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Spirulina as a Feed Supplement in Aqua Feed

S Jeyaprakashsabari[1], M V Rajeshwari[2] and T Nivetha[3]
[1]Scientific Assistant, [2]Scientist C, [3]Research Scholar, Centre for Aquaculture, Sathyabama Institute of Science and Technology, Chennai

SUMMARY

Animal based protein sources were commonly used in all the aqua feed formulation in the aqua feed industry. Especially fish meal and fish oil were the mostly consumed protein and lipid sources in aqua feed. But in the recent times due to their over consumption, their production trend tends to decrease coupled with higher price. So now the formulator's aims at utilizing the algae – spirulina, a plant based protein source, as an alternative source of protein to replace fish meal in aqua feed in-order to reduce the operating cost in aquaculture.

INTRODUCTION

Globally the consumption rate of animal protein was increasing gradually, which leads to higher the demand for the feed ingredients to be used in animal feed production. Especially in aquaculture, aqua feed industry mainly depends on animal protein sources; particularly fish meal is the major protein source to be used in every aqua feed. But due to its high price and demand, researchers are now encouraged to shifting from animal to plant based protein feed ingredient as a replacement for fish meal in aqua feed (Dawood et al., 2020b). Among various plant sources Spirulina – micro algae will be a promising protein feed ingredient. Spirulina is nothing but a dried biomass of blue green algae, which is a multi-cellular, filamentous and photoautotrophic cyanobacterium (Vonshak and Tomaselli, 2000). They naturally distributed over the tropical and sub-tropical water bodies which are highly alkaline and saline in nature. Three species are cultivated worldwide with *Arthrospira platensis* ranks first followed by *Arthrospira fusiformis* and *Arthrospira maxima*. They are highly nutritional, contains upto 60-70% protein which makes them to be used in the diet of humans and live stocks including cattle, poultry and fishes. Particularly in aquaculture, many researchers are now focusing on the use of spirulina as a dietary supplementation in the diet of fishes and shrimps. At the same time its protein content is almost equal to the fish meal, so it can also be able to replace the fish meal partially or totally in the aqua feed in order to reduce the cost of feed in aquaculture.

Spirulina

Nutritional profile

Spirulina are highly proteineous, which makes their demand higher as a protein supplement in the aqua feed market. It contains upto 60-70% protein in dry weight, but at the same time based on the harvest time and harvest procedure it may vary to some extent (AFAA, 1982). Generally, it contains 6-8% lipid in dry weight, but in some cases it may go upto 11% (Hudson and Karis 1974). They are good source of energy with 13.6% carbohydrates including glucose, rhamnose, mannose, xylose, galactose (Shekharam et al., 1987) and they are also rich in vitamin B, vitamin E and essential minerals like calcium, iron, magnesium, manganese, phosphorus, potassium, selenium and zinc, required for the growth of organism (Bensehaila et al., 2015). Though the protein content of spirulina is complete, they contain all the essential amino acid which is required for the animal's growth.

Spirulina culture

Spirulina can be cultured either in an open system or in a closed system. Open system, which was done in open ponds replicating the natural pond conditions were suitable for the large scale production of algal biomass. They are cost effective due to their limited equipment and low maintenance. In closed systems all the conditions are under controlled with minimal risk of contamination and loss of water due to evaporation. Growth of spirulina mainly depends on the following decisive factors (Ciferri, 1983) such as,

- Temperature should be maintained at 30◦c
- pH >8.5
- Macro & Micro nutrients - especially nitrogen, carbon, phosphorus, sodium and potassium
- Constant stirring speed
- Good water quality

Among the various nutrients nitrogen plays a crucial role and contributing a significant amount in the cost of production. Now a day commonly used nitrogen sources were sodium nitrate ($NaNO_3$) and potassium nitrate (KNO_3) (Ajayan et al., 2012). The medium commonly used as a substrate for the growth of this micro algae is Zarrouk's medium (Zarrouk, 1966).

