tenderness was not improved by aging in this study as is commonly observed (Swanek et al., 1997). Perhaps the low number of head per treatment in this trial is a possible explanation. The fact that response differed among cuts suggests that response to VITD in tenderness, like the response to aging, will differ with the specific muscle group being tested. Improved tenderness of the expensive cuts would be of greatest interest in the hotel and restaurant trade, whereas tenderness of lower-priced cuts could make cuts that currently must be cooked with moist heat more suitable for grilling.

Implications

In the current investigation, dietary supplementation of feedlot steers with 6 MIU VITD daily for 4 or 6 d prior to harvest numerically increased tenderness of all three subprimals investigated. Supplementation with VITD also reduced the percentage of tough steaks at 7 d of postmortem aging for all subprimals. However, including VITD in the diet tended to decrease feed intake and hot carcass weights. Clearly, VITD will improve tenderness of muscles investigated but the optimum dosage rate and duration of feeding VITD remains to be pinpointed to reduce or avoid effects on feed intake and carcass weights.

Literature Cited

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Table 1. Diet and calculated nutrient composition (% of DM).

Ingredients	% of diet DM
Whole corn	79.2
Cottonseed hulls	5.0
Cane molasses	4.0
Supplement	8.0
Vitamin D supplement	3.8
Supplement	

Cottonseed meal	62.5
Soybean hulls	10.0
Urea	7.5
Salt	3.75
Limestone 38%	13.75
Potassium chloride	1.9
Zinc sulfate	.06
Manganous oxide	.05
Vitamin A-30[a]	.1375
Rumensin-80[b]	.2350
Tylan-40[c]	.1187
Vitamin D supplement	
Cracked corn	68.0
Soybean hulls	25.7
Cane molasses	3.0
Vitamin D	3.3
Diet composition, calculated	
NEm, Mcal/cwt	94.53
NEg, Mcal/cwt	60.33
Crude protein	12.37
Calcium	.57
Phosphorus	.31
Potassium	.71
Magnesium	.16

[a]30,000 IU Vitamin A per lb of premix provided at the rate to supply 5775 IU of Vitamin A per d.

[b]80 g Monensin per lb of premix provided at the rate to supply 30 g/ton of Monensin per d.

[c]40 g Tylosin per lb of premix provided at the rate to supply 10 g/ton of Tylosin per d.

Table 2. Least squares means for live weight and carcass traits of steers supplemented with vitamin D at 6 MIU for 4 or 6 d prior to harvest.

	Vitamin D, MIU/d		Contrasts[a]

Item	0	6 for 4 d	6 for 6 d	SE	C vs D	4 vs 6 d
Steers, n	12	6	6			
Live weight	1313.40	1261.83	1239.50	30.16	.07	.64
HCW, lb	815.45	781.33	763.00	19.12	.05	.54
Dressing %	62.01	61.92	61.55	.42	.45	.58
Lean maturity[b]	153.33	146.66	153.33	6.47	.65	.52
Marbling score[c]	415.83	406.66	390.00	13.88	.26	.45
PYG[d]	3.24	2.80	3.05	.12	.03	.21
FYG[e]	3.28	2.96	3.16	.10	.07	.22
KPH fat, %	3.95	2.08	2.33	1.48	.29	.91
Ribeye area, in^2	12.95	13.23	12.66	.49	.98	.47

[a]Contrasts: C vs D = control vs all with vitamin D; 4 vs 6 = Duration of feeding vitamin D for 4 d vs 6 d.

[b]Lean maturity: 100 to 199 = light cherry red, fine in texture.

[c]Marbling scores: 300 to 399 = Slight (U.S. Select); 400 to 499 = Small (U.S. Choice).

[d]Preliminary Yield Grade.

[e]Final Yield Grade.

Table 3. Least squares means for Strip Loin, Top Sirloin and Inside Round steaks with Warner-Bratzler shear force values of steers supplemented with vitamin D at 6 million IU for either 4 or 6 d.

