



Original Research Paper

Assessment of the Nutritional Profiling and Feeding Value of *Spirulina platensis* rich diet for *Ompok bimaculatus*

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Abstract

The present study was conducted to evaluate the nutritional profile of diets formulated with conventional feed ingredients supplemented with *Spirulina platensis* for *Ompok bimaculatus* (Butter catfish). Four experimental diets were formulated by feeding *Spirulina platensis* at 10%, 15%, 20% and 25% level of inclusion along with other feed ingredients like maize flour, soybean meal, mustard oil cake and rice bran. Proximate composition of the prepared diets was determined using the standard AOAC (2005) methods for the contents of crude protein, crude fat, ash, moisture and fiber. Results indicated that addition of *Spirulina platensis* significantly improved the nutritional quality of the meal. Diets containing 15-20% *Spirulina* have increased the level of crude protein (up to 45-48%) with moderate fat (6-8%) and low crude fiber (1-2%) with appropriate amount of ash and carbs. The combined use of *Spirulina* with additional plant-based sources of protein like soybean meal, mustard oil cake and rice bran led to the formulation of a nutritionally balanced diet with adequate amounts of macronutrients and micronutrients. This synergistic combination probably enhanced nutritional uptake, feed conversion efficiency, and immunological regulation in *Ompok bimaculatus*. It has been widely recognized that incorporation of *Spirulina* into composite feed formulations enhances fish growth performance, physiological health and overall aquacultural sustainability. The present study revealed that *Spirulina platensis* at 15-20% inclusion in formulated feed showed the most promising nutritional profile and can be used as the long-term and quality protein source for the development of aquafeed in *Ompok bimaculatus* cultures.

Keywords- *Spirulina platensis*; *Ompok bimaculatus*, proximate composition, *Spirulina* rich diet, soybean meal, corn flour, mustard oil cake, rice bran.

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INTRODUCTION

Fish growth is thought to be primarily regulated by protein turnover, which is the equilibrium between protein synthesis and protein breakdown (Katersky and Carter, 2010; Carter *et al.*, 2012; Matias *et al.*, 2023; Youssef *et al.*, 2023). It is an indicator of how well the dietary protein meets the quantitative and qualitative AA needs of fish (Mente *et al.*, 2021; Panserat and Kaushik, 2010). The growth of fish is largely based on the eating of the right and balanced quantities of both essential and non-essential amino acids (Katersky and Carter, 2010; Kaushik and Seiliez, 2010; Teles *et al.*, 2020; Dileep *et al.*, 2021). The immediate content of the formulated experimental diets consisted of varying amount of *Spirulina platensis* (10%–25%) and showed gradual improvement in nutritious quality with increase in *Spirulina* inclusion (Table 1). Higher level of *Spirulina* fed resulted in slightly decreasing moisture content indicating that the pellet is likely to be more stable and having longer shelf life which is a desirable characteristic for aquaculture diets. Akter *et al.*, (2021) reported reduction in moisture content upon addition of algae, indicating improved feed processing properties.

The mineral content from nature was directly related to the amount of *Spirulina* added. It is said that *Spirulina* is rich in essential minerals such as calcium, iron, magnesium and phosphorus that are important in skeletal growth and metabolic functions of fish (Nakagawa and Montgomery, 2007). Blue-green algae, also known as *Spirulina* (Arthrospira), multicellular filamentous cyanobacteria (Ciferri, 1983), have been used as a source of protein by North Africans and Mexicans for thousands of years (Jensen *et al.*, 2001). *Spirulina* is a filamentous multicellular blue-green alga used in feeds for aquatic animals because of its high protein content (50%–70%), essential fatty acids, vitamins, essential amino acids, minerals and antioxidant pigments such as carotenoids (Nakagawa and Montgomery 2007).