Role of spirulina in aquaculture

Spirulina plays an important role in aqua feed industry because it can be used as a feed additive or dietary supplementation to replace the primary protein source like fish meal in aqua feed. It can also be used as an immuno-stimulant in aquaculture. Though spirulina protein content is higher than any other plant protein sources it can be an effective substitute for the fish meal in aqua feed. Although its production cost is high, several measures were taken up by the feed formulators and researchers to increase the yield and income by maintaining suitable conditions for the growth of micro algae in-order to reduce the cost of production. Some of the ideal roles of spirulina in aquaculture were listed below (Ragaza et al., 2020),

- Improving the growth performances,
- Increasing the RBC count and improved blood profile
- Improves pigmentation
- Increases the stress tolerance capacity
- Enhancing the immune-competence ability
- Improved reproduction performance
- Sustainability

More than 40 species of micro algae have been used in the culture of larval and adult stage finfish and shellfish (Chen, 2003). Among various algae, spirulina were promising as a feed ingredient in the diet of tropical fishes due to its pigment (Ciferri and Tiboni, 1985). It is reported to have higher palatability and fishes which consume spirulina in their diet are found to have low abdominal fat, better flavour, brighter skin, and firmer flesh (Mori, 1987). Besides food fishes, it also had positive impacts on the ornamental fishes, particularly phycocyanin pigment in the spirulina helps in enhancing the colour in ornamental fishes. Globally animal protein sources, particularly fish meal and fish oil were consumed as a primary protein and lipid source in every aqua feed. But in the last decade the rate of production of fish meal and fish oil tends to decrease coupled with increased cost in the market. So the plant based feed ingredient will be used in the production of aqua feed, particularly the micro algae like spirulina will have the potential to be used in the diet of fishes to overcome the dependence of the aqua feed industry on the fish meal for the production of aqua feed. Besides feed, water is the important decisive factor in the growth of fishes in aquaculture. Recently spirulina was found to have the effluent treatment capacity to maintain the quality of water, which will be an excellent integrated strategy for fish aquaculture (Zhang et al., 2019). So all these will make the feed formulators to use spirulina in fish feed formulation.

Spirulina as feed for fishes

Spirulina can be used as a dietary supplementation either to replace fish meal partially or totally in the diet of many tropical freshwater and marine fishes. Indian major carps like Catla (*Catla catla*) and Rohu (*Labeo*

rohita) are found to accept the diet in which 100% fish meal was replaced by spirulina with no negative effects (Nandeesha et al., 2001). In Nile tilapia (*Oreochromis niloticus*) the survival was good upto 100% replacement of fish meal with spirulina but increasing the replacement level will reduce the growth and essential fatty acid profile in the body (Takeuchi et al., 2002). Inclusion of 30% spirulina in the diet of red tilapia (*Oreochromis sp*) as a carotenoids supplement is found to enhance the body colouration (Ruangsomboon et al., 2010). In common carp (*Cyprinus carpio*), complete replacement of fish meal upto 100% with spirulina is possible with improved growth and improved protease, lipase and amylase activities (Nandeesha et al., 1998). Moreover highest weight gain was observed in the rainbow trout (*Oncorhynchus mykiss*) fed with 7.5% inclusion of spirulina in their diet (Teimouri et al., 2013) and attained increased red blood count, white blood count, total protein and albumin level when fed with 10% included Spirulina in their diet (Yeganeh et al., 2015). It is also possible to substitute 50% of fish meal with Spirulina in Silver bream diet (*Rhabdosargus sarba*), but the replacement level beyond 50% was not possible due to the deficiency of amino acid (El-Sayed, 1994). Mozambique tilapia (*Oreochromis mossambicus*) was also found to have good growth upto 40% replacement of fish meal with spirulina, but its lysine and methionine content were low (Olvera-Novoa et al., 1998)**.** Ornamental Guppy (*Poecilia reticulate*) fed upto 40% inclusion of spirulina as a fish meal replacement shows good growth without any negative effects (Dernekbasi et al., 2010).

Spirulina as a feed for crustaceans

In giant freshwater prawn (*Macrobrachium rosenbergii*), the inclusion of spirulina at the rate of 5-10% in the feed will enhance the pigmentation and significantly improved the growth, survival and feed utilization (Nakagawa and Gomez-Diaz, 1995). But in Pacific white-leg shrimp (*Litopenaeus vannamei),* upto 75% of fish meal can be effectively substituted by spirulina with better growth and 100% replacement of fish meal will leads to deficiency of amino acids like arginine, threonine and lysine in the feed (Macıas-Sancho et al., 2014).

CONCLUSION

Now-a-days the commercial scale production of spirulina in the market will make them as a nutritional supplementation in the humans and livestock diet, due to their higher protein content, excellent amino acid profile, along with certain vitamins and mineral content. Particularly the use of spirulina as a feed supplement in the diet of fishes and crustaceans will improve their growth, health and pigmentation. They can also effectively substitute the fish meal completely or partially with no negative effects based on the type of species cultured. So it can be a cost effective fish meal substitute and at the same time it is more eco-friendly compared with any other animal and plant based protein sources to be used in aqua feed.

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