Eubiotics in Aquaculture

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Abstract

Aquaculture is the most rapidly growing sector in worldwide food production. However, this rapid expansion faces hurdles such as disease outbreaks, declining water quality, and overuse of antibiotics. As an alternative to antibiotics and growth promoters, "Eubiotic," a term that refers to beneficial substances that promote a balanced microbial environment in the gut and the culture water, has gained attention. Eubiotics encompasses probiotics, prebiotics, synbiotics, organic acids, Phyto-biotics, vitamins, and minerals. All of these substances promote better fish and shrimp health, enhanced immune response, and better nutrient digestion. Thus, Eubiotics promote better aquaculture productivity by inhibiting harmful microbes and promoting beneficial gut microbiota while reducing harmful environmental effects. However, the challenge persists in determining optimal dosages, providing similar effects in various species and strain specificity. Future research should focus on developing tailored eubiotic formulations, cost-effective production methods, and strategies for integrating these solutions into everyday aquaculture practices.

Keywords: Eubiotics, disease resistance, immunity, sustainable production, prophylaxis

Introduction

The aquaculture plays a crucial role in the global food security and employs millions of people worldwide. Approximately 61.8 million people are directly or indirectly dependent on primary production of fishes (FAO, 2022). As per FAO 2022, global fish and aquaculture production is estimated at 223.2 million tonnes, where 185.4 million tonnes is contributed by aquatic animals and 37.8 million tonnes by algae. In 2021, per capita fish consumption is around 20.6 Kg, and 162.5 million tonnes of aquatic animal is consumed globally. Revolution of aquaculture can be brought through utilizing and formulating proper nutrients and additives as per the requirement of cultured organisms, which promote growth, gut health, immune responses, disease resistance, and feed efficiency. Considering cost-effectiveness and sustainability, the focus of fish nutrition has shifted towards natural additives like plant extracts and compounds derived from algae. Managing production costs is a concern for fish farming, especially when it comes to fish feed expenditures, which account for 50–70% of a farm's budget (FAO, 2020). Fish farmers should monitor production costs and use innovative methods for utilizing plant proteins to enhance the feed efficiency of the cultured organisms. Feed additives are chemicals that are fortified in diets to enhance shelf life and quality of the feed. To improve feed's appearance, palatability, and digestibility, they are applied in trace amounts. Feed binders, carotenoid supplements, medications, antibiotics, hormones, antifungals, antioxidants, fibre and flavourings are examples of non-nutritive feed additives that are significant components of fish feeds. These additives affect the final product's quality and improve pellet stability, diet safety, and the performance of fish and animals (Yadav *et al.*, 2021). Additives in feed aim for healthy growth and higher production, classified into essential, growth-promoting, and auxiliary additives. In order to improve nutritional balance and encourage healthy animal growth, essential feed additives are utilized; these consist of cholesterol, fatty acids, phospholipids, fish oils, vitamins, and minerals. To increase growth and the food conversion ratio, phosphatidylcholine, cholesterol, fish oils, fatty acids, vitamin premixes, and minerals can be added. Growth-promoting additives, such as synthetic compounds, single-cell proteins, and plant and animal materials, are added to feeds to promote the growth of aquatic animals. To improve the growth performance of culture organisms, eubiotics, probiotics, prebiotics, synbiotics, enzymes, hormones, antibiotics, medications, and phytobiotics are used in formulated feed, which enhances the growth and immunity of the culture organisms. In aquaculture, eubiotics are natural feed additives being hypostatised as a possible remedy for antimicrobial resistance in aquaculture. Similar to yeast cell wall components, these additions enhance performance and support gut health by preventing the colonization of dangerous pathogens (Santovito *et al.*, 2018). This leads to reduced expenses and improve the better health outcomes. Additional advantages of eubiotics include decreased antibiotic dependence, increased feed efficiency, and a decrease in bacteria resistant to antibiotics. By lowering the demand for antibiotics, they also support food security and sustainability. Eubiotics present a viable alternative to antibiotics in contemporary aquaculture, improving fish productivity and health without causing side effects.

This article highlights at the use of eubiotics in aquaculture, comparing them to antibiotics and highlighting environmentally friendly practices that may improve fish growth and health by balancing gut microbiomes.

What are Eubiotics?

The term "eubiotics," which comes from the Greek word "eubiosis," describes the process of keeping the microbiota in the gut or gastrointestinal tract in an ideal balance. They use organic acids, probiotics, prebiotics, and essential oils to enhance animal health and growth performance. These products' antibacterial qualities and capacity to modify gut microbiota determine their success. For healthy gut function, the gut microbiota, which consists of microorganisms living in symbiotic relationships with the host, is essential. Age, nutrition, sex, immunity, host genetics, medication use, location, and socioeconomic status are some of the variables that affect gut flora. Combining various feed additives can reduce pathogenic bacteria (dysbiosis) and increase lactic acid bacteria (eubiosis) in the animal's digestive tract, resulting in a healthy intestinal microbial ecology (Elala *et al*., 2015).

