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Fish Free Fish feed in Aquaculture: The Right Step Forward for Sustainability

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SUMMARY

One of aquaculture's most critical environmental challenges is growing sustainable fish feed.Modern aquaculture feeds are over-reliant on ocean-derived fishmeal and fish oil. There is increased thought on how long the capture fisheries can support the need for fishmeal and fish oil. With stagnation in world capture fisheries, the utilization of forage fish for fish meal production is expected to infringe on fish used for human consumption, resulting in increased costs. With a rapidly growing aquaculture sector, the aqua feed sector has diverted its research expertise tolooking for Fish Meal and Fish oil alternatives. Developing a fish-free aqua feed is one that has emerged and finds credence in looking for alternative protein sources for aqua feed. This article looks into marine algae as one possible alternative for fish meal and fish oil in developing an aqua feedfor the sector's sustainability.

INTRODUCTION

Aquaculture, the best manufacturer of edible protein, maintains to grow faster than any other principal food region in the world in response to the hastily increasing worldwide demand for fish and seafood. Food and Agriculture Organization (FAO, 2018) pronounced that feed inputs for aquaculture manufacturing constitute 40 to 75% of aquaculture production costs and are a vital market motive for aquaculture production. Ocean-derived fishmeal (FM) and fish oil (FO) in aquafeeds have raised sustainability concerns as the supply of wild marine forage fish will no longer meet the rising call and will restrain the aquaculture boom (FAO 2016 & 18, Pauly et al., 2016, Checkley et al., 2017). The use of forage fish (which includes herrings, sardines, and anchovies) for FMFO manufacturing also affects human food security because approximately 16.9 million of the 29 mt of forage fish this is caught globally for aquaculture feed are directed away from human consumption each year (Cottrell et al. 2020). The fraction of global resources of fishmeal and fish oil in aquafeeds has risen unexpectedly, in general, due to the increase of salmonid aquaculture: from 10% of fishmeal in 1980 and 20% of fish oil in 1990 to 73% of fishmeal and 71% of fish oil in 2010 (Shepherd and Jackson, 2013; Chauton et al., 2015; Cashion et al., 2016; FAO, 2016). As the call for farmed fish endures to expand, there is an emergent recognition of the sustainability of feed utilized in aquaculture production. For all these reasons, growing fish-free fish feed is a key leverage point for reforming aquaculture to facilitatethe conservationof natural ecosystems instead of negative ones. And also, it decreases the strain on forage fish, and for this reason,it will give a boost to our global marine fisheries.

Fish-free fish feed - alternatives to fish meal and fish oil

Feed manufacturing enterprise heavily relies upon fish meal as a nutritional protein component. Fish meal is a super helpful resource to satisfy the fish's critical amino acid requirement and has high protein content material and exact availability of micronutrients. Research has been conducted to search for much less high-priced protein sources to replace fishmeal. Fish meal and oil production depend significantly on marine fishery productions and bycatch. Consequently, increasing terrestrial animal manufacturing is competing for the fish meal as a fantastic feed element. Growing opposition and limited availability of fish meal and fish oil have stimulated the aquaculture industry to find new opportunity feed elements. Coyle et al. (2004) suggested that feed costs account for more than 50% of total manufacturing costs in aquaculture attributed to the use of the expensive fishmeal. Several authors decided that plant components may be used to replace fish meal in the diet if the animal showed no difference in the typical performances at the same time as fed plant feed (Espe et al., 2007; Hansen et al., 2011; Lund et al., 2011; Daniel, 2017). Several researchers also validated the effects of plant proteins on the overall performance of animalswere minimal (Merrifield et al., 2010; Kpundeh et al., 2015; Li et al., 2016). Robinson and Li (1994) advocated that plant proteins can be used as a natural alternative for animal protein without damaging effects.

The protein of plant origin is preferred in comparison to animal origin protein in the culture of carps (Singh et al. 2004). Algae meal protein can replace as much as 50% of corn gluten protein in the diets for juvenile Nile tilapia without unfavorable boom consequences. Better inclusion of algae meal protein led to extensively reduced growth performance of juvenile tilapia, likely tormented by the increased Fe and Al availability (Hussein et al., 2012). The aquafeed enterprise reduces reliance on FM and FO via using grain and oilseed crops (e.g., soy, corn, canola), however, these terrestrial plant elements have low digestibility, anti-dietary factors, and deficiencies in critical amino acids (lysine, methionine, threonine, and tryptophan) (Li et al., 2009; He et al. 2013). Crop oils also lack lengthy-chain omega-3s (n-3s), eicosapentaenoic acid (EPA),and docosahexaenoic acid (DHA), which areessential for human health (Turchini et al., 2009, Sarker et al., 2013). Alternatives to terrestrial crops have been too costly for extensive adoption by aquafeed manufacturers. However, nutritional disadvantages and poor fillet quality have provoked researchers to investigatemarine microalgae as the potential for FMFO replacements in fish feeds due to their balanced essentialamino acids, minerals,vitamins, and long-chain n-3 fatty acids (Sarker et al., 2018).

