

## Mini Review

### The Effect of *Schizochytrium* sp. Supplementation on the Growth and Health of Fish. ~~in Diet on Fish Growth and Health~~

#### ABSTRACT

Aquaculture is a part of the global fisheries industry that is growing quickly, and fish feed is a big reason for that. Fish oil is the primary source of omega-3 long-chain polyunsaturated fatty acids, which are suitable for fish growth and health. However, the price of fish oil is rising, and the amount being made is decreasing. Aquafeeds made from alternative resources will help sustain aquaculture. The potential of microalgae as a source of oil production has great potential due to its rapid growth. Several studies have shown that *Schizochytrium* sp. has a high lipid and DHA content and can be used to replace fish oil in aquafeed. This review's goal is to find out how using *Schizochytrium* sp. in fish feed affects their growth and health. The nutritional value and optimal dosage of *Schizochytrium* sp. for various fish sizes are discussed. The optimal concentration of *Schizochytrium* sp. varies by species and can replace fish oil in the range of 20–80%. Several studies found that replacing fish oil in fish food with *Schizochytrium* sp. made the fish grow faster, live longer, gain weight, and eat more food. In the future, *Schizochytrium* sp. and several types of marine algae have the potential to serve as alternative sources that can replace fish oil in fish feed.

Comment [S1]: Statement should be rephrased

Comment [S2]: Ssentences need to be rephrased

*Keywords:* Aquafeed, *Schizochytrium* sp., Fish oil, DHA, microalgae

#### 1. INTRODUCTION

Aquaculture is one of the sectors that can meet human food needs. Based on data from FAO (2022), total aquaculture production in the world reached 122.6 million tonnes of the 214 million tonnes of total fisheries and aquaculture in 2020. This value shows that the contribution of aquaculture to the fisheries sector is equivalent to 49.2%. The total production came from inland waters (54.4 million tonnes) and marine aquaculture (68.1 million tonnes). In 2019, the global annual per capita consumption of aquatic foods will reach 20.5 kg. In several countries, such as Indonesia, Ghana, Cambodia, and Bangladesh, aquatic foods meet protein intake needs of around 50% or more. Meanwhile, globally, aquatic food fulfills 20% of the average per capita intake of animal protein. This shows that aquaculture is a sector that has the potential to continue to be developed.

Comment [S3]: reference

One of the factors that influences the success of aquaculture is the availability of quality feed that meets the nutritional needs of fish. N-3 highly unsaturated fatty acids (n-3 HUFA) such as

docosahexaenoic acid (DHA) are important dietary lipids for growth, fish reproductive processes (Furuita et al., 2002), lipid metabolism, fish immunity (Li et al., 2020), membrane permeability and plasticity, enzyme activation, prostaglandin production (Dadgar, 2016), and stress tolerance increase (Mutti et al., 2017). Freshwater fish are known to be able to synthesize Hufa by changing C18 (Ren et al., 2020). However, in general, seawater fish cannot synthesize hufa, so it needs to be available in fish feed (Lee et al., 2003). Fish oil is usually used as a source of fatty acids, but the price of fish oil is increasing and its production is decreasing (Lee et al., 2022). This will lead to an increase in production costs (Medagoda et al., 2021). Meanwhile, the demand for fish oil continues to increase for the aquaculture sector so that it can reduce fish oil intake for other sectors such as food and medicine (<https://www.globenewswire.com>). Therefore, alternative feed ingredients that can be used as substitutes for fish oil need to be developed.

*Schizochytrium* sp. is a fast-growing thraustochytrid microalgae, containing 66% lipid with 27% DHA (Allen et al., 2019). Several researchers have reported the effect of *Schizochytrium* sp. supplementation in fish feed as a source of DHA. This review article aims to describe the effect of *Schizochytrium* sp. on fish feed and its potential to be used as a substitute for fish oil.

