



Using Nutrition to Improve Immunity against Disease in Dairy Cattle: Copper, Zinc, Selenium, and Vitamin E

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Using nutrition to increase a cow's defense against infection has been a recent area of research. Vitamins and minerals, such as vitamin E, selenium, copper, and zinc, when properly supplemented, can enhance a cow's immunity against diseases, such as mastitis, by increasing resistance to infections and by decreasing severity of infections when they do occur. This publication addresses the role of vitamin E, selenium, copper, and zinc in improving immune function.

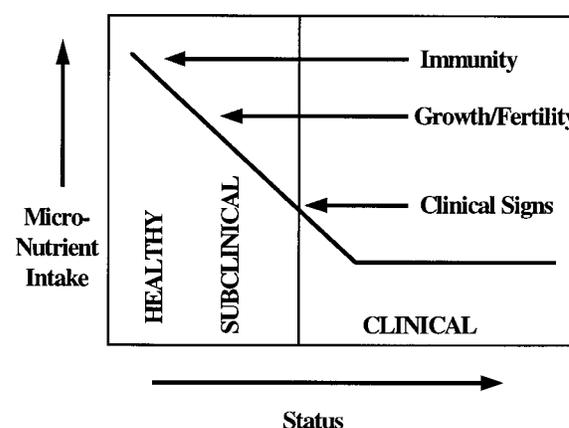
Cow requirements for vitamins and minerals are influenced by several factors, including age, stage of pregnancy, and stage of lactation. Figure 1 shows that, for some vitamins and minerals, the amount required for optimal immune response is greater than the amount required for growth and reproduction. Cattle can have sufficient vitamin and mineral intake for adequate growth and reproductive performance but not have optimal immune performance. By the time clinical signs of deficiency become apparent, immunity, growth, and fertility already may have been compromised.

Nutrition Complements Good Management Practices

Mastitis is a costly disease in the dairy industry, and mastitis incidence can be measured to determine disease resistance or level of immunity of cows. Nutritional supplementation is one tool that can be used further to decrease mastitis, but good management practices must also be followed. Examples of such management practices include pre- and post-milking teat dipping, dry cow therapy, and providing cows with a clean, dry environment. Farms with a bulk tank somatic cell count of 500,000 to 600,000 cells/ml would be less likely to see a decrease in somatic cell count from nutritional supplementation than lower somatic cell count herds because there is an apparent problem with at least one aspect of proper mastitis management practices.

Farms with lower bulk tank somatic cell counts will likely benefit the most from nutritional supplementation of vitamins and minerals. Even with a somatic cell count of 200,000 cells/ml, about 6 percent of the quarters in the herd are still infected. This somatic cell count level results in a loss of 800 pounds over the lactation for second and higher lacta-

Figure 1. Vitamin and Trace Mineral Function¹



¹ Adapted from Wikse, 1992 Texas A&M Veterinary Beef Cattle Short Course

tion cows. Farms with low somatic cell counts likely are following proper management practices, and the addition of supplemental nutrients will complement the sound management practices. It is important to remember that nutrition alone will not control mastitis.

Role of Micro-Nutrients

Increased susceptibility to infectious disease because of malnutrition in livestock has been recognized for many centuries. The potential to influence immune function by nutritional supplementation has gained interest, especially because of the desire to decrease antibiotic use to ease consumer concerns.

Selenium and Vitamin E

An Ohio State study in the early 1980s looked at the effects of supplemental vitamin E and selenium on mastitis incidence and severity. Results are summarized in Table 1. The greatest benefit was found when vitamin E and selenium were

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Table 1. Clinical Cases of Mastitis¹

Treatment	Cases of Mastitis per Lactating Quarter		Length of Each Clinical Case of Mastitis per Lactating Quarter	
	Cases	% Reduction ²	Months	% Reduction ²
Control ³	0.41	0	0.95	0
Selenium	0.36	12	0.51	46
Vitamin E	0.26	37	0.53	44
Vitamin E + Selenium	0.26	37	0.36	62

¹ Adapted from Smith et al., 1984, *Journal of Dairy Science*, 67:1293.