Spirulina is one of the most popular microalgae in aquaculture and it is used as feed supplements to replace fishmeal to lower the cost. Several studies have reported the improvement of growth performance and health of aquatic animals by *Spirulina* administration (Abdel-Latif, El-Ashram, *et al.*, 2022; Alagawany *et al.*, 2021; Gao *et al.*, 2024; Li *et al.*, 2022; Rana *et al.*, 2024; Trevi *et al.*, 2023). Besides a high omega-3 fatty acid content that improves fish growth and immunity, its amino acid composition is very similar to that of fish meal (Tacon 1993).

Spirulina is also a good source of vitamins and minerals and can replace the vitamin-mineral premix in animal feeds (Moury *et al.*, 2018). In addition, *Spirulina* can be added to fish feed to stimulate fish growth (Abdel-Tawwab and Ahmad 2009; Jung *et al.*, 2019; Zhang *et al.*, 2020; Abdel-Tawwab *et al.*,

2021). But some plant protein components such as lectins, tannins, alkaloids, cyanogenic glycosides, protease inhibitors, and saponins limit the availability of other nutrients and have adverse effects on animal health (Khajali and Rafiei, 2024). Hence it is necessary to find alternate plant-based protein sources where the anti-nutritional factors will not be a big problem for example, algal protein. Many species of algae, such as *Spirulina platensis*, *Arthrospira maxima*, *Chlorella vulgaris* and others, are used in aquaculture around the world, mainly for nutritional purposes (Chen *et al.*, 2022). *Spirulina* is a cheaper and better source of protein than fish meal. *Spirulina* is considered a sustainable and viable alternative to fish meal in aquaculture because of its essential amino acids, minerals, antioxidants and immune-boosting properties, which can potentially reduce the risk and costs of medication in fish farming (Onura *et al.*, 2022; Al Mamum *et al.*, 2023; Ungsethaphand *et al.*, 2009). Fish manufacturers search for alternative raw materials as a cheap supply of protein because fish meal is a significant source of protein but is highly expensive. Compared to fish meal and fish oil, plant ingredients are more widely available at competitive rates and offer nutritional qualities that can largely meet fish nutritional needs (NRC 1993; Millamena 2002). Diets for herbivorous and omnivorous fish species and crustaceans typically comprise 15–30% soy bean meal, with an average of 25% in 2008. Soybeans are the most popular source of plant proteins used in compound aqua diets (FAO 2011). In aquaculture operations, proper nutrition has been found to be essential for preserving fish health and promoting healthy growth. The great rise of fish farming has been largely attributed to the development of high-quality meals, particularly those based on plants and animals. Feed accounts for more than half of fish farming's variable operating costs (National Research Council, 1993). Most of the costs are related to the protein source from feed ingredients. Because of this, there is increasing potential to replace costly feedstuffs like fishmeal with unconventional feed ingredients like algae (Badwy TM *et al.*, 2008).

To increase fish productivity in sustainable aquaculture, high-quality feeds derived from a dependable source of feed ingredients are essential. Traditionally fish meal (FM) has been the principal source of protein in aqua diets due to its high protein content and excellent amino acid balance. It can be substituted by other raw materials as it is a good source of vitamins, minerals and essential fatty acids (Naylor *et al.*, 2009; Oliva-Teles, *et al.*, 2015; Olsen and Hasan 2012). The present study evaluated *Spirulina platensis* as a sustainable, economic and nutritious alternative for fish meal in the diet of *Ompok bimaculatus* with emphasis on its role in stimulating protein turnover and growth. The present study was conducted to

evaluate the effects of graded levels of *Spirulina platensis* (10-25%) on the nutritional quality of feeds, proximate composition and suitability for fish amino acid and energy requirements. The study is aimed at establishing *Spirulina platensis* as a viable partial replacement for fish meal to promote sustainable aquaculture by reducing feed costs and improving nutritional efficiency without compromising fish growth and health.

