avitech scientific bulletin

SEPTEMBER 2002

NUTRITION AND IMMUNITY

The role and interactions between nutrition in immunity is a subject that has, of late been in focus. As the poultry industry expands and individual farm sizes and complexity of operations grow, disease challenge increases and formulating a diet that strengthens the immunocompetence of poultry is an area that, becomes increasing relevent.

Immunity

Immunity is the ability of a bird to fight infection and disease which is determined by its capacity to respond to an invading pathogen. The body protects itself against foreign materials such as bacteria and virus through its immune system. Invading organisms trigger the action of lymphocytes i.e white blood cells or macrophages (scavengers in the body). These lymphocytes are produced and programmed by Bursa and Thymus and are called B-cells and T-cells respectively. B-cells migrate to the spleen where they produce antibodies on stimulation by the antigen, which is referred to as Humoral immunity. The thymus, which is found in the neck of the bird, produces T–cells that work in cooperation with macrophages to kill invading bacteria and virus. This is referred to as CMI (Cell Mediated Immune response). Generally, humoral immunity is the main defence against bacteria, whilst CMI is critical for protection against virus.

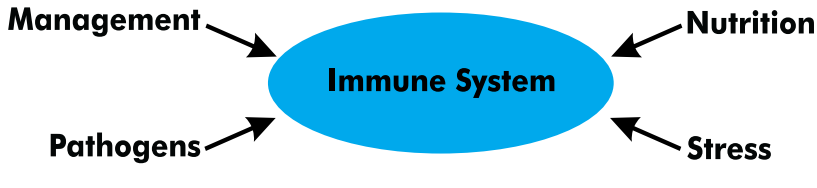
Passive Immunity (Maternal Immunity)

A day old chick has an inadequately developed immune system and therefore has to depend on the immunity acquired from the mother. This short lived immunity which is often referred to as passive immunity is acquired by the chick from the mother through immunoglobulins. Passive immunity status depends on adequate vaccination and antibody titre in breeding hens. The higher the titre in the hen, the greater the transfer to the chick. In diseases like New Castle Disease, IBD & IB, about 50% of the titre of the breeder hens is passed on to the chick. Titre level and titre uniformity in breeder hens, therefore, plays a critical role towards passive immunity in chicks.

Active Immunity

As the chicken grows, passive immunity is replaced by active immunity. Active immunity is derived from an active mechanism of immunity. Vaccines are used to stimulate the bird's immune system. Vaccination is one of the most effective ways of preventing diseases. A viral vaccine generally stimulates a greater immune response and therefore the use of viral vaccine to prevent diseases is a common practice. As drugs and antibiotics, have little or no role to play in viral infections, the control of viral diseases is through better husbandry practices and vaccination. Vaccination failures under field conditions occur due to complex interaction of many factors viz. Stress, mycotoxins, latent form of immunosuppressive diseases, underlying nutritional

Factors affecting the Avian Immune system



deficiencies, vaccine storage conditions, vaccination procedures etc.

Role of Nutrition in Immunity

Nutrition plays an important role in Immune enhancement.The nutrients recognized as having an important role in immunity are as follows:

1. Energy
2. Protein
3. Vitamins : A, E, C, B6, B12, Folic acid and choline
4. Minerals : Selenium, Zinc, Copper , Manganese and Iron.

The Role of Nutrients in Immunity

- **Energy**

The immune system is influenced by various hormones. Carbohydrates and fats influence the immune system by changing hormonal secretions inside the body. The hormones e.g thyroxin, corticosteroids , IGF-1 , growth hormones , insulin , glucagons, catacholamines are all influenced by the dietary intake of energy which in turn regulates the activity of the immune cells. Hence absolute requirement of energy will maintain the required proportion of these hormones.

Dietary fats affect immunocompetence either by altering the cell membrane structure or by modulating the synthesis of prostaglandins. Mortality associated with *E.coli* and *Mycobacterium tuberculosis* was reduced by increasing the level of fat from 3 % to 9% as reported in one study.