² Percent reduction was calculated comparing the supplemental groups with the untreated control group.

³ Control cows were not given supplemental vitamin E or selenium in addition to amount found naturally in the diet.

supplemented together at a rate of 1000 international units (IU) vitamin E per day and an injection in the dry period 21 days before calving of 0.045 mg of selenium per pound of body weight.

This study and others completed by Ohio State University researchers have shown that supplementation with vitamin E decreases the incidence of mastitis, and selenium decreases the duration of these infections. Combining the two supplements results in the greatest increase in defense against mastitis. Deficiencies of vitamin E and selenium also have been found to increase the incidence of retained placenta. Selenium deficiency alone can increase the incidence of embryonic death and uterine infections and can decrease fertility.

Forages are the main source of natural vitamin E in a cow's diet. The amount of vitamin E in a plant decreases as a plant matures. Vitamin E also declines with increased length of storage and processing. Thus, plants with adequate vitamin E in the field may not provide adequate amounts of vitamin E when the plant is stored as hay or silage and fed to cows. Hay, in particular, has low amounts of vitamin E, whereas cattle consuming pasture as the sole forage source may receive adequate amounts of vitamin E from grazed forage alone.

The Ohio study (1984) mentioned previously was conducted in a known selenium-deficient area. In fact, two-thirds of the land where forages for dairy cattle are raised is selenium-deficient. Kentucky is considered a selenium-deficient state. Selenium-deficient soils produce selenium-deficient plants, and without proper supplementation, the cow eating the plants will also be deficient.

Copper and Zinc

Copper has an important role in the immune system helping to fight off infections and diseases. Deficiencies of copper also have been associated with retained placenta, embryonic death, and decreased conception rates. Inadequate copper status may be related to an increased incidence of infections at calving,

increased severity of infections, and a higher somatic cell count than that seen in copper-adequate cattle.

Feedstuffs grown in Kentucky likely will be copper-deficient. Clinical signs of copper deficiency may include a discoloration of the haircoat (for example, black hair of cattle can become reddish). Since copper is stored in the liver, the best way to determine copper status is to biopsy the liver. Blood tests for copper can be inaccurate because only severely deficient cattle will show low concentrations of copper in the blood. Cattle with marginal copper status may have adequate blood concentrations of copper but have liver stores that are inadequate for proper immune function. Proper supplementation will

help avoid marginal deficiencies, which can decrease the ability of cattle to resist infections.

Zinc is also an integral part of the immune system. Zinc is important for production of keratin, which lines the inside of the teat duct and helps to keep out micro-organisms that can cause mastitis. Zinc deficiencies also will delay sexual maturity and may also cause fetal abnormalities.

Recommended Feeding Levels

The National Research Council (NRC-1989) recommends feeding selenium at a supplemental level of 0.3 ppm. This is also the legal limit established by the Food and Drug Administration (FDA) for supplemental selenium. Note that 0.3 ppm selenium is not the legal limit of total selenium in a ration but the limit of supplemental selenium in a ration. Feeding at levels above NRC and FDA recommendations has not shown any benefit in enhancing the defense against mastitis. The selenium status of cattle is best determined by blood testing because the absorption of selenium can be decreased by substances in the intestinal tract such as high concentrations of sulfates or nitrates from water or feed. Some forms of selenium are more available than other forms. Sodium selenite is a common source of supplemental selenium.

Suggested Feeding Levels in Total Diet

- Vitamin E: 1000 IU/day for dry cows, 500 IU/day for lactating cows
- Selenium: 0.3 ppm
- Copper: 20 ppm
- Zinc: 40-60 ppm

The 1989 NRC recommendation for vitamin E is 150 IU/day for dry cows and 300 IU/day for lactating cows. However, the beneficial effect of vitamin E on the cow's defense against mastitis requires greater intakes than the NRC recommendation. Dry cows often are fed poorer quality feeds than lactating cows and therefore may benefit from 1000 IU/day of supplemental vitamin E throughout the dry period. Lactating cows should be supplemented with 500 IU/day of vitamin E because they are fed higher quality feeds than dry cows. This recommendation is based on a significant reduction in udder infections, clinical mastitis, and somatic cell counts seen when cows were supplemented with these amounts of vitamin E.