Materials and Methods

Diet Preparation and Nutritional Profiling of *Spirulina platensis*

In order to ensure high quality and nutritional consistency, the fish meal and *Spirulina* powder used in the experiment were purchased fresh from local markets. The diet formulation and preparation were carried out following the standard protocol described by Akter *et al.*, (2021), with Minor changes to suit the experimental design. The major ingredients used in the preparation of the feed included mustard oil cake, corn flour, *Spirulina platensis*, soybean meal and rice bran all selected for their high nutritional value and suitability for fish diets. Prior to feed formulation, the proximate compositions (Table 1) of each feed ingredient were analysed to determine their moisture, crude protein, lipid, ash, and carbohydrate contents. The analysis ensured that the designed diets met the nutritional requirements of *Ompok bimaculatus* and properly maintained the balance between protein, fat and energy sources.



Ingredient Before Grinding

The experimental diets contained graded levels of *Spirulina platensis* 10, 15, 20 and 25%, respectively. All components were finely ground using a mechanical grinder to obtain a uniform particle size and then were fully blended to ensure homogeneity. For a soft, cohesive dough about 50 mL of distilled water was added for each 100 g of dry mixture. The dough was then extruded through a mechanical grinder to form pellets suitable for the experimental fish (about 2 mm in diameter). To prevent the growth of microbes and achieve a longer shelf life, the produced pellets were extensively air-dried at room temperature for two to three days to obtain a stable and dry texture. The dried feed pellets were stored in labelled plastic bags and maintained in cool

and dry place until use to maintain their quality (Akter *et al.*, 2021).



Ingredient After Grinding Process

Proximate Analysis

The proximate composition of each experimental diet was analyzed again by standard procedures recommended by the Association of Official Analytical Chemists (AOAC, 2005) after preparation. This analysis was carried out to verify that the nutrient composition of the feeds matched the intended formulation. Finally, the nutritional profiling was performed by estimating contents of moisture, protein, fat, ash and fibre, which provided a complete overview of the diet's nutritional adequacy for the experimental fish feeding trial.

Ash content was calculated by igniting a known-weight sample (2.3 g) in a muffle furnace heated at 600 °C for six hours. The samples were then cooled in a desiccator and weighed. The following calculation was used to determine the proportion of ash:

$$\text{Ash content} = \frac{\text{Weight of Ash} \times 100}{\text{weight of Original Sample}}$$

Moisture content was found by drying the sample in an oven set to 100–102°C for 16 hours with a known weight.

Experimental Diet Pellets with Different Levels of *Spirulina* Inclusion



Crude protein was determined using the standard semi-micro Kjeldahl method. The % total nitrogen was determined as follows:

$$\% \text{ Total Nitrogen} = \frac{(S-B) \times N \times 140}{Wt \times 1000}$$

where N is the acid's normality,

The percentage of crude protein was estimated by multiplying the total nitrogen by the conversion factor of 6.25.

Crude fibre was evaluated as the loss of ignition of dried lipid-free residues following digestion with 1.25% or 0.255 N H₂SO₄ and 1.25% or 0.313 NaOH. To dissolve any organic ingredient, 10 mL of acetone was added.

The formula was used to calculate the percentage of fiber.

% Crude fibre = $\frac{\text{weight of residue} - \text{weight of ash}}{\text{Sample Weight}} \times 100$

Nitrogen-free extract (% carbohydrate) was calculated by removing the total of moisture%, crude fat%, crude protein%, and ash% from 100.

Table 1 - The proximate composition (%) of the Supplementary diet. In 50 grams

Experimental diet composition (%)	S ₁₀	S ₁₅	S ₂₀	S ₂₅
Ingredients				
Moisture	10.9	10.1	10.5	9.4
Ash	7.0	7.6	8.2	9.6
Protein	18	19	20	21
Fiber	1.1	1.2	2.0	2.2
Carbohydrate	1	1.1	0.9	1.2

Results and Discussion

Proximate Composition of the Experimental Diets

The proximate composition of prepared Experiment meals with graded levels of *Spirulina platensis* (10%–25%) revealed incremental improvement in nutritional quality with increase in *Spirulina* inclusion (Table 1). Feeding *Spirulina* at higher levels slightly reduced moisture content, which is indicative of greater stability and shelf life of the pellets, a desired attribute in aquaculture feeds. Similar reductions in moisture content with incorporation of algae signalling superior feed processing qualities were also found by Akter *et al.*,

(2021).

