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Therapeutic and Nutritional aspects of Spirulina in Aquaculture

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Abstract

Fish nutrition plays a critical role in promoting proper growth and health in sustainable fish farming. The conventional fish feeds are not so cost effective and eco-friendly for maintaining fish health. Thus, alternative fresh feed with high nutritional values especially plant derived demand is increasing day by day for massive expansion of aquaculture. The unconventional fish meal ingredients like Spirulina is used as a fish feed to replace expansive feeds. The good nutritional profile and additional bioactive components like sulphated polysaccharides, phycocyanin and gamma-linolenic acids seem to increase physiological activity and growth. Its therapeutic properties such as anti-oxidative, immunotoxicity, starvation tolerance, immunostimulant, anti-inflammatory, anti-bacterial and carcass quality provide disease resistance in fishes.However, no side effects of Spirulina feeds have been reported and this can be used as the best alternative plant based nutritional feed for aquaculture with such a good nutritional and therapeutic characteristics.

Keyword: *Fish; Health; Feed; Nutrition; Physiological effect*

Introduction

The aquaculture insistence is growing day by day in so far as the main source of animal protein demands for human nutriment (FAO, 2018). So, it is mandatory expand fish production by promoting comprehensive fish farming in order to increase manifold the productivity per unit area. So, to compensate this productivity rate high stocking density of culture practices should be emphasized on fish feed and commercialisation which are the most significant factors. Aqua feed has many ingredients in highly balanced nutritious components for enhancing the digestive mechanisms in fish and shrimp body. It leads the better body weights, high health, optimum immunity, more survivals, less incidence of disease etc. in aquaculture ponds. Spirulina is a unique high quality natural diet with enriched optimum protein for fish and shrimp which has proven as a best supplementary feeding in aquaculture.

Spirulina is blue green algae like a spiral of long thin threads under genus Arthrospira, the phylum Oscillatoriaceae. Spirulina is called blue green algae (Cynobacteria) because of presence of both green (chlorophyll) and blue (phycocyanin) pigments in its cellular structure. The two common species more important for their nutritious value are Spirulina maxima and *Spirulina plantensis.*

The Aztecs civilization used it first time as an endurance-booster-and now-a-day spirulina is devoured as staple diet itself. Spirulina is crammed of proteins, vitamins especially β-carotenes & vitamin B12, minerals and 4-7% lipids of its biomass. Moreover, it is also

rich source of trocopherols, phenolic acids, γ-linolenic acid and lacks cellulosic cell wall which makes it tastier and easily ingestible (Dillon et al., 1995). The therapeutic values of Spiulina like anti-oxidative (Reddy et al., 2003), anti-inflammatory & immunomodulatory effects (Hirahashi et al., 2002) reported in vitro and in vivo studies. In recent times, the spirulina feed supplements in aquaculture, poultries and hatcheries, aquariums etc. are commercialized in different countries. So, owing the spirulina feed use, cultivation methods at large scale with different species is always an engrossing area of interest.

Nutritional aspects of Spirulina in aquaculture

In aquaculture management dietary supplements play a critical role in overall productivity rate. As a major dietary constituent, Spirulina is capturing more attention and acceptance as fish meal due to high protein, vitamins and essential fatty acid content. Moreover, the culturing process, harvesting and processing of Spirulina is very easy and cost effective. Nutritional components of Spirulina ranges between 60-70% proteins (Ishimi et al., 2006) including all the essential amino acids in appropriate concentration, carbohydrates, fatty acids like α- linolenic acid, eicosapentaenoic acid, docosahexaenoic acid, γ- linolenic acid, and ψ-3 and ψ-6-poly unsaturated fatty acids (Mendes et al., 2003), vitamins and minerals which are in adequate concentration and comparable to other in use fish feeds (Allen, 2016). These components altogether will increase all nutritional quality of fishes which is also beneficial for human health (figure 1). The shelf life of feed is more than other feeds due to presence of phenolic compounds and enhances the absorbability of constituents (Milié et al. 1998 & Nandeesha et al. 1998).