The amount that needs to be supplemented will depend on forage quality and losses during storage. Cattle that are receiving 50 percent of their forage from above-average quality pasture probably do not need supplemental vitamin E. The various forms of supplemental vitamin E fed have different availabilities to the cow. DL-alpha-tocopherol acetate (commonly supplemented form) has an activity of 1 IU/mg, while d-alpha-tocopheryl acetate has an activity of 1.36 IU/mg. Pay attention to the form used because the amount required to reach a feeding level of 1000 IU/day will vary among the different forms of vitamin E available. Blood concentrations of alpha-tocopherol can be used to determine actual vitamin E status.

Table 2. Relative Bioavailability of Selected Mineral Sources¹

Element	Source	Bioavailability
Selenium	Sodium selenite	High
Copper	Copper oxide	Low
	Copper carbonate	Intermediate
	Copper sulfate	High
Zinc	Zinc oxide	High
	Zinc sulfate	High
Iron	Iron oxide	Unavailable but may interfere with absorption of other minerals

¹ Adapted from McDowell, *Minerals in Animal and Human Nutrition* (1992).

The latest NRC (1989) recommended that copper be supplemented at 10 ppm in the total diet. Recent research has shown that cows fed 7 to 8 ppm copper (70 to 80 percent of NRC recommendation) have inadequate concentrations of copper in the liver. Feeding 20 ppm of supplemental copper in the total diet seems to have the greatest positive impact on immune function. As with selenium, different forms

of copper have different availabilities to the cow. Copper oxide is not very well absorbed by the cow's intestinal tract. Copper sulfate is a better source of copper than copper oxide. Research has shown that copper proteinate has equal or greater availability when compared with copper sulfate. Amount of available copper absorbed by cattle also can be decreased when dietary iron, sulfur, molybdenum, or zinc intakes are high.

The NRC-recommended level for zinc is 40 ppm in the total diet. Zinc should be fed at 40 to 60 ppm in the total diet to help maintain an optimal immune system. Zinc sulfate and zinc oxide both have a high bioavailability of zinc. Zinc sulfate's bioavailability may be greater than that of zinc oxide. Other forms of zinc that are highly available are zinc proteinate and zinc methionine.

All of the minerals and vitamins should be force fed using a total mixed ration (TMR) or be included in the grain mix. This method ensures all cattle consume the supplemented nutrients. Trace mineral salt blocks may not allow for consumption of adequate amounts of these trace minerals and vitamins. If minerals are fed free-choice, average intake needs to be monitored to ensure cattle are receiving adequate amounts of vitamin E, selenium, copper, and zinc.

Conversion Factors

0.1% = 1000 ppm

(Move decimal four places to the right)

1 ppm = 1 mg/kg

1 ppm = 0.45 mg/lb

1 mg/lb = 2.2 ppm or 2.2 mg/kg

Importance of Supplementing Heifers

Supplementing heifers with the proper amounts of vitamins and minerals is very beneficial. Many feeds grown in Kentucky will not provide adequate amounts of selenium, copper, and zinc. Vitamin E levels also can be deficient by the time the plant is stored and then fed. All four of these nutrients when provided at proper amounts have been shown to decrease mastitis at calving. Selenium, copper, and zinc should be supplemented at the previously mentioned levels. Vitamin E may need to be supplemented if the heifers are not consuming good quality pasture.

Keys to Improving Immune Function through Nutrition

- Follow proper milking management practices which include pre- and post-milking teat dipping, dry cow therapy, and providing cows with a clean, dry environment.
- Properly supplement heifers along with lactating and dry cows.
- Supplement vitamins and trace minerals in diet or grain mix to ensure intake of:
 - Vitamin E*: 1000 IU/day for dry cows,
500 IU/day for lactating cows
 - Selenium*: 0.3 ppm in total diet
 - Copper*: 20 ppm in total diet
 - Zinc*: 40 to 60 ppm in total diet
- Be aware of differences in bioavailability among different forms of these micro-nutrients.