Effects Of Short Term Feeding Of Vitamin D_3 On Pork Quality

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ASL-R1613

Summary and Implication

We tested the hypothesis that supplemental dietary vitamin D_3 could be used to improve tenderness of pork. On the basis of elevation of blood calcium concentration and constant feed intake, we determined that 500,000 IU daily for three days before slaughter was the optimal dosage. This dosage resulted in no improvement in pork tenderness as based on two commonly used tenderness measurements. Several other measures of pork quality were determined, but only one was affected by dietary vitamin D_3. Carcasses from the vitamin D_3 supplemented pigs had more carcass shrinkage than did those of nonsupplemented pigs. Thus, this initial study indicated that supplemental dietary vitamin D_3 does not improve pork tenderness and other measures of pork quality.

The principal objective of this experiment was to test whether supplemental dietary vitamin D_3 improved tenderness of pork. Two commonly used methods of assay for tenderness were used to complete the objective. Both methods of assay demonstrated that supplemental dietary vitamin D_3 did not improve tenderness. Perhaps other doses of vitamin D_3 or other feeding schedules of the vitamin D_3 may result in an improvement in pork tenderness as occurred for beef. Future research is needed to address these issues.

Introduction

Studies at Iowa State University with beef cattle indicate that short term daily bolus administration of 5 million or 7.5 million IU of vitamin D_3 9 days before slaughter significantly improves tenderness of 14-day postmortem beef. The hypothesis was that an increase in plasma calcium would increase cellular calcium levels and that those increases at death would increase the fragmentation of titin, nebulin, and other muscle proteins through the increased activity of the calpain system. Our objective was to determine if short term feeding of vitamin D_3 also would improve the tenderness of pork without any detrimental effects.

Materials and Methods

Experiment 1. Eight market weight pigs were allotted randomly to treatments of 250,000 or 500,000 IU of vitamin D_3 daily for 7 days or until feed intake decreased. Pigs were penned individually and fed 2.5 kg of feed per day to ensure consumption of the vitamin D. Daily blood samples were taken for the first 8 days and every other day for the next 14 days for assay of plasma calcium concentrations.

Experiment 2. Twelve market weight pigs were fed 500,000 IU of vitamin D_3 daily for 1, 2, or 3 days in 2.5 kg of feed. Pigs were penned individually and fed 2.5 kg of feed per day to ensure consumption of the vitamin D. Daily blood samples were taken for 7 days for assay of plasma calcium concentrations.

Experiment 3. Twenty-four market weight barrows were allotted randomly to a group fed a control diet or to a group fed the control diet supplemented with 500,000 IU of vitamin D_3. Diets were fed for 3 days. Pigs were allotted to groups by weight and litter. Pigs were penned individually and fed 2.5 kg of feed per day to ensure consumption of the vitamin D. On day 4 all pigs were given control diets for 6 hours and then taken to the ISU Meats Laboratory for next-day slaughter. Blood samples were taken prior to initiating treatments and an hour before slaughter for determination of plasma calcium concentrations.

Pigs were weighed at initiation of treatments and just before slaughter. At 60 and 90 minutes after stunning, color and pH were determined for the longissimus muscle. A hot carcass weight and a 24-hour cold carcass weight were taken.

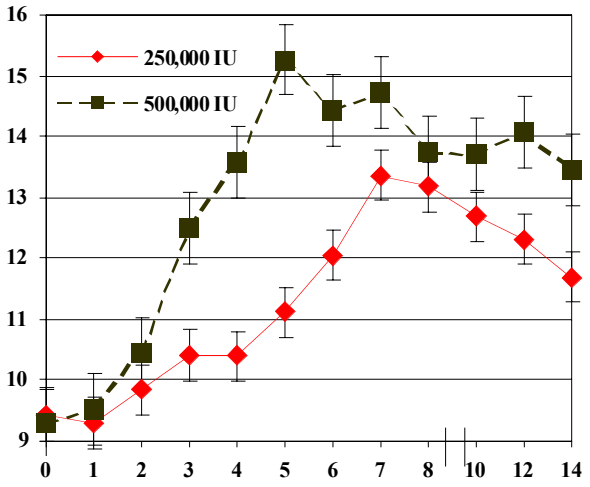
At 24 hours postmortem, carcasses were fabricated into primal cuts, including ham, loin, belly, picnic shoulder, and Boston butt. Carcasses were ribbed between the 10^{th} and 11^{th} rib and loin eye area, 10^{th} rib fat, first rib fat, last rib fat, and last lumbar vertebra fat. Subjective scores for color, marbling, and firmness were taken on each carcass. Loins were deboned and cut into chops. Starting at the 10^{th} and 11^{th} rib junction, chops were cut in alternating thickness for samples for specific pork quality measures. The first chop was 0.63-cm thick followed by two 2.54-cm chops. This alternating method was used for all the loin to get a representative sample of the entire loin. The 2.54-cm chops were paired and wrapped on styrofoam trays with oxygen permeable polyvinyl overwrap. All chops were held at 2^{o}C for 1, 7, 14, and 21 days. At each representative day, a package of chops was measured for lean color, pH, and water holding capacity. Chops subsequently were cooked to an internal temperature of 71^{o}C and cored for Warner-Bratzler shear force and Star probe determination of tenderness. Additionally, the semimembranosous muscle was