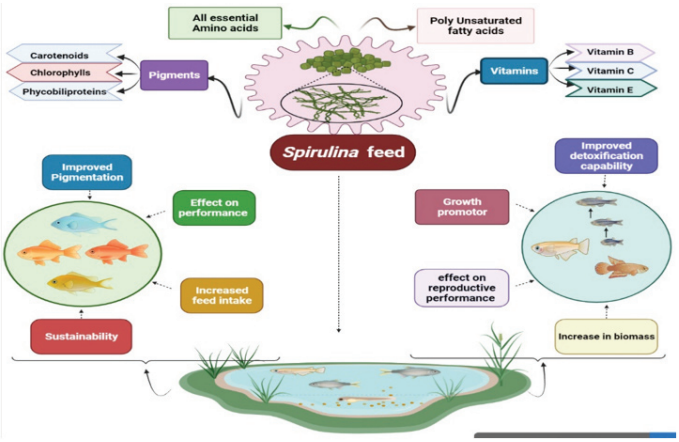

Figure 1: *Nutritional Aspects of Spirulina in fish.*

Spirulina as a growth promoter

Ayyappan et al., 1991 revealed the significance of Spirulina in fin-fish culture as analysed the quality of Spirulina meal fed in Indian major carp such as Rohu (Labeo rohita) and Mrigal (Cirrihinus mrigal) showed more growth rate than common carps, grass carp and catfishes. Therefore,concluded the Spirulina mealas a better substituent of protein source of feed as growth promoter in both herbivorous fishes and omnivorous fish cultures. Along with increase in growth rate,body weight of fishes also linearly rise in Spirulina meal in diet more than 25% (Nandeesha, et al. 2001and Guroy, et al. 2012).

In addition to fish culture Spirulina diet has remarkably improved the survival, growth rate and feed utilization in prawn culture (Macrobrachium rosenbergii) with dietary level range 5-20%. Similar study is reported on the juvenile's white shrimp species of Litopenaeus vannamei fed with partial Spirulina diet & show the promising results with better health and growth rate (Hanel et al., 2007).

As a colouring agent

Red Tilapia fishes fed on diet as main constituent i.e. 30% Spirulina platensis possesses more content of carotenoids than those not fed on Spirulina and demonstrated that Spirulina in Red Tilapia diets imparts a chief role in pigmentation and can be exploited as dietary source for coloration agent to gain more market acceptance (Ruangsomboon et al. 2010). Thus, Spirulina feed supplements have good remarkable impact on fish pigmentation and growth rate in aquaculture.

Therapeutic values of Spirulina as fish feed

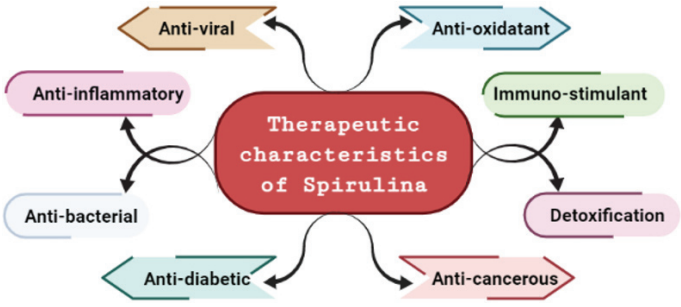

Figure 2: *Diagrammatic representation of therapeutic characterstics of Spirulina.*

Spirulina is a nutraceutical food supplement, but its additional possible health advantages created a lot of interest in recent years as a possible source of medicinal compounds and has been shown in multiple studies shows its therapeutic values, including antioxidant, immunomo-stimulatory, anti-inflammatory, anticancer, antiviral, and antibacterial properties (Hoseini et al., 2013; Wu et al., 2016) (figure 2).

Anti-oxidant properties

Aquatic animals use a variety of defence mechanisms to resist free radical damage, including antioxidant enzymes like glutathione S-transferase, catalase, and Superoxide dismutases, as well as compounds like glutathione, ascorbic acid, polyphenolics, carotenoids, and alpha tocopherol. It has a positive effect on haematological, biochemical indices, Malondialdehyde, superoxide dismutase, and catalase in Nile tilapia at a concentration of 1% (Mahmoud et al., 2018). S. platensis contains a high amount of beta-carotene, which can scavenge ROS molecules such as peroxyl, alkoxyl, and hydroxyl radicals, as well as have a role in reduction of nitrite and nitric oxide synthase to reduce liver lipid peroxidation. Dietary supplementation with 100% spirulina could be a useful addition to fish diet and a viable treatment for iron-induced oxidative stress in Notopterus notopterus (Kumar & Sibi, 2020).

