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Review Article

Nutritional Effect on Immunity in Animals

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Abstract

Nutrition is an important component in maintaining good health. Various nutrients are essential for maintaining a functional immune system. Fatty acids, vitamins and minerals enhance s the production and activity of cytokines which are chemical signaling molecules that regulate s the immune response. Complex inter-relationships exist among certain micronutrients, immune function and disease resistance in animals Chromium supplementation has been found to improve cell-mediated and humoral immune responses. Selenium and vitamin E enhances the ability of isolated neutrophils to kill bacteria. Copper enhances the production of antibodies, cell-mediated immunity, interferon and tumour necrosis factor by mononuclear cells. Zin c plays an important role in maintaining innate immunity. Cobalt deficiency has been associated with reduced resistance to parasitic infestation. Vitamin A-deficient animals are more susceptible to various types of infections. Antioxidant properties of β-Carotene affect immune function and disease resistance independent of its role as a precursor of vitamin A.

Keywords: Deficiency, Immune system, Nutrition

Introduction

Nutrition and immunity are so inter-related that a single or a group of nutrients can have a direct or indirect effect on immunity. Nutrients affect the immune system by activating immune cells or mediating immune cell interactions. They affect the immune system by influencing DNA synthesis substrates, cell physiological integrity, energy metabolism, and signaling of hormones (Chandra and Newberne, 2012). Nutrition affects every physiological process in the body and indirectly has important implications for immunity and the incidence of a disease. Dairy calves are more susceptible to diseases and mortality during the first few weeks of life. To improve disease resistance among pre-weaned calves, colostrum feeding, use of additives such as prebiotics, probiotics, and proteins from hyper-immunized eggs or plasma proteins, and adoption of such as housing and managemental conditions to provide comfort to animals are normally advocated. Vitamins, minerals, and many dietary antioxidants such as polyphenols and carotenoids play an important role in boosting immunity, their deficiencies led to immunological suppression. For the effective functioning of the host defense mechanism, a balanced supply of micronutrients such as vitamin E, Carotenoids, Vitamin A, and Vitamin C as well as other trace elements like Zinc (Zn), Copper (Cu), Chromium (Cr), selenium (Se), Manganese (Mn), Cobalt (Co) and Iron (Fe) is critical.

Role of Nutrients in the Immune Response

The antioxidant vitamins such as carotenoids, vitamin E, and vitamin C have recently received a lot of attention because of their effects on immunity and disease etiology. Antioxidants have long been known to boost immunity. Free radicals are produced as a result of metabolism, immunological response, corticosteroid production, auto-oxidation of unsaturated organic molecules (e. g. polyunsaturated fatty acid esters), radiation, and some oxidases, dehydrogenases, and peroxidases activities.

Vitamin C, vitamin E, and ß-carotene are the most common antioxidant sources in the tissue defense system against free radical damage. Metalloenzymes such as glutathione peroxidase (selenium), catalase (iron), and superoxide dismutase (copper, zinc, and manganese) are also important in preventing oxidative damage to internal cellular constituents. Mazur-Bialy *et al.* (2015) reported that vitamin B_2 deficiency impairs macrophage survival and the ability to trigger an immunological response.

Vitamin A and β-carotene

Carotenoids, including carotene, lutein, canthaxanthin, lycopene, and astaxanthin, are plant pigments and anti-oxidants (Lee and Downey, 2001). β-Carotene is the major precursor of vitamin A, which occurs naturally in feedstuffs. β-carotene may affect immune function, independent of its role as a source of vitamin A. β-Carotene as such, can serve as an antioxidant, while vitamin A is not an important antioxidant. Michal *et al.* (1994) evaluated the effects of β-carotene and vitamin A on immune function and the incidence of retained placenta and metritis in dairy cows. Supplementation of β-carotene did not consistently affect neutrophil bactericidal activity (Michal *et al.*, 1994). Supplementation with β-Carotene during the dry period has been reported to reduce mammary gland infections in ruminants resulting in enhanced lymphocyte blastogenesis and neutrophil killing activity (Lee and Downey, 2001).

Vitamin E and Selenium

Vitamin E and Selenium play overlapping and essential roles in support of the immune system in ruminant animals. Their functions as anti-oxidants when use in large portions. Feeding elevated levels of Selenium to ruminant animals reduces the incidence of diseases including intra-mammary infections (Smith *et al.*,1984). The addition of Selenium to the diet increases neutrophil killing activity. Selenium deficit results in neutrophil adhesion, which may decrease neutrophils' capacity to assault and sequester pathogens (Banchereau *et al.*,2000). Vitamin E increases lymphocyte proliferation and avoids peripartum reductions in neutrophil superoxide anion generation and hampers IL-1 production by monocytes. The administration of Selenium alone or in conjunction with vitamin E enhances the formation of specific antibodies against *Escherichia coli* and the generation of specific antibodies was higher following the administration of Selenium alone (Huntley, 1992).

