EFFECTS OF SUPPLEMENTAL VITAMIN D_3 ON MEAT TENDERNESS[1]

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Story In Brief

Two studies were conducted to evaluate the effects of supplemental vitamin D_3 on Warner-Bratzler shear values of longissimus muscle steaks from feedlot beef steers. In Exp. 1, 118 steers (1,164 lb mean live weight) from two trials were supplemented with either 0 or 5 million IU of vitamin D_3 per day for 5 d immediately prior to slaughter. In Exp. 2, 44 steers (1,256 lb mean live weight) slaughtered on two different dates were supplemented with either 0 or 7.5 million IU of vitamin D_3 per day for 10 d immediately prior to slaughter. Longissimus muscle steaks (1 inch thick) were aged for either 7, 14 or 21 d and then frozen. After steaks were thawed, broiled to a internal temperature of 158° F, and allowed to cool to 68° F, eight 0.5 inch diameter core samples were obtained and sheared. Vitamin D_3 supplementation in Exp. 1 resulted in a 6.6% reduction in shear force values and a 21.8% reduction in the number of tough steaks (>4.5 kg shear force) after 7 d of postmortem aging. Vitamin D_3 supplementation in Exp. 2 lowered 7 d WBS values by 18.0% and tended to reduce the number of tough steaks after 14 and 21 d of postmortem aging (by 23.3% and 22.5%), respectively. Plasma calcium concentration at slaughter was greater (10.39 vs 9.23 mg/dl) and plasma magnesium was lower (1.99 vs 1.46 meq/l) for steers that received supplemental vitamin D_3 in Trial 1. Presumably, increased activity of proteases associated with the calpain system during aging is responsible for increased meat tenderness.

(Key Words: Vitamin D3, Calcium, Tenderness, Beef.)

Introduction

Inadequate tenderness was ranked by the 1995 National Beef Quality Audit as the second most important beef quality problem (Smith et al., 1995). The NBQA estimated that the economic loss associated with beef toughness equals $7.64 per animal or $217 million annually to the beef industry (Smith et al., 1995). In order to compete with other food protein sources, the beef industry must provide the consumer with a consistently high quality, palatable product.

Koohmaraie et al. (1991) determined that injecting meat with calcium chloride increases tenderness through activation of the calpain proteolytic system. Exogenous calcium applied to prerigor muscles activates both μ - and m- calpain, accelerates aging, and enhances meat tenderness (Wheeler et al., 1992).

In studies of parturient paresis of lactating dairy cows, orally administered vitamin D_2 at 5 million IU daily for two weeks prepartum increased serum calcium by 2.1 mg/dl (Hibbs et al., 1951). Therefore, we tested the impact of supplemental dietary vitamin D_3 on tenderness of longissimus muscle steaks from beef steers.

Materials and Methods

In Exp. 1, 118 steers (1,164 lb mean live weight), consisting of 20 Angus-Hereford crossbred steers in Trial 1 and 98 Saler or Charolais-sired steers with Brangus dams in Trial 2, were supplemented with either 0 or 5 million IU of vitamin D3 per day for 5 d immediately prior to slaughter. Steers in Trial 1 were assigned randomly to 8 pens, with either 2 or 3 steers per pen. Steers in Trial 2 were divided into groups based on breed of sire (Charolais or Saler) and weight class (heavy, medium and light). Steers in Trial 2 were assigned randomly to 20 pens with 4 or 5 steers per pen. In Exp. 2, 44 crossbred steers (1,256 lb mean weight) slaughtered on two different dates, designated as trial 3 and 4, were supplemented with either 0 or 7.5 million IU of vitamin D_3 per day for 10 d immediately prior to slaughter. In Trial 3, 20 steers were fed individually; in Trial 4, 24 steers were fed in 4 pens with 6 steers per pen. To ensure that all of the vitamin D3 included in the diet was consumed, steers in both experiment 1 and 2 were limit fed their high concentrate diet (1.5 % of their body weight daily) while vitamin D3 was supplemented. All steers were slaughtered at commercial packing plants. Following a 48 hour postmortem chill (2° C), yield and quality grade of each carcass was determined by a USDA grader and a rib section was removed from the left side of each carcass. Longissimus muscle steaks (2.5 cm thick) were prepared, vacuum packaged, aged at 36° F for either 7, 14 or 21 d (except for Trial 1 when only 1 steak was prepared and aged 7 d) and then frozen at -22° F. Steaks later were thawed for 24 hours at 36° F and broiled on a impingement oven to an internal temperature of 158° F. After cooling to 68° F, eight 0.5 inch diameter core samples were obtained from each steak; shear force values were measured using a Warner-Bratzler attachment to an Instron Universal Testing Machine. The maximum shear force value for each of the eight core samples was determined, averaged, and used as a single measurement.

