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SEAWEED BASED NUTRACEUTICAL IN AQUACULTURE

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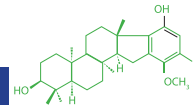
INTRODUCTION

Aquaculture has emerged as an essential source of seafood for the ever growing human population, playing a significant role in ensuring global food security. With the increasing demand for nutritious seafood driven by population growth and the depletion of wild fish stocks, aquaculture serves as a vital link between supply and demand (Garlock, et al., 2022). However, continually increasing aquafeed costs and disease outbreaks have become common challenges and questioning the sustainability of aquaculture (Barasa et al., 2022; Afewerki et al., 2023). Addressing these challenges is imperative, necessitating the urgent need to find a cost-effective and health-promoting feed ingredients. The goal is to support fish growth while preventing diseases in aquaculture production. In recent times, there has been a surge in interest regarding the utilization of diverse seaweeds—such as red seaweed (e.g., *Gracilaria, Porphyra*), brown seaweed (e.g., *Laminaria, Ascophyllum*), and green seaweed (e.g., Ulva, formerly *Enteromorpha*)—as potential sources of bioactive compounds and feed ingredients for incorporation into aquafeed given their favorable nutritional composition, environmental sustainability, and potential health-promoting factors for farmed fish (Wan et al., 2019). Numerous studies suggest that seaweed and seaweed-based functional metabolites, when included as supplements in aquafeed, can enhance serum immune and antioxidant status, as well as disease resistance in fish (Akbary et al., 2018; Thepot et al., 2021).

Seaweeds, also known as macroalgae, have gained significant attention as a potential source of nutraceuticals in fish feed due to their rich composition of bioactive compounds. These compounds include polysaccharides, polyphenols, pigments, and fatty acids, which offer numerous health benefits for fish, such as enhanced growth, improved immune response, and increased antioxidant capacity (Wan et al., 2018).

One of the key advantages of seaweed-derived nutraceuticals is the presence of polysaccharides. These complex carbohydrates have shown immunomodulatory effects in fish, improving their immune system functionality and disease resistance. For example, fucoidan, a sulfated polysaccharide derived from brown seaweeds, has been shown to enhance immunity in



fish, increase phagocytic activity, and improve the production of immune-related enzymes (Hemre et al., 2014). Additionally, ulvans derived from green seaweeds have demonstrated immunostimulatory effects, stimulating the production ofimmune-related enzymes (Hemre et al., 2014). Additionally, ulvans derived from green seaweeds have demonstrated immunostimulatory effects, stimulating the production of immune-related molecules and enhancing immune response in fish (Kumari and Rath, 2014).

In addition to their immunomodulatory properties, seaweed-derived nutraceuticals also possess antioxidative activities. The high content of pigments, such as chlorophylls, carotenoids, and phycobiliproteins, present in seaweeds act as potent antioxidants, protecting fish cells from oxidative stress and reducing the production of reactive oxygen species (ROS) (Matsui et al., 2016). These antioxidants help to maintain fish health, improve their growth performance, and reduce the detrimental effects of stressors. Further more, the fatty acid composition of seaweeds makes them an attractive nutraceutical source for fish feed. Seaweeds are known to contain a high proportion of polyunsaturated fatty acids (PUFAs), including omega-3 fatty acids such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). These PUFAs play crucial roles in fish growth, development, and overall health, particularly in regards to brain function, lipid metabolism, and immune response (Mabeau and Fleurence, 1993).

Several studies have investigated the effects of incorporating seaweed-derived nutraceuticals in fish feed. For example, the inclusion of *Gracilaria* spp. in the diet of rainbow trout (*Oncorhynchus mykiss*) induced a significant improvement in growth performance, feed conversion ratio, and protein efficiency ratio, compared to a control diet (Martínez-Bertos et al., 2013). Similarly, the supplementation of *Ascophyllum nodosum* extract in the diets of *Atlantic salmon (Salmo salar)* resulted in enhanced growth, improved immune response, and increased resistance against pathogens (Reverter et al., 2014).