Vitamin C

Vitamin C improves components of the immune system such as antimicrobial, natural killer (NK) cell activities, lymphocyte proliferation, chemotaxis, and delayed-type hypersensitivity. Vitamin C acts against the toxic, mutagenic, and carcinogenic effects of environmental pollutants by stimulating liver detoxifying enzymes. Vitamin C contributes to maintaining the redox integrity of cells and thereby protects them against reactive oxygen species which are generated during the respiratory burst and by the various inflammatory response (Sies and Stahl, 1995).

Fatty Acids (Omega-3and-6 fatty acids)

The generation of cytokines, eicosanoids (e.g., prostaglandins), and leukotrienes by fatty acids influence immunity. Arachidonic acid is formed by diets high in Omega-6 fatty acids, such as linoleic acid (C18:2), whereas eicosapentaenoic acid is formed by diets high in omega-3 fatty acids such as linolenic acid, C18:3, flaxseed, and fish oils (EPA). Arachidonic acid-derived eicosanoids have a higher inflammatory potential than EPA-derived eicosanoids. As a result, feeding fatty acid combinations rich in Omega-3fatty acids lowers inflammatory responses and the generation of pro-inflammatory cytokines such as IL-1, IL-6, and TNF-α. Flaxseed studies found that increasing progesterone and PGE4 levels enhanced TNF-α and nitric oxide levels (McEwen, 1992).

Antioxidants

These are chemicals that counteract the oxidation reaction by stabilizing the number of unstable oxygen atoms (free radicals) that can damage cells over time. The oxidation caused by free radicals can harm DNA, RNA, and cell lipids (fat molecules that make up the cell membrane) all of which are important for cell membrane integrity. Cell death can be hastened by lipid layer thinning (Ward *et al.*, 1993). Vitamins A, C, and E as well as minerals like zinc and selenium are important antioxidants. The antioxidant properties of vitamins A and E in particular are beneficial to horses. Vitamin A, for example, may influence lymphocyte growth and mucous membrane maintenance, both of which aid in the fight against infections.

Minerals and their role in Immunity

Chromium (Cr)

Chromium supplementation in livestock diets boosts immunity. Chromium increased blastogenesis in the lymphocytes. The same effect was not observed in lymphocytes from healthy calves. Cr supplementation improved the health and immunity of animals by lowering blood cortisol and increasing serum IgM and total immunoglobulins in calves. Chang and Mowat (1992) investigated the benefit of giving Chromium to calves who had been exposed to the stressors of feedlot placement (travel, crowding, antigen exposure, limitation of feed, and water supply). Chromium supplementation may be able to decrease stress and the resulting immunosuppression (Vivier *et al.*,2008). Chang *et al.* (1994) stated that supplemental Chromium boosted blastogenic responses of peripheral blood lymphocytes in morbid calves, but had no effect on healthy calves. According to Kheiri and Toglyani (2009), Chromium supplementation increased antibody titre against the Newcastle virus in chicks.

Copper (Cu)

Animals' immunological responses are influenced by copper deficiency. The humoral immune response to albumin vaccination was altered by Cu or Zn (Raulet, 1989). In ruminants with Cu deficiency, Minatel and Carfagini (2000) found that the innate immune response is compromised. Neutrophils from Cu-deficient calves and sheep have lower microbiocidal activity, O_2 generation, and superoxide dismutase activity. Spears (2000) stated that following illness exposure, copper shortage resulted in a decrease in serum IgM concentration. Ward *et al.* (1993) reported that reduced cell-mediated immune response, as measured by skin swelling response to PHA when cattle were Cu-deficient by feeding Mo and S. Gengelbach *et al.* (1997) studied cattle and found that Cu deficiency combined with high Mo and Fe had inconsistent effects on immune function, suggesting that Cu deficiency may not affect specific immune function in calves.

Cobalt (Co)

The effect of cobalt supplementation on immunological reactivity in vitamin B_{12}-deficient lambs improves humoral and cell-mediated immune responses to microbes. Cobalt deficiency affects neutrophil function and resistance to parasitic infection. Neutrophils from Cobalt deficient calves have a lower ability to destroy yeast, such as *Candida albicans* (MacPherson *et al.,* 1987; Paterson and MacPherson, 1990). Following an experimental infection with *Ostertagiaostertagi*, cobalt deficient calves exhibited a decreased pre-patent period and more faecal egg production (MacPherson *et al.*, 1987). After spontaneous infection with gastrointestinal nematodes, Vellema *et al.* (1996) found greater faecal egg counts in Cobalt deficient lambs.