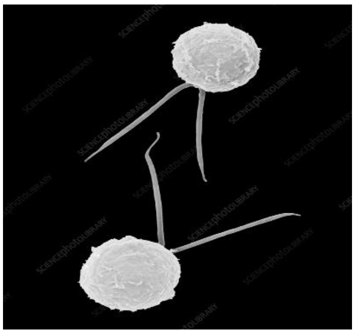
Fish free feed on Growth performance and nutrient utilization

Many studies have attempted to update a portion of or, in some instances, all fishmeal with altered protein ingredients in a few species. Several trials resulted in less than optimal growth, health, feed conversion, and other overall performance metrics. Some research evaluating partial fishmeal replacement in commercial diets reported the same increase in health and other criticalgeneral performance metrics compared to diets with full fishmeal inclusion. A few studies have discovered that aquatic animals fed with fish meal-depleted diets generally tend to lower their feed consumption and growth performances. The reduction in the feeding and growth with response to higher stages of dietary plant proteins has been suggested in several aquatic animals, including rainbow trout (Gomes et al., 1995; Adelizi et al., 1998), European sea bass (Dias et al., 1997), black tiger shrimp (Richard et al., 2011) and abalone (Bautista-Teruel et al., 2003). Adelizi et al. (1998) show that fish fed commercial trout feed exhibited considerably extra weight benefit and a decreased feed conversion ratio; however,it appreciably decreased protein efficiency ratio than fish fed the experimental diets. A few studies confirmed that lower increase performance in rainbow trout-fed diets containing increased levels of plant substances was linked to a reduction in feed consumption (Panserat et al., 2009; Lazzarotto et al., 2018). Torstensen et al. (2008) suggested that growth rates of post-smolt Atlantic salmon grown from 0.3 to 4 kg were not affected by replacing 40% fishmeal with plant proteins and krill meal and 70% fish oil with vegetable oil. But, Atlantic salmon-fed diets with 80% fishmeal replacement through plant proteins and krill meal grew extensively slower compared to a control group fed a diet with complete fishmeal inclusion. Burr et al. (2012) discovered that juvenile (31.5 g) Atlantic salmon fed diets containing blends of soy, corn, wheat, algae, and poultry by-product proteins grew at equal rates, to a mean length of approximately 250 g, as compared to salmon fed a fish meal-based diet. Davidson et al. (2016) published works to evaluate a fishmeal-free feed for Atlantic salmon by blending combined nut meal, fowl meal, and other protein assets. It achieves identical growth performance, feed conversion, and survival when fed food with whole fishmeal replacement. Miller et al.(2007) suggest that completely replacing dietary fish oil with *Schizochytrium* oil increased the amount of DHA in juvenile Atlantic salmon muscle and decreased the extent of EPA.

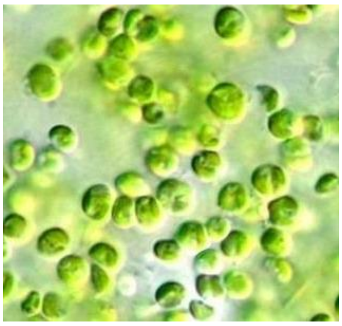
Table 1: Composition of microalgal species in the percentage of dry biomass matter (Koyande et al., 2019)

Microalgae Species	Composition (%dry matter)		
	Protein	Lipids	Carbohydrates
Anabena cylindrica	43-56	4-7	25-30
Aphanizomenon flos-aquae	62	3	23
Chaetoceros calcitrans	36	15	27
Chlamydomonas rheinhardii	48	21	17
Chlorella vulgaris	51-58	14-22	12-17
Chlorella pyrenoidosa	57	2	26
Diacronema vlkianum	57	6	32
Dunaliella salina	57	6	32
D. bioculata	49	8	4

