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Postbiotics in Aquaculture: A New Era for Sustainable Fish Farming

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Introduction

Aquaculture is generating widespread curiosity because of its potential to meet rising food demand. However, one of the challenges in aquaculture is disease susceptibility, which can have a significant impact on both production quality and quantity. To maintain and boost aquaculture productivity, prospective strategies must be developed. In recent decades, chemicals produced by bacteria have emerged as a potential solution to this problem. For a long time, probiotics, prebiotics, and symbiotics have been considered viable feed additions for the treatment of bacterial, viral, and parasite diseases in fish and shellfish. According to recent studies, the positive effects of microbial supplementation can be achieved without the presence of viable bacterial cells. Instead, bacterial metabolites and structural cell components play a major role in mediating these effects. This recognition has led to the introduction of terms such as paraprobiotics and postbiotics, which refer to inactivated microbial cells and microbial-derived bioactive compounds that confer health benefits to the host. This article highlights the role of postbiotics in aquaculture, explaining how they work, their benefits, and their potential as sustainable tools for disease management.

What Are Postbiotics?

Postbiotics are bioactive compounds produced during the fermentation process of beneficial microorganisms. Simply put, they are the useful components left behind after probiotics have done their work.

These compounds may include:

- Short-chain fatty acids
- Organic acids
- Enzymes
- Peptides

- Cell wall components (such as β-glucans and peptidoglycans)

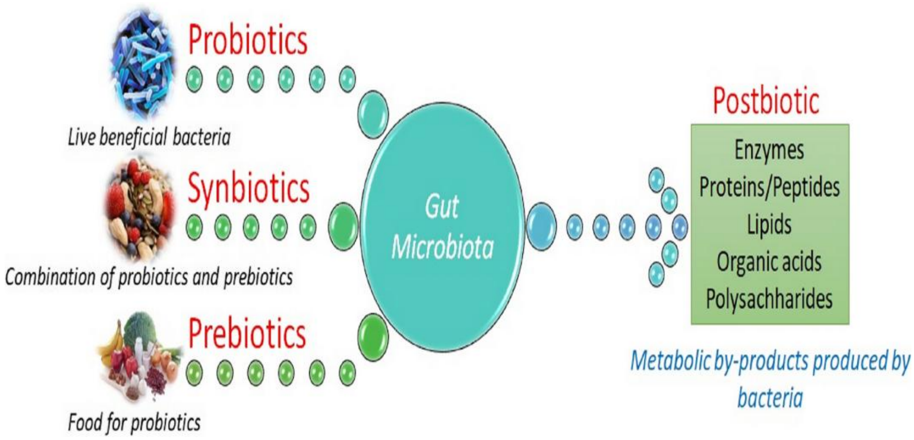

Fig 1. How Postbiotics Differ from Other "Biotics" (Source: Mishra et al., 2024)

Classes of postbiotics and characteristic features

Beneficial microbes produce substances known as postbiotics, which can be categorised according to their composition. These include carbohydrates like galactose-rich polysaccharides and teichoic acids, lipids like butyrate and propionate, proteins like lactocepin and the p40 molecule, vitamins and cofactors like vitamin C, and organic acids like propionic acid and 3-phenyl lactic acid. They also contain more complex substances, like fragments of bacterial cell walls.

Postbiotics are substances that are readily absorbed and effectively processed by the body. Once inside, they can interact with numerous organs and tissues, resulting in a variety of beneficial biological effects (Shenderov 2013). Their ability to provide many of the same health benefits as probiotics without requiring the consumption of live bacteria is one of their main advantages.

Postbiotics are thought to be a safer option because they don't contain live microorganisms, particularly in circumstances where probiotics could be dangerous. Due to this, they have particular interest for use in aquaculture, where they may aid in defending against pathogens that cause disease. The various postbiotic compounds that microorganisms produce is portrayed in Figure 2.