Coccidiosis most likely impairs micelle formation. Fat with a high content of short and medium chain triglycerides may not form micelles. Unsaturated fatty acids are less likely to face this problem.

Higher levels of dietary lipids especially unsaturated fatty acids enhance the immune function by stimulating macrophages. It has also been demonstrated that dietary fatty acid composition could increase the immune response against vaccinations. Polyunsaturated fatty acids have important structural functions notably in the brain and nervous tissues and are precursor of prostaglandin's, thromboxanes and leucotrienes, a group of hormone like compounds. Conjugated linoleic acid has shown to reduce the negative effects of cytokines in animals undergoing immune stress.

- **Proteins**

Protein is especially important for empowering the immune system as antibodies and T-cells are made of protein and need a constant supply to make sure that the chicken's body is well defended. The plasma amino acid pattern determines the immunoreactions. Dietary Methionine levels slightly in excess of the requirement for maximum growth rate are required in order to maximize the antibody titres. It has been studied that 0.65% Methionine and 3300 mg/kg diet choline enhanced humoral mediated immunity (Swain ,1996). Methionine deficiency produced severe lymphocyte depletion and atrophy of the bursa. Arginine is an important amino acid and has an unique role in immunophysiology.

Moderate to severe deficiency of proteins or specific essential amino acids in diet causes:

- altered functioning of the immune system,
- depression of antibody titre to the selected antigen,
- reduced lymphocyte population,
- reduced lymphocytic responses to mitogenic stimulation and
- increased susceptibility to infection.

It is of prime importance to supply the required quantity of protein at an early stage of the bird growth as both the important organs of the immune system i.e. Bursa and Thymus grow at a faster rate than the bird's own body. Any deficiency of protein at this stage leads to improper development of these organs leading to immunulogical stress to the bird and increases susceptibility to diseases.

In broiler chicks during the course of maintenance some 1.17% of Lysine requirement is used on the immune system. This rises to approximately 6.71% during a disease challenge and this is taken at the expense of growth. The highest priority for nutrients is

for the macrophages, which offer the front line defence mechanism. After macrophages comes the B-cells and T-cells.

In Coccidiosis the supply of protein should be decreased. If there is high dietary protein there will be an increased activity of the enzyme trypsin in the small intestine of the bird. This will in turn lead to faster release of coccidia from their oocytes, which will aggravate the coccidial symptoms. Studies by starving chickens prior to oral vaccination reduced infection, probably due to lower excystation resulting from lowered trypsin levels induced by starvation.

Nutrient recommendations are typically developed using indices of productivity such as growth and egg production. The criteria for adequacy of Immuno-competence are often not examined. Fortunately, for most nutrients, the levels, which optimize growth or reproduction, are also adequate for optimal immunocompetence. The leucocytes have a high position in the hierarchy of competition for nutrient use. During the acute phase of the immune response, the greatest nutritional need is for the synthesis and release of acute phase proteins by the Liver. This process requires more energy and amino acids than needed by responding leucocytes. Synthesis of acute phase proteins is comparatively more sensitive than specific immunity to deficiencies of several nutrients including amino acids and trace minerals (Hunter and Grimble, 1994, Koh et.al.,1996).

- **Vitamins**

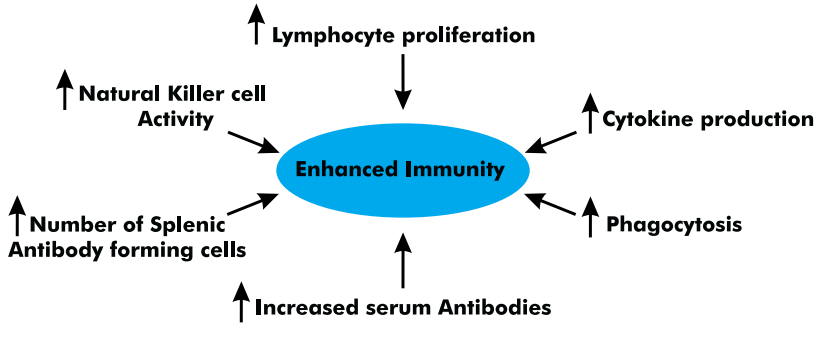
Vitamins have a wide range of metabolic functions, most frequently as cofactors in intermediary metabolism. Deficiencies of vitamins are well known to cause immune impairment. When fed in excess of requirements, however, the immune response can be stimulated.