Anti-bacterial properties

Against harmful microorganisms, spirulina has powerful antibacterial properties (Qureshi and Ali, 1996). The use of 0.1 percent Spirulina resulted in increased bacterial clearance (E. coli and S. aureus) 30 minutes after injection, with nearly undetectable in the blood. Spirulina's immune-potentiating properties were credited with the increased bacterial clearance. The methanol extract of S. platensis more influential than dichloromethane and volatile antibacterial components in terms of antimicrobial activity (Voet al., 2015).

Anti-viral properties

In addition to antibacterial Spirulina exhibit antiviral properties that inhibited viral replication at higher concentrations while reducing viral replication at lower concentration. Furthermore, it reduces viral cell penetration and replication of Virus in a dose-dependent manner. The antiviral effect is attributed to a sulphated polysaccharide known as "Calcium Spirulan" (Ca-Sp), which has been demonstrated to suppress viral replication by preventing viral entry into target cells without causing host damage. Because of its minimal anticoagulant activity, long half-life in the circulation, and dose-dependent bioactivity, active Ca-Sp could be a viable option for therapeutic intervention against HIV-1 and other viruses (Hayakawa et al., 2000)

Detoxification properties

Spirulina has a one-of-a-kind ability to detoxify (neutralise) or chelate harmful minerals, which has yet to be confirmed in any other microalgae (Khan et al., 2005). Arsenic from water and food can be detoxified using spirulina. Bioactive compounds from spirulina have been isolated at Beijing University, and they have shown anti-tumour activity as well as the ability to neutralise or detoxify harmful and deadly effects of heavy metals. As a result, spirulina could be utilised to chelate or detoxify heavy metals (minerals) harmful effects in water, food, and the environment (Jung et al., 2019).

Anti-inflammatory properties

Phycocyanin of spirulina seems to have an anti-inflammatory impact by inhibiting the formation of leukotriene B4, an inflammatory metabolite of arachidonic acid. C-phycocyanin is a scavenger of free radicals and has hepatoprotective properties. It also avoided inflammatory stomach and intestinal illnesses, which are necessary for adequate nutrient absorption (Wu et al., 2016).

Immuno-stimulatory properties

Immunostimulants may provide protection against infections by increasing nonspecific defence systems that are necessary to reduce stress and illness (Talpur et al., 2013). Various fish species, including channel catfish, Nile tilapia, rainbow trout, and great sturgeon, have been demonstrated to exhibit immunostimulation effects from spirulina (Promya & Chitmanat, 2011;Ragap et al., 2012; Yeganeh et al., 2015; Adel et al., 2016). Fish immune systems can be stimulated by spirulina by boosting phagocytic activity, lysozyme activity, skin mucus bactericidal activity, and WBC levels. It can control the expression of cytokine genes in tilapia leucocytes, which operate as signalling molecules in the immune system (Khalil et al., 2017).

Anti-Cancerous properties

Spirulina has been examined for anti-cancer properties, either alone or in combination with other substances, and its mechanisms of action have been well-described through a number of pathways. It has been shown to reduce oral carcinogenesis in different animal. Supplementing with spirulina lowered the incidence of liver tumours from 80% to 20%. Chen & Wong, 2008 found that at 48 hours after treatment, there was a significant reduction in

p53, as well as suppression of cell proliferation, increased p21, and decreased retinoblastoma expression levels. Spirulina also boosted Bax expression while decreasing Bcl-2 expression, indicating apoptotic induction.

Anti-Diabetic properties

Now-a-days, spirulina has been shown to have anti-diabetic and anti-obesity properties. It's water-soluble fraction is efficient in decreasing serum glucose levels during fasting, while the water-insoluble fraction lowered glucose levels upon glucose loading (Takai et al., 1991). Mani et al., 1998reported that Spirulina supplementation at 2 g/day for 21 days resulted in a significant reduction in fasting blood sugar levels. spirulina has also been demonstrated to lower blood pressure.

Conclusion

Spirulina is a non-toxic and an excellent nutritional supplement for numerous fish species, as it improves growth, carcass composition,disease resistance, reproductive function, and pigmentation. However, it is a nutraceutical food supplement, but it has additional therapeutical aspect to improve health including antioxidant, immunostimulatory, anti-inflammatory, anticancer, antiviral, and antibacterial properties. As a result, spirulina can be used as a potential replacement for animal-derived proteins in fish diets to improve fish weight and promote growth which is basic requirement for fish farmers to improve its income source.

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