EFFECTS OF DIETARY SUPPLEMENTATION OF FEEDLOT STEERS WITH VITAMINS E AND D_3 ON LIVE PERFORMANCE, CARCASS TRAITS, SHELF-LIFE ATTRIBUTES AND LONGISSIMUS MUSCLE TENDERNESS

1999 Animal Science Research Report

Pages 59-66

Authors:

D.N. Vargas, A.E. Down, D.S. Webb, H. Han, J.B. Morgan and H.G. Dolezal

Story in Brief

Cattle (n=119) were divided into four dietary treatment groups: Control, Vitamin D_3, Vitamin E and Vitamin E and D. Treatments Vitamin E and Vitamin E and D were supplemented with 1,000 IU/hd/d of vitamin E for the final 54 d of the feeding period. Steers in the Vitamin D and Vitamin E and D groups received 6 million IU/hd/d of vitamin D for the final 6.5 d prior to slaughter. Strip loins were divided into four sections and stored in refrigerated conditions for 7, 14, 21 or 28 d. At the end of each aging period steaks were cut for Warner-Bratzler shear force determination and shelf-life analysis. Shear force values were higher for Control steaks compared with all other treatments. After 7 d of aging, Vitamin D steaks had lower shear force values than those in the Vitamin E treatment group. Additionally, steaks from the Vitamin D and Vitamin E and D groups required fewer aging days to become "very tender" relative to Control and Vitamin E treatments. Lean color scores were higher at display d 4, 5 and 6 for steaks from cattle fed vitamin E when compared with non-vitamin E-supplemented treatments. Redness values were higher for Vitamin E and Vitamin E and D steaks when compared with Control and Vitamin D treatments, while yellowness values were higher for steaks from cattle in the Vitamin E group relative to all other treatments. Steaks in the Vitamin D and Vitamin E and D groups remained acceptable in the retail case longer after reaching 8.5 lb of shear force than Vitamin E or Control treatments. Therefore, in order to optimize the "color-tenderness relationship" of beef, it is recommended that finishing cattle be supplemented with both vitamins E and D_3.

Key Words: Vitamin E, Vitamin D_3, Shelf-Life, Tenderness, Beef Color

Introduction

Changes in consumer preferences in recent years have compelled the beef industry to re-evaluate its product quality as well as all influencing factors throughout the production chain. In 1991 researchers from Colorado State and Texas A&M Universities conducted the first National Beef Quality Audit (NBQA, 1991) from which it was found that the top concern of beef purveyors, restaurateurs and retailers was excessive external fat levels. Between the time this information was disseminated to the industry and the 1995 National Beef Quality Audit (NBQA, 1995), excessive external fat levels had dropped out as the top quality concern the industry was making progress. However, now the top three quality concerns included 1) low overall uniformity and consistency of beef products, 2) inadequate tenderness, and 3) low overall palatability. Production practices between the two audits had effectively reduced the amount of external fat on carcasses, but had also decreased the degree of intramuscular marbling.

Because of these production changes, beef researchers have been forced to find new, alternative ways to influence tenderness and overall palatability. Perhaps the most promising work in this area is research by Swanek et al. (1999), which suggests that large doses of dietary vitamin D_3 can enhance the tenderness of beef. Results from this study demonstrated that supplementing finishing cattle with 5 million IU/hd/d of vitamin D_3 for the final 5 to 10 d prior to harvest decreases ($P<.05$) shear force values of longissimus steaks aged for 7 d. Vitamin D_3 promotes increased calcium levels in muscle, which is associated with accelerated postmortem tenderization. Application of findings such as these should facilitate the delivery of consistently tender beef to retail outlets, even under "short-aged" conditions.

