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A review: Spirulina platensis as alternative fish feed ingredients

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Abstract
Fisheries is one of the sectors that contributes to the global economy three times larger than the landed sector. Global Fish production is increasing 2.1% from 175.1 million tones in 2017 to 178.8 million tones in 2018. The aquaculture production increased 4% in 2018 from 83.6 million tones to 87 million tones. Production from capture fisheries are larger than aquaculture, but it only increased about 0.3% in 2018. So that, aquaculture is of importance as a source for food and nutrition. The increasing activity of aquaculture causes the increasing feed demand. Therefore, quality alternative fish feed ingredients need to be developed. Spirulina platensis is known to contain many nutrients such as proteins, carbohydrates, fats, minerals and others. *Spirulina platensis* has also been shown to increase the growth rate and survival rate of some fish larvae.

Keywords: aquaculture, fish feeds, growth rate, Spirulina platensis, survival rate

1. Introduction
Aquaculture is predicted to take over capture fishery as the main source of fish providers in 2030 [1]. From 2011 to 2030, global production of aquaculture is expected to increase 47% (63.6 to 93.6 tons). Whereas, fishery production of capture is expected to increase only 3% (90.4 to 93.2 tons) [2]. However, there are several challenges to maintaining the quality of aquaculture production. One of the main challenges is high production costs and low quality. Around 40-60 of aquaculture production expenditure is feed cost. Feed will also affect growth rate and survival rate. Feeds with good nutrition will support increased growth rates and survival rates of fish larvae. If the price of feed ingredients is cheap with high nutritional content, it will reduce production costs. Therefore, alternative feed ingredients with high nutritional content and inexpensive need to be developed. The nutritional contents needed for fish growth are protein, essential amino acids, carbohydrates, the essential fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), and various other ingredients [3].

One ingredient that has been proven to have a high nutritional content and can increase the rate of production and survival rate of various types of fish is *Spirulina platensis* [4]. Therefore, this article aims to explain the potential of *Spirulina platensis* as an alternative fish feed ingredient. and various other ingredients [3]. One ingredient that has been proven to have a high nutritional content and can increase the rate of production and survival rate of various types of fish is *Spirulina platensis* [4]. Therefore, this article aims to explain the potential of *Spirulina platensis* as an alternative fish feed ingredient. and various other ingredients [3]. One ingredient that has been proven to have a high nutritional content and can increase the rate of production and survival rate of various types of fish is *Spirulina platensis* [4]. Therefore, this article aims to explain the potential of *Spirulina platensis* as an alternative fish feed ingredient.

2. Chemical Composition of Spirulina platensis
Spirulina platensis is filamentous blue green algae. Spirulina platensis can live in a broad range of habitats such as fresh water, brackish water, or sea water. The optimum temperature for growth are 35ºC, light intensity, 4000 lux [5] optimum salinity of 5 ppt [6], ph 8.5-9 [7]. *Spirulina platensis* can photosynthesize with the main pigment contained, namely phosocyanin, carotenoids [8], xanthophyll, chlorophyll a, chlorophyll b and others [9].

Spirulina platensis has been widely produced and commercialized for various human needs such as food supplements [10], cosmetics, drugs, and fish feed [11]. The nutritional content of *Spirulina platensis* is protein, amino acids, essential fatty acids, pigments, vitamins, minerals [10], carbohydrates, lipids and secondary metabolites [12]. However, the nutritional content of *Spirulina platensis* can be influenced by the content in the growth media used. Limited phosphorus in the medium will cause increased carbohydrate content while decreasing protein [13]. High salinity mediums cause lower protein content [14]. High protein content can be influenced by nitrogen content in the medium. The higher the nitrogen, the higher the protein content of *Spirulina platensis* [15]. The nutrient content (carbohydrate, protein, fat, and ash content) in *Spirulina platensis* that is cultured in various growth media can be seen in Table 1 and the amino acid content can be seen in Table 2.

