International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 3 Issue 5, August 2019 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

The use of Macroalgae as a Feed Supplement in Fish Diets

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How to cite this paper: Latife Ceyda Irkin "The use of Macroalgae as a Feed Supplement in Fish Diets" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-3 | Issue-5, August 2019, pp.966-969, **https://doi.org/10.31142/ijtsrd26538**

IJTSRD26538

ABSTRACT

Alternative feed additives must be able to supply comparable nutritional value at a competitive cost. Land-based crops, especially grains or oilseeds, have been favored alternatives due to their low costs, and have proved successful when they were used as substitutes of the fishmeals. A variety of herbs and spices have been successfully used in fish culture as growth promoters and immune-stimulants in recent years. Algae, including both macroalgae (seaweeds) and microalgae (e.g. phytoplankton), and which are popularly thought of as 'plants', would be good candidates to serve as alternatives to fishmeals. Therefore it can be difficult to make usual generalizations about the nutritional value of these diverse group of organisms. It is necessary to consider particular qualities of specific algae group using in fish meals.

KEYWORDS: *Algae, fish, feed, nutritional*

INTRODUCTION

Macroalgae are a diverse plantlike organism group that lives attached hard substrata in coastal areas. Based on their pigmentation, they can be classified into Chlorophyta, Phaeophyta and Rhodophyta. There are about 8.000 species of macroalgae along with the coastal areas to 270 m deep [1]. Macroalgae are able to adapt to the extreme environmental conditions by producing unique secondary metabolites including proteins, polysaccharides, lipids, pigments and minerals [2].

Several macro and microalgae are widely used in fish meals and there are lots of studies into the effects of algae in fish diets. Macroalgae are able to produce a wide range of nutritional compounds with unique biological properties. The benefits of the macroalgal ingredients provide basic nutrition for functional alternatives feed in aquaculture [3]. Algae are the base of the food chain that produces food resources that fish are easily adapted to consume.

THE CHEMICAL COMPOSITION OF MACRO ALGAE

The chemical composition of macroalgae varies with species, the season of harvest, geographic origin, physiological status and environmental conditions. Several studies have been conducted to investigate the biochemical and nutritional composition of various algae collected from different parts of the world [4].

Macroalgae represent great potential for its use in animal feed or for the extraction of biologically active compounds that could be incorporated into the dietary diets. Macroalgae are also known for their richness in bioactive molecules (antioxidant, antibacterial and antitumor) [5].

Protein is regarded as the most expensive nutrient in animal feed [6]. Macroalgae are promoted for the nutritional value of their proteins[7]. Species and the season of the collection are the most common factors affecting both macroalgal protein content and amino acid composition [7]. The protein content in brown macroalgae is low in comparison with green algae (10-26%) and red algae (35-47%) [8]. Also, most macroalgae species are a rich source of essential amino acids such as aspartic and glutamic acid [9]. Macroalgal contents of amino acids are threonine, lysine, tryptophan, cysteine, methionine and histidine [7].

The large group of macroalgae contains different polysaccharides and carbohydrates. Red algae contain carrageenans, sulfated galactan, xylans, agars and porphyrins. Brown algae contain sulfated fucoidans, laminarin and alginates. Green algae contain sulfated galactans and xylans [10]. These polysaccharides are an integral part of the thriving biomedical and pharmaceutical industries. Macroalgal polysaccharides especially Fucoidan and laminarin show a wide range of biological activities such as anti-inflammatory, antimicrobial, anticoagulant, antioxidant, antiviral, antitumor, antiseptic, anti-proliferative and immunostimulatory [11]. Also, macroalgae have a similar or higher level of dietary fiber compared with other terrestrial plants [12].

Macroalgae species have generally low lipid contents but the proportion of polyunsaturated fatty acids (PUFA) is high [13]. PUFAs are considered essential nutritional components for human and animals, playing a role to prevent cardiovascular diseases, diabetes and osteoarthritis [14]. The content of PUFA is generally higher than another organism in water. PUFA content varies from 34 % of the total fatty acid in *Porphyra sp.* to 74 % in *Undaria pinnatifida* [15].

Ulva sp. is unique in comparison with fish-derived oil and plants due to high levels of PUFA (octa decatetraenoic acid, eicosapentaenoic acid and docosahexaenoic acid) which are generally higher than terrestrial plants. Brown algae have the highest total lipid content followed by green and red algae [16]. There is variation in total lipid content between species and seasons. High lipid level was investigated in winter and spring for *Ulva lobate, Egregia Menzies* and *Chondracanthus canaliculus* [17].

Vitamins are essential organic micronutrients, that organisms cannot synthesize directly in sufficient quantities and so instead must obtain from diets. Macroalgal components are rich in several vitamins. Sea vegetables-laver (*Porphyra umbilicalis*), sea spaghetti (*Himanthalia elongata*), and *Gracilaria change* contain high levels of vitamin C comparable to vegetables such as tomatoes and lettuce [18]. Macroalgae also are a good source of Vitamin B group (particularly B_1, B_{12}), as well as the lipophilic vitamin A (derived from the carotenoid β-carotene) and vitamin E (α-tocopherol) [19]. Kelp (*Macrocystis pyrifera*) can contain levels of α-tocopherol (the most active form of vitamin E) at par with plant oils rich in this vitamin, such as palm, sunflower seed and soybean [20; 21]. Moreover, values of β-carotene (provitamin A) found in *Codium fragile* and *Gracilaria chilensis* can exceed those measured in carrots [20].