Maintaining beef□s desirable, bright cherry-red color during its retail display presents an entirely different set of quality challenges. In fact, in 1993 the National Cattlemen□s Beef Association (NCA, 1993) estimated that approximately $520 million is lost annually due to the discoloration of retail beef products. In an effort to recapture some of this "lost value" current research has focused the use of antioxidants to extend the retail case-life of beef. Wescott (1997) illustrated that by decreasing the rate of lipid oxidation and lean discoloration, a $4.00 investment of supplemental vitamin E ensures that fewer beef cuts are discounted or discarded due to premature browning, resulting in $30.00 to $35.00 of savings per carcass marketed through commercial retail outlets.

It is well established that storing carcasses in refrigerated conditions for 14 d or more improves the tenderness of beef. However the cost of improved tenderness is decreased retail case-life. When beef is aged for long periods it loses inherent factors that contribute to lean color and lipid stability. Therefore the objective of the current study is to determine if simultaneous supplementation of vitamins D_3 and E can effectively stabilize beef color while maximizing meat tenderness.

Materials and Methods

Cattle (n=119) were fed (124 d) a high concentrate finishing diet at a commercial feedyard. Steers were divided into four dietary treatment groups: Control , Vitamin D_3 , Vitamin E and Vitamin D_3 and E. Cattle receiving vitamin E received 1,000 IU/hd/d for the final 54 d of the feeding period. Steers receiving Vitamin D_3 were supplemented with 6 million IU/hd/d for the last 6.5 d immediately prior to harvest. Carcass data (quality and yield grade factors) were collected after a 36-h chill period. The strip loin from the right side of each carcass was removed, identified, and transported to the Food and Agricultural Products Research and Technology Center for evaluation. After 7 d postmortem, strip loins were fabricated into four 3.5-in sections. The cranial section was further fabricated into two 1-in steaks for Warner-Bratzler shear force and shelf-life. Shear force steaks were individually vacuum packaged and frozen until the time of analysis. The remaining three strip sections were aged at 40° F for either 14, 21 or 28 d.

Case-Life Analysis. Steaks were individually placed on Styrofoam trays, overwrapped with polyethylene film and displayed in a retail case illuminated by fluorescent lamps, emitting 175 foot-candles for 7 d. The case temperature ranged from 36 to 37° F. Steaks were randomly arranged in two cases at the beginning of each display day in attempt to avoid the variability of light exposure within each case. A three-member trained visual panel evaluated steaks twice per day for lean color, percent discoloration and overall appearance. Objective color measurements were determined using the L*(lightness), a*(redness), and b*(yellowness) color space using a Minolta colorimeter immediately following each visual appraisal. Measurements were taken at three different locations on each steak and averaged to obtain one L, a*, and b* value per steak.

Shear Force Evaluation. Steaks were randomized, thawed at 40° F for 12 to15 h, then cooked to an internal temperature of 158° F using an impingement convection oven. Cooked steaks were allowed to cool to 77° F before removing six cores per steak parallel to the orientation of the muscle fibers. Shear force values were determined for each core using a Universal Instron Testing Machine with a Warner-Bratzler attachment.

Statistical Analysis. Analysis of data was performed using the General Linear Model procedure of SAS (SAS, 1985). Means were separated using least squares means and probability differences. Regression analyses were performed for Warner-Bratzler shear force and shelf-life data in order to determine days of aging necessary for steaks to become "very tender" and days of acceptability in the retail case.

Results and Discussion

Live Performance. Initial weight, dry matter intake and feed efficiency were all statistically similar (Table 1). Cattle supplemented with vitamin D for the last 6 d of the feeding period (i.e., Vitamin D and Vitamin E and D) had lighter ($P<.05$) final weights compared with steers in the Control and Vitamin E groups. Furthermore, cattle receiving supplement with vitamin D had a lower average daily gain relative to the non-vitamin D-supplemented treatment group. Although dry matter intake between treatment groups were statistically similar, the reduced average daily gain of cattle supplemented with vitamin D is undoubtedly due to the sharp decrease in feed intake noted during the final 2 d of feeding. It is hypothesized that these marked decreases in dry matter intake are a result of a brief period of hypercalciemia caused by vitamin D supplementation.

