

Vitamin A in Cow-Calf Production

Impacts of Maternal Supplementation and Status on Offspring

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Summary with Implications

The young calf is at greatest risk of vitamin A deficiency when cow vitamin intake is low in late pregnancy. Two studies were conducted to evaluate the relationship between cow and calf vitamin A status and how vitamin A status of cow-calf pairs was influenced by maternal vitamin A supplementation. In general, calves did not have adequate liver vitamin A concentrations despite cows having adequate liver vitamin A stores following calving. Both cow liver stores and cow vitamin A intake during late gestation influence the amount of vitamin A in colostrum, so it benefits the calf if the cow has both adequate liver vitamin A stores and receives adequate supplemental vitamin A in late gestation. Current supplemental vitamin A recommendations provided to cows fed stored feeds for a year or more do not result in adequate beef cow or calf liver vitamin A concentrations. USDA is an equal opportunity employer and provider.

Introduction

Vitamin A has several important roles in the body. It is well-known for its role in vision, but it is also important for proper immune function and epithelial integrity, specifically in the gastrointestinal and respiratory tracts. Clinical deficiency is unlikely to occur in most cases, but marginal deficiencies can still impact calf health and potentially cow productivity. Calves are born with very low vitamin A stores, and their primary source of vitamin A is colostrum. Vitamin A concentrations in colostrum have been reported to be six

to fourteen times greater than that of milk, so colostrum is critical for establishing vitamin A stores in the young calf. Calves not getting enough vitamin A from colostrum are at increased risk for diarrhea and respiratory disease in their first one to two weeks of life.

Fresh green forage contains high amounts of beta carotene, a vitamin A precursor. It is used by the cow to synthesize the vitamin A needed to support a variety of biological functions. Excess vitamin A can be stored in the liver and used during times when dietary vitamin A intake is low. Cows fed diets consisting primarily of stored forages and concentrates may be at risk for vitamin A deficiency because these feedstuffs are low in beta carotene. Low amounts of vitamin A in the cow's diet during late gestation which may lead to a deficiency in the calf and impact its health. There is minimal placental transfer of vitamin A, so calves at birth rely on colostrum to supply vitamin A. The objectives of these studies were to identify the relationship between cow and calf vitamin A status using plasma and liver samples, and to understand the effect of amount of supplemental vitamin A provided from mid-gestation to early lactation on liver vitamin A concentrations in the cow and her calf.

Procedure

Experiment 1

The study was conducted at the U.S. Meat Animal Research Center near Clay Center, Nebraska. Multiparous beef cows that had previously been grazing on pasture (6.4 ± 1.2 years of age; $n = 120$) in mid-gestation were assigned to receive 9,638 IU/d vitamin A ($n = 30$) or 24,973 IU/d vitamin A ($n = 90$). These amounts were approximately one-third and two-thirds of the current recommendation of 1,273 IU/lb DM (33,000 IU/d in this study) for gestating beef cows weighing 1,300 lb consuming 2.0% of body weight in DM per day. Cows were individually supplemented

in Calan gates from 111 days pre-calving to 32 days post-calving. Their diet consisted of alfalfa hay, corn silage, and a pellet that contained supplemental vitamin A, which was provided as retinyl acetate. Basal diet vitamin A concentration was calculated to be 223 IU/lb DM based on its beta carotene content, so mean vitamin A intake from the basal diet was $4,583 \pm 649$ IU/d. For assessing vitamin A status, liver biopsies and blood samples were collected at day 0 (111 days pre-calving) and day 144 (32 days post-calving), and calves were sampled at 32 ± 7 days of age. Vitamin A concentrations, measured as retinol, were analyzed in plasma and liver, and Pearson correlations were used to test for linear relationships between cow liver and plasma retinol concentrations, calf liver and plasma retinol concentrations, and liver retinol concentrations between the cow and her calf.

