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Supplemental levels of vitamins A, E in milk replacers suggested

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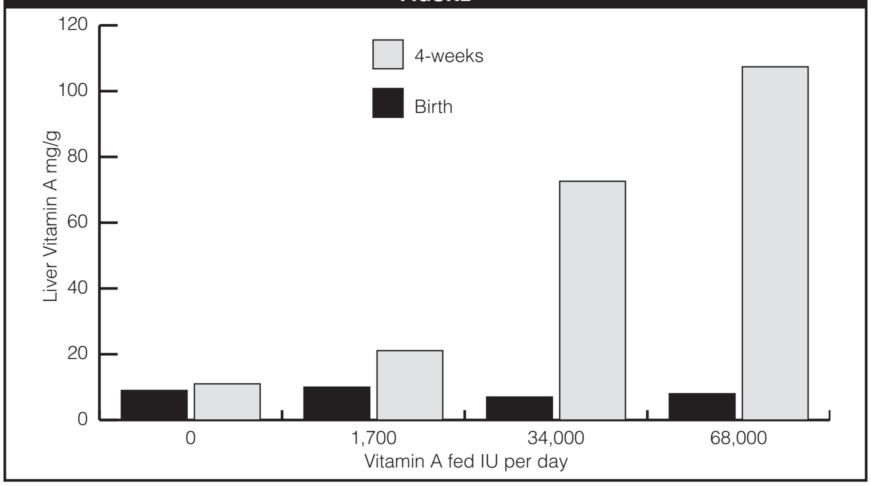
Vitamin A levels in the liver of calves at birth are low because there is little transfer of vitamin A across the placenta of the dam. This may be a protective mechanism to prevent teratogenic effects when dams have been fed high levels of vitamin A (Hammel et al., 2000). This background led these authors to study responses by liver bioassay, plasma concentrations and relative dose response (RDR).

RDR was done by fasting calves at least eight hours, taking a baseline plasma sample and then taking plasma samples at four, six and eight hours after an oral dose of vitamin A. At South Dakota State University, 56 male calves from two commercial dairies were housed in individual outdoor hutches. Pooled colostrum was fed to each calf with periodic sampling for vitamin A content to ensure that levels were consistent throughout the study. Calves were then fed a 20% protein and 20% fat milk replacer without any vitamin A supplementation so that vitamin A levels could be added separately to the milk replacer when fed according to protocol. Amount of liquid milk replacer fed was adjusted weekly to 10% of bodyweight. Fresh water was offered daily, but calf starter was not fed.

Concentrations of vitamin A in the liver at birth were similar but did not increase by four weeks for calves with 0 or 1,700 international units (IU) per day supplementation (Figure 1, p. 18).

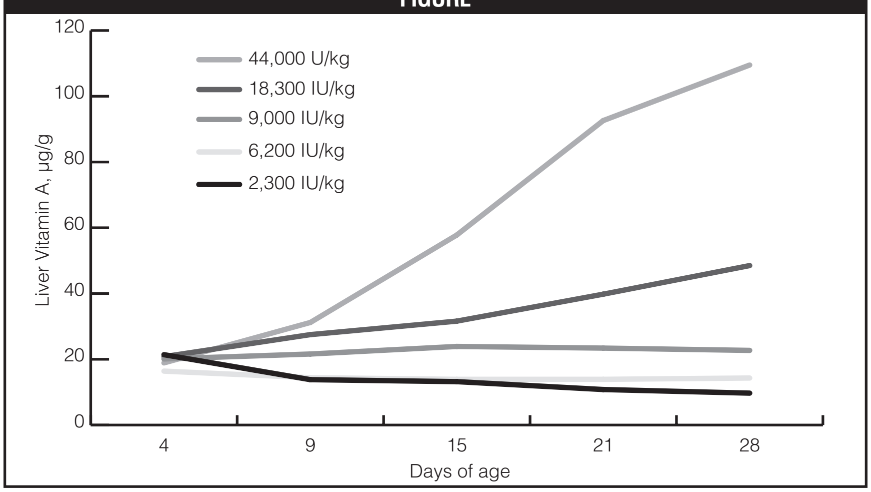
In contrast, vitamin A levels in liver samples from calves supplemented with 34,000 and 68,000 IU per day were much greater ($P = 0.0001$) than mean concentrations of vitamin A in liver samples at birth. Mean RDR at 20 hours after colostrum feeding, which was also eight hours after initiation of vitamin A supplementation, increased ($P < 0.05$) with increasing levels of vitamin A at 6.8, 23.0, 44.3 and 72.6% for the 0, 1,700, 34,000 and 68,000 IU per day treatments, respectively. By four weeks, mean RDR were positive for the 0 and 1,700 IU vitamin A per day treatments but negative for the 34,000 and 68,000 IU treatments, reflecting their positive vitamin A status.