Carcass Traits. Cattle in the Vitamin D treatment group produced carcasses with higher ($P<.05$) preliminary yield grades relative to the Vitamin E and D treatment, while carcasses from the Control and Vitamin E groups were intermediate. Kidney, pelvic and heart fat percentage was higher ($P<.05$) in carcasses from Vitamin E and D cattle when compared with the Control group. All other carcass traits were not influenced by vitamin supplementation.

Visual Panel. Panelist lean color scores were higher ($P<.05$) for steaks from cattle fed vitamin E (i.e., Vitamin E and Vitamin E and D) on display d 4, 5 and 6 compared with their non-vitamin E-supplemented counterparts (Figure 1). These data suggest that "short-term" supplementation of feedlot cattle with vitamin E is a plausible way to reduce the rate of metmyoglobin formation in steaks aged for various time periods prior to retail display. The percentage of lean discoloration was not affected ($P>.05$) by dietary treatment. However, steaks from cattle supplemented with vitamin E (Vitamin E and Vitamin E and D) maintained higher ($P<.05$) overall appearance scores when compared with the Vitamin D treatment.

Objective Color Measurements. Results from Minolta colorimeter readings show that steaks from the Control, Vitamin D and Vitamin E groups all had L* values higher ($P<.05$) than the Vitamin E and D treatment. Steaks from cattle in the Vitamin E and Vitamin E and D groups had higher ($P<.05$) a* values regardless of aging period. These data suggest that "short-term" supplementation of vitamin E is an effective method to prolong the time that beef appeared cherry-red in the retail case. Minolta b* values were higher ($P<.05$) for steaks in the Vitamin E group relative to all other treatments following 7 and 28 d of storage. Similarly, b* values for Vitamin E and D steaks were higher ($P<.05$) relative to Control and Vitamin D treatments after 14 d of aging. However, after more extended aging periods, Vitamin E and D b* values declined below those of Vitamin D steaks and were statistically similar to Control steaks.

Vitamin E supplementation extended the retail display-life of steaks from .2 to .7 d relative to Control and Vitamin D groups. This equates to 5 to 17 h of additional display time, providing beef retailers the opportunity to realize the full value of their beef products. These results are similar to those reported by Arnold et al. (1992), who found that supplementing feedlot cattle with vitamin E at 300 IU/d for 266 d, 1140 IU/d for 67 d or 1200 IU/d for 38 d effectively extended the retail shelf-life of longissimus lumbarum steaks by 2.5 to 4.8 d.

Shear Force Analysis. Steaks from Control cattle were tougher ($P<.05$) than all other treatments across all aging periods (Table 2). After 7 d of postmortem storage, steaks from the Vitamin D group were ($P<.05$) more tender than Vitamin E steaks. These results are in partial agreement with Swanek et al. (1999) who reported that vitamin D supplementation reduced both shear force values and tenderness variation after a 7-d aging period. In the present study, cattle in the Vitamin D and Vitamin E and D treatment groups experienced a 50% reduction in feed intake during the last 2 d of the feeding period. This decline in feed intake is presumably due to the metabolic affect of Vitamin D supplementation. With elevated serum calcium levels, it is possible that cattle experienced a brief period of hypercalciemia, causing them to consume less feed. Therefore, although vitamin D supplementation did improve the tenderness of steaks aged for 7 d, supplementing cattle with levels of vitamin D that maintain normal intakes may further augment this response.

Shear force did not differ for steaks aged for more extended time periods. However, steaks from cattle supplemented with vitamin D (Vitamin D and Vitamin E and D) required fewer aging days to become "very tender" (WBS $\leq$ 8.5 lb) relative to Control and Vitamin E treatments (Figure 2). This indicates that vitamin D supplementation can be used to accelerate the aging process and improve the tenderness of beef products provided to consumers.

