



# Microalgae for immunomodulation and gut health improvement in poultry industry

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## ABSTRACT

The upsurge in the poultry products demand have made it indispensable for augmented supply of quality feed and nutrition to the poultry industry. The extreme use of antibiotics as growth promoters in poultry industry have outstretched the problems of microbial resistance to antibiotics and entry into the food chain, ultimately affecting the consumers. Thus, emphasis to enhance the immunity of birds is essential. This can be achieved with immune modulators and gut health promoting ingredients used as a supplement in the feed. Novel sources as microalgae can be a part of poultry feed ration, owing to its rich protein, essential amino acids, fatty acids profile and presence of bioactive molecules that have immunomodulation and gut health-enhancing properties. The current review emphasizes the need of immunomodulation and gut health in poultry industry and highlights specifically role of microalgae in immunomodulatory response and gut health improvement in birds.

**Keywords:** Immune modulation, Gut health, Microalgae, Poultry.

## INTRODUCTION

Global poultry sector is burgeoning constantly due to perpetual upsurge in demand of poultry products (Steinfeld, 2003). To cater this high demand, it becomes imperative to increase the quality production of eggs and meat. Some of the peculiar advantages of poultry over other meat businesses include high FCR (Feed Conversion Ratio), high economic returns (due to short life cycles), comparatively small land requirement for poultry set up than other animals and higher employment opportunities ([www.poultrytrends.com/2016](http://www.poultrytrends.com/2016) ; Wahyono et al., 2018).

Although poultry provides numerous fringe

benefits, poultry industry aims for effective disease control, increasing demand, product quality and evenhanded production costs (Hafez et al., 2020). Out of the mentioned objectives, consumers prevalently are concerned about the poultry products quality and safety (FAO Statistics 2020; USDA 2020; Hafez, 2010). Literature elaborately indicates the occurrence and cause of food borne illness due to Salmonella and Campylobacter sp. in poultry industry (CDC 2012). To combat the infection, abusive use of antibiotics resulted into resistant strains, which is challenging and alarming for public health. Fortification of poultry diet with antibiotics promotes the growth and modify the immune system of chickens (Barcelo, 2007), but certainly, these antibiotics and antimicrobial agents

penetrates into the food chain, which may have negative impacts on consumers. Consequently, the immunity of the bird is the most vital factor for poultry industry, where the immunity of the bird must be modulated in a sustainable way.

The effective way of combating the issue is "alternative to antibiotics"- which are simply demarcated as "the substance that can be substituted for therapeutic drugs" (Kogut, 2017). The current mini review emphasizes on use of feed additives in poultry industry to strengthen the immune system and gut health of birds and role of microalgae in immune modulation and gut health improvement of poultry birds.

## IMMUNE MODULATORS AND MODE OF ACTION

Immune system plays a fundamental role in growth and development of birds, moreover helps in prevention of various diseases. Typically, avian immune system has two types of immune responses that are innate and acquired responses. Innate immune response is "non-specific" and major components are mucosal epithelium, secretions of gastric and respiratory track, soluble serum proteins, phagocytic cells, T-cells, thrombocytes, eosinophils, basophils and natural killer (NK) cells (Delves et al., 2000). These cells of innate immune system recognizes the patterned biomolecules which are usually known as pathogen or danger associated molecular patterns (P-DAMP) which includes polysaccharides, nucleotides, nucleic acids, glycoproteins and lipoproteins. These P-DAMP's are recognized by the cells of innate immune system, which activates the acquired immune response. This interplay of innate and acquired immune responses provides complete defence against the pathogens. Poultry industry is vulnerable to various bacterial and viral diseases thus immune system of birds play a crucial role in driving the economics of poultry businesses. As mentioned earlier, surplus use of antibiotics

develops resistance in pathogens, which is an alarming situation for public health. One of the pre-eminent solution to this problem is use of "immune modulator" as a feed ingredient. Immune modulators are either natural or synthetic substances, which stimulate, suppress, regulate and normalize any component of immune system (Agarwal et al., 1999).