FIGURE



1. Liver vitamin A concentration (South Dakota study).

FIGURE



2. Liver vitamin A concentrations (Illinois study).

However, values obtained with individual calves did not always indicate vitamin A status accurately or reflect the group average. Retinol concentrations in plasma were all less than 20 µg/dl at four weeks. In fact, mean concentrations of retinol in plasma were less than 15 µg/dl for all treatments, indicating that the 20 µg/dl threshold considered normal in older cattle is not appropriate for young calves.

A study at the University of Illinois (Swanson et al., 2000) followed a similar protocol to the above study except for its use of non-pooled colostrum for the first two feedings followed by a milk replacer with 9,000 IU vitamin A/kg of dry matter (DM) for days 2 and 3. For days 4-28, milk replacer (22% protein and 20% fat) was constituted with water to contain 12.5% DM with either 2,300, 6,200, 9,000, 18,300 or 44,000 IU vitamin A/kg of DM. This was fed at 5% of bodyweight twice daily for the first week and then increased to 6% for the duration of the study. Fresh water was available, but no starter was fed.

Liver vitamin A concentrations are shown in Figure 2.

Liver vitamin A concentrations actually decreased over time for diets containing 2,300 and 6,200 IU vitamin A/kg, were maintained for the diet with 9,000 IU and increased for both 18,300 and 44,000 IU diets. Liver vitamin A means across time were the same for the 2,300 and 6,200 IU diets and were exceeded ($P < 0.05$) by the other vitamin A treatments, which also differed ($P < 0.05$) among themselves.

Mean serum retinol concentrations across sampling times were higher ($P < 0.05$) for calves fed 44,000 IU vitamin A/kg than for calves fed the other vitamin A concentrations and higher ($P < 0.05$) for calves fed 9,000 or 18,300 IU vitamin A/kg than for those fed 2,300 or 6,200 IU/kg. Means of 8.0-10.8 µg/dl also reflect even lower levels than in the South Dakota study and are well below the 20 µg/dl threshold.

The fact that calves fed the 9,000 IU diet did not have increased vitamin A liver concentrations indicated that the 1989 National Research Council (NRC) recommendation of 3,800 IU/kg (or 1,700 IU/lb.) was too low, while the 2001 NRC recommends 9,000 IU/kg (4,100 IU/lb.) plus 4,000 IU/kg (1,800 IU/lb.) in starter and grower diets, respectively.

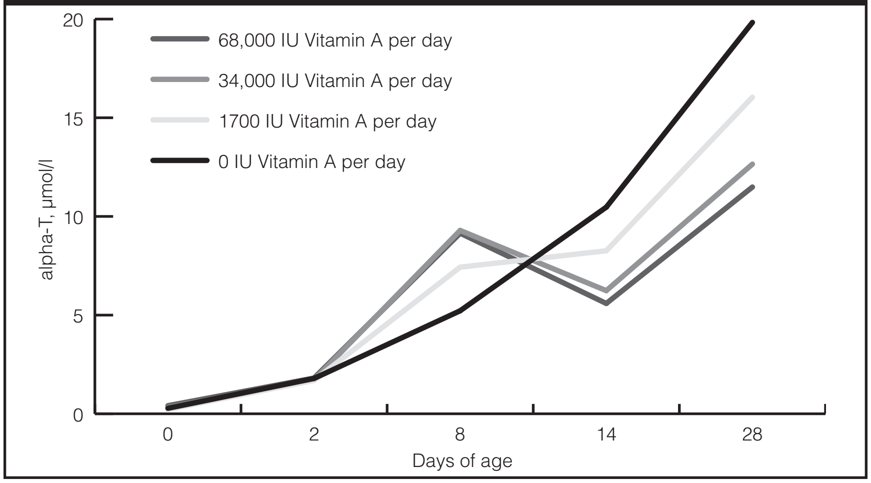
However, the authors of the Illinois study acknowledged that under less desirable environmental conditions, they would recommend adjusting levels of vitamin A to 11,000 IU/kg DM (5,000 IU/lb.). They also indicated that serum alpha-tocopherol concentration, health and growth were not affected by feeding the 44,000 IU/kg DM level in milk replacer diets for up to four weeks.