The ash content, which is a natural source of minerals, was directly proportional to the dose of *Spirulina* supplementation. *Spirulina* is said to be rich in vital minerals such as calcium, iron, magnesium and phosphorus that are crucial for skeletal growth and metabolic activities in fish (Nakagawa and Montgomery, 2007). Comparable trends have been observed in diets of *Clarias gariepinus* and *Oreochromis niloticus* fed *Spirulina*-based diets (Abdel-Latif *et al.*, 2022).

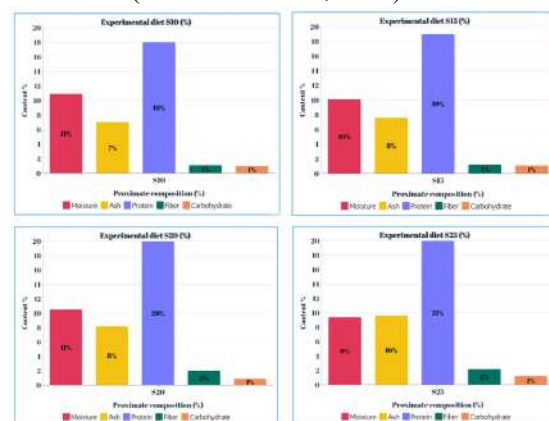


Table 1 presents the proximate compositions of experimental diets that were created using different amounts of *Spirulina platensis* (10%–25%) as ingredients. The data indicates a substantial positive linear association between the inclusion rate of *Spirulina* and the nutritional composition of diets produced with this ingredient (Ramírez-Rodriguez *et al.*, 2021). The moistures of these diets were between 9.4% in the S10 diet and 10.9% in the S25 diet, with an inverse trend for moisture noted as the amount of *Spirulina* increased (Islam *et al.*, 2017). Because of the significant moisture contents in aquafeeds, diets with lower moisture contents increase pellet stability, decrease spoilage by microorganisms, and increase the storage life of pellets (Cheng *et al.*, 2025). Other researchers have confirmed these results in aquafeeds produced for other species of freshwater fish that contain *Spirulina* as an ingredient. The ash content of diets from this experiment also exhibited a linear increase from 7.0% in the S10 diet to 9.6% in the S25 diet, which can be attributed to the fact that *Spirulina platensis* has a high mineral content, particularly macro and microminerals that are essential to many of the metabolic processes, bone formation, and regulation of physiological functions of fish (e.g., calcium, iron, magnesium, and phosphorus). The inclusion levels of *Spirulina* in these diets resulted in a noticeable increase in crude protein concentrations from 18% in the S10 diet to 21% in the S25 diet; As a result, this study's findings support the high contribution of *Spirulina* to the protein content of aquafeeds due to its high-quality protein containing the full complement of amino acids needed by fish. Thus, the higher concentrations of

protein in diets created using these inclusion rates of *Spirulina* should provide the *Ompok bimaculatus* with more suitable diets to support their growth and to promote protein synthesis.

Table 2. The proximate composition of experimental diets with graded levels of *Spirulina platensis*

Parameter	S1 0 (1 0 % <i>Sp</i> <i>iru</i> <i>lin</i> <i>a</i>)	S1 5 (1 5 % <i>Sp</i> <i>iru</i> <i>lin</i> <i>a</i>)	S2 0 (2 0 % <i>Sp</i> <i>iru</i> <i>lin</i> <i>a</i>)	S2 5 (2 5 % <i>Sp</i> <i>iru</i> <i>lin</i> <i>a</i>)	Treatment Inclusion	Nutritional Significance	Reference
Mortality (%)	9.4–10.9	~10.5	~10.2	~9.4	Slighly decrease	Improved pellet stability and shelf life	Akter <i>et al.</i> , 2021; Islam <i>et al.</i> , 2017; Cheng <i>et al.</i> , 2025

