Bioavailability of Vitamin A (Retinol) Sources for Cattle

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Vitamin A destruction occurs in the rumen with retinol losses up to 80%. For the sources of vitamin A studied Microvit A and Rovamix A appear to be more available to cattle.

Summary

An experiment was conducted to evaluate bioavailability of five sources of vitamin A (retinol). Fifty-three yearling Angus × Brahman cattle, consisting of 39 steers and 14 heifers, were stratified by BW and gender and randomly assigned to six high concentrate diet groups receiving either no vitamin A supplementation (control), or vitamin A supplemented from the following sources: Microvit A (ADISSEO, Acworth, GA), Rovamix A (DSM, Parsippany, NJ), Sunvit A, Lutavit A, and Microvit A DLC (ADISSEO). Vitamin A treatment groups were fed daily 80,000 IU retinol/animal in a low retinol concentrate diet (78.5% oats, 10% cottonseed hulls, 8% molasses, and 2% cottonseed meal) for 84 d. Every 28 d body weight was determined and liver biopsies and plasma were collected and analyzed for retinol concentrations. All retinol treatments showed significant increases in liver retinol concentrations compared to control animals (P < 0.0001), which steadily decreased over time. At all collection times, Microvit A led to numerically greater concentrations of retinol in liver than did all other treatments. However, at experiment termination, there was no significant difference in liver retinol concentration among Microvit A, Rovamix A, Lutavit A, and Microvit A DLC diets. When liver retinol concentrations at all collection times were considered, Microvit A and Rovamix A appeared to provide the most bioavailable vitamin A.

Introduction

Vitamin A generally is supplemented to ruminant diets to insure maximum health and productivity. Unfortunately, considerable supplemental retinol is destroyed by ruminal microbes. The amount of concentrate in a diet is one factor associated with ruminal destruction. Rode et al. (1990) reported an 80% loss of vitamin A when cattle were fed 70% concentrate diets, but, when fed high-forage diets, losses were only 20%. There is a need for minimizing ruminal destruction to increase the amount of vitamin A that reaches the duodenum. In order to protect vitamin A from pre-intestinal destruction, gelatin beadlets have been developed commercially that contain not only vitamin A but also carbohydrates and antioxidants to stabilize the vitamin A. The objective of this study was to compare the bioavailability of five different forms of supplemental vitamin A fed to beef cattle.

Procedure

Fifty-three yearling Angus × Brahman cattle, consisting of 39 steers and 14 heifers, that

weighed 750.2 ± 44 lbs, were stratified by gender and BW and assigned randomly to one of seven pens and one of eight Calan gates (American Calan, Northwood, NH) within pens at the University of Florida Beef Research Unit in August of 2002. High concentrate dietary treatments included 78.5% oats, 10% cottonseed hulls, 8% molasses, and 2% cottonseed meal. Experimental treatments were control (no supplemental vitamin A), Microvit A (ADISSEO, Acworth, GA), Rovamix A (DSM, Parsippany, NJ), Sunvit A, Lutavit A, and Microvit A DLC (ADISSEO) fed daily at 80,000 IU/animal. Vitamin A pre-mixes were formulated and mixed every two wk. Feed intake gradually increased, therefore vitamin A additions changed so that cattle always received 80,000 IU/d. A total of nine cattle were used per treatment except for eight in the control group. In each pen, poor quality Bermuda grass hay (low vitamin A content, 0.71 µg of β-carotene/g) and water were supplied for ad libitum consumption.

On d 0, 28, 56, and 84, all animals were restrained and weighed, and liver biopsy and blood samples were collected. Vitamin A was analyzed by a standardized HPLC system. The experiment was a completely random design. All data were analyzed using the Mixed Procedure of SAS (SAS for Windows 8e; SAS Institute, Inc., Cary, NC) for repeated measures. The model included terms for a covariate (value from d 0), treatment, time, and treatment × time.

Results

Body weights increased with time ($P < 0.0001$), but there were no effects of treatment ($P = 0.86$) or of treatment x time ($P = 0.31$) detected. As there were no differences among treatments, control cattle with minimal dietary vitamin A were able to rely on storage reserves of retinol for body growth.

Retinol concentrations in plasma (Table 1) were affected by treatment ($P = 0.01$) and time ($P = 0.04$). There were no interactions between treatment and time ($P = 0.96$). Using d 0 values as the covariate, both Microvit A and Rovamix A increased ($P < 0.05$) plasma retinol (d 84 and overall) compared to control and also compared to the Sunvit A treatment groups ($P < 0.05$). On d 84, both Lutavit A and Microvit A DLC were intermediate and did not differ from control; Lutavit A also did not differ from Microvit A or Rovamix A, and Microvit A DLC did not differ from Microvit A. Similar trends at d 28 and d 56 were evident.