Vitamin A

Chicks hatched from the hens deficient in vitamin A have a weak immune system and are more susceptible to a wide variety of infectious diseases. Mucous membranes of the eyes, respiratory and digestive tract are the immune system's first line of defence against invading pathogens. Vitamin A helps to keep these membranes healthy. Deficiency of vitamin A reduces the antibody response, causes lymphocyte depletion from bursa and thymus and result in lower weight of these organs.

Hydrocortisones which are immunosuppressive are also reduced by Vitamin A. Vit.A @ 14000 IU/kg diet increased the weight of Bursa, Thymus, Spleen and Liver (Swain, 1996). Vitamin A above minimum levels for growth is important in the prevention of severe lesions and losses from chronic respiratory disease (CRD). In therapeutic nutrition studies, administration of 60 IU of Vitamin A per chick per day during a severe attack of coccidiosis almost completely prevented mortality, whereas 100 % mortality occurred with vitamin A deficient diets. However, high levels of Vit.A interfere with Vit.E absorption and the potential for deleterious interactions in commercial diets exists. Veltmann et.al (1984) found that supplementing broiler diets with vitamin A increased the morbidity due to malabsorption (stunting) syndrome presumably by an interaction with vitamin D or vitamin E.

Immunological role of Vit. A



Vitamin D

Vit.D along with vitamin A, vitamin C and Vit E maintain the structural integrity of the

cells and increased the cellular and humoral immune response. Vitamin A, D & E have a direct regulatory action on the lymphocytes by binding to intracellular receptors or by modifying the release of second messengers. In Europe, 3000-5000 IU/kg of Vit.D are typically specified to support growth and minimize rickets. It also regulates the differentiation of monocytes to macrophages and osteoclasts.

Vitamin E

Vitamin E is well known to increase the antibody titres to antigens and to decrease mortality in the face of disease challenges. Vitamin E supplementation above the NRC requirement value of 20mg/kg increased the immune response and decreased mortality in the face of E. coli , New castle disease and coccidiosis. The levels needed to achieve this effect are typically in the order of 100-300 mg/kg. Injection of eggs with vitamin E can also enhance the immune status of young poultry, by minimizing its loss in plasma post-hatch. Vit E at the concentration of about 250mg/kg was observed to prevent drop in production by laying hens exposed to periods of chronic heat stress. Heat stress depresses egg production due to depressed secretion of vitellogenin from the liver, even though its synthesis was not impaired . Vitellogenin is a precursor of egg yolk proteins and is the major protein taken up by developing oocytes.

Vitamin E is a fat-soluble vitamin stored in the lipoprotein fraction of cell membranes. Selenium forms an integral component of the enzyme glutathione peroxidase , a cytosolic enzyme present in all cells. Vit. E in cell membrane and glutathione peroxidase together form a vital part of the biological antioxidant system stabilizing the oxidation-sensitive fatty acids in cellular metabolism.

Rapidly proliferating cells of the stimulated immune systems are particularly prone to peroxidative damage by free radicals like peroxides and superoxides. The role played by vitamin E and Selenium in enhancing phagocytic activity and immune response is by maintaining low levels of free radicals in cells and thus preventing the formation of lipid peroxidases and damage to vital organelles of the cells. Researches have shown that low levels of Vit.E & Selenium resulted in depressed bursal weight , reduced overall number of lymphocytes found in other lymphoid organs. Vitamin E is also known to have a role in production of prostaglandins, the compounds that regulate the immune response. Supplemental Vit.E (300 mg/ Kg diet) in poultry was shown to reduce prostaglandins levels in the immunopoietic organs and simultaneously improved antibody responses. In breeder hens this resulted in greater transfer of passive antibody to the progeny.