Plasma from blood samples obtained during exsagination in Trial 1 were analyzed for calcium, magnesium, triglyceride, glucose, chlorine, phosphorus, sodium and potassium using a Roche Cobas Mira (Roche Diagnostic Systems, Inc., New Jersey).

For statistical analysis, samples from Exp. 1 were considered to be blocked by Trial (1 and 2) and for Trial 2 by breed of sire and weight class. Levene□s test was performed to test for heterogeneity of variances among the 12 group by treatment combinations. Variance was not heterogeneous according to that test. Shear force and carcass data were analyzed using the general linear model procedure of SAS (1985) using pen(rep*trt) as the error term. For Exp. 2, Trial 3 and Trial 4 were considered as two blocks based on feeding system (individual vs pen fed) and slaughter date. The mixed model procedure of SAS (1985) was used to analyze shear force and carcass data for Exp. 2.

Results and Discussion

In Trial 1 (Table 1), vitamin D_3 supplementation resulted in 26.6% lower ($P<.001$) blood plasma magnesium concentration, but plasma calcium concentration was 12.6% greater ($P<.03$).

Least square means for carcass characteristics for Exp. 1 are reported in Table 2. Carcass weight (P<.08) and ribeye area (P<.08) both tended to be greater for control steers, presumably due to chance. Least square means for shear force values for Exp. 1 are reported in Table 3. WBS values were 6.6% lower (P<.01) (more tender) and the number of tough steaks was 21.8% lower (to P<.01) for steers supplemented vitamin D3 at 7 d postmortem aging.

Least square means for carcass characteristics for Exp. 2 are reported in Table 4. Marbling score (P<.06) and final yield grade (P<.09) both tended to be greater for steers supplemented with vitamin D_3, presumably due to chance. In Exp. 2 (Table 5), vitamin D3 supplementation resulted in 18.0% lower (P<.02) WBS values at 7d postmortem aging and tended to reduce the number of tough steaks by 23.3% (P<.09), and by 22.5% (P<.07) at 14 and 21 d of postmortem aging.

Implications

Dietary supplementation with vitamin D_3 for 5 or 10 d prior to slaughter increased tenderness of longissimus steaks at 7 d postmortem aging. Supplementation with vitamin D_3 for 5 d also reduced the percentage of tough steaks at 7 day of postmortem aging whereas supplementation with 7.5 million IU for 10 d prior to slaughter tended to decrease the percentage of tough steaks at the longer aging periods. Optimum dosage levels and times for vitamin D_3 to reduce shear force of the longissimus and other muscle groups remain to be pinpointed.

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Table 1. Least squares means for blood plasma samples for steers supplemented with either 0 or 5 million IU of vitamin D3 for 5 days prior to slaughter (Trial 1).