Use of Eubiotics in aqua feed

By using feed additives to increase animal health and productivity, eubiotics promote aquaculture growth. They improve nutrition absorption, boost immunity, and maintain a balanced gut microbiota. This improves feed utilization, lowers the need for antibiotics, and lowers antimicrobial resistance, all of which increase growth rates and profitability. The integration of eubiotics supports environmentally friendly methods. Eubiotics are not only used in aquaculture, but they also help to improve the health, productivity, and sustainability of a variety of animals, including poultry, dairy cattle, pigs, sheep, goats, dogs, Cats, horses, and exotic animals.

Types of Eubiotics

Types of eubiotics that can be used in aquafeed are described below:

Probiotics as an eubiotics

The word "probiotic," which comes from the Greek for "benefit" and "life," has expanded throughout time to refer to substances and organisms that enhance the balance of gut microbiota. They were first identified in fermented dairy products in 1908. When given in sufficient quantities, these living microbes help the host's health. Live or dead aquaculture probiotics are given to the host through feed or rearing water, and they can improve health, growth, feed utilisation, stress response, disease resistance, or overall vigour (Hai, 2015).

Generally, bacteria having an almost exclusive saccharolytic metabolism (i.e., no proteolytic activity) can be considered potentially beneficial, typical for lactobacilli and bifidobacteria (Slavin, 2013). Probiotics have become well-known as a substitute for antibacterial medications in the aquaculture industry as a way to boost output and avoid illness. They can be used in aquaculture for a variety of purposes, such as adding probiotics to ponds to improve water quality, bacterial growth, disease resistance, and immune development.

Common criteria for probiotics

- Withstand acidic environments
- Able to withstand stomach secretions
- Stimulation of the immunological system
- Growth in the mobility of the gut
- Adaptable to mucus survival
- In food, probiotics should be viable during storage and transportation, exhibit fermentative activity, and be resistant to drying.

Mode of Action:

According to Oelschlaeger (2010), probiotics can work in the host system in 3 key ways:

- Strengthen the host's innate and acquired immune systems, thus reducing the spread of infectious diseases and gut inflammation.
- Direct action against harmful gut bacteria, maintaining healthy microbial balance in the gut.
- By producing beneficial microbial compounds, which include antimicrobials, host metabolites, and toxins. These are essential for the probiotic role.

Prebiotics as a eubiotics

Prebiotics are indigestible substances that specifically promote the development and activity of advantageous gut microorganisms, and they are essential for improving the sustainability and health of aquaculture. Prebiotics improve fish and prawn digestion, immunity, and stress tolerance by acting as a "fertilizer" for the natural microbiota, in contrast to probiotics, which add live beneficial bacteria. Inulin, mannan-oligosaccharides (MOS), and beta-glucans are examples of common prebiotics that have been demonstrated to improve disease resistance, growth performance, and survival rates in cultured organisms. Additionally, by strengthening the natural defence of aquatic animals, they lessen the need for antibiotics, improving environmental sustainability and health management (Torrecillas *et al.*, 2014). The addition of prebiotics to feed appears to be a useful tactic to accomplish the aquaculture industry's commitment to sustainable and productive operations.

Mode of action:

As mentioned by Slavin (2013), prebiotics are utilized in the colon part of the intestine by the process of fermentation. Beneficial bacteria like *Lactobacillus sp.* and *Bifidobacterium sp.* use saccharolytic metabolism to break down substrates.

Synbiotics as an eubiotics

Synbiotics refer to nutritional supplements combining probiotics and prebiotic food ingredients and in the form of synergism that improve the survival and implantation of live microbial dietary supplements in the tract are either stimulated by growth or by metabolically activating the health-promoting bacteria.

Mode of action:

The mechanism of synbiotic effects is through modulation of metabolic activity in the intestine, preservation of the intestinal biostructure, growth of the beneficial microbiota, and simultaneous suppression of any possible pathogens in the GI tract.