Supplementation of high levels of Vit.E in ration in E.coli, Infectious bursal disease and Newcastle disease infection have given effective results. E.coli infection in broiler chickens is most prevalent from 35 days onwards. Strategic application of high vitamin E (150 to 300 IU/Kg) from 32 days of age for about 10 days can be useful.

Vitamin C

Vitamin C is one of the most vital nutrients for a healthy immune system as it boosts the immune system. Vitamin C increased antibody protection against sheep red blood cells and Newcastle disease virus. It enhanced phytohaemagglutinin-mediated proliferation of lymphocytes and delayed type hypersensitivity response (cell mediated immunity). It also improved disease resistance against Infectious bronchitis, New Castle disease, Marek's disease, E. coli and Mycobacterium avium. Vitamin C mediated stimulation of immunity is most efficacious when birds experience environmental, nutritional, social or pathogenic stressors. Vitamin C has also antioxidant properties and maintains the stability of leucocyte membranes in the face of higher levels of reactive oxygen intermediates at inflammatory sites. Vitamin C has a strong fighting action against Salmonella gallinarum when fed at a high level of 1000 ppm daily for 3 weeks. The improvement was related to the increased production of immunoglobulins specific to such infections, the alleviation

of nutritional anaemia and stress.

Vitamin B-complex

B vitamins are needed for a healthy immune system. Administration of vitamins like B_2, B6, B_{12} have positive effects on the body weights and immunomodulatory effects under heat stress. Vitamin B requirements are reassessed periodically, as performance of modern genotypes improve. Fatty liver and kidney syndrome is occasionally seen in modern broilers, which may be due to non-inclusion of Biotin in their diets. Dietary supplementation of Biotin is necessary for antibody production in Reovirus infection responsible for Mal-absorption syndrome. Deficiency of Vit.B6 has an adverse effect on cell multiplication and immune functions. It is also important for the development and maintenance of the lymphoid tissue.

- **Minerals**

Zinc

Immunological role

Zinc supplementation increases

- Thymocyte count in Thymus
- Peripheral T-cell count
- Natural Killer cell activity
- Macrophage function
- Neutrophil activity
- Antibody production

Role of Zinc against viral infection:

✓Reduces viral penetration

✓Increases production of antiviral Interferon.

✓Inhibits proteases involved in viral capsid formation

Zinc deficiency causes hypoplasia of Thymus, Spleen, Lymphnode and Lymphoid organs and also decreases T-cell function. Zinc deficiency in breeder diets also decreases antibody response in the progeny

Selenium

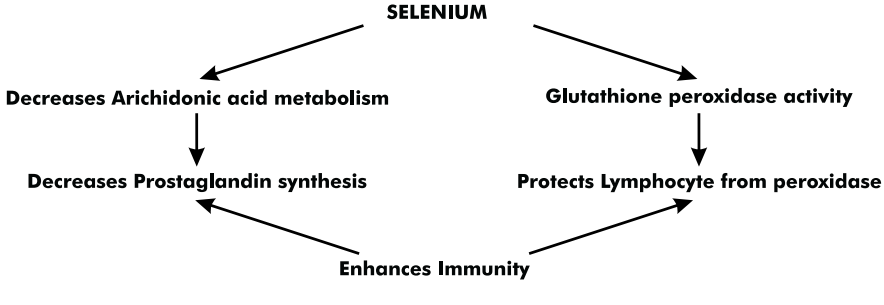
Selenium @ 1 mg/Kg diet has shown to have an immuno-stimulatory role. Feather development is stimulated by thyroid hormone, and improving selenium status has been associated with earlier and more complete feathering broilers. Inadequate selenium intake or intake of a selenium source that has low biological activity results in poor semen quality, reduced egg hatchability and in some cases, low livability and future performance of the young.

