

Nutritional Influences on Immunity

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There are a tremendous number of interactions between nutrition and immune function. These interactions range from detrimental effects of protein-energy malnutrition on the entire immune system to the effects deficiencies in micronutrients have on certain aspects of the immune system. The impact prepartum nutrition of beef cows has on the health and growth of beef calves were reviewed and presented in the Proceedings of the 16th Kentucky Ruminant Nutrition Workshop (1997) by Dr. John Johns. The review dealt mainly with decreased survivability and performance of calves born to cows that were thin (BCS < 5) as a result of low energy intake. Cows that have low energy intake also likely will have low intake of other important nutrients such as selenium, copper, zinc, and vitamins A and E. Deficiencies of these nutrients may decrease immune function of animals at all stages of life. This review will briefly address interactions between selected nutrients and immune function in cows and calves at parturition, during milk feeding for dairy calves, and at weaning for beef calves.

Nutrition and Immune Function in the Periparturient Period

Dairy cows and mastitis. The importance of selenium and vitamin E for prevention of mastitis in dairy cows has been reviewed extensively. Researchers at The Ohio State University have established that supplementing vitamin E and selenium to dairy cows and heifers can decrease the incidence of mastitis by greater than 50% compared to unsupplemented control diets.

Smith and others established in 1984 that cows supplemented with vitamin E at 740 mg/d during the dry period had a 37% lower incidence of mastitis after calving than control cows. Additionally, an injection of selenium (0.1 mg/kg BW) at 21 days before calving decreased the number of days a quarter had clinical signs of mastitis by 37%. The combination of vitamin E and selenium decreased the number of quarters that had clinical signs of mastitis by 41%. These results provide evidence for an interaction between vitamin E and selenium in controlling mastitis. A later study reported a 42% decrease in the incidence of mastitis at calving in heifers that were supplemented with vitamin E and selenium for 60 days prior to calving.

The same authors also conducted a field study to determine the relationship between vitamin E and selenium supplementation and mastitis in well-managed herds. They reported that bulk tank SCC was lower in herds with greater selenium concentrations in plasma of cows. The incidence of mastitis was also lower in herds where cows had high plasma selenium concentrations and were also fed high amounts of vitamin E, again indicating an interaction between vitamin E and selenium. A field study conducted in Switzerland also indicated that herds with lower selenium concentrations in serum had greater problems with mastitis.

Recently, researchers supplemented vitamin E at 1000 IU/d during the first 46 days of the dry period, 4000 IU/d during the last 14 days of the dry period, and 2000 IU/d during lactation. Selenium supplementation was at low amounts. Feeding vitamin E at 4000 IU/d prevented the decline in plasma vitamin E normally observed at calving. The percent of quarters with new infections at calving and the percentage of quarters with clinical mastitis during the first 7 days of lactation were both decreased when cows were fed the very high amounts of vitamin E compared to cows fed low or intermediate amounts of vitamin E. The study found that cows with plasma vitamin E concentrations $< 3.0 \mu\text{g/ml}$ had a 9.4 fold greater chance of having mastitis during the first 7 days of lactation compared to cows with plasma vitamin E concentrations $> 3.0 \mu\text{g/ml}$. Clearly, supplementation of vitamin E and selenium has an impact on the immune system and is important in helping control mastitis in cows and heifers. Supplementation of vitamin E should be at least 1000 IU/d and selenium should be supplemented at 0.3 ppm for the total ration. Plasma concentrations of vitamin E greater than $3.5 \mu\text{g/ml}$ are considered adequate. Plasma concentrations of selenium should be between 0.07 and $0.5 \mu\text{g/ml}$.

Copper is another mineral involved in helping control mastitis. Several reports from researchers at the University of Kentucky indicate that supplementation of copper (as copper sulfate or copper proteinate) to heifers prepartum may help decrease the incidence and severity of mastitis at calving. Heifers supplemented with 20 ppm copper prior to calving had more uninfected quarters after calving than heifers not supplemented with copper. Research also indicates that the copper in copper oxide is largely unavailable and should not be used as a copper supplement. Care should be taken when supplementing Jersey cattle as they appear to be more sensitive to copper than Holsteins. Supplementation of diets for dairy cows with 20 ppm appears to be safe and effective in helping control mastitis. Plasma concentrations of copper are not an appropriate indicator of copper status in cattle.

Chromium has been reported to have beneficial effects on immune function of stressed animals. Although calving is a very stressful time for dairy and beef cows, little is known of the effects of supplemental chromium on health at parturition. Several indicators of immune function were measured in cows supplemented with chromium around parturition (Burton et al., 1993, 1995 and 1996). Leukocyte proliferation, antibody production, and cytokine production, were affected by supplementation of chromium, but the number of animals used for the studies was too low to determine whether supplementation of chromium affected incidence or severity of disease.

Beef Cows. Few studies have reported effects of vitamin E supplementation to beef cows on immune function of cows or calves. One study supplemented vitamin E to 134 beef cows at 80 or 1000 IU/d for up to 100 days prior to calving. Supplementation of beef cows with 1,000 IU/cow/d increased plasma vitamin E in cows two weeks prior to calving and at calving compared to cows supplemented with 80 IU/d. Supplementation with 1,000 IU/d also increased the concentration of vitamin E in

colostrum, resulting in greater vitamin E concentrations in plasma of calves at 48 hours after birth and a lower incidence of treatable scours compared to calves of dams fed 80 IU/d.