removed from the ham and cured. Processing yields and percentage water loss were measured on each ham section.

Results and Discussion

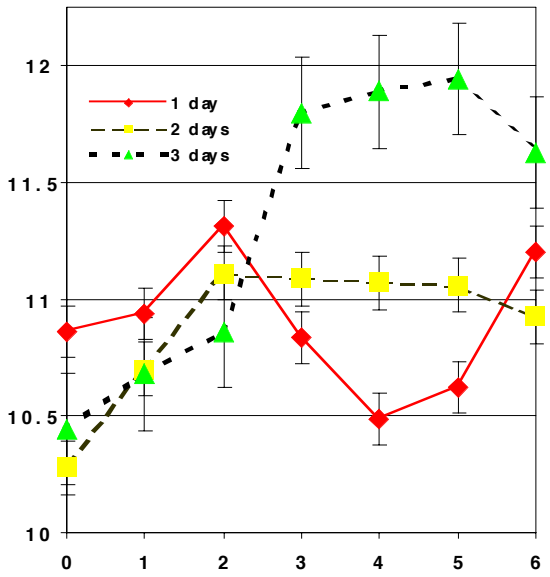
Experiment 1. Pigs fed the 500,000 IU of vitamin D_3 daily exhibited more elevated and stable plasma calcium concentration for short-term feeding (Figure 1). Therefore, the 500,000 IU daily dosage was used in experiment 2.

Figure 1. Effect of dosage of vitamin D_3 on plasma calcium concentrations, mg/dl.



Time of treatment (day)

Figure 2. Effect of number of days of feeding 500,000 IU of vitamin D_3 on plasma calcium concentrations, mg/dl.



Time of treatment (day)

Experiment 2. Pigs fed the 500,000 IU of vitamin D_3 daily for 3 days had plasma calcium concentrations that became elevated and remained elevated for 3 days, which is long enough for adoption of the technology for most commercial situations

Experiment 3. The initial plasma calcium concentrations were not different, but the pigs supplemented with the vitamin D_3 for 3 days had a higher plasma calcium concentration just prior to slaughter (day 5, Table 1).

Table 1. Effect of dietary vitamin D_3 on plasma calcium concentration, mg/dl.

Time	Control	Treated	P>F
Day 0	10.3	10.4	0.62
Day 5	10.0	12.6	0.01

Although there were no differences in beginning and ending body weights of the pigs, the control pigs tended to gain more weight (Table 2). Because the controls tended to also have a greater dressing percentage, the difference in body weight gain is not attributed to gut fill. Also, all pigs ate all of their daily-allotted 2.5 kg of feed.

There were no differences in hot carcass weight, but there was a difference in the 24-hour carcass weight (Table 2). This difference indicates a slightly lighter beginning carcass weight for the vitamin D-fed pigs and a slightly higher 24-hour carcass shrinkage. In contrast, the pigs fed the supplemental vitamin D_3 had a greater ultimate pH (Table 2). The other 24-hour carcass quality measurements showed no differences between treatments.

Table 2. Effect of dietary vitamin D_3 on carcass characteristics

Item	Control	Treated	P>F
Body weight			
Day 0, kg	117.4	117.2	0.31
Day 5, kg	121.9	119.3	0.87
Gain, kg	4.5	2.1	0.12
Hot carcass weight, kg	89.2	87.2	0.21
Ultimate pH	5.27	5.32	0.04
Dressing %	73.0	71.9	0.10
24-hour carcass weight, kg	87.3	84.3	0.05
Carcass shrink, kg	1.9	2.9	0.20
Carcass shrink, %	2.1	3.3	0.17

The lightness, redness, and yellowness of the loin muscle were not consistently significantly affected by the supplemental vitamin D_3 (Tables 3 and 4), although three of the nine measures of colors were significantly affected ($P<0.05$). Vitamin D supplementation also had an influence on water holding capacity of loins.