Macroalgae grow in the oceans that they absorb a range of minerals and other nutrients. They are also fairly simple food making easy for the human and animal body to break down and release the healthful substances providing a variety of vitamins and minerals. Macroalgae are low-calorie food, rich in some health-promoting molecules and materials such as dietary fiber, fatty acids, essential amino acids, vitamins A, B, C, D and E, riboflavin, niacin, pantothenic acid and folic acid.

Macroalgae can also accumulate large amounts of heavy metals (arsenic, cadmium, lead and other heavy metals) in some species can limit their use in animal feeds. The bioavailability of these metals is important to determine toxicity risk factors. For many macroalgae species, the level of heavy metals are below feed safety limits [5]. Recent researches show that the interest in macroalgal biomass is a popular potentially feedstock for the production of feeding alternative ingredients for terrestrial and aquacultural livestock.

MACROALGAE AS FUNCTIONAL FEED ADDITIVES IN AQUACULTURE

There is a rising interest in scientific studies to determine new alternative feed additives for human and animal nutrition. The concept of chemical-free organic feed has become appealing including natural forms of vitamins, mineral and other nutrient components. Functional feed additives were described as dietary components that provide health benefits in basic nutrition [22]. Functional feed additives also have a different chemical composition for antibacterial, antioxidant, anti-hypertensive and anti-tumor activities [22].

Animal nutrition has productive parameters such as weight gain and feed utilization. Animal nutrition gained attention to produce functional feed additives with beneficial health effects that increase the price of animal products [23].

Alternative feed additives of production animals modify to incorporate the economic and health benefits of the ingredients for animal nutrition. Functional feed additives could be described as dietary components that provide environmental and economic benefits, health and growth [24]. Aquaculture is a fast-growing sector of the food economy, increasing more than 10 % per year and accounts for more than 50 % of water products consumed [24].

The development of new ingredients and feed formulations help the reduce production cost and improve animal health represents. Fishmeal is extensively used in aquaculture for fish as well as other animals thanks to its substantial content of high-quality proteins and essential amino acids. The use of animal protein sources such as fishmeal is expected to be reduced or eliminated as a result of environmental, economic and sanitarian problems [24]. Alternative feed ingredients should be able to supply nutritional value at a competitive minimal cost. Commonly crop plant proteins are used in fish feeds but they are deficient in certain amino acids such as methionine, lysine, threonine and tryptophan.

Macro and microalgae play a vital role in aquaculture. For example the addition of microalgae to larval fish tanks provide a number of benefits such as preventing bumping against the walls of the tanks [25], enhancing predation and nutritional value of zooplankton [26;27] and improving larval digestive and immune [28;29]. Marine algae are well-matched organisms to the nutritional requirements for fish. Larval feeds are deserving most attention in efforts to discover the best algae used in fishmeals. The particular properties of algae must be carefully considered lipid, protein/amino acid and pigment profiles.

Several studies reported that dietary supplements with algae and their extracts, due to the presence of nutritional components can enhance the immune resistance and growth performance. Macroalgae species with protein content could be a potential novel feed ingredient in aquaculture [30].

The use of different percentages of macroalgae in fish diets shows positive results in productive parameters, enhance animal health and increase beneficial compounds in products. Similarly, recent studies used macroalgae in diets of aquaculture production systems. The addition of 5% of *Porphyra yezoensis* or *Ulva pertusa* to the red sea bream (*Pagrus major*) increased body weight, muscle protein deposition and feed utilization in comparison with the fish normal diet [31]. *Porphyra dioica* at levels of 10 % in rainbow trout feed showed positive effects on growth performance and increased the pigmentation of fish [32]. Dietary macroalgae supplementation (*Ulva, Gracilaria* and *Fucus* sp.) improved immune system and antioxidant activity in European seabass (*Dicentrarchus labrax)* [33]. Mineral-rich macroalgae have been incorporated in commercial salmon feeds at 15 % in vitamin and mineral pre-mixes [34]. *Ulva* species are important macroalgae because of a good source of protein, pigments minerals and vitamins (especially vitamin C) that have been investigated as a dietary ingredient for fish species [35]. Fishmeal provides lipids rich in PUFAs', omega-3 and omega-6 fatty acids. These are fish oil lipids that have become highly prized for production. Algae at the base of the aquatic food chain originate this fatty acid that is indeed essential nutrients for many fish [36]. The optimum inclusion level varies depending on algae or consumer species. The inclusion of algae in formulations results in pellet quality, better growth performance and higher animal product quality [37]. Different strains of micro and macroalgae vary in their efficacy within formulated animal feeds. There is sufficient evidence of beneficial properties to promote algal biomass as a source of micronutrients [38].

CONCLUSION

Nutritional studies evaluate algae as an advantageous major feed additive for the cultivation of animals. Animal nutrition and production studies as the 'superfood' of both micro and macroalgae have been investigated to support the claims made by basic evidence. Several compounds in algae can have beneficial effects. When these compounds are used in aquaculture, algae provide an improved immune system and gut function, a good lipid metabolism, an antiviral and antibacterial action. In addition, algae are a good source of protein, amino acids, vitamins and minerals.

Studies suggest that several macroalgal species have beneficial health effects and potential as a source of bioactive compounds for aquacultural production. Current researches indicate an important role for macroalgae in the production of compound feed that improve animal health. There is interest in the variety of bioactive compounds in macroalgae such as fucoidan, laminarin and phlorotannins.

Macroalgae biomass as a source of macro and micronutrients can be an alternative for the development of animal feed and derived animal products. In addition, the extraction of macroalgal compounds has shown positive results as prebiotics for improving the health of animals.

Both micro and macroalgae have naturally potential as feed supplements to replace the synthetical ones. The natıral forms of nutrients are more bio-available than synthetic forms.

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