Dhama et al., 2015 reported some of the key objectives of immune modulators against internal and external pathogenic invasions:

- To elicit potent immune response against disease causing pathogens.
- To improve immunity throughout in neonatal period.
- To boost local protective immune reactions at susceptible sites.
- To overcome immunosuppressant effects due to various factors.
- Post vaccination-enriched and long-term immune response.
- Maintain immune surveillance.

## TYPES OF IMMUNE MODULATORS

Broadly there are two types of immune modulators- immune-stimulants and immune-suppressants. Immune stimulants activate the immune systems against the pathogenic invasion whereas; immune suppressants typically subdue the immune response and mostly used in treatment of autoimmune diseases (Das et al., 2020). Literature highlights use of various immune modulators and its importance in poultry industry. Table 1 summarizes various feed additives as immune modulators reported in poultry industry (Hadden 1996; Chao et al., 2008; Lee et al., 2013; Lee, 2008; Gao et al., 2008; Schwartz et al., 2021; Emadi et al., 2007; Jang et al., 2007; Krishan et al., 2014; Koutsos et al., 2003; Yuan et al., 2014; Garbe, et al., 1992; El-Senousey et al., 2018, Das et al., 2020; Qaisrani et al., 2015; Zhang et al., 2011).

**Table 1.** Various immune modulators used in poultry industry as feed additives and their mode of action.

Sr.no	Immune modulator	Mode of action
1	Probiotics and Prebiotics	Transforms intestinal microbiota and immune system to lower pathogens colonization
2	Cinnamaldehyde	Suppresses the lipopolysaccharide-induced production of TNF , interleukin 6 (IL-6) and IL-1
3	Mixture of capsicum and turmeric oleoresins	Effective against necrotic enteritis
4	Oriental Plum Powder	Increases interferon gamma (IFN- $\gamma$ ) and IL-15 levels
5	Yeast Product Supplementation	Positively modified innate and acquired immune system by enhancing antibody (Serum Ig M) titres against Newcastle disease virus, increases IgA concentration in duodenum
6	$\beta$ - Glucans	Improved macrophage phagocytic activity, proliferation of white blood

		cells, increasing activity of NK cells Synthesize tumour necrosis factor (TNF)- $\alpha$ , IL-1 $\beta$ , interferon (IFN)- $\gamma$ , IL-2, and IL-4 thereby by maintains the integrity of digestive track
7	Turmeric Rhizome Powder (TRP)	Increases blood IgA, IgG, and IgM levels and decreases the ratio of monocytes in broilers dosed with SRBCs (sheep red blood cells)
8	Essential oils	Boost trypsin, amylase and jejunal chyme secretions. Reduces the pathogens adherence to intestinal wall
9	Vitamin A	Enhances antibody titres against Newcastle Disease Virus (NDV) by modulating T cell number and critical immune functions in chickens
10	Vitamin C	Prevents oxidative stress by decreasing mRNA expression levels of IL-1b, IL-6, and IFN- $\gamma$ in broiler chickens
11	Butyrate	Improves weight gain, carcass characteristics and increase in size of intestinal villi in birds. Growth promoting effects in broilers.

## MICROALGAE AS A POTENTIAL IMMUNE MODULATOR AND ITS ROLE IN GUT HEALTH IMPROVEMENT IN POULTRY

Considering the detrimental effects of antibiotics, European Union has banned use of antibiotics as growth promoters in poultry nutrition (European commission 2001). This had opened prospects for development of new antimicrobial agents as a feed additive, which potentially can be safe and satisfy the objectives of immune modulation. A microalga provides opportunities for development of novel immune modulators, which may be incorporated as an additive in the poultry feed.

Microalgae are unicellular or multicellular photosynthetic organisms, which flourishes in fresh, or seawater. These organisms are excellent sources of valuable nutrients like proteins, essential amino acids, essential fatty acids, carotenoids, antioxidants, vitamins, minerals etc. The rich nutritional profile of microalgae has gained interest and applied in development of novel products (El-Ghany et al., 2020). Literature explicitly highlights microalgae potential as immunomodulatory, anti-inflammatory, antioxidant, antimicrobial and antiviral properties, evaluated through various animal trials (Uyisenga et al., 2010; Abdel-Daim et al., 2013; Shokri et al., 2014; AbouGabal et al., 2015). Microalgae are potential feed additives for humans and promising replacement of feed rations in animals and poultry (Yoshida et al., 1980; Vonshak, 2002; Meineri et al., 2009; Kanagaraju et al., 2016). Pertaining to the use of antibiotics in poultry feed, literature highlights the potential of microalgae as immune modulators.