## 2. *Schizochytrium* sp.

*Schizochytrium* sp. is a spherical, unicellular microorganism that lives in seawater (Wang et al., 2018), freshwater (Allen et al., 2019) or brackish water. Microalga with a cell diameter of 9–14  $\mu\text{M}$  can form biflagellate zoospores, aplanospores, and amoeboid cells. Species in the genus *Schizochytrium* are distinguished based on the formation, size, and number of zoospores present in the zoosporangium (Honda et al., 1998). *Schizochytrium* sp. reproduces by means of cell division. The availability of oxygen in the water is important for the development of this aerobic heterotrophic algae (Bi et al., 2018). *Schizochytrium* sp. classification based on the WoRMS (World Register of Marine Species) is as follows:

Kingdom : Chromista  
Subkingdom : Harosa  
Infrakingdom : Heterokonta  
Phylum : Bigyra  
Subphylum : Sagenista  
Class : Labyrinthulea  
Order : Thraustochytrida  
Family : Thraustochytriaceae  
Genus : *Schizochytrium*

## 3. NUTRITIONAL VALUE OF *Schizochytrium* sp.

**Comment [S4]:** More information are required  
1.State the nutritiobnal components in tabular form  
2. The anti nutritional components if any  
3.Reports to justify the statements

*Schizochytrium* sp. contains various nutrients that are good for fish growth, including protein, carbohydrates, lipids, fiber (Hadley et al., 2017), and vitamins. The vitamins contained include biotin (0.3 mg), choline (1440 mg), folic acid (0.1 mg), niacin (14 mg), vitamin a (33.6 µg), beta carotene (2.3 µg), vitamin b1 (4.4 mg), vitamin b2 (2.9 mg), vitamin b6 (1.4 mg), vitamin b12 (54.9 µg), vitamin e (0.45 µg), and pantothenic acid 3.5 mg (Hadley et al., 2017). The minerals contained include magnesium, calcium, sodium, and other metal elements (Song et al., 2019). SFA (saturated fatty acid) (233 g/kg), MFA (mono-unsaturated fatty acids) (53 g/kg), and PUFA (poly unsaturated acid) (713 g/kg) are all present in this algae. The content of DHA in dried whole-cell *Schizochytrium* sp. is around 20% DHA on a per weight basis. In addition, *Schizochytrium* sp. contains several bioactive compounds, such as flavonoids, β-glucans, β-carotene, polysaccharides, nucleotides, and peptides. *Schizochytrium* sp. contains amino acids that are good enough for digestion, including arginine, lysine, isoleucine, histidine, methionine, threonine, tryptophan, and valine (Hadley et al., 2017).

#### 4. THE EFFECT OF *Schizochytrium* sp. ON FISH GROWTH

Several studies have shown that *Schizochytrium* sp. can be used as an alternative ingredient to replace fish oil in various types of fish, either partially or completely. This algae can also be used as a feed additive. *Schizochytrium* sp. can replace 20%–80% of the fish oil in juvenile rainbow trout feeds (Lee et al., 2022). Replacement of 20% fish oil by algae showed growth performance (weight gain, SGR, FE, and PER), which was greater than the control (100% fish oil) and other treatments (40, 60, 80, and 100% *Schizochytrium* sp.). The nutrient composition of the fish's body was also not significantly different from the control. Another study on juvenile rainbow trout was conducted by Osmond et al (2021), who tested the replacement of fish oil (FO) as a whole with *Schizochytrium* sp. oil (MO) or with Camelina oil and *Schizochytrium* sp. (MO/CO) oil. The results showed that the overall replacement of fish oil by *Schizochytrium* sp. showed growth performance similar to that of the control (fish oil). Substitution of fish oil with *Schizochytrium* sp. can be done on gilthead seabream fish (*Sparus aurata*). Santigosa et al (2021) tested the use of *Schizochytrium* sp. Oil, rapeseed oil, and camelina oil to completely replace fish oil. The results showed that the replacement of fish oil with these three oils did not make a significant difference in the growth performance of gilthead seabream (*Sparus aurata*). This demonstrates the ability of *Schizochytrium* sp. to replace fish oil. Karapanagiotidis et al (2022) also tested the effect of replacing 50% and 100% of the fish oil with *Schizochytrium* sp. and *Microchloropsis* sp. on gilthead seabream (*Sparus aurata*) feed. The test results showed that the weight gain and specific growth rate of gilthead seabream (*Sparus aurata*) were higher than the control. Apart from rainbow trout and gilthead seabream *Sparus aurata*, partial or complete replacement of fish oil with *Schizochytrium* sp. is also performed on juvenile Nile tilapia