Organic acids as eubiotics

In aquaculture, organic acids are becoming a more effective and sustainable technique that supports the development and well-being of aquatic species raised for food. Formic acid, acetic acid, citric acid, butyric acid, and other naturally occurring substances are well-known for their safety and adaptability. Organic acids reduce the pH in fish and shrimp's digestive tracts by acting as acidifiers when added to the diet. This acidic environment promotes the growth of good gut bacteria like *Lactobacillus sp.* while suppressing pathogens like *Vibrio spp.* and *E. coli*. Better digestion, increased nutrient absorption, and greater feed conversion efficiency are the outcomes which help aquatic species become healthier and grow more quickly (Ng & Koh, 2017). Apart from improving gut health, organic acids also improve water quality in aquaculture systems, especially Recirculatory aquaculture systems (RAS), by controlling pH levels and lowering toxic ammonia. By preventing bacteria from growing in feed and water, their antimicrobial qualities aid in preventing illnesses. Additionally, certain organic acids, such as butyric acid, strengthen aquatic species' immune systems, increasing their resistance to stresses from the environment and diseases (Zarei *et al*., 2021). Organic acids are a natural and efficient substitute for antibiotics in the aquaculture sector, which is moving away from them to avoid resistance problems.

Mode of action:

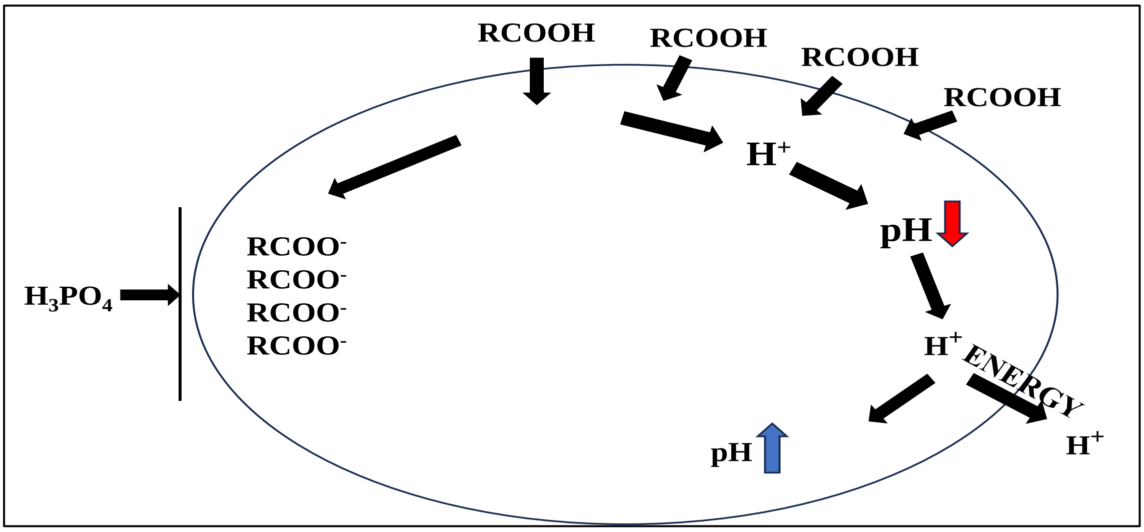

Figure: Mode of action of organic acid on pH-sensitive bacteria

Organic acids added to feed can lower the pH of the stomach, which speeds up the conversion of pepsinogen to pepsin, therefore enhancing the rate at which minerals, proteins, and amino acids are absorbed (Park *et al*., 2009). Organic acids have natural antimicrobial properties because they can easily pass through cell membranes in their lipophilic, un-dissociated form. Once inside the cell, they alter proton levels and disrupt the balance of related anions in the cytoplasm, making it difficult for microbes to survive (Dibner & Buttin, 2002).

Essential oil as eubiotics:

Essential oil offers flavouring for enhanced appetite and supports normal gut health thus enhancing digestive function. Oils extracted from herbs like Peppermint, Lavender, Frankincense, Eucalyptus etc. are having beneficial properties which promote anti-pathogenic properties. Essential oils (EPA, DHA, AA etc) extracted from algae and fish also act as a good source of eubiotics. There are several commercial products like Veramaris and DHA gold, which offer essential oils as eubiotics.

Mode of action:

It acts as antimicrobial as it is having substances like carvacrol, thymol, eugenol and cinnamaldehyde which disrupt bacterial cell wall. They reduce gut inflammation by inhibiting pro-inflammatory cytokines (TNF-α, IL-6, etc).

Phytogenic, Vitamins and minerals as eubiotics

Eubiotics in aquaculture enhance immunological response, metabolic processes, and gut health. Minerals like calcium, phosphorus, magnesium, and zinc support bone health and immunological defence. Vitamin A, D, E, and C support immune responses and other physiological welfare. Phytogenic substances which are made from plant components, increase probiotic growth, decrease pathogenic load, and stimulate the gut microbiota. These substances improve general health and resilience to stress, alter the immune system, and lower the risk of disease. A healthier, more productive aquaculture system with less reliance on chemicals and antibiotics results from the combination of these eubiotics, which enhance the growth, immune system, and disease resistance of aquatic animals.