Table 1: Nutrient content of *Spirulina platensis* cultured in different medium

Medium	Protein (%)	Carbohydrates (%)	Lipids (%)	Ash Content (%)	Ref.
Sea water	63,45	28.41	0.59	7.55	[16]
Fresh water	62.83	30.73	0.51	5.93	[16]
Zarrouk's medium	53.92	13.12	6.57	13	[15]
Walne Media	50.05	15.48	0.506	14,45	[17]

Table 2: Amino acid content in *Spirulina platensis* (g/100 g protein)

Amino acids	Richmond medium [14]	Salinated water [14]	*Spirulina platensis* Powder [18]
Isoleucine	6.70	5.71	5.85
Leucine	9.80	9.26	8.91
Valine	7,10	6.45	6.46
Lysine	4.80	4.42	4.84
Tyrosine	5.30	5.26	4.40
Phenylalanin	5.30	4.45	4.75
Methionine	2.50	2.05	2.38
Cysteine	0.90	0.59	1.02
Tryptophan	0.30	0.06	1.14
Threonine	6.20	4.65	4.92
Histidine	2.20	9.17	1.57
Alanine	9.50	8.51	7.48
Arginine	7.30	7.09	7.30
Glutamic acid	10.30	13.40	15.58
Proline	4.20	3.75	3.66
Serine	5,10	5,00	4.32

The minerals contained in Spirulina platensis include calcium (Ca), magnesium (Mg), phosphorus (P), Sodium (Na), Potassium (K), Ferrum (Fe), Manganese (Mn), Zinc (Zn), and Copper (Cu) [15]. The mineral content of Spirulina platensis can also be influenced by differences in culture media. Different media will cause different levels too. Ca, Mg, P levels are higher in Spirulina platensis that is cultivated in seawater. This can be caused by high salinity which causes mineral salts to accumulate in Spirulina platensis [16].

3. *Spirulina platensis* as Alternative Fish Feed

Research on *Spirulina platensis* as an alternative feed has been widely carried out. *Spirulina platensis* has been shown to increase growth in monosex nile tilapia (*Oreochromis niloticus*) [11], hybrid red tilapia (*Oreochromis niloticus* x *Oreochromis mossambicus*) [19], Rainbow Trout (*Oncorhynchus mykiss*) [20], Asian sea bass (*Lates calcarifer*) [21], Milk fish (*Chanos chanos*) [22], Common carp (*Cyprinus carpio*) [23] and others.

*Spirulina platensis*can increase feed intake and activity of intestinal flora to break down components in the feed making it easier for nutrient absorption. *Spirulina platensis* also stimulates the production and action of the enzymes protease and lipase and helps the use of fat for growth compared to storage [19]. These things that cause the administration of *Spirulina platensis* to the feed can increase the specific growth rate of fish.

Spirulina platensis known to reduce feed costs in red tilapia thereby increasing profits [19]. Not only in red tilapia, 1-20% inclusion level of Spirulina can reduce feeding costs in both omnivorous and herbivorous fish species [24]. This is allegedly because the use of Spirulina platensis can reduce the feed conversion ratio (FCR). Feed Conversion Ratio is the ratio of the amount of feed needed to grow 1 kg of fish. The lower FCR the more efficient the feed used. It means a low FCR is an indication of a high quality [25].

Spirulina platensis also proven to be able to increase the survival rate of larvae of several types of fish. Administration of 75 and 100% *Spirulina platensis* can increase the survival rate of Hybrid Red Tilapia larvae by 100% compared to controls which are only 90% [19]. These results are also in line with research on gourami. Administration of 50, 100, 150% *Spirulina platensis* in gouramy larvae can increase survival rates successively by 40, 63, and 49% [26]. Giving 2,5, 5, and 10% *Spirulina platensis* in larvae of juvenile great sturgeon fish (*Huso huso* Linnaeus, 1754) also increased survival rates respectively by 93.33 ± 1.7 96.66 ± 2.2 96.66 ± 2.4 compared to control of 93.33% [4]. This is because the use of Spirulina platensis in the feed can increase the number of white blood cells [19], increase the IgG and IgM antibodies [11] thus increasing immunity.

4. Conclusion

In Conclusion, *Spirulina platensis* contain a lot of nutrition such as amino acid, protein, carbohydrate, minerals, and vitamins. The nutrition content in *Spirulina platensis* can be influenced by medium composition. *Spirulina platensis* can be used as potential alternative fish feed.

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