The positive effects of seaweed-derived nutraceuticals on fish growth and health are attributed to their bioactive compounds. For instance, polysaccharides derived from seaweeds have been shown to enhance the digestion and absorption of nutrients in fish. This is mainly due to their prebiotic properties, promoting the growth of beneficial gut microbiota and facilitating nutrient utilization (Burrells et al., 2015). In addition to their nutritional benefits, seaweeds also possess antimicrobial and antiviral activities. These properties are of significant interest in aquaculture, as they can help reduce the use of antibiotics and mitigate the risks of disease outbreaks. For example, the administration of seaweed extracts from several species, including *Undaria pinnatifida, Alaria esculenta,* and *Laminaria digitata*, has demonstrated potent antimicrobial effects against various fish pathogens, reducing the mortality rate and improving fish health (Smith et al., 2012).

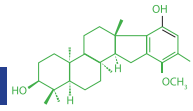
NUTRACEUTICAL

Nutraceuticals, a term derived from "nutrition" and "pharmaceutical," refer to bioactive compounds present in certain foods, supplements, and functional foods that offer health benefits beyond basic nutrition. These substances encompass a diverse range, including vitamins, minerals, antioxidants, probiotics, prebiotics, omega-3 fatty acids, herbs, amino acids, fiber, polyphenols, and enzymes. Acting as preventive agents, nutraceuticals contribute to overall well-being and may play a role in reducing the risk of chronic diseases. For instance, antioxidants neutralize free radicals, probiotics support gut health, and omega-3 fatty acids aid cardiovascular and brain health. The use of nutraceuticals aligns with a holistic approach to health, emphasizing the potential therapeutic and preventive properties of natural compounds. However, it's crucial to integrate these bioactive substances into a balanced diet and lifestyle, and individuals should consult with healthcare professionals before incorporating nutraceutical supplements, especially if they have existing health conditions or are taking medications.

SEAWEED NUTRITIONAL VALUE

Macroalgae exhibit considerable diversity in their nutritional makeup, making them a valuable reservoir of essential nutrients. They are rich in proteins, vitamins (such as C, E, and B complex), minerals (calcium, iodine, iron, and magnesium), and dietary fiber. Moreover, macroalgaeharbor a range of bioactive compounds, including polysaccharides, polyphenols, carotenoids, and phycobiliproteins, contributing to their potential health advantages. The bioactive components found in macroalgae possess various positive properties, positioning them as promising candidates for functional foods and nutraceuticals. For example, polysaccharides derived from macroalgae showcase immunomodulatory, antioxidant, and antitumor activities. Research has illustrated that seaweed can enhance animal health, exhibiting antibacterial, antioxidant, and anti-inflammatory attributes in diverse species like pigs, fish, chickens, and ruminants.

The chemical composition of seaweed varies based on factors such as species, harvest time, and environmental conditions like temperature, light, salinity, and nutrients. Additionally, macroalgae have the potential to enhance gut health through prebiotic activity, stimulating the growth of beneficial gut bacteria. Certain macroalgae species, thanks to their high polyphenol content, contribute to anti-inflammatory, antiviral, antibacterial, and cardioprotective effects. Furthermore, specific macroalgae species contain omega-3 fatty acids, offering potential benefits for cardiovascular health.



USES OF SEAWEEDS IN AQUACULTURE:

FUCOIDAN:

Fucoidan is used as a feed supplement in fish feed to improve growth performance, immunity, antioxidant capacity, digestive enzyme activity, and hepatic morphology in fish. It has been found to have growth promotion, antioxidant, and strong immunity properties, making it a promising feed additive to enhance the growth and immunity in aquatic animals. Additionally, fucoidan has been shown to regulate gastrointestinal function, have anti-inflammatory, anti-oxidation, anti-tumor, anti-bacterial, and immunomodulatory properties. Therefore, it is used to enhance the overall health and performance of fish in aquaculture.