Retinol concentrations in liver (Table 2) were affected by treatment ($P < 0.01$) and a treatment x time interaction was detected ($P < 0.0001$); retinol-supplemented cattle had greater ($P < 0.05$) and more sustained concentrations of liver retinol compared to a steady decline for the control group through d 84 (Table 2). Overall Microvit A had the numerically highest concentration of liver retinol, but it did not differ statistically from Rovamix A and Lutavit A. However, averaged over all sampling times, Microvit A led to greater liver retinol ($P < 0.05$) than did Sunvit A ($P < 0.05$) and Microvit A DLC ($P < 0.05$). Control animals clearly had decreased retinol concentrations in liver compared to all vitamin A dietary supplements.

According to previous studies (Hammell et al., 2000; McDowell, 2000), plasma retinol concentration is a less reliable indicator of vitamin A status than is liver retinol concentration. Unless there is a severe deficiency, the liver maintains relatively normal plasma retinol concentrations. Our study demonstrated large differences due to vitamin A supplementation between treatments and control in liver retinol concentrations, but only subtle differences in plasma retinol. The liver is the site for greatest storage of retinol and is the best indicator of vitamin A status (McDowell, 2000).

Increasing the amount of vitamin A reaching the duodenum increases the availability for absorption and storage as is illustrated by elevated liver retinol concentrations (Table 2). Vitamin A availability is limited in ruminants due to losses by ruminal destruction. Ruminal destruction is especially high when ruminants are fed high concentrate diets. Rode et al. (1990) reported that in vitro ruminal microbial degradation of vitamin A was 80% when the diet

contained 70% concentrate, whereas diets high in forage only resulted in a 20% destruction of vitamin A in vitro.

It was hypothesized that some vitamin A supplements with protective coatings are more resistant to rumen destruction or have improved duodenal availability and that these would result in greater liver concentrations of retinol. If these coatings were resistant to intestinal digestion, then supplemented vitamin A could pass the duodenum, the site of vitamin A absorption, and therefore be excreted. Certain products, like Microvit A and Rovamix A, appear to have better resistance to ruminal destruction or improved duodenal availability than other products tested in this experiment.

Literature Cited

Hammell et al. 2002. J. Dairy Sci. 22:1256.
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Table 1. Effect of vitamin A sources on plasma retinol concentrations of cattle

Item	Control	Microvit A	Rovamix A	Sunvit A	Lutavit A	Microvit A DLC	SEM[1]
n	8	9	9	9	9	9	
			Pretrial plasma retinol, µg/mL				
Day 0	0.329	0.365	0.333	0.310	0.297	0.329	0.021[2]
			Covariate adjusted plasma retinol, µg/mL				
Day 28	0.331^{ab}	0.389^{a}	0.381^{ab}	0.321^{b}	0.350^{ab}	0.335^{ab}	
Day 56	0.312^{ab}	0.350^{a}	0.365^{a}	0.281^{b}	0.339^{ab}	0.345^{a}	0.010[3]
Day 84	0.284^{c}	0.357^{ab}	0.369^{a}	0.286^{c}	0.324^{abc}	0.305^{bc}	
Overall mean	0.308^{b}	0.366^{a}	0.372^{a}	0.296^{b}	0.337^{ab}	0.328^{ab}	0.017[4]

[a-c] Treatments within the same row not bearing a common superscript differ ($P \leq 0.05$)

[1]Standard errors of the means (SEM) were the largest among treatments (i.e., for control).

[2]SEM for d 0.

[3]SEM for covariate adjusted day means.

[4]SEM for covariate adjusted overall means.

Table 2. Effect of vitamin A sources on liver retinol concentrations of cattle

Item	Control	Microvit A	Rovamix A	Sunvit A	Lutavit A	Microvit A DLC	SEM[1]
n	8	9	9	9	9	9	
			Pretrial liver retinol, µg/g of wet liver				
Day 0	158	160	146	131	158	151	27[2]
			Covariate adjusted liver retinol, µg/g of wet liver				
Day 28	121^{c}	183^{a}	153^{ab}	141^{bc}	161^{ab}	158^{ab}	
Day 56	90^{c}	178^{a}	163^{ab}	153^{ab}	151^{ab}	135^{b}	5[3]
Day 84	70^{c}	187^{a}	183^{a}	143^{b}	168^{ab}	156^{ab}	
Overall mean	94^{c}	183^{a}	166^{ab}	145^{b}	160^{ab}	150^{b}	10[4]

[a-c] Treatments within the same row not bearing a common superscript differ ($P \leq 0.05$)

[1] SEM were the largest among treatments (i.e., for control).

[2] SEM for d 0.

[3] SEM for covariate adjusted day means.

[4] SEM for covariate adjusted overall means.