Zinc (Zn)

Zinc is required for the better development and function of cells involved in innate immunity, these includes neutrophils, natural killer cells, phagocytosis, and cytokines (Prasad, 2008). Animals with zinc deficiency have reduced levels of thyroid hormone, which leads to lymphocyte depletion. Zinc is also necessary for the activation of B lymphocytes. Zn-deficient cells have a lower ability to proliferate. Because the immune response necessitates fast cell proliferation (e.g.T and B-lymphocytes) in response to specific antigens, Zn deficiency prevents this aspect of immunity from developing.

Selenium

Selenium is a component of glutathione peroxidase, an enzyme that inactivates oxygen radicals like hydrogen peroxide and prevents them from causing cellular damage, according to Rotruck *et al.* (1973). Specific immune system components have been demonstrated to be affected by selenium (Mulhern *et al.,*1985). Serum IgM (an antibody produced by B cells) concentrations and anti-IBR virus titres were lower in selenium-deficient calves challenged with the infectious bovine rhinotracheitis virus, according to Reffett *et al.* (1988). When triggered with cytokines, bovine mammary endothelial cells grown in selenium-deficient cell culture conditions showed increased neutrophil adhesion, suggesting that selenium may alter neutrophil migration into tissues and consequent inflammation (Maddox *et al.,*1999; Spears, 2000).

Specific Nutrients and their Effect on Immunity

Essential amino acids, folic acid, vitamin B_6, vitamin B_{12}, vitamin C, vitamin A, vitamin E, linoleic acid, iron, zinc, selenium, and copper all have an effect on one or more immune indices in non-ruminants. Scientists have avoided studying the effects of ruminants because of their ability to manufacture amino acids and vitamins with the help of microbial population. However, few studies have shown that cobalt, copper, selenium, chromium, vitamin A, and E can help ruminants' immune systems (Spears and Kegley, 2002). Antioxidant nutrients have been proven to protect the immune system cell membranes, which are vulnerable to Reactive Oxygen Species (ROS) mediated damage. Vitamin C, E, carotene, and zinc, as well as selenium, have antioxidant characteristics that support the cell membrane, which enhances the immune system as a whole (Aderem and Underhill,1999).

Conclusion

Nutrition has a significant impact on an animal's lifetime immunity. During the early and late phases of an animal's life, its function is critical. Due to altered nutritional status and nutritional metabolism that influenced on the immune status of animals which influenced by a deficit of a single or a set of protein-energy, vitamins, and minerals. The key to changing the immunological status and raising the immunity of an animal is identifying particular nutritional deficiencies and supplementing with the appropriate nutrients for proper maintenance of immunity and health.

Conflict of Interests

There is no conflict of interest.

Contribution of Authors

During the writing of the manuscript, all of the authors contributed equally. They read the final manuscript and gave it their approval for publishing.