**Comment [S5]:** It is best to present the effects and references in a tabular form for easy reading

(*Oreochromis niloticus*). Weight gain and protein efficiency ratio in fish fed artificial feed with 100% replacement fish oil from *Schizochytrium* sp. were higher than control (Sarker et al., 2016). The addition of *Schizochytrium* sp. on artificial feed at various concentrations of 10, 20, 30, and 40% can increase weight gain, biomass, specific growth rate, and feed intake of juvenile Piau (*Leporinus friderici*). Fish fed artificial feed supplemented with 40% *Schizochytrium* sp. showed the best growth performance (Prates et al., 2018). This is presumably because the algae can be digested properly by fish (Sarker et al., 2016). Another reason is that this algae contains various bioactive compounds, such as EPA and DHA.

## 5. THE EFFECT OF *Schizochytrium* sp. ON FISH HEALTH

*Schizochytrium* sp. can be used as a substitute for fish oil or as an additive in feed because it has a good effect on fish health. Zebrafish fed with the addition of 120 g/kg *Schizochytrium* sp. experienced an increase in the survival rate and density of goblet cells in the intestinal wall when challenged with *Edwardsiella piscicida* (Shi et al., 2021). Ibrahim et al. (2022) conducted a feed test containing a mixture of *Nannochloropsis oculata* and *Schizochytrium* and *Spirulina* species at equal proportions (1:1:1) for 12 weeks with various added concentrations (0.75, 1.5, and 3%) to Nile tilapia (*Oreochromis niloticus*). Giving a mixture of the three microalgae is known to significantly increase serum lysozyme activity. Nitric oxide (NO) and alternative complement pathway activity (ACH50) increased as the concentration of the microalgae mixture increased. Substitution of fish oil with various concentrations of *Schizochytrium* sp. i.e., 20, 40, 60, 80, and 100% substitution, is known to have a positive effect on the health of rainbow trout. This was indicated by the fact that the lysozyme activity of rainbow trout fed 20% *Schizochytrium* sp. was the highest, while the activity of lysozyme in the control and other treatments was not significantly different. An increase in lysozyme activity indicates an increase in the immune response of fish (Lee et al., 2022). The addition of 3% *Schizochytrium* sp. on feed for weeks can increase the non-specific immunity of golden pompano (*Trachinotus ovatus*) (Xie et al., 2019).

## 6. CONCLUSION

Application of *Schizochytrium* sp. as a substitute for fish oil in feed ingredients improved growth performance, survival rate, and health of fish. The high nutritional value of *Schizochytrium* sp. can help to support the use of alternative sources, especially microalgae oil as a substitute for fish oil in feed ingredients, to help support the sustainability of aquaculture.

