IMPROVING DISEASE RESISTANCE WITH NUTRIENTS THAT BOLSTER THE IMMUNE SYSTEM

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Introduction

Animals are dependent on an efficient host defense system for eliminating potential disease causing organisms. A number of different components of the host defense system are involved in the prevention of various diseases. Nonspecific immune components include phagocytic cells, complement, lysozyme, cilia on epithelial surfaces and barriers formed by skin and mucous membranes. The major types of phagocytic cells are neutrophils in blood and macrophages in tissues. When foreign materials such as disease causing organisms enter the body, they are first subjected to phagocytic cells, that serve to bind, ingest and destroy foreign material. Antigen specific immunity refers to the humoral and cell-mediated immune responses. The humoral immune response consist of specific antibodies that recognize and react with antigens. Antibodies are produced in response to antigens. Antibodies are produced in response to antigen stimulation by B-lymphocytes that are derived from the bone marrow. The cell-mediated immune response depends largely on T-lymphocytes produced in the thymus.

A number of different nutrients have been shown to affect immune functions. Reduced disease resistance has also been associated with deficiencies of certain micronutrients. Dietary requirements of some nutrients for maximum immune response may be higher than for maximum body weight gain or milk production.

Vitamin A and Carotene

Beta carotene is the major precursor of vitamin A that occurs naturally in feedstuffs. Research suggest that beta carotene may have functions independent of its role as a source of vitamin A. Beta carotene, as such, can serve as an antioxidant while vitamin A is not an important antioxidant.

Supplementation of 300 mg/day of beta carotene to dairy cows, fed 53,000 IU of vitamin A/day, reduced milk somatic cell count (Chew and Johnston, 1985). In this study, beta carotene supplementation started 30 days prepartum and continued through 10 weeks postpartum. Cows supplemented with beta carotene around dry-off also had lower rates of new mammary gland infections during early dry-off (Chew, 1993). Oldham et al. (1991) supplemented dairy cows, fed 50,000 IU of vitamin A/day, with 300 mg of beta carotene for two weeks prior to drying off, throughout the dry period and for the first six weeks of lactation. Beta carotene supplementation in this study did not affect milk somatic cell count, incidence of clinical mastitis or incidence of new intramammary infections, compared to cows fed only 50,000 IU of vitamin A/day.

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β carotene is often not measured in forages

Michal et al. (1994) evaluated the effects of beta carotene and vitamin A on immune SLIDE

Dahlquist & Chew 1985

Presented at the 7th Florida Ruminant Nutrition Symposium, Gainesville, January 11-12, 1996

function and incidence of retained placenta and metritis in dairy cows. Control cows in this study received no supplemental vitamin A. Cows supplemented with 300 or 600 mg of beta carotene/day, for 4 weeks prior to calving, had lower incidence of retained placenta and metritis than control cows. The ability of blood lymphocytes to respond to mitogen stimulation was also increased by beta carotene supplementation. Incidence of retained placenta was similar in cows fed beta carotene and those fed 120,000 IU of vitamin A/day; however, incidence of metritis was lower in cows fed beta carotene.

It is well documented that vitamin A deficient animals are more susceptible to bacterial, viral and parasitic infections (Chew, 1987). Chew and Johnson (1985) reported that increasing the intake of vitamin A from 53,000 to 173,000 IU/day in dairy cows starting at 30 days prepartum decreased somatic cell counts in milk during early lactation. In contrast, Oldham et al. (1991) found that increasing vitamin A from 50,000 to 170,000 IU/day did not affect somatic cell count or mammary gland health in cows. Young calves fed milk replacer with high vitamin A concentrations (87,000 IU/kg DM) had improved fecal consistency compared with that for calves fed milk replacer low (7,000 IU/kg DM) in vitamin A (Eicher et al., 1994).

Vitamin E and Selenium

Selenium and vitamin E will be discussed together because both nutrients are involved in the cellular antioxidant defense system. Selenium function as an essential component of the enzyme glutathione peroxidase that destroys hydrogen peroxide and lipid hydroperoxides. Vitamin E functions as an antioxidant that scavenges free radicals and protects against lipid peroxidation. Both selenium and vitamin E have been shown to affect various measures of immune function (Stabel and Spears, 1993).