Shelf-Life After Becoming "Very Tender". When analyzed in terms of days of retail acceptability after becoming "very tender" (shear force $\leq$ 8.5 lb) steaks from cattle supplemented with vitamin D had an advantage (Figure 3). After becoming "very tender" the lean color of steaks from the Vitamin D and Vitamin E and D treatments remained acceptable to consumers for an additional 1.2 to 2.5 d beyond that of Vitamin E and Control groups. This suggests that accelerating the postmortem aging process not only ensures consumers are provided with an adequately tender product, but also allows retailers to take advantage of the metmyoglobin reducing ability inherent in "short-aged" beef.

Conclusions

Supranutritional supplementation of vitamins to finishing cattle has recently been of great interest to many researchers. Many studies have successfully improved the retail color stability of beef by providing high levels of vitamin E in feedlot diets. Furthermore, it has recently been shown that feeding vitamin D in doses above nutritional requirements provides a favorable tenderness response. The current study illustrates that feeding vitamin D in conjunction with vitamin E is an effective means of accelerating the postmortem tenderization process while simultaneously stabilizing the color of beef. Optimization of the color-tenderness relationship of beef should allow the industry to provide consumers with a high-quality beef product.

Implications

One of the most formidable challenges currently facing the United States beef industry is recapturing market share that has been lost to competing protein sources. Much of this decline can be attributed to decreased eating quality of beef which has resulted from adjustments in production practices aimed at decreasing excessive carcass fat levels. Because identification of genetic lines that are capable of producing high-quality (i.e., high marbling) carcasses with minimal external fat has proven difficult, recent research efforts have focused on finding alternative methods to improve beef quality. The present study demonstrates that dietary supplementation of vitamins E and D_3 to feedlot steers may be one such tool for improving the appearance and tenderness of beef.

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Acknowledgements

The authors thank Dr. John Wagner and Continental Beef Research, Lamar, CO, for their financial support and cooperation throughout this project.

Table 1. Treatment means for live performance data.

	Treatment

Characteristic	CON	VITD	VITE	COMBO
Initial wt, lb	1039± 48	1041± 51	1037± 46	1035± 49
Final wt, lb	1273± 48	1256± 62	1268± 52	1245± 50
DMI, lb	20.5± .11	19.8± 1.6	19.5± .8	18.8± 1.2
ADG, lb	3.66± .21	3.36± .19	3.61± .14	3.29± .15
Feed/gain	5.65± .37	5.87± .13	5.40± .22	5.73± .35

Table 2. Treatment least squares means for Warner-Bratzler shear force values.

Treatment	Shear force, lb	SEM
CON	8.55[a]	.09
VITD	8.05[b]	.11
VITE	8.00[b]	.09
COMBO	7.87[b]	.09

[a,b]Letters within columns with different superscripts differ (P<.05).