**Comment [S6]:** Add more information to the conclusion and recommendation

## REFERENCES

- Allen KM, Habte-Tsion HM, Thompson KR, Filer K, Tidwell JH, Kumar V. Freshwater Microalgae (*Schizochytrium Sp.*) As A Substitute To Fish Oil For Shrimp Feed. *Sci Rep.* 2019; 9, 6178  
<https://doi.org/10.1038/S41598-019-41020-8>
- Bi ZQ, Ren LJ, Hu XC, Sun XM, Zhu SY, Ji XJ, & Huang H. Transcriptome And Gene Expression Analysis Of Docosahexaenoic Acid Producer *Schizochytrium Sp.* Under Different Oxygen Supply Conditions. *Biotechnology For Biofuels.* 2018; 11,249.  
<https://doi.org/10.1186/S13068-018-1250-5>
- Dadgar S. Effect Of Different Levels Of N-3 Hufa On Larvae Culture Performances Of Beluga (*Huso Huso*) Fish. *Iranian journal of fisheries sciences.* 2016; 15( 2), 751–759.
- Fao. The State Of World Fisheries And Aquaculture 2022. Towards Blue Transformation. Rome, Fao. 2022. <https://doi.org/10.4060/Cc0461en>
- Furuita H, Tanaka H, Yamamoto Y, Suzuki N, Takeuchi T. Effects of High Levels of N-3 HUFA in Broodstock Diet on Egg Quality and Egg Fatty Acid Composition of Japanese Flounder, *Paralichthys olivaceus*. *Aquaculture.* 2002; 210, 323-333
- Hadley KB, Bauer J, Milgram NW. The Oil-Rich Alga *Schizochytrium Sp.* As A Dietary Source Of Docosahexaenoic Acid Improves Shape Discrimination Learning Associated With Visual Processing In A Canine Model Of Senescence. *Prostaglandins Leukot Essent Fatty Acids.* 2017;118:10-18. Doi:10.1016/J.Plefa.2017.01.011
- Honda D, Yokochi T, Nakahara T, Erata M, & Higashihara T. *Schizochytrium Limacinum Sp. Nov.*, A New Thraustochytrid From A Mangrove Area In The West Pacific Ocean. *Fungal Biology.* 1998;102, 439-448.
- Ibrahim D, Abd El-Hamid MI, Al-Zaban MI, Elhady M, El-Azzouny MM, Elfeky TM, Al Sadik GM, Samy OM, Hamed TA, Albalwe FM, Et Al. Impacts Of Fortifying Nile Tilapia (*Oreochromis Niloticus*) Diet With Different Strains Of Microalgae On Its Performance, Fillet Quality And Disease Resistance To *Aeromonas Hydrophila* Considering The Interplay Between Antioxidant And Inflammatory Response. *Antioxidants.* 2022; 11, 2181.  
<https://doi.org/10.3390/Antiox11112181>
- Karapanagiotidis IT, Metsoviti MN, Gkalogianni EZ, Psoufakis P, Asimaki A, Katsoulas N, Papapolymerou G, Zarkadas I. The Effects Of Replacing Fishmeal By *Chlorella Vulgaris* And Fish Oil By *Schizochytrium Sp.* And *Microchloropsis Gaditana* Blend On Growth Performance, Feed Efficiency, Muscle Fatty Acid Composition And Liver Histology Of Gilthead Seabream (*Sparus Aurata*). *Aquaculture.* 2022; 561, 738709, Issn 0044-8486,  
<https://doi.org/10.1016/J.Aquaculture.2022.738709>
- Li M, Xu C, Ma Y, Ye R, Chen H, Xie D, Zhang G, Zhang M, Wang M, You C, Wang S, Ning L, Luo M, & Li Y. Effects Of Dietary N-3 Highly Unsaturated Fatty Acids Levels On Growth,