Vitamin E and selenium status of dairy cows has been shown to affect the susceptibility of dairy cows to intramammary infections. Supplementing a diet low in selenium and vitamin E with 740 IU of vitamin E/day, throughout the dry period, reduced incidence of clinical mastitis at calving by 37% (Smith et al., 1984). In this study, injecting .1 mg of selenium per kg of body weight at 21 days prior to calving did not affect the incidence of clinical mastitis, but duration of clinical symptoms was reduced by 46% (Smith et al., 1984). Cows supplemented with both vitamin E and selenium had a shorter duration of clinical signs of mastitis than cows supplemented with either nutrient alone. Vitamin E and selenium also were related to rate of clinical mastitis and bulk tank milk somatic cell count in a survey study of dairy herds in Ohio (Weiss et al., 1990). In this study, high serum selenium concentrations were associated with reduced rates of mastitis and lower bulk tank milk somatic cell concentrations. High blood concentrations of vitamin E were associated with decreased rate of clinical mastitis.

Experimental mastitis, induced by intramammary challenge with *E. Coli*, was more severe and of longer duration in cows fed .04 ppm of selenium compared to cows fed .14 ppm of selenium (Erskine et al., 1989). However, severity and duration of infection was not affected by selenium deficiency when mastitis was induced by intramammary challenge with *Staphylococcus aureus* (Erskine et al., 1990).

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Vitamin E and selenium supplementation of dairy cow diets has reduced incidence of

retained placenta and severity of udder edema in some studies (Miller et al., 1993). Supplemental selenium or vitamin E are most effective when the other nutrient is present in the diet in adequate amounts. For example, feeding 1,000 IU of vitamin E/day reduced the severity of udder edema in primiparous cows when the diet contained at least .12 ppm of selenium. When dietary selenium was less than .07 ppm, supplemental vitamin E did not affect udder edema (Miller et al., 1993).

A 2-year study with beef cows and calves fed feedstuffs marginally deficient in selenium indicated that bimonthly selenium-vitamin E injections reduced calf death losses (4.2 vs 15.3%) from birth to weaning (Spears et al., 1986). Most of the deaths in this study were attributed to diarrhea and subsequent unthriftiness. Incidence of diarrhea was lower in calves born to cows fed 1,000 IU of vitamin E/day during the third trimester of pregnancy than in calves from cows fed 80 IU of vitamin E/day (Zobell et al., 1995).

Reffett et al. (1988) examined the effects of selenium deficiency on disease resistance in calves inoculated intranasally with infectious bovine rhinotracheitis virus. Susceptibility to the viral challenge appeared to be unaffected by selenium status of the calves as body temperature responses and reductions in feed intake following the disease challenge were similar across treatments. Selenium deficiency also did not affect susceptibility of stressed steers to a *Pasteurella hemolytica* challenge (Stabel et al., 1989). Droke and Loerch (1989) found that injecting stressed steers with selenium and (or) vitamin E did not affect health status during the receiving period. However, steers injected with both selenium and vitamin E had a greater antibody response following *Pasteurella hemolytica* vaccination (Droke and Loerch, 1989). Selenium supplementation of low selenium diets did not improve parasite resistance in sheep experimentally injected with *Haemonchus contortus* (Jelinek et al., 1988) or *Ostertagia circumcincta* and *Trichostrongylus colubriformis* (McDonald et al., 1989).

Copper

Little controlled data to indicate than deficiencies are real.

Copper may affect tissue damage resulting from infectious diseases through its anti-inflammatory properties and its role in the antioxidant defense system. Two copper containing enzymes, ceruloplasmin and superoxide dismutase, exhibit anti-inflammatory activity as do a number of copper complexes (Suttle and Jones, 1986). Serum ceruloplasmin increases during infection and inflammation.

Copper also functions via superoxide dismutase to prevent oxidative tissue damage from superoxide radicals. Phagocytic cells, when stimulated by invading microorganisms, produce large quantities of superoxide radicals that must be detoxified by superoxide dismutase. In copper deficiency, superoxide dismutase activity is reduced and this may increase the likelihood of oxidative tissue damage resulting from infection and inflammation.

The ability of neutrophils to kill ingested *Candida albicans* was reduced in steers fed a copper-deficient diet (Boyne and Arthur, 1981). Peripheral blood granulocytes from ewes and calves fed copper-deficient diets had similar phagocytic capacity but reduced ability to kill ingested *Candida albicans* compared to controls adequate in copper (Jones and Suttle, 1981). Copper deficiency induced by feeding cattle either 5 ppm Mo or 500 ppm of Fe also impaired

Libbey et al. 1985 Abomasal Ulcers in calves. Which causes which?

neutrophil function (Boyne and Arthur, 1986).

Copper depletion in calves produced by feeding a low copper diet under controlled conditions reduced serum IgM concentrations, but did not affect clinical signs (feed intake or rectal temperature) of respiratory disease following inoculation with IBR virus and *Pasteurella hemolytica* (Stable et al., 1993).