	Vitamin D_3, IU/d			
Item	0	5 * 10^6	SE	Probability level (P<)
Steers, n	10	10		
Ca, mg/dl	9.23	10.39	.29	.03
Mg, meq/l	1.99	1.46	.06	.001
Triglyceride, mg/dl	22.5	26.9	.20	.21
Glucose, mg/dl	153.6	200.2	38.01	.42
Cl, mM	103.6	104.0	1.08	.79
P, mg/dl	6.66	6.36	.15	.20
Na, mM	149.2	148.0	1.51	.58
K, mM	7.22	6.77	.44	.50

Table 2. Least squares means for carcass traits for steers supplemented with either 0 or 5 million IU of vitamin D3 per day for 5 days prior to slaughter (Trials 1 and 2).

	Vitamin D_3, IU/d			
Item	0	5 * 10^6	SE	Probability level (P<)
Steers, n	59	59		
Carcass weight, kg	336.2	326.4	3.53	.08
Marbling score a	300.4	294.5	9.00	.70
Preliminary Yield Grade	2.85	2.80	.03	.35
Final Yield Grade	2.40	2.37	.08	.91

Ribeye area, cm2	86.2	84.1	.80	.08
Internal (KPH) fat, %	1.96	1.87	.06	.39
Skeletal Maturity b	148.8	145.9	2.44	.43
Lean Maturity c	136.1	139.9	2.43	.30

[a] Marbling score: 200 to 299 = "traces" (U.S. Standard); 300 to 399 = "slight" (U.S. Select).

[b] Skeletal maturity: 100 to 199 = A maturity: approximately 9 to 30 months chronological age at slaughter.

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

Table 3. Least squares means for Warner-Bratzler shear force values for steers supplemented with either 0 or 5 million IU of vitamin D3 per day for 5 days prior to slaughter (Trials 1 and 2).

		Vitamin D_3, IU/d			
Item		0	$5 * 10^6$	SE	Probability level (P<)
Steers, n		59	59		
Shear force, kg					
	Aged 7 day	4.70	4.39	.08	.01
	Aged 14 day	4.03	3.87	.09	.25
	Aged 21 day	3.58	3.60	.11	.90
Steaks with shear force values > 4.5 kg, %					
	Aged 7 day	56.0	34.2	5.53	.01
	Aged 14 day	20.0	17.0	7.22	.78

	Aged 21 day	6.0	8.0	4.75	.77

Table 4. Least squares means for carcass traits for steers supplemented with either 0 or 7.5 million IU of vitamin D_3 per day for 10 prior to slaughter (Trials 3 and 4).

			Vitamin D_3, IU/d	
Item	0	7.5 * 10^6	SE	Probability level (P<)
Steers, n	22	22		
Carcass weight, kg	358.5	368.4	7.56	.38
Marbling score [a]	384.3	434.0	18.0	.06
Preliminary Yield Grade	2.81	3.00	.10	.15
Final Yield Grade	2.16	2.63	.19	.09
Ribeye area, cm^2	92.5	90.0	2.45	.50
Internal (KPH) fat, %	1.99	2.30	.17	.20
Skeletal Maturity [b]	130.0	124.7	3.95	.35
Lean Maturity[c]	185.3	177.7	10.92	.62

[a] Marbling score: 300 to 399 = "slight" (U.S. Select); 400 to 499 = "small" (U.S. Choice).

[b] Skeletal maturity: 100 to 199 = A maturity: approximately 9 to 30 months chronological age at slaughter.

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

Table 5. Least squares means for Warner-Bratzler shear force values for

steers supplemented with either 0 or 7.5 million IU of vitamin D_3 per day for 10 prior to slaughter (Trials 3 and 4).

				Vitamin D_3, IU/d	
Item		0	7.5 * 10^6	SE	Probability level (P<)
Steers, n		22	22		
Shear force, kg					
	Aged 7 day	5.13	4.21	.28	.02
	Aged 14 day	4.40	3.81	.25	.13
	Aged 21 day	4.04	3.44	.24	.13
Steaks with shear force values > 4.5 kg, %					
	Aged 7 day	55.8	39.2	9.59	.23
	Aged 14 day	47.5	24.2	9.37	.09
	Aged 21 day	32.5	10.0	8.46	.07

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