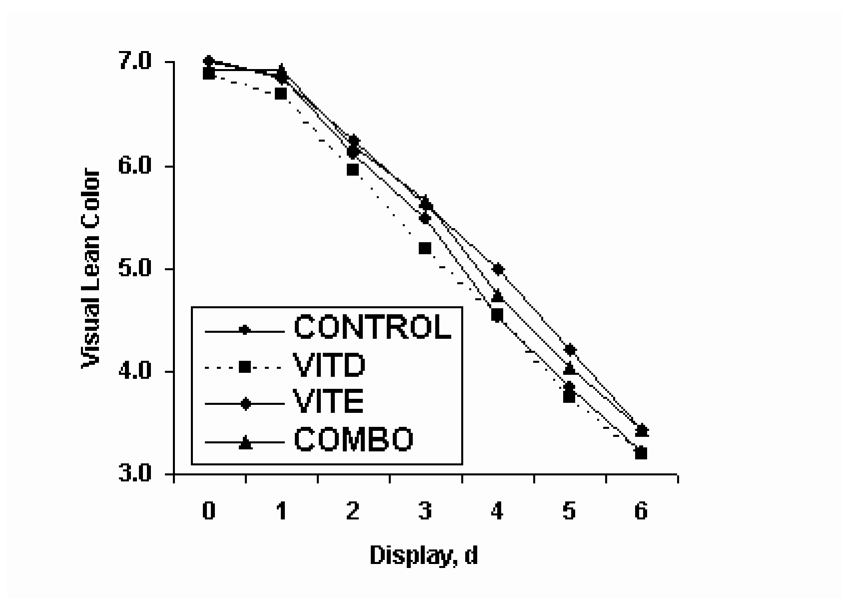

Figure 1. Effect of vitamin D and E supplementation and display time on lean color means.

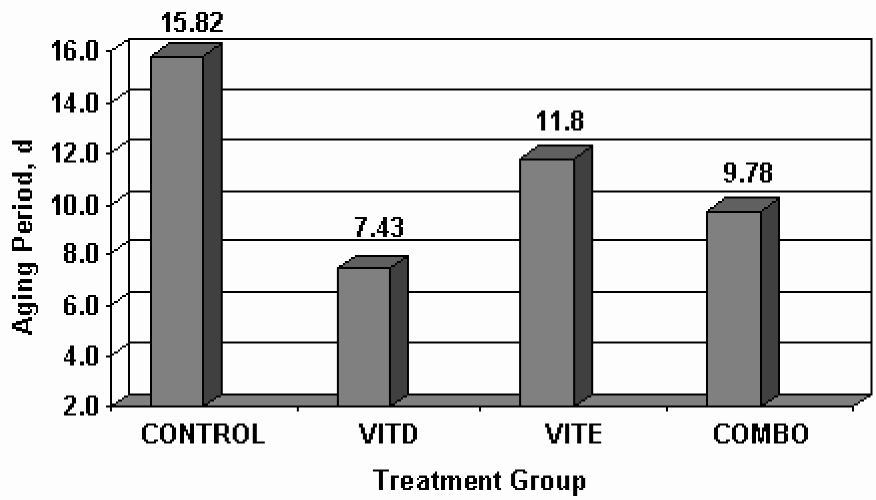

Figure 2. **Aging days required for steaks to become "very tender" (less than or equal to 8.5 lb shear force).**

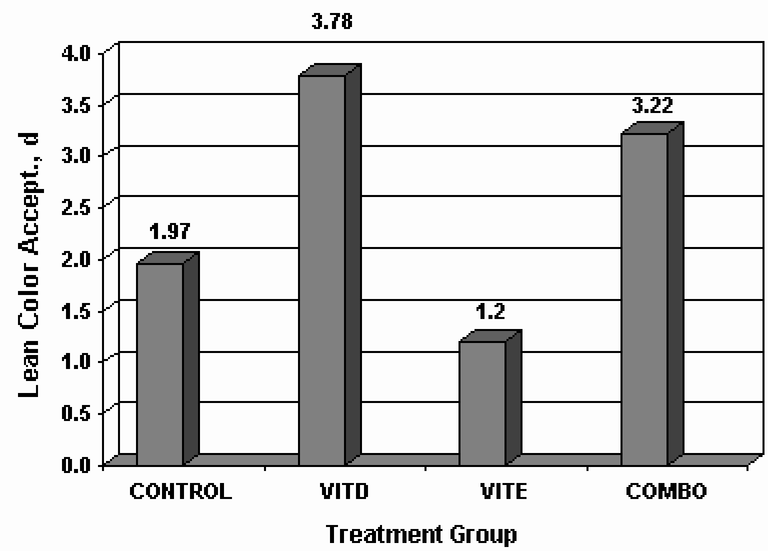

Figure 3. **Days of lean color acceptability in retail case stratified by vitamin treatment.**