Manganese

Manganese plays an important role in poultry metabolism, bone development, bone strength, egg production, growth, reproduction and enzyme activity. Polymerase enzyme, which is manganese dependent, forms the shell glycoprotein matrix as foundation. Zinc and manganese have impact on epithelial tissues, and hence also have impact on reproductive tract, footpad quality, intestinal morphology and intestinal lesions. Epithelial tissue is the first line of defence. Manganese also plays a role in the development, repair and maintenance of epithelial tissues.Highly bioavailable form of these minerals like organic minerals helps in reducing the incidences of cellulites and decrease the footpad lesions by 25-30%. This reduces greatly the lameness problems in breeder hens. Organic minerals also showed a higher titer response for infectious bronchitis, IBD and New castle disease in breeders.

Copper

Many of the copper dependent enzymes play a role in the immune system. Copper is also necessary for enzymes that are necessary to increase structural strength and elasticity of connective tissue such as the eggshell membrane and blood vessels, and increase bone strength. Providing copper in a highly bioavailable amino acid



complex form is an excellent way of ensuring maximum broiler breeder performance.

Iron

Iron is an interesting trace element in that either a deficiency or excess can compromise the immune system. It has been well documented that serum iron falls early in response to bacterial and viral infections and rebounds quickly with recovery. This hypoferremia is believed to be an important protective component of the acute phase response to infection. Once the infection is established, iron supplementation has been shown to increase the bactericidal activity of Liver and splenic macrophages. For example, chicks innoculated with *S. gallinarum* had significantly increased survival when iron (100 ppm of diet or more) was added to a basal diet containing 200 ppm of iron (Berger, 1996).

Others

Biogenic performance enhancers (BPE)

BPE were recently developed and are used as feed additives to enhance the immune response. These products are biologically active complexes and have naturally occurring ingredients such as purines and pyrimidines, with heat processed dried brewers' yeast as carrier. They improve the immune response leading to an increased resistance to pathogens, with a resulting improvement in other parameters such as fertility and egg production.

Conclusion

In summary, the immune system is one of the most complex and intricate cellular and molecular interactions known in all of biology. All the nutrients discussed act as keys, which unlock the ability of the immune system to ward off invaders. Proper nutrient supplementation will not eliminate disease, but it will allow the animal's immune system to operate at optimum levels to minimize the risk of infection and disease.

References:

1. Bains,B.S.(1994). Vitamin E and immunity in Poultry. World Poultry- Misset Volume 10 No.7.Pg.-51.
2. Berger,L.L.(1996).Trace Minerals: Keys to Immunity. Collected from the website of Salt Institute. Pg.1-7.
3. Dhawale,A.(1998). Immunostimulators in Poultry: A Review. Poultry Punch.Feb.Issue- 63-72.
4. Hunter,E.A.L., and R.F.Grimble (1994). Journal of Nutrition. 124: 2319-2328.Issue 14, 4-5.
5. Jacques,K,A. (2002). How Selenium works. Feeding Times. Vol.7. No.2.Pg,10-11.
6. Kidd, M.T., Ferket, P.R. and M.A.Qureshi. (1996).Zinc metabolism with special reference to its role in immunity. World's Poultry Science Journal, Vol.52,Nov. 309-324.
7. Koh,T.S..,R.K.Peng, and K.C.Klasing.(1996). Poultry Science 75: 867-872.
8. Mellor,S. (2002).The Impact of Vitamins on Bird Health and Performance. Poultry Jagat. Vol.XVII,
9. Swain,B.K.(1996). Ph.D. Thesis submitted to I.V.R.I., Izatnagar,Bareilly (U.P.)India.
10. Swick,R.(1995). Importance of Nutrition on Health Status in Poultry. ASA Technical Bulletin.po15-1995.
11. Veltmann Jr.,J.R., L.S.Jensen, and G.N.Rowland. (1984). Avian Dis.29:446-452.

AVITECH
ANIMAL HEALTH PVT. LTD.

Corporate Heights, SCO - 24, Sector - 14, Gurgaon 122001 India

Ph : (0124) 6315044 / 45 / 46 Fax : (0124) 6314680 email : avitech@vsnl.com