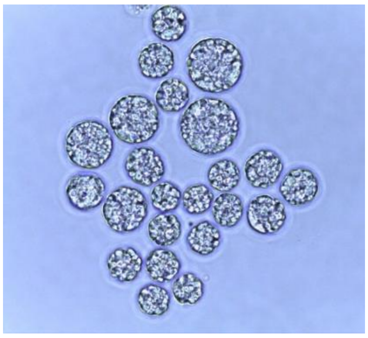
Euglena gracilis	39-61	22-38	14-18
Haematococcus pluvialis	48	15	27
Isochrysis galbana	50-56	12-14	10-17
Porphyridium cruentum	28-39	9-14	40-57
Prymnesium parvum	28-45	22-38	25-33
Scenedesmus obliquus	50-56	12-14	10-17
S. dimorphus	8-18	16-40	21-52
S. quadricauda	47	1.9	21-52
Spirogyra sp.	6-20	11-21	33-64
Spirulina maxima	60-71	6-7	13-16
S. platensis	46-63	4-9	8-14
Synechococcus sp.	63	11	15
Tetraselmis maculata	52	3	15



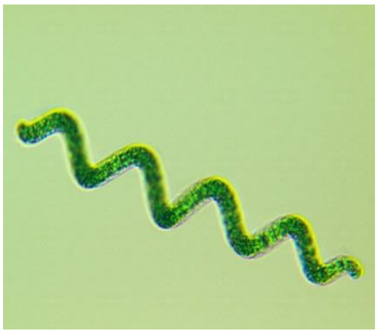
*Isochrysis*sp



Nannochloropsis sp



Schizochytrium sp



Spirulina sp

Figure 1. Microscopic images of common microalgal species

Sarker et al. (2020a) studied two marine microalgae, *Nannochloropsis* sp. and *Isochrysis* sp., and concluded that *Isochrysis* sp. is a better alternative for fishmeal and fish oil than *Nannochloropsis* sp. Also, they conducted a digestibility experiment accompanied by a growth experiment using feeds with different combinations of *Nannochloropsis* sp., *Isochrysis* sp., and *Schizochytrium* sp. and observed lower feed consumption by fish-fed diets combining multiple microalgae in comparison to fish-fed the reference diet, and additionally indicates that *Isochrysis* sp. and *Schizochytrium* sp. isan excellent applicant for DHA supplementation in trout diet formulations. Sarker et al. (2020b) carried out a study to develop a new aquafeed formulation by combining the protein-rich (50%) defatted marine microalgal biomass of *Nannochloropsis oculata* with another DHA-rich (30% of general fatty acids) marine microalgae (*Schizochytrium* sp.), to absolutely replace FMFO (fish-free) in tilapia aquafeeds and suggested that tilapia fed the fish free food regimen for 184 days exhibited better weight gain and specificgrowth rate than fish fed the reference diet. Those reviews will offer an impetus to further research in this area, enabling higher utilization of algae resources to get rid of all fish meal and fish oil from the aquaculture diet for sustaining the current growth rate of aquaculture production.

The nutritional benefit of marine algal biomass in thefish-free diet

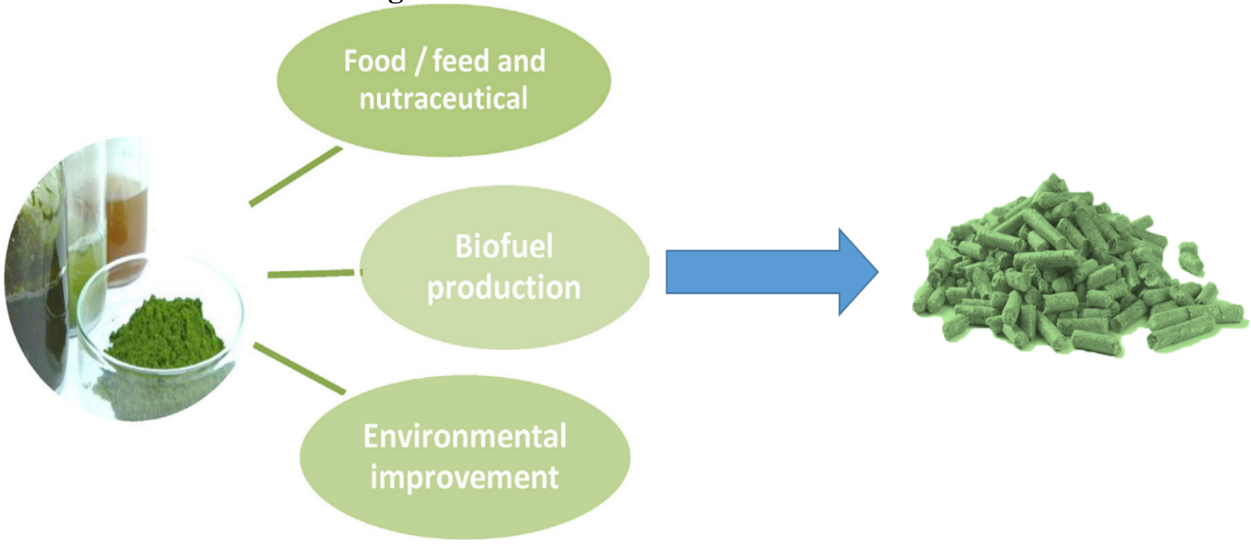


Fig 2. General applications of algal biomass (Guedes et al., 2019)

