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SUPPLEMENTAL VITAMIN D₃ AND BEEF TENDERNESS

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Story in Brief

The objectives of this study were to determine the effects of supplemental vitamin D₃ on beef muscle. Specifically, does supplementing vitamin D₃ improve any aspect of beef palatability, which includes juiciness, tenderness, and flavor? In the experiment, 44 steers were fed either 0 or 7.5 million International Units of vitamin D₃ per head per day for 10 d, immediately prior to slaughter. After humane slaughter, the carcasses were allowed to proceed through a 36-h chill before one strip loin was removed from each carcass. Steaks, measuring 1 in thick, were cut from each strip loin, and allowed to age for either 7, 14, or 21 d. Results indicated: 1) that plasma and muscle calcium concentrations were higher for vitamin D₃ supplemented steers, 2) cuts from vitamin D₃ supplemented steers displayed improved Warner-Bratzler shear force values, and 3) sensory panelists preferred cuts originating from carcasses of vitamin D₃ supplemented steers. Evidence is presented which indicates the improvement in palatability could be linked to calpain proteases that are activated by supplemental vitamin D₃.

Key Words: Vitamin D₃, Calcium, Tenderness, Proteases, Postmortem Changes

Introduction

Recent surveys have indicated that an excessive amount of variation exists in the tenderness of beef cuts at the retail and food service levels (Morgan et al., 1991; Hamby, 1992). The latest National Beef Quality Audit ranked inadequate tenderness as the second most important beef quality problem (Smith et al., 1995). They estimated the annual loss associated with beef toughness equals \$217 million to the U.S. beef industry. Thus, the National Cattlemen's Beef Association, along with other industry personnel, has focused its attention on programs targeted at improving, or predicting beef tenderness. One method in particular is called CAT (calcium-activated tenderization). The underlying premise of CAT is to elevate muscle calcium levels to the point that both μ - and m-calpain proteases are activated and utilized during the postmortem aging process. Calpain proteases are proteolytic enzymes that degrade certain muscle proteins, and thus enhance muscle tenderization. This experiment was conducted to evaluate the use of supplemental vitamin D₃ and its subsequent effects on calpain proteases.

Materials and Methods

Ten days prior to slaughter, 44 crossbred steers were fed either 0 or 7.5 million International Units of supplemental vitamin D₃ per head per day. After harvesting, the carcasses were chilled for 36 hours. Carcasses were then ribbed and USDA quality and yield grade information was recorded (Table 1). After collection of grade information, one strip loin was removed from each carcass and five steaks (1 in thick) were cut from each strip loin. The first steak was aged for 7 d and used for trained sensory evaluation, the second, third, and fourth steaks were aged for 7, 14, and 21 d, respectively, and used for Warner-Bratzler shear force determination, and the fifth steak was used for total muscle calcium determination.

Sensory Evaluation. Steaks were cooked to and held at 158° F for up to 10 min before they were cut into 0.4 x 0.4 x 0.4 in cubes and served to an eight member sensory panel, trained according to Cross et al. (1978). Each panelist independently evaluated two cubes from each sample for juiciness, beef flavor intensity, tenderness, and connective tissue amount using 8-point scales (8 = extremely juicy, intense, tender, none; and 1 = extremely dry, bland, tough, abundant) and off-flavor on a 4-point scale (4 = none, 1 = intense). Scores for each sample were the mean scores for all eight panelists (Table 2).

Shear Force Determination. Steaks for Warner-Bratzler shear force were cooked to an internal temperature of 158° F. They were then allowed to cool to 68° F before being cut into 0.5-in diameter cores and sheared on an Instron Universal Testing Machine with a standard Warner-Bratzler attachment and 5cm/min crosshead speed.

Total Calcium and Calpain Protease Determination. Twenty-four hours postmortem the total calcium content of muscle samples was measured using procedures described by Nakamura (1973). Upon completion of the homogenization process, the amount of calcium was measured with an atomic absorption spectrophotometer. At the same time, activities of μ -calpain, and m-calpain were determined on unfrozen loin muscle, according to the procedures of Koochmaraie (1990). The results for each procedure are included in Table 3.

Results and Discussion

Those steers receiving vitamin D₃ supplementation displayed elevated muscle calcium concentrations when compared with non-supplemented steers, and strip loin cuts from supplemented steers exhibited an 18% reduction in shear force values. Activities of muscle μ -calpain, and m-calpain measured at 24 h postmortem, from vitamin D₃ supplemented steers, were lower than activities for the non-supplemented group. This might indicate that supplementation of vitamin D₃ increases muscle calcium concentrations enough to activate and accelerate μ -calpain, and m-calpain.

The acceleration in activity causes the proteases to perform their normal functions, but decreases the time required for them to be effective. Thus, as protease activity is enhanced and accelerated, a subsequent enhancement in postmortem aging and improvement in overall palatability is realized.

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Table 1. Least squares means for the main effect of treatment on simple carcass traits from vitamin D₃ supplemented steers.

Trait	Control	VITD	P<
Hot carcass weight, kg	358.5	368.4	.38
Adjusted fat thickness, cm	1.02	1.00	.15
Longissimus muscle area, cm ²	92.5	90.0	.50
Kidney, pelvic, and heart fat, %	2.0	2.3	.20
USDA yield grade	2.2	2.6	.09
Skeletal maturity ^b	130	125	.35
Lean maturity ^c	185	178	.62
Marbling score	384	434	.06

^aAnimals fed vitamin D were supplemented with 7.5 million IU per d for 10 d.

^bSkeletal maturity: 100 to 199 = A maturity.

^cLean maturity: 300 to 399 and 400 to 499 = slight and small degree of marbling, respectively.

Table 2. Least squares means for the main effect of treatment on sensory panelist evaluation of vitamin D₃ supplemented steers^a.

Item	Treatment		SEM	P <
	Control	Vitamin D ₃		
Juiciness ^b	5.46	5.76	.14	.31
Tenderness ^b	4.77	5.53	.06	.02
Connective tissue amount ^b	7.04	6.99	.07	.54
Beef flavor intensity ^b	5.84	6.02	.11	.28
Off-flavor ^c	3.88	3.75	.03	.78

^aSensory evaluation was conducted on longissimus samples which were aged for 7 d postmortem.

^b8 = extremely juicy, tender, none detected, intense to 1 = extremely dry, tough, abundant amount, bland.

^c4 = none detected to 1 = extreme off flavor.

Table 3. Least squares means for the main effect of treatment on longissimus muscle calcium content, Warner-Bratzler shear force, and calpain activity of vitamin D₃ supplemented steers.

Item	Treatment		P <
	Control	VITD	
n	22	22	
Ca, μ g/g	14.2	21.3	.02
Shear force, d 7	5.13	4.21	.02
Shear force, d 14	4.40	3.81	.07

Shear force, d 21	4.04	3.44	.13
Shear force > 4.6 kg, d 7	55.8	39.2	.23
Shear force > 4.6 kg, d 14	47.5	24.2	.09
Shear force > 4.6 kg, d 21	32.5	10.0	.07
μ -Calpain, activity/g	.56	.19	.05
m-Calpain activity/g	.99	.62	.07



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