Experiment 2

This study took place at the Panhandle Research and Extension Center in Scottsbluff, Nebraska. Multiparous beef cows ($n = 54$) that had been fed in the drylot for a year or more were stratified by body condition score and time in the drylot and assigned to a pen. Pens ($n = 9$) were then randomly assigned to receive 1 of 3 amounts of supplemental vitamin A: the current recommendation for gestating beef cows (31,000 IU/d; 1X), 3 times (93,000 IU/d; 3X), or 5 times the current recommendation (155,000 IU/d; 5X). The 1X treatment was set in this study assuming a cow weight of 1,200 lb that consumed 2.0% of body weight in DM per day. Prior to treatment initiation, all cows were receiving 31,000 IU/d (1X). Treatments were initiated in mid-gestation and concluded 32 days post-calving. Cows were limit-fed a diet consisting of wheat straw, corn silage, and wet distillers grains. Vitamin A, as retinyl acetate, was added to the diet via a micro-nutrient machine. Liver biopsies were collected for retinol analysis on cows 24 days before treatment initiation, d 40 and d 81 of

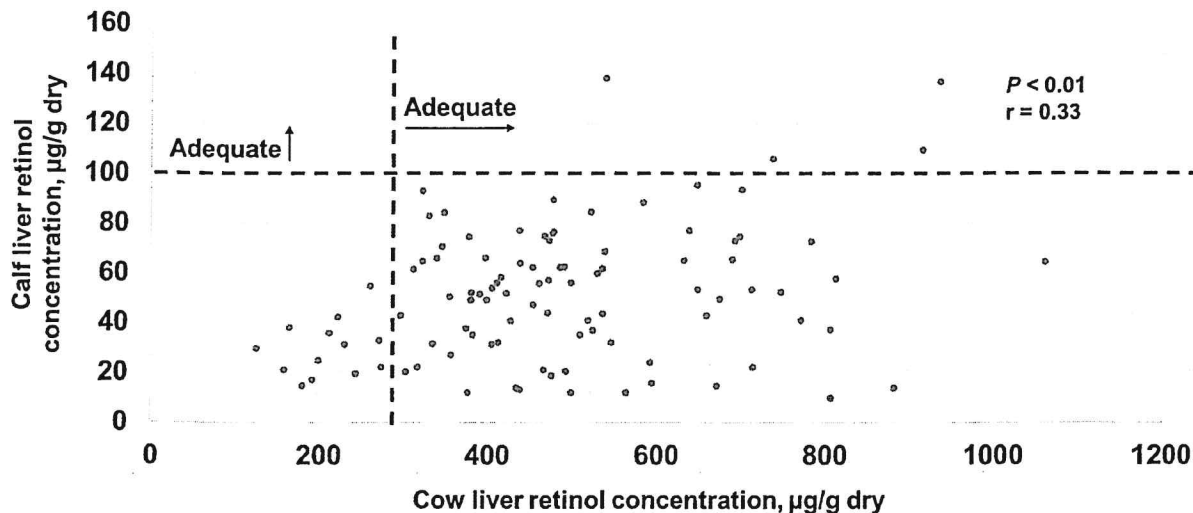


Fig. 1. Relationship between cow and calf liver retinol concentrations measured 32 days post-calving from Experiment 1. Dashed lines indicate the liver retinol concentration considered adequate for cows (300 µg/g DM) and calves at 32 days of age (100 µg/g DM).

supplementation, and both cows and calves were sampled 32 d post-calving (mean 165, SD 22 d of supplementation).