The interplay of the immune, gut health and microbiota plays a crucial role in safeguarding poultry business from threatening diseases like necrotic enteritis, which has prominently hit the poultry sector since years (Broom, 2017). Although, gut health is not defined clearly however, as a holistic approach it considers morphological and physiological functions of intestinal tract, which includes digestion, absorption of nutrients, energy balance, efficient immune response, inflammatory balances and adequate microbiota (Diaz et al., 2019).

Microalgae are well known for their rich nutritional properties which may help to strengthen the gut health of birds and overcome the shortcomings in poultry industry due to poor gut health. Concrete literature surveys emphasizes that the incorporation of microalgae in diets of animals have demonstrated to improve the immune response and gut function of the animals (Nakagawa, 1997; Michiels et al., 2012). One of the study reported use of microalgae as prebiotics, which improved gastrointestinal health of birds (Sako et al., 1999).

In another study, microalgae positively influence gut health and decrease inflammation caused by the pathogens (Baurhoo et al., 2007). Table 2 highlights the use microalgae as immune modulators and its role in gut health improvement of poultry birds and mode of action (Qureshi et al., 1994; Qureshi et al., 1996; Al-Batshan et al., 2001; Mariey et al., 2014; Farag et al., 2016; Lokapirnasari et al., 2016; Samia et al., 2018; Rezvani et al., 2012; Kor et al., 2015; Kang et al., 2013; Cheng et al., 2004; An et al., 2008; Guzmán et al., 2003; Austic et al., 2013; Waldenstedt et al., 2003)

**Table 2.** Role of microalgae in immune modulation and gut health improvement in poultry birds.

Sr.no	Microalgae strain	Immunomodulation function and Role in Gut Health Improvement
1	<i>Spirulina sp.</i>	Enhanced phyto-haemagglutinin mediated propagation of lymphocytes and phagocytosis of macrophages. Aids in development of lymphoid organs.
2	<i>S. platensis</i>	Increased leukocyte count and macrophage phagocytic activity in H5N1 infected chickens Exhibited antimicrobial, immune-modulatory, anti-inflammatory and antioxidant

		activity Increased antibody titres against NDV in layers. interferon Increased proteins levels in birds dosed with sheep red blood cells (SRBCs)
3	<i>Chlorella sp.</i>	Supplementation with Chlorella enhanced phyto-hemagglutinin reaction, which binds to T cells and stimulates metabolic activity and cell division detected in broilers. Chlorella supplemented in drinking water of laying hens increased antibody titres against SRBCs by increasing the levels of IgM and IgG Used as replacement of antibiotic growth promoter with and showed improved immune indices and the intestinal micro floral population
4	Algal $\beta$ -glucan	Improved cell mediated immune response through modulating macrophage activity. Elevates NDV specific antibody titres on supplementation of algal $\beta$ - glucan
5	Chlorella stigmatophora <i>Phaeodactylum</i> <i>tricornutum</i>	Extracts reported to have anti-inflammatory, analgesic and free radical scavenging activities
6	<i>Staurosira sp</i>	Partial replacement of soybean meal with microalgae in feed had no adverse effects on growth performance, plasma and liver biomarkers
7	<i>Haematococcus</i> <i>pluvialis</i>	Partial replacement with Haematococcus reduced caecal Clostridium perfringens count

## CONCLUSION

The promising role of microalgae as immune-modulator and gut health enhancing properties will revolutionize the poultry sector in term of quality and nutritional feed. Potential of microalgae as immune modulator will surely replace the abusive and threatening use of antibiotics and help to maintain the gut health of the birds. Additionally, microalgae can be a reliable, sustainability driven and cost economical alternative ingredient in poultry ration. However, successful commercialization of microalgae as ingredient require further advancements in large scale production and downstream processing of microalgae derived products.

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