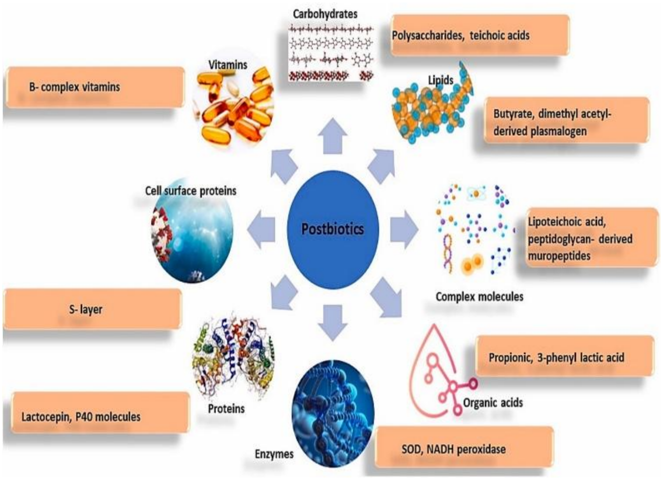

Fig 2. Different elements of postbiotics produced by a microorganism

Isolation and production of postbiotics

In contrast to prebiotics and probiotics, postbiotics are still a relatively new concept. Most of the research to date has concentrated on creating cell-free liquids that include advantageous substances released by probiotic bacteria, particularly lactic acid bacteria. These postbiotic mixtures can be obtained either with or without the bacterial cells being broken open. The type of bacteria used, the growth medium, and the production conditions all affect the final composition of postbiotics.

There is no single method to produce postbiotics because they comprise a wide variety of compounds. Bacterial breakdown and a variety of industrial and laboratory procedures may be involved in their production. Choosing the fermentation medium, cultivating the bacteria, harvesting the products, concentrating and preserving them, and then using them are important processes (Sudhakaran et al., 2022). A streamlined process for creating and separating postbiotics from lactic acid bacteria is shown in Figure 3.

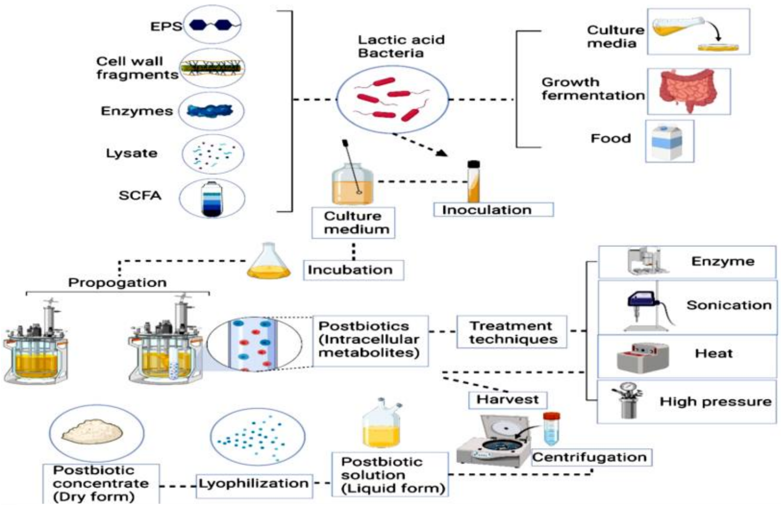

Fig 3. Isolation and production of postbiotics from lactic

Potential mechanism of action o

The way these microbial products interact with the host's body is thought to be the source of postbiotics' health benefits. They can help lower inflammation and boost the immune system through this interaction. Postbiotics are becoming more well-known in aquaculture as a potential substitute for vaccines and chemical treatments in the prevention and management of fish diseases. Even though the advantages of postbiotics are becoming more widely acknowledged, researchers are still trying to fully comprehend the precise molecular mechanisms underlying their action.

It is also known that postbiotics affect the immune system. For example, pili and the proteins p40