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Calf Note #242 – Vitamin C in calf diets

Introduction

Publication of the 8th Edition of The Nutrient Requirements of Dairy Cattle by the National Academies of Science, Engineering, and Medicine (NASEM, 2021) represented a major advance in our understanding of nutrient requirements and nutrient supply in young calves. Over 20 years of research was interpreted and incorporated into these new recommendations. In addition to new models for energy and protein requirements, the NASEM Committee reviewed requirements for vitamins and minerals for young calves. The topic of this Calf Note is the recommendation (or lack thereof) of vitamin C for young calves. Let's begin by reviewing some research published regarding feeding of vitamin C.

Vitamin C and Immune Response

Vitamin C (ascorbic acid) is a water-soluble vitamin that plays important roles in the body, but perhaps none as important as serving as an antioxidant to protect cells against oxidative damage. There are hundreds of substances that act as antioxidants in the body. The most familiar ones are vitamin C, vitamin E, β-carotene, and other related carotenoids, along with the minerals selenium and manganese. They're joined by glutathione, coenzyme Q10, lipoic acid, flavonoids, phenols, polyphenols, phytoestrogens, and many more. Most are naturally occurring, and their presence in food is likely to prevent oxidation or to serve as a natural defense against the local environment (Harvard University, Nutrition Source).

Vitamin C is synthesized from either D-glucose or D-galactose through glucuronic acid pathway in the liver. L-Ascorbic acid present in cattle diet is destroyed by rumen microorganisms, making them dependent on endogenous synthesis. We assume that endogenous synthesis is sufficient to meet the physiological requirement.

The role of vitamin C in calf performance and health has been studied for many years. For example, Lundquist and Phillips in 1943 reported that plasma concentration of vitamin C in the newborn calf is about 2X normal concentrations but declines with time after birth (Figure 1). Concentrations decline after birth and vitamin C synthesis in the calf begins at about 2 or 3 weeks (Lundquist and Phillips, 1943).

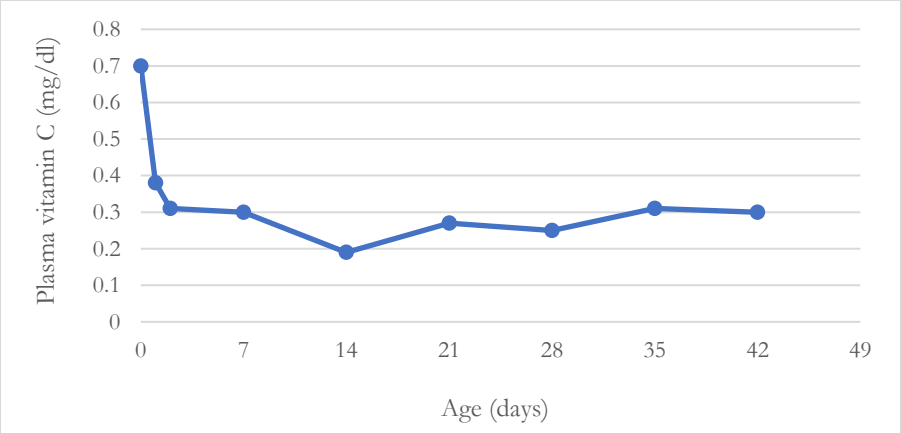

Figure 1. Concentrations of vitamin C in newborn calves. From Lundquist and Phillips 1943.

Matsui (2012) summarized existing literature regarding vitamin C in young calves to approximately 30 d of age and concluded that supplementary vitamin C generally improves resistance to disease and suggested that vitamin C is conditionally essential, particularly during periods of stress. Vitamin C concentration is approximately two-fold higher in colostrum than milk and calves fed colostrum typically have higher circulating vitamin C concentrations, though these concentrations decline rapidly after birth to approximately 21 d of age (Lundquist and Phillips, 1943; Hidiroglou et al., 1995).

Vitamin C supplementation has been reported to prevent diarrhea in calves (Cummins and Brunner, 1989; Seifi et al.,1996; Sahinduran and Albay, 2004) or improve indices of disease such as ocular and nasal discharges of sick calves (Eicher-Pruitt et al., 1992). However, neither 2001 NRC nor 2021 NASEM recommended routine supplementation of vitamin C in calf diets. Because vitamin C has – at least in many cases – been shown to support immune status in calves, particularly prior to 3 weeks of age, its use in CMR intended for stressed calves or in supplements to support immune health early in life is recommended. Inclusion rates evaluated in published research were: 1,000 mg 3x/d for the first week; 1,000 mg 2x/d for the second week; and 1,000 mg 1x/d for the third week after birth (Seifi et al., 1996) and 1,000 mg 3x/d during the first week; 500 mg 3x/d during the second week; and 250mg 3x/d during the third week (Sahinduran and Albay, 2004). Hemingway (1991) reported successful treatment of neonatal diarrhea in calves treated with ascorbic acid as reported by Seifi et al. (1996) except that 1,000 mg fed 1x/d was continued until animals were observed to be ruminating.

Research that supplemented vitamin C generally supplemented 3,000 mg/d during week 1; 1,500 to 2,000 mg/d during week 2; and 750 to 1,000 mg/d during week 3. Eicher-Pruiett added 10 g of vitamin C/kg of CMR and fed the CMR (13.5% DM) at a rate of 10% of BW. Intake of vitamin C in this study exceeded 6 g/d, which may be excessive. Supplementation at a rate of 1-2 grams per day seems appropriate for inclusion in CMR or in a milk supplement.

Summary

Vitamin C is a nutrient important to neonatal immune response and maintaining calf health. While the 2021 NASEM publication did not recommend vitamin C in milk replacer diets, I believe that vitamin C should be supplemented in milk and CMR to provide 1 to 2 grams per day. The potential benefit to improved health is significant and the cost of supplementation is generally low. Supplementation in calf starters is unnecessary, as rumen bacteria are efficient in degrading vitamin C.

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