Results

Experiment 1

Because cows had recently spent time on green grass, initial liver retinol concentrations (mean 830 µg/g DM) of cows were well above adequate. By 32 days post-calving, mean cow liver retinol concentration (482, SD 182 µg/g DM) had decreased but was still considered adequate based on the current reference range of 300–700 µg/g DM. Cow plasma retinol (mean 272, SD 40 ng/mL) was slightly below the reference range of 300–800 ng/mL. No linear relationship ($P = 0.10$; $r = 0.16$) was observed between liver and plasma retinol in cows, which is not surprising because plasma retinol concentrations are tightly regulated and will not fluctuate unless liver vitamin A concentrations are very low. A positive correlation ($P < 0.01$; $r = 0.37$) was detected between calf liver (mean 51, SD 27 µg/g DM) and plasma (mean 190, SD 47 ng/mL) retinol concentrations. Both were below what would be considered adequate (100–350 µg/g DM in liver; 225–325 ng/mL in plasma) for calves at 32 days of age. It is suspected a correlation was observed here because most calves had liver retinol concentrations less than 100 µg/g DM (Fig. 1), which may have been too low to allow the

calves to maintain adequate plasma retinol concentrations.

There was a positive correlation ($P < 0.01$; $r = 0.31$) between cow and calf liver retinol 32 days post-calving (Fig. 1), suggesting that as cow retinol liver concentrations increased, calf liver retinol concentrations increased. However, it appears that despite cows having adequate liver retinol concentrations, when supplemental vitamin A was fed below current recommendations, it did not result in calf liver retinol stores considered adequate given current reference ranges. This is likely because cow liver retinol stores are not the only contributor to vitamin A in colostrum. Research in beef cattle indicates cow stores only contribute about 40% of the vitamin A found in colostrum, while the other 60% comes from the cow's diet. Therefore, dietary vitamin A the cow receives during late gestation, as well as her liver vitamin A stores, affect the amount of vitamin A her calf receives via colostrum to build its own liver vitamin A stores.

Experiment 2

No differences ($P = 0.86$) in initial cow liver retinol concentration (mean 186 µg/g DM; Fig. 2) were observed between treatments. Cows were receiving the 1X amount of supplemental vitamin A before the study, suggesting the current supplemental vitamin A recommendation of 31,000 IU/d was not enough to get cows to adequate liver retinol concentrations (300–700 µg/g DM).

A significant treatment × day interaction ($P < 0.01$) was observed for cow liver retinol. On d 40, cows in 1X had liver retinol concentrations (178 µg/g DM) that were not different ($P = 0.12$) from 3X (213 µg/g DM) but less ($P = 0.02$) than 5X (241 µg/g DM), while 3X and 5X did not differ ($P = 0.21$). Liver retinol on d 81 was lower ($P < 0.05$) in 1X (189 µg/g DM) compared to 3X (334 µg/g DM) and 5X (412 µg/g DM), which did not differ ($P = 0.20$). For cow liver retinol 32 days post-calving, 1X (187 µg/g DM) was less ($P < 0.05$) than 3X and 5X, and 3X (454 µg/g DM) was less ($P < 0.05$) than 5X (674 µg/g DM). Liver retinol concentrations of 1X cows remained below adequate reference ranges (300–700 µg/g of DM) throughout the study, whereas 3X and 5X were elevated into the adequate range by d 81 of supplementation.

Calf liver retinol concentration also differed among treatments ($P = 0.01$; Fig. 3), as calves of cows in 1X had lower ($P < 0.05$) liver concentrations than 3X and 5X calves which did not differ ($P = 0.12$). Liver retinol concentrations considered adequate for calves at 32 days of age (100–350 µg/g of DM) were not observed in 1X calves (51 µg/g DM) but were observed in calves from 3X and 5X cows (119 and 165 µg/g DM, respectively).