	Vitamin D, MIU/d				Contrasts[a]	
Item	0	6 for 4 d	6 for 6 d	SE[b]	C vs D	4 vs 6 d
Steer, n	12	6	6			
Strip loin shear force, lb						
Aged 7 d	9.13	10.27	8.05	.13	.90	.0001
Aged 14 d	9.06	8.34	7.88	.12	.001	.28
Aged 21 d	9.46	8.82	8.84	.11	.02	.96
Top sirloin shear force, lb						
Aged 7 d	9.24	9.70	9.28	.09	.31	.22
Aged 14 d	9.61	9.48	8.70	.10	.04	.03
Aged 21 d	9.84	8.22	7.96	.08	.0002	.35
Inside round shear force, lb						
Aged 7 d	11.13	10.42	10.18	.16	.03	.66

Aged 14 d	10.90	11.39	11.02	.20	.57	.59
Aged 21 d	11.24	11.64	10.71	.18	.90	.14

[a]Contrasts: C vs D = control vs all with vitamin D; 4 vs 6 = duration of feeding vitamin D for 4 d vs 6 d.

[b]Standard error.

Table 4. Percentage of Strip Loin, Top Sirloin and Inside Round steaks with WBS values greater than 8.5 lb.

	Vitamin D, MIU/d		
Item	0	6 for 4 d	6 for 6 d
Steer, n	12	6	6
Strip loin shear force values >8.5 lb, %			
Aged 7 d	52.48	30.69	16.83
Aged 14 d	58.24	20.88	20.88
Aged 21 d	58.00	24.00	18.00
Top sirloin shear force values >8.5 lb, %			
Aged 7 d	46.67	27.50	25.83
Aged 14 d	54.46	26.79	18.75
Aged 21 d	61.73	20.99	17.28
Inside round shear force values >8.5 lb, %			
Aged 7 d	51.81	26.61	22.58
Aged 14 d	49.58	26.05	24.37
Aged 21 d	50.39	26.77	22.83

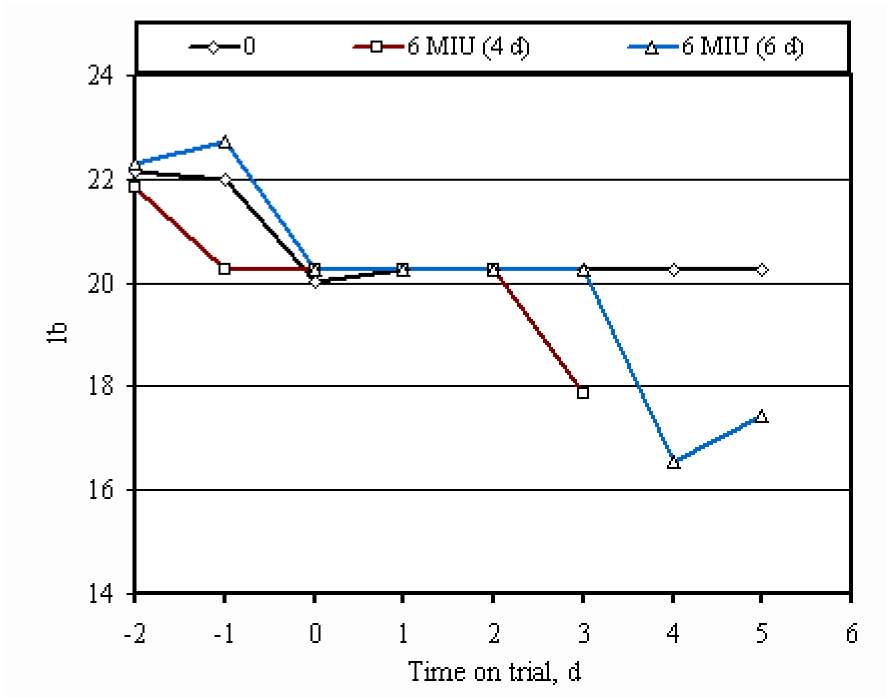

Figure 1. **Least squares means for DMI of steers supplemented with**
6 million IU of vitamin D for either 4 or 6 d.

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