

PHYTOBIOTICS IN AQUACULTURE: A SUSTAINABLE APPROACH TO ENHANCING HEALTH AND PERFORMANCE

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Received: June 26, 2024; Accepted: Sept 10, 2024

Introduction

Phytobiotics, also known as phytogetic feed additives, are compounds obtained from plants having bioactive qualities that are good for the health of animals. They are becoming more popular in aquaculture as a sustainable, natural substitute for artificial chemicals and antibiotics. Phytobiotics include herbs, spices, essential oils and other extracts. These compounds were originally employed in agricultural and human medicine. Now they are being used in aquaculture due to the concern about antibiotic resistance and a trend toward natural products. Phytobiotics compounds (like alkaloids, tannins, saponins, glycosides, terpenoids, phenolics, flavonoids, essential oils or steroids) offer several advantages in aquaculture, such as enhance feed intake, digestion and nutrient absorption which improves growth as well as feed efficiency (Bhanja *et al.*,2023). Their antioxidant, antibacterial and anti-inflammatory properties also promote the health of aquatic species. They help disease prevention in aquaculture systems by enhancing immunity and reducing stress.

Mechanisms of action

Antimicrobial Activity: The inherent antibacterial qualities of phytobiotics are making their usage in fish feed more common. The growth of pathogenic bacteria and fungus in fish digestive systems can be inhibited by these plant-based compounds. Aquatic species are less likely to have disease outbreaks when phytobiotics are introduced to their diet. This strategy reduces the need for antibiotics in fish feed for safe and sustainable aquaculture practices.

Antioxidant Activity: Phytobiotics provides the antioxidant properties to maintain the resilience and overall health of aquaculture species. These herbal compounds are rich in antioxidants, which effectively neutralize harmful free radicals in the body. In this way,

phytobiotics protect cells from oxidative damage, which is associated with number of diseases.

Anti-inflammatory Activity: Some phytobiotics have excellent anti-inflammatory properties that are beneficial to aquaculture species. These substances improve immunological functioning in addition to relieving stress by reducing inflammation in the body. Enhanced immune system can help aquaculture species to resist infections and diseases for better growth.

Digestive Stimulant: Phytobiotics improves the digestive processes and nutrient utilization in fishes by stimulating the digestive enzymes. These enzymes break down complex nutrients into simpler forms for better absorption, leading to improved growth performance and feed conversion ratios (FCR). The increased efficiency in nutrient absorption allows fish to utilize feed more effectively and provides accelerated growth rates and larger body sizes (Gonelimali *et al.*, 2018).

A few examples of phytobiotics utilized in aquaculture along with a description of their mechanism are shown in Table 1.

Types of phytobiotics

Phytobiotics provides a natural and sustainable approach to improve the health of aquaculture species. There are several types of phytobiotics used in aquaculture with its unique benefits and modes of action (Fig.1).

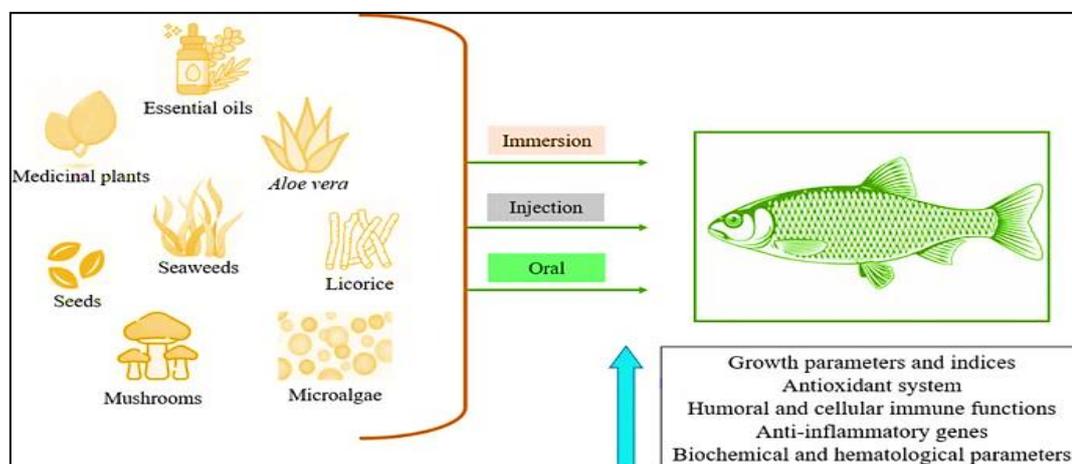


Fig.1. Mode of administration and benefits of phytobiotics used in aquaculture (Kalaiselvan *et al.*, 2024).