Ash (%)	7.0	~8.1	~8.9	9.6	Liner increase	Reflects high mineral content (Ca, Fe, Mg, P) important for metabolism and bone formation	Nakagawa & Montgomerie, 2007; Abdel-Latif <i>et al.</i> , 2022
Cruude Protein (%)	18	~19	~20	21	Liner increase	Provides essential amino acids for growth and protein synthesis in <i>Ompok bimaculatus</i>	Ramírez-Rodríguez <i>et al.</i> , 2021
Cruude Fibre (%)	1.1	~1.6	~1.9	2.2	Moderate increase	Acceptable for catfish diets and support	Leeuwen <i>et al.</i> ,

					ease	ts gut health	2006
Carbohydrate (%)	0.9	~1.0	~1.1	1.2	Slight increase (stable)	Suitable for carnivorous/omnivorous fish with limited carbohydrate utilization	—

The changes in crude fibre content of the experimental diets ranged from 1.1% (control diet) to 2.2%. As the fibre content increased in the experimental diets with *Spirulina* supplementation, the fibre remained at an acceptable concentration for use as a catfish diet, and therefore, would not negatively impact the digestibility of nutrients in the diets (Leenhouders *et al.*, 2006). Small amounts of fibre may also help with good gut health and digestion. The level of carbohydrate was low and similar in all experimental diets (0.9-1.2%). For carnivorous and omnivorous fish species such as *Ompok bimaculatus*, low levels of carbohydrates are suitable as fish of this species do not have the ability to utilize carbohydrates in their diets. The results revealed that the formulated diets have balanced amount of nutrition mainly protein based.

Nutritional Significance and Implications

The addition of *Spirulina* to experimental diets has resulted in significant improvements of both the nurse's protein and the diet's mineral content (Neumann 2018). *Spirulina* is a highly digestible source of protein and does not contain any of the anti-nutritional factors generally found within terrestrial sources of protein that would hinder fish utilization of *Spirulina* as a complete source of nutrition (Allen, k.2016). *Spirulina platensis* also contains other important bioactive components such as fluorescent or colored proteins (phycocyanins), carotenoids (which provide color), vitamins, and essential fatty acids (Bortolini *et al.*, 2022); each of these components has been shown to support immune function and to have antioxidant properties.

Table 3. Nutritional and Functional Significance of *Spirulina* Supplementation

Parameter	Effect of <i>Spirulina</i> Inclusion	Biological Importance	References
Protein Quality	Increased high-quality digestible protein	Supports fish growth and protein synthesis	Neumann, 2018; Allen, 2016
Mineral Content	Increased macro and micro minerals	Important for skeletal development and metabolism	Nakagawa & Montgomery, 2007
Bioactive Compounds	Presence of phycocyanin, carotenoids, vitamins and fatty acids	Enhances immunity and antioxidant activity	Bortolini <i>et al.</i> , 2022
Pellet Stability	Reduced moisture levels	Improved storage life and reduced spoilage	Cheng <i>et al.</i> , 2025
Optimal Inclusion Level	15–20% <i>Spirulina</i>	Balanced nutrition without excessive ash and fibre	Present Study

The current study did not directly measure growth and immune parameters related to supplemental protein; however, the improved proximate composition data support the potential for improved protein utilization and physiological performance from the supplemental protein. Results indicated that the diets with *Spirulina* included at 15–20% are optimum for nutrition in terms of increased protein content without adversely impacting moisture, fiber or ash levels within the diets. When the level of *Spirulina* was increased to 25%, protein and mineral contents were improved; however, the ash and fiber contents were also increased which must be considered when using these high levels of *Spirulina* in long-term feeding studies.

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