Dietary vitamin D_3 had no effect on color, firmness, marbling, or pH of loins at 1, 7, 14, or 21 days postmortem (Table 5). Also, yield and purge of hams were unaffected.

Both the Warner-Bratzler shear and Star probe measures of tenderness of the loin muscle showed no differences in meat tenderness (Table 6). Thus, our hypothesis that supplemental dietary vitamin D_3 given prior to slaughter would improve pork tenderness was not supported by this study.

Table 3. Effect of dietary vitamin D_3 on quality of loins.

Item	Control	Treated	P > F
Lightness[a,d]			
7 days	40.1 (41.6)	38.6 (40.0)	0.02 (0.09)
14 days	39.6 (41.8)	38.4 (41.1)	0.01 (0.16)
21 days	39.6 (41.9)	39.2 (41.2)	0.56 (0.39)
Redness[b,d]			
7 days	13.7 (13.9)	14.0 (14.3)	0.36 (0.51)
14 days	13.4 (13.8)	14.0 (14.3)	0.03 (0.30)
21 days	13.8 (13.6)	14.3 (14.6)	0.21 (0.09)
Yellowness[c,d]			
7 days	6.78 (7.26)	6.50 (7.23)	0.18 (0.95)
14 days	6.69 (7.38)	7.28 (7.30)	0.47 (0.67)
21 days	7.08 (7.28)	6.94 (7.49)	0.55 (0.34)
Water holding capacity[e]			
1 day	3.24	2.86	0.12
7 days	2.86	2.73	0.19
14 days	3.03	3.21	0.71
21 days	3.20	2.97	0.42

[a]Lightness; 0 is very dark, 100 is very light.
[b]Redness; 0 is very pale, 100 is very red.
[c]Yellowness; 0 is a lack of yellow, 100 is very yellow.
[d]Measured 1 or (24) hours after opening vacuum-packed loins.
[e]Ratio of areas of exudates to tissues (0.3 g) on filter paper after 3000 psi for 3 minutes.

Table 4. Effect of dietary vitamin D_3 on Hunter color scores

Item*	Control	Treated	P > F
60 min.			
Lightness	33.5	30.0	0.19
Redness	12.4	11.5	0.07
Yellowness	4.2	3.1	0.10
90 min.			
Lightness	31.8	29.1	0.17
Redness	13.4	11.6	0.06
Yellowness	4.9	3.5	0.07
24 hour			
Lightness	40.0	39.2	0.52
Redness	13.9	14.1	0.47
Yellowness	6.5	6.3	0.53

*Lightness; 0 is very dark, 100 is very light.
*Redness; 0 is very pale, 100 is very red.
*Yellowness; 0 is a lack of yellow, 100 is very yellow.

Table 5. Effect of dietary vitamin D_3 on additional measures of quality of loins and hams.

Item	Control	Treated	P > F
Loin			
Color, 1-5[a]	1.73	1.82	0.68
Firmness, 1-5[b]	2.55	2.91	0.27
Marbling, 1-5[c]	2.09	2.09	1.0
pH			
1 day	5.53	5.60	0.15
7 days	5.79	5.79	0.93
14 days	5.57	5.60	0.28
21 days	5.80	5.76	0.25
Ham			
Yield, %[d]	92.4	92.1	0.93
Purge, ml[e]	10.0	8.4	0.45

[a] Color: 1-pale, pinkish gray; 5-dark, purplish red.
[b] Firmness: 1-very soft and watery; 5- very firm and dry.
[c] Marbling: 1- practically devoid; 5-moderately abundant or greater.
[d] Yield after 10% pump and curing.
[e] Purge is exudate after freezing.

Table 6. Effect of dietary vitamin D_3 on tenderness of loins*

Method/Time Postmortem	Control	Treated	P > F
Warner-Bratzler shear, kg			
1 day	3.57	3.65	0.82
7 days	3.10	3.06	0.88
14 days	3.01	3.06	0.83
21 days	2.92	3.04	0.51
Star probe			
1 day	5.73	5.92	0.58
7 days	5.26	5.65	0.54
14 days	5.71	5.46	0.33
21 days	5.04	5.20	0.31

* Loins were cooked at 71°C; measured at 21°C.