Microalgae can reduce the dependence on traditional raw materials in aquafeed. Using microalgae should have enormous beneficial effects and will probably replace or reduce fish meal and fish oil because of their dietary quality and tremendous impact on the growth rate of aquatic species due to extended triglyceride and protein deposition in muscle, improved resistance to disease, reduced nitrogen output into the environment, omega-three fatty acid content, physiological interest, and carcass quality (Becker 2004). Microalgae have lovely potential to offer protein, lipids, nutrients, carotenoids, and energy in feed. Typically, microalgae contain 30–40% protein, 10–20% lipid, and 5–15% carbohydrate within the overdue logarithmic growth phase (Brown et al. 1997). There are some drawbacks and demanding situations to using microalgae as a substitute for fishmeal and fish oil in the aquaculture enterprise, such ashigh manufacturing costs of microalgae (Becker 2007; Sarker et al., 2016a), some microalgae might also have poorly digestible cell walls (Skrede et al. 2011). Sarker et al. (2016a) endorsed that Schizochytrium sp is a pretty digestible factor for tilapia and thatelevated levels led to improved growth, FCR, and PER (Sarker et al., 2016b). Sarker et al. (2020) reported that the aggregate of Schizochytrium sp. And defatted biomass of *N. Oculata* within the fish-free feed exhibited two real benefits. First, fish fed the fish-free feed had an advanced growth rate. Second, they found maximum in-vitro protein digestibility within the fish-free feed, suggesting that protein originating from defatted *N. Oculata* biomass becomesmore digestible in the presence of *Schizochytrium* sp. Thus, the mixture of defatted N. Oculata biomass and *Schizochytrium* sp. It seems to be higher perfect to the digestive enzymes found in tilapia digestive structures than in traditional diets with FMFO; the presence of *Schizochytrium* sp may also aid more excellent digestion at the higher inclusion degrees of *N. oculata* defatted biomass. Kousoulaki et al., (2016).reported in a study that determined dietary inclusion of *Schizochytrium* sp. Stimulated muscle or tissue improvement of Atlantic salmon. The human health benefit of using highly digestible 22:6n-3 DHA-rich *Schizochytrium*sp suggests that tilapia-fed fish-free feed yielded the highest amount of 22:6n-three DHA in fillet - almost two times that of conventional feed. However, there is still confined availability of upgraded knowledge and current progress on using microalgal biomass to replace fishmeal and fish oil to developa sustainable aquaculture industry. This text critiques the current stage of complete information on widespread attributes of microalgal species used as a complete substitute for fishmeal and fish oil in aquaculture diets.

CONCLUSION

Fishmeal and oil are aquaculture feed's primary protein source and lipid supplies. Out of 178 million tonnes of total fish production, 89% (157million tonnes) of world production was used for human consumption. The remainder, over 20 MT, was used for non-food purposes – the vast majority for fish meal and fish oil (FAO, 2022). Microalgae can be considered a promising alternative that may replace fishmeal and oil and make specific sustainability requirements in aquaculture. Based on the available reviews in the literature, the effect of nutritional algae-based components on fish has been thoroughly mentioned in this evaluation. It is regarded that several authors operating in the fish feed studies have accredited the inevitable requirement of setting the plant-based total protein components to replace fish meal in the diet for commercially cultivable aquatic animals. Taking this board, we may additionally desire that fish meal will not be part of the fish diets in the future. In establishing scientific evidence and good knowledge on how best microalgae can be used in fish feeds, alarge quantity of nicely-designed feeding trials are required to evaluate the ability of microalgae as an alternative to fishmeal and fish oil. But it already appears that microalgae will play a critical role in the effort to move the components of aquafeed to a more sustainable future. The microalgal components of fish-free feed indicate the capacity to deliver the increasing aquaculture enterprise with a stable and low-priced supply of wholesome protein and oil for fish-free feed, doing so without causing damage to oceans or food protection for aid-poor people. It can be concluded that feed formulators can improvethe cost-powerful aqua feedswithout a fish meal and oil byadding algae biomass.

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