SLIDE → Copper deficiency in lambs grazing improved pastures resulted in increased susceptibility to bacterial infections and greater mortality (Woolliams et al., 1986). Over a 2-year period, death losses in lambs from birth to 24 weeks of age were much higher in a low copper line compared to a high copper line (28 vs 12%). Lamb survival was enhanced in the low copper line but not in the high copper line by administration of copper at six weeks of age. Many of the lamb deaths were associated with bacterial infections with *Pasteurella hemolytica* and *E. coli* being the most commonly isolated organisms. The increased disease susceptibility in copper deficient lambs may have been confounded with molybdenum as pastures contained from 1.2 to 3.1 ppm of molybdenum (Woolliams et al., 1986).

Zinc

A number of zinc dependent enzymes are involved in protein synthesis and cell division. The immune system depends on rapid cell proliferation when functioning properly, thus, it is not surprising that the immune system is adversely affected by severe zinc deficiency.

Zinc deficiency is known to severely impair immune function in laboratory animals. A genetic disorder (lethal trait A46) of zinc metabolism has been reported in Holstein and Shorthorn calves that results in severe zinc deficiency due to impaired zinc absorption. Calves with lethal trail A46 exhibit thymus atrophy and impaired lymphocyte response to mitogen stimulation (Perryman et al., 1989). Lambs fed a semi-purified diet severely deficient in zinc (3.7 ppm) had a lower percentage of lymphocytes and a higher percentage of neutrophils in SLIDE peripheral blood as well as reduced in vitro lymphocyte blastogenesis (Droke and Spears, 1993). However, immune responses in lambs marginally deficient in zinc (8.7 ppm) did not differ from those observed in lambs fed adequate zinc (Droke and Spears, 1993). Susceptibility to *Pasteurella hemolytica* infection was similar in lambs fed zinc-deficient (5.5 ppm of zinc) and those fed zinc adequate diets (45 ppm of zinc; Droke et al., 1993).

Cobalt

Neutrophils isolated from ewes and calves deficient in cobalt had a reduced ability to kill *Candida albicans* (MacPherson et al., 1989). Increased disease susceptibility has also been noted in cobalt deficient lambs (Ferguson et al., 1988; MacPherson et al., 1989).

Iron

Iron deficiency has decreased immunity. However, iron deficiency in cattle is unlikely unless parasite infestations or diseases exist that cause chronic blood loss. In fact, cattle grazing pastures or being fed harvested silage or hay may be exposed to excessive levels of iron through

Chromium Mowat et al. 1993 Feedlot cattle

forage, water or soil ingestion. High intakes of iron may also result in cattle being more susceptible to various infectious diseases. Diseases causing organisms require iron for their growth. Iron is normally bound in the body in such a manner that microorganisms have difficulty in obtaining iron for their growth. However, high dietary iron may increase the incidence of disease, because iron becomes more available for microbial growth when iron levels in the body are elevated. Long term exposure to high levels of iron can also result in tissue damage, especially in the liver and spleen.

Organic Trace Minerals

Limited research suggest that certain organic or chelated trace minerals may enhance the immune response or improve health above that noted in ruminants fed inorganic trace elements. Zinc methionine has reduced milk somatic cell counts in a number of studies. In eight experiments, feeding zinc methionine to provide 180 or 360 mg/d of zinc reduced somatic cell counts by an average of 32% (Kellogg, 1990). ← SLIDE

In a 3-year study with steers grazing pasture, zinc methionine inclusion in the mineral mix reduced incidence of footrot from 5.4 to 2.5% (Brazle, 1993). Spears et al. (1991) studied the effect of zinc level and source on immune response to vaccination in stressed steers that had recently been weaned and shipped. Steers were fed a control diet that contained 26 ppm of zinc or the control diet supplemented with 25 ppm of zinc from either zinc oxide or zinc methionine. Antibody titers were determined on serum samples collected on days 0 and 14 as a measure of the immune response to IBR and PI_3 vaccination. Antibody titers against IBR on day 14 following vaccination were 47 and 31% higher in steers supplemented with zinc methionine compared to control and zinc oxide fed steers, respectively. Calves experimentally challenged with IBR virus tended to recover from the disease more rapidly when fed zinc methionine compared to zinc oxide (Chirase et al., 1991). Antibody titers to IBR were higher in stressed steers fed copper proteinate compared to those fed copper sulfate following vaccination against IBR (Nockels, 1991). ← SLIDE

Rakes et al. 1993 SCC unchanged Uterine infections .59 → .27 organic TM suppl.

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Don't want the immunity system stimulated constantly so give Vit E + Se only during stressful periods.

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