In another study, selenium was supplemented to beef cows grazing selenium-deficient pastures by providing ad libitum access to a salt-mineral mix containing 120 mg of selenium/kg of mix. A control group of cows received no supplemental selenium. Cows supplemented with selenium in the salt-mineral mix had greater concentrations of IgG in colostrum compared to control cows. Calves from the cows supplemented with selenium had greater serum concentrations of IgG than calves from control cows. These studies provide an indication that attention to micronutrients in diets of beef cows prior to parturition may improve the health, and thereby the performance, of calves. Further studies with beef cows in the perpartum period are needed to investigate interactions of nutrition and immune function during this important time and its effects on calves.

Nutrition and Immune Function of Calves

Liquid-feeding period. Because dairy calves are hand-fed, there is greater opportunity to manage nutrition to enhance immune function during the liquid feeding period than there is for beef calves. Transfer of vitamins across the placenta from dam to calf is limited, therefore, both beef and dairy calves must rely on high quality colostrum to provide vitamins early in life. Dairy calves often are switched to milk replacers supplemented with vitamin A, D, and E and the B vitamins a few days after birth. Vitamin E supplementation in milk or milk replacer for dairy calves has been shown to enhance performance and immune function in several studies. Therefore, supplementation of milk replacers with 125 IU/lb of milk replacer is a common practice. Recent studies have shown that supplementation of calves with high amounts of vitamin A, however, may interfere with vitamin E and can have an adverse effect on performance. Because plasma vitamin A concentrations are not a true indicator of the vitamin A status of young calves, care must be taken to **not** over supplement vitamin A. Studies have shown that vitamin A concentrations in plasma from young calves will have low values (< 20 µg/dl) even when liver concentrations of vitamin A are very high.

One study examined the effects of supplementing beef calves prior to weaning with vitamin E, selenium, and copper. The researchers found that vitamin E supplementation prior to weaning improved weight gains through the receiving period but did not find any effects on immune function of any of the supplements.

Weaning. Weaning, transport, and entering the feed lot are extremely stressful times for calves. In addition, exposure to disease organisms is increased as a result of confining calves together, exposing them to new environments, and exposing them to new cattle. Several studies have investigated supplementation of chromium as a means of bolstering the immune system in stressed feeder calves. Calves supplemented with 0.4 ppm of chromium for 28 days after receiving had 30% greater weight gains than calves not supplemented with chromium. During the growing period, calves supplemented with 0.2 ppm chromium and fed a diet containing soybean meal had increased serum immunoglobulin concentrations and decreased serum cortisol. A later study used chromium levels of 0, 0.2, 0.5, and 1.0 ppm for

30 days after receiving. Calves fed 0.2 and 1.0 ppm chromium had improved gains and dry matter intake (Table 1). There was no morbidity in the group of calves fed 0.2 ppm chromium whereas calves not supplemented with chromium had 43% morbidity from 2 - 30 days after receiving. Calves supplemented with chromium also had greater serum IgG₁ concentrations compared to control calves.

Table 1. Performance and morbidity of feeder calves supplemented with chromium during the first 30 days after arrival.

Item	Level of Chromium, ppm			
	0	0.2	0.5	1.0
No. of Calves	21	21	21	21
Daily gain, Kg	0.66 ^c	0.84 ^b	0.70 ^{bc}	0.84 ^b
DMI, Kg/d	3.99 ^c	4.66 ^b	3.91 ^c	4.57 ^b
Morbidity, % 2-30 d	42.9 ^c	0 ^b	23.8 ^{bc}	23.8 ^{bc}
Rectal Temperature, °C				
2 d	103.5 ^c	102.5 ^b	102.5 ^b	102.5 ^b
5 d	103.4 ^c	102.6 ^b	103.1 ^{bc}	102.5 ^b

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^{bc}Within a row, values with different letters are significantly different.

Other researchers investigated the effects of supplementing copper to older Holstein calves. They found that when calves with adequate copper status were challenged with IBR virus and *Pasteurella hemolytica*, there was a rapid increase in plasma copper and serum ceruloplasmin that was not observed in calves with deficient copper status. This likely indicates an important function for copper in immune function. More research is needed regarding supplementation of copper to calves at weaning.

Summary

Both dairy and beef cows and their calves should benefit from supplementation of cows prior to calving with vitamin E and selenium. Suggested rates of supplementation for vitamin E are 1000 IU/cow daily. Selenium should be supplemented to provide 0.3 ppm in the total ration. Copper should be supplemented to dairy cows at 20 ppm in the diet. Concentrations of other minerals such as zinc, manganese, and molybdenum should be monitored because of interactions between these minerals and copper. High concentrations of molybdenum in rations can prevent utilization of copper.

For dairy calves, supplementation with vitamin E can be beneficial but care must be taken to not over supplement vitamin A. Further studies are needed to determine benefits of

mineral supplementation to dairy calves. For receiving calves, chromium supplementation has been shown to enhance immune function and performance, especially for calves fed corn silage.

There are no magic bullets, however, nutrition is a tool that can be used to help bolster the immune system to fight infection. Nothing can overcome allowing animals to be exposed to overwhelming numbers of disease causing organisms. Remember, no matter how good the Texans were at fighting, the Alamo still fell when the soldiers with Santa Anna became too great.