In the Illinois study, the vitamin E level was 220 IU/kg DM in the milk replacer. A multi-institutional 4 x 2 study (Ametaj et al., 2000) done at South Dakota State University evaluated four levels of vitamin A (0, 1,700, 34,000 and 68,000 IU per day) with 100 IU vitamin E per day as either the esterified form (RRR-alpha-tocopheryl acetate), which is more stable and less costly, or RRR-alpha-tocopherol. The protocol was similar to the other South Dakota study (Hammell et al.), including dietary levels of vitamin A.

Plasma retinal levels increased with increasing dietary vitamin A levels similar to the study of Hammell et al. Plasma RRR-alpha-tocopherol levels with vitamin A dietary levels are shown in Figure 3.

Alpha-tocopherol levels were not different at birth and increased ($P < 0.001$) with age. However, by 28 days of age, calves fed the two highest levels of vitamin A had the lowest levels ($P < 0.01$ and 0.0001) of alpha-tocopherol. The other isomer, RRR-gamma-tocopherol, did not differ in plasma at 28 days of age. The authors cited previous studies that have also shown that high levels of vitamin A have reduced plasma RRR-alpha-tocopherol concentrations.

FIGURE



3. Plasma RRR-alpha-tocopherol levels.

Figure 3 suggests that after 14 days of age, some unknown mechanism suppresses circulating levels of vitamin E in neonatal calves. However, the authors also noted that these plasma levels were still within normal limits (>4.64 µmol per liter) for 28-day-old dairy calves, and these calves did not exhibit symptoms of vitamin E deficiency.

They also noted that it is conceivable that feeding 20- to 40-fold of the 1989 NRC requirement of vitamin A with the 1989 NRC requirement of vitamin E to neonatal calves for longer periods could deplete body stores of vitamin E and ultimately produce symptoms of vitamin E deficiency.

Discussion

There are several major factors in trying to amalgamate these three studies. First, there were different levels of vitamin E fed with different levels of vitamin A. In Hammell et al., no supplemental vitamin E was fed, so the only sources of vitamin E would have been from the initial feeding of colostrum at 5% of bodyweight and from that naturally occurring in the milk replacer ingredients.

The daily levels of supplemental vitamin A fed were the same in this study and in Ametaj et al., namely 0, 1,700, 34,000 and 68,000 IU with daily supplemental vitamin E of 100 IU in the latter study.

In Swanson et al., daily intakes of supplemental vitamin A over the last three weeks averaged 1,733, 4,650, 6,602, 13,725 and 33,814 IU with daily supplemental vitamin E of 165 IU. The required vitamin E was increased from 40 IU/kg DM in the 1989 NRC to 50 IU/kg DM in the 2001 NRC.

Since the amount of milk replacer DM fed daily in these studies over the last three weeks was estimated to be 0.6-0.75 kg, this equates to a daily vitamin E requirement of 24-30 IU, based on the 1989 NRC, and 30.0-37.5 IU, based on the 2001 NRC.

Similarly, daily supplemental vitamin A would need to be 5,400-6,750 IU to meet the 2001 NRC requirements. The highest level of vitamin A fed in the study of Swanson et al. was equal to about one-half the highest level in the other two studies, and the vitamin E level fed was about 65% greater than in the study of Ametaj et al.

Other factors could include the level of vitamin E in colostrum as the levels of vitamin E fed to dry cows has greatly increased. Additionally, because of the nature of these studies, no starter was fed making these atypical diets.

The Bottom Line

It appears best to keep daily supplemental intakes of vitamin A from milk replacers within the range of 4,000 to less than 30,000 IU when a pound of dry milk replacer is being fed in liquid form if the daily supplemental vitamin E intake from milk replacer is within a minimum range of 23-100 IU.

Perhaps higher levels of vitamin A could be fed if the levels of vitamin E were also elevated, but what are the prospects that this scenario would be advantageous?

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