Current status of eubiotics in aquaculture:

Use of eubiotics in commercially important freshwater and brackish-water species are mentioned in table no 1.

Table no. 1. Current status of eubiotics in aquaculture of commercial fish species

Sl.no.	Fish sp	Inclusion level	Results	References
1.	*Oreochromis niloticus*	0.2%, 0.3%	Dietary supplementation with 0.3% KDF stimulates intestinal flora, promotes cellular and humeral innate immunity, and lowers cumulative mortality in fish groups fed KDF and challenged orally with Aeromonas hydrophila. Dose-dependent	Elala *et.al.*, 2015

			resistance increases, suggesting acidifiers can be an efficient tool for sustainable, economical, and safe fish production.	
2.	*Snakehead Fish*	5%,10%and15%	The study used varying amounts of 15 ml/100 gm feed to assess the effects of eubiotics on snakehead fish feed (*Channa striata*). According to the results, the most successful feed treatment at the conclusion of raising was 15 ml/gm.	Safitri *et al.*, 2024
3.	*Siberian sturgeon*	Diet supplemented with 2% acetic acid (diet 2), 0.01% protein (diet 3), and a combination of 2% acetic acid and 0.01% protein (diet 4).	According to the study, diets 2 and 4 increased gut bacterial counts, decreased gut pH, and increased enzyme activity while producing the highest final body weight, weight gain, and specific growth rate.	Zare *et.al.*, 2021
4.	*Labeo rohita*	Potassium Format (PF) PF10, PF20, and PF30	The study discovered that by raising growth rate, feed conversion ratio, total serum globulin level, and digestive enzyme activity, PF10 supplementation can improve the nutritional efficiency and	Sidiq *et al.*, 2023

			physiological activities of rohu fingerlings.	
5.	*Clarias gariepinus*	B1-0%, B2-0.05%, B3-0.1%, B4-0.05%, B5-0.1%.	The study found that fish fed a 0.1% mix of formic, acetic, and propionic acid or 0.1% butyric acid had a significantly higher RGR without affecting their K and CR.	Asriqah *et al.*, 2019
6.	*Acanthopagrus latus*(fingerlings)	Butyric acid glyceride(BAG) including 0,0.25,0.5,&1%	The study indicates that incorporating 1% of BAG into the diet can enhance growth performance and overall health in *A. latus* fingerlings.	Zarei *et al.*, 2021
7.	*Caspian Brown trout (Salmo trutta caspius)*	G0: 0 g kg^{-1} Bio-Aqua and 0% NaDF G1: 0.2 g kg^{-1} Bio-Aqua and 0% NaDF G2: 0.2 g kg^{-1} Bio-Aqua and 0.5% NaDF G3: 0.2 g kg^{-1} Bio-Aqua and 1% NaDF G4: 0.2 g kg^{-1} Bio-Aqua and 1.5% NaDF	The expression of the immune-regulating genes IL-10, IL-1β, GTP, FATP, and IGF was significantly improved in all probiotic (Bio-Aqua) and acidifier (NaDF) treated groups.	Mohammadian *et al.*, 2023

8.	*Gilthead Sea Bream (Sparus aurata)*	A: No probiotic (Nisin-Producing *Lactococcus lactis*) B:2×10^9CFU/kg C:5×10^9CFU/kg	Higher growth and immune gene expression was observed in C group of diets.	Moroni *et al.*, 2021
9.	*European sea bass*	Blend of microencapsulated organic acids (citric and sorbic acid) and nature identical compounds (thymol and vanillin) A 0 mg kg feed^{-1} B 250 mg kg feed^{-1} C 500 mg kg feed^{-1} D 1000 mg kg feed^{-1}	Upregulation of IL-8, IL-10 and TGFβ genes, enhanced immune function was observed in higher concentration groups	Busti *et al.*, 2020

Future perspective of eubiotics in aquaculture

Using eubiotics in aquaculture production offers the possibility of using an alternate antimicrobial agent instead of an antibiotic growth promoter. It is used in aquafeed to improve gut flora and health as an alternative to additives. In order to boost growth and serve as an antibiotic substitute, future studies must assess eubiotics such as probiotics, prebiotics, essential oils, and organic acids.

Conclusion

Eubiotics are proving to be a game-changer in aquaculture by maintaining a balanced gut and better nutrient absorption, leading to improved fish health, better immunity, and less dependency on antibiotics. With ongoing research and innovation, eubiotics can become a reliable and practical solution for fish farmers worldwide.

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