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References

1. Aderem, A., & Underhill, D.M. (1999). Mechanisms of phagocytosis in macrophages. *Annual Review of Immunology*, 7(11), 593-623.
2. Banchereau, J., Briere, F., Caux, C., Davoust, J., & Lebecque, S. (2000) Immunobiology of dendritic cells. *Annual Review of Immunology*, 18(1), 767-811.
3. Chandra, R.K., & Newberne, P.M. (2012). Nutrition, immunity, and infection: mechanisms of interactions. *Springer Science and Business Media, Netherlands.*
4. Chang, X., & Mowat, D.N. (1992). Supplemental chromium for stressed and growing feeder calves. *Journal of Animal Science*, 70, 559–565.
5. Chang, X., Mallard, B.A., & Mowat, D.N. (1994). Proliferation of peripheral blood lymphocytes of feeder calves in response to chromium. *Nutrition Research*, 14, 851-864.
6. Gengelbach, G.P., Ward, J.D., Spears, J.W., & Brown, T.T. (1997). Effects of copper deficiency and copper deficiency coupled with high dietary iron or molybdenum on phagocytic cell function and response of calves to a respiratory disease challenge. *Journal of Animal Science,* 75, 1112–1118.
7. Huntley, J. F. (1992). Mast cells and basophils: a review of their heterogeneity and function. *Journal of Comparative Pathology*, 107(4), 349-372.
8. Kheiri F., & Toghyani M. (2009). Effect of different level of chromium chloride on performance and antibody titre against Newcastle and Avian Influenza virus in broiler chicks. *16th Europeans Symposium on Poultry Nutrition.* pp 331-334.
9. Lee, W.L., & Downey, G.P. (2001). Neutrophil activation and acute lung injury. *Current Opinion Critical Care*,7(1), 1-7.
10. MacPherson, A., Gray, D., Mitchell, G.B.B., & Taylor, C.N. (1987). *Ostertagia* infection and neutrophil function in cobalt-deficient and cobalt-supplemented cattle. *British Veterinary Journal* 143, 348–353.
11. Maddox, J. F., Aherne, K. M., Reddy, C. C., & Sordillo, L. M. (1999). Increased neutrophil adherence and adhesion molecule mRNA expression in endothelial cells during selenium deficiency. *Journal of Leukocyte Biology* 65, 658–664.
12. Mazur-Bialy, A.I., Pochec, E., & Plytycz, B. (2015). Immunomodulatory Effect of Riboflavin Deficiency and Enrichment - Reversible Pathological Response Versus Silencing of Inflammatory Activation. *Journal of Physiology and Pharmacology*, 66, 6.
13. McEwen, B.J. (1992) Eosinophils: A review. *Veterinary Research Communication*, 16(1), 11- 44.
14. Michal, J.J., Chew, B., Wong, T.S., Heirman, L.R., & Standaert, F.E. (1994). Modulatory effects of dietary β-carotene on blood and mammary leukocyte function in peripartum dairy cows. *Journal Dairy Science,* 77, 1408-1422.
15. Minatel, L., & Carfagnini, J.C. (2000). Copper deficiency and immune response inruminants.*Nutrition Research*, 20(10), 1519–1529.
16. Mulhern, S.A., Taylor, G.L., Magruder, L.E., & Vessey, A.R. (1985). Deficient levels of dietary selenium suppress the antibody response in first and second-generation mice. *Nutrition Research*, 5, 201-209.
17. Paterson, J.E., & MacPherson, A. (1990). The influence of a low cobalt intake on the neutrophil function and severity of *Ostertagia* infection in cattle. *British Veterinary Journal*, 146, 519–530.
18. Prasad, A.S. (2008) Zinc in Human Health: Effect of Zinc on Immune Cells. *Molecular Medicine,* 14(5-6), 353–357.
19. Raulet, D. H. (1989). Antigens for delta T cells. *Nature*, 339, 342.
20. Reffett, J. K., Spears, J.W., & Brown, T.T. (1988). Effect of dietary selenium on the primary and secondary immune response in calves challenged with infectious bovine rhinotracheitis virus. *Journal of Nutrition*, 118, 229-235.
21. Rotruck, J.T., Pope, A.L., Ganther, H.E., Hafeman, D.G., Swanson, A.B., & Hoekstra, W.G. (1973). Selenium: Biochemical role as a component of glutathione peroxidase. *Science* 179, 588–590.
22. Sies, H., & Stahl, W. (1995). Vitamins E and C, beta-carotene, and other carotenoids as antioxidants. *American Journal of Clinical Nutrition*, 62(6), 1315S-1321S.
23. Smith, L.K., Harrison, J. H., Hancock, D.D., Todhunter, D. A., & Conrad, H. R. (1984). Effects of vitamin E and selenium supplementation on incidence of clinical mastitis and duration of clinical symptoms. *Journal of*

Dairy Science, 67, 1293-1300.
24. Spears, J. W. (2000). Micronutrients and immune function in cattle. *Proceeding of the Nutrition Society,* 59, 1-8
25. Spears, J. W., & Kegley, E. B. (2002). Effect of zinc source (zinc oxide vs zinc proteinate) and level on performance, carcass characteristics, and immune response of growing and finishing steers. *Journal Animal Science*, 80(10), 2747-2752.
26. Vellema, P., Rutten, V.P.M.G., Hoek, A., Moll, L., & Wentink, G.H. (1996). The effect of cobalt supplementation on the immune response in vitamin B_{12} deficient Texel lambs. *Veterinary Immunology and Immunopathology,* 55: 151–161.
27. Vivier, E., Tomasello, E., Baratin, M., Walzer, T., and Ugolini, S. (2008). Functions of natural killer cells. *Nature immunology,* 9(5), 503-510.
28. Ward, J.D., Spears, J.W., & Kegley, E.B. (1993). Effect of copper level and source (copper lysine vs copper sulphate) on copper status, performance, and immune response in growing steers fed diets with or without supplemental molybdenum and sulphur. *Journal Animal Science,*71(10), 2748-2755.

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