- Lipid Metabolism And Innate Immunity In Juvenile Golden Pompano (*Trachinotus Ovatus*). *Fish & Shellfish Immunology*. 2020;105,177–185.  
<https://doi.org/10.1016/j.fsi.2020.06.060>
- Medagoda N, Kim MG, Gunathilaka BE, Park SH, Lee KJ. Effect Of Total Replacement Of Fish Oil With Tallow And Emulsifier In Diet On Growth, Feed Utilization, And Immunity Of Olive Flounder (*Paralichthys Olivaceus*). *Journal of The World Aquaculture Society*. 2021; 1-14
- Mutti DW, Ballester ELC, Martino RC, Wasielesky WJ, Cavalli RO. Feeding N-3 Hufa Enriched *Artemia* To The Larvae Of The Pink Shrimp *Farfantepenaeus Paulensis* Increases Stress Tolerance And Subsequent Growth. *Latin American Journal Of Aquatic Research*. 2017; 45 (1).
- Lee SM, Lee JH, Kim KD. Effect of dietary essential fatty acids on growth, body composition and blood chemistry of juvenile starry flounder (*Platichthys stellatus*). *Aquaculture*. 2003; 225, 269–281.
- Lee S, Park CO, Choi W, Bae J, Kim J, Choi S, Katya K, Kim KW, Bai SC. Partial substitution of fish oil with microalgae (*Schizochytrium* sp.) can improve growth performance, nonspecific immunity and disease resistance in rainbow trout, *Oncorhynchus mykiss*. *Animals*. 2022; 12(9),1220. <https://doi.org/10.3390/ani12091220>
- Osmond ATY, Arts MT, Hall JR, Rise MI, Bazinet RP, Armenta RE, Colombo SM. *Schizochytrium* Sp. (T18) Oil As A Fish Oil Replacement In Diets For Juvenile Rainbow Trout (*Oncorhynchus Mykiss*): Effects On Growth Performance, Tissue Fatty Acid Content, And Lipid-Related Transcript Expression. *Animals*. 2021; 11(4):1185.  
<https://doi.org/10.3390/ani11041185>
- Prates AS, Schorer M, Moura GD, Lanna EA, Castro GH, & Pedreira MM. Microalgae *Schizochytrium* Sp. In Feed For Piau *Leporinus Friderici*. *American Journal Of Animal And Veterinary Sciences*. 2018; 13, 130-135.
- Ren HT, Zhang GQ, Huang Y, Gao XC. Effects Of Different Dietary Lipid Sources On Fatty Acid Composition And Gene Expression In Common Carp. *Czech Journal Of Animal Science*. 2020; 65 (2), 51–57.
- Sarker PK, Kapuscinski AR, Lanois AJ, Livesey ED, Bernhard KP, Coley MI. Towards Sustainable Aquafeeds: Complete Substitution Of Fish Oil With Marine Microalga *Schizochytrium* Sp. Improves Growth And Fatty Acid Deposition In Juvenile Nile Tilapia (*Oreochromis Niloticus*). *Plos One*. 2016; 11(6): E0156684. Doi:10.1371/Journal. Pone.0156684
- Song Z, Peng YB, Song YF, Wang QK, He YH, Liu S. Analysis Of Nutrient Composition And Polysaccharide Characteristics Of Fungus *Schizochytrium* Sp. *Journal Of Dalian Ocean University*. 2019; 34(2), 247-251.

- Wang X, Wang H, Pierre JF, Wang S, Huang H, *Et Al*. Marine Microalgae Bioengineered *Schizochytrium Sp*. Meal Hydrolysates Inhibits Acute Inflammation. *Scientific Reports*. 2018; 8, 9848. <https://doi.org/10.1038/S41598-018-28064-Y>
- Santigosa E, Brambilla F, Milanese L. Microalgae Oil As An Effective Alternative Source Of Epa And Dha For Gilthead Seabream (*Sparus Aurata*) Aquaculture. *Animals*. 2021; 11(4):971. <https://doi.org/10.3390/ani11040971>
- Shi Y, Cao X, Ye Z, Xu Y, Wang Y, Li Z, Hang W, & He N. Role Of Dietary *Schizochytrium Sp*. In Improving Disease Resistance Of Zebrafish Through Metabolic And Microbial Analysis. *Aquaculture*. 2021, 539, 736631
- Xie J, Fang H, Liao S, Guo T, Yin P, Liu Y, Tian L, & Niu J. Study On *Schizochytrium Sp*. Improving The Growth Performance And Non-Specific Immunity Of Golden Pompano (*Trachinotus Ovatus*) While Not Affecting The Antioxidant Capacity. *Fish & Shellfish Immunology*. 2019; 95, 617–623. <https://doi.org/10.1016/J.Fsi.2019.10.028>
- <https://www.Globenewswire.Com>

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