Conclusion

A cow with adequate liver vitamin A stores at the time of calving does not ensure

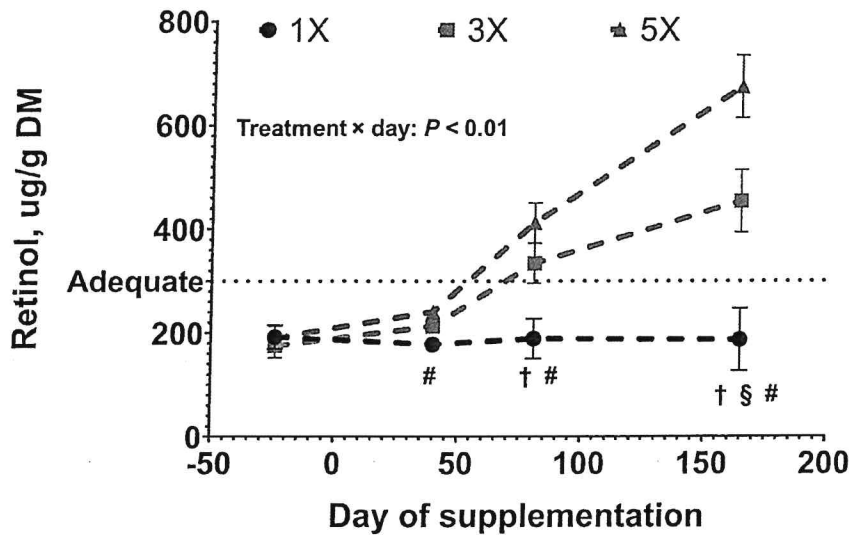


Fig. 2. Effect of amount of supplemental vitamin A [1X = 31,000 IU/d (current recommendation), 3X = 93,000 IU/d, and 5X = 155,000 IU/d] on cow liver retinol concentrations throughout Experiment 2. Initial liver concentrations were measured 24 days prior to treatment initiation (average 149 days before calving), and Day 165 concentrations were measured 32 days post-calving. Supplementation began on Day 0. Dashed line indicates the liver retinol concentration considered adequate for cows (300 µg/g DM). Significant differences ($P \leq 0.05$) between treatments within time point denoted as follows: † (1X vs. 3X) § (3X vs. 5X) # (1X vs. 5X)

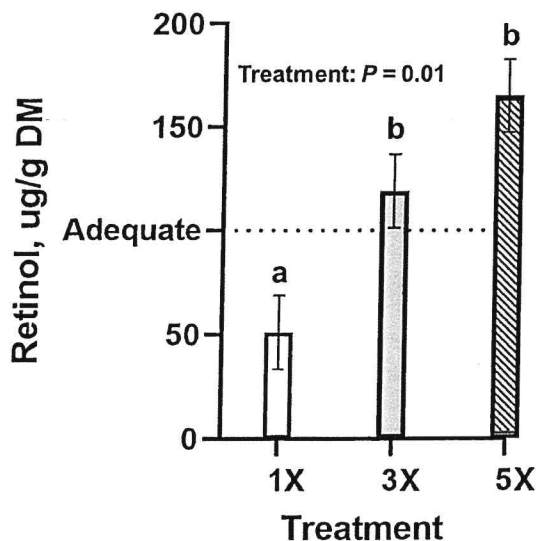


Fig. 3. Effect of cow supplemental vitamin A amount [1X = 31,000 IU/d (current recommendation); 3X = 93,000 IU/d; 5X = 155,000 IU/d] on calf liver retinol concentration at 32 days of age in Experiment 2. Dashed line indicates the liver retinol concentration considered adequate for calves at 32 days of age (100 µg/g DM). ^{a,b} Means lacking a common superscript differ ($P \leq 0.05$).

that the calf will also have adequate liver vitamin A stores. These results suggest that for cows fed stored feeds long term (1 year or longer), the current recommendation for supplemental vitamin A will not result in their calf's liver vitamin A concentrations being within the adequate reference range. These data also suggest that cows with initially low liver retinol stores needed to be fed 93,000 IU/d (3 times the current recommendation) of vitamin A for 81 days to achieve adequate liver retinol concentrations. However, continuing to feed this amount did appear to result in continuously increasing liver stores. More research is needed to understand the quantity of supplemental vitamin A required to maintain cow liver retinol concentrations in the adequate range and ensure adequate concentrations in the colostrum for the calf.

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