The study found that feeding fucoidan had positive effects on the growth performance of juvenile common carp. Specifically, the results showed that fish fed diets with a fucoidan supplementation of 1,666.67–1,757 mg/kg had the best growth performance. This was evidenced by improvements in final weight, weight gain, and specific growth rate (SGR) compared to the control group. Additionally, the feed conversion ratio (FCR) in the group with optimal fucoidan supplementation was significantly lower, indicating improved feed utilization. The study also conducted regression analysis, which showed that the optimal dietary content of fucoidan for growth was 1,757 mg/kg. Therefore, the study demonstrated that fucoidan supplementation positively influenced the growth performance of juvenile common carp.The study found that fucoidan supplementation had significant effects on the immunity and antioxidant capacity of the fish. Specifically, the supplementation of fucoidan led to improvements in various immune parameters and antioxidant activities in juvenile common carp. Here are some of the key findings:

CARRAGEENAN:

Carrageenan, a class of sulfated galactose, is primarily derived from red seaweed. It is found in the cell wall and intercellular matrix of various algae species, including *Chondrus crispus, Gymnogongrus fucellatus, Soleria chordalis, Cystoclonium purpureum,* and *Kappaphycus alverezii*, the latter being of main interest (Sahu et al., 2011; Webber et al., 2012). Carrageenan plays a significant role in fish feed formulations, serving as a valuable additive due to its gelling, thickening, and stabilizing properties. Its incorporation into fish feed enhances the overall texture and stability of the feed pellets. Additionally, it helps prevent the segregation of feed components during production and storage. Moreover, carrageenan contributes to the palatability of the feed, making it more appealing to fish. Its ability to form a gel can also assist in controlling the release of nutrients and bioactive compounds, ensuring a steady and controlled nutrient delivery to the fish. The use of carrageenan in the diet has also been found

to enhance the growth and survival of common carp. Carrageenan was incorporated at two graded levels in the experimental diets (Murthy et al., 2017).

AGAR AND ALGINATE:

Alginate is derived from brown seaweed, such as kelp and *Laminaria* species. Alginate polysaccharides or agar exhibit immunostimulant properties capable of enhancing the immune system and reducing fish mortality rates. Moreover, these compounds function as antioxidants and prebiotics, promoting the overall health of fish. The incorporation of agar and alginate into fish feed has demonstrated an augmentation in the count of fish leukocytes, pivotal elements of the immune system (Mulyarasi et al., 2021). Notably, sodium alginate extracted from brown algae *Undaria pinnatifida* and *Macrocystis pyritera* has been found to enhance the non-specific defense system in common carp and increase resistance against *E. tarda* infection (Fujiki K et al., 1994). Furthermore, alginic acid (Ergosan), extracted from the brown alga *Macrocystis pyritera*, has been reported to elevate the non-specific defense response in snakehead (Channastriata) (Miles et al., 2001).

PIGMENTS

In terms of pigment composition, seaweeds can be categorized into three groups: chlorophylls (Chl), carotenoids, and phycobiliproteins (PBPs). These groups represent distinct types of natural pigments that contribute to the diverse colors observed in seaweeds. Fucoxanthin, constituting the primary carotenoid in brown seaweeds, accounts for over 10% of the total carotenoids produced in nature (Rodríguez-Bernaldo et al., 2010). The green hue characteristic of green seaweeds results from the presence of chlorophyll a and b, β-carotene, and xanthophylls, while the red color in red seaweeds is attributed to the proteinic pigments phycoerythrin and phycocyanin (O'Sullivan et al., 2010; Hamid et al., 2015). These pigments play a crucial role in fish nutrition and overall health (Rodriguez-Amaya, 2016), contributing to the skin and flesh color of fish such as salmon, tilapia, and seabream (Gomes et al., 2002; Araújo et al., 2016). The color of fish skin and flesh significantly influences consumer preferences. In promoting organic aquaculture, incorporating seaweeds in aquafeeds becomes a bright alternative to synthetic colorants, offering both vibrant hues and natural health benefits for fish.

CONCLUSION

Seaweed-based nutraceuticals have emerged as a valuable tool in advancing the sustainability and performance of aquaculture. By harnessing the power of the ocean's natural resources, the industry can promote the health and well-being of farmed species while minimizing its

environmental impact. By incorporating seaweed-derived nutraceuticals in fish feed, the dependency on fish-based ingredients can be reduced, thus alleviating the pressure on wild fish populations. As research and development in this field continue, seaweed-based solutions hold great promise for a more resilient and sustainable future for aquaculture.

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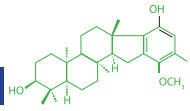

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