Essential Oils: Essential oils are highly concentrated plant extracts that are rich in bioactive compounds. They are often used in aquaculture as antimicrobial agents and digestive stimulants. Essential oils such as eucalyptus, thyme and clove are known for their strong antimicrobial properties. They help to control the growth of pathogenic bacteria and fungi in

aquaculture systems. Additionally, essential oils can stimulate the production of digestive enzymes, improving nutrient absorption and feed conversion ratios in aquaculture species.

Tab.1: Common herbs used as phytobiotics in aquaculture and their effects (Jana *et al.*, 2018).

Herbs	Scientific Name	Effect
Essential Oils	<i>Various</i>	Antimicrobial, digestive stimulant
Garlic	<i>Allium sativum</i>	Antimicrobial, immune system booster
Oregano	<i>Origanum vulgare</i>	Antimicrobial, antioxidant
Thyme	<i>Thymus vulgaris</i>	Antimicrobial, antioxidant
Cinnamon	<i>Cinnamomum verum</i>	Antimicrobial, anti-inflammatory
Ginger	<i>Zingiber officinale</i>	Antimicrobial, anti-inflammatory
Turmeric	<i>Curcuma longa</i>	Antimicrobial, anti-inflammatory
Neem	<i>Azadirachta indica</i>	Antimicrobial, insecticidal
Aloe Vera	<i>Aloe barbadensis</i>	Antimicrobial, immunostimulant
Green Tea Extract	<i>Camellia sinensis</i>	Antimicrobial, antioxidant
Grape Seed Extract	<i>Vitis vinifera</i>	Antimicrobial, antioxidant
Yucca Extract	<i>Yucca schidigera</i>	Ammonia reduction, anti-inflammatory
Citrus Extracts	Citrus spp.	Antimicrobial, antioxidant

Herbs and Spices: Various spices and herbs that are used in cooking by humans can also be used in aquaculture. Oregano, thyme and garlic contain bioactive compounds that can benefit aquaculture species. These compounds can have antimicrobial, antioxidant and anti-inflammatory properties. This help to improve the overall health and resilience of aquaculture species. Herbs and spices can be incorporated into aquafeeds or added directly to aquaculture systems to provide these benefits.

Plant Extracts: Plant extracts are concentrated forms of bioactive compounds extracted from plants. They can have a range of beneficial effects on aquaculture species, including antimicrobial, antioxidant and anti-inflammatory activities. Plant extracts such as grape seed extract, green tea extract and citrus extract have been studied for their potential to improve the health as well as growth performance of aquaculture species. These extracts can be used as supplements in aquaculture systems to apply its benefits.

Phytochemicals: Plants include bioactive substances called phytochemicals that can be beneficial for the health of animals. They include compounds with antioxidant and anti-inflammatory properties such as polyphenols, flavonoids and alkaloids. Phytochemicals can help to protect aquaculture species from oxidative stress, inflammation and improve their overall performance. Phytochemicals can be found in a wide variety of plants and can be incorporated into aquafeeds as supplements in aquaculture systems.

Benefits of Phytobiotics in Aquaculture

Phytobiotics are an important addition to the aquaculture industry since they have various potential benefits for productivity:

- *Improved Growth Performance:* In aquaculture species, phytobiotics can accelerate growth and improve feed conversion rates. This leads to higher production yields and increased profitability for farmers.
- *Disease Prevention:* Aquaculture species can be protected against disease by the immune-stimulating and antibacterial properties of phytobiotics. They can minimize disease incidence and reduce the demand for antibiotics, which can promote environmentally sustainable aquaculture operations.
- *Enhanced Immune Function:* Phytobiotics can boost the immune function of aquaculture species. They make fishes more resistant to infections and diseases. This can lead to healthier fish and reduced mortality rates.
- *Reduced Environmental Impact:* Phytobiotics are natural and biodegradable, making them a more environment friendly alternative to antibiotics and synthetic chemicals. Phytobiotics may decrease the harmful effects of these compounds on aquatic ecosystems by minimizing their use
- *Improved Product Quality:* Phytobiotics can improve the overall health and quality of aquaculture products. This can result in products that are more nutritious, flavourful and visually appealing, making them more desirable to consumers.

Conclusion

Aquaculture has become fastest growing sector and plays important role in meeting the increasing global demand for seafood. The use of antibiotics and other chemicals in aquaculture has drawn challenges such as consumer safety and environmental impacts. This has prompted researchers to look for new ways to support the growth and health of farmed

shrimp and fish. Phytobiotics, or bioactive compounds produced from plants, have become a promising substitute that can improve aquaculture species health and performance. These compounds also lower the need for artificial chemicals and antibiotics. This article explores the role of phytobiotics in aquaculture, their mechanisms of action and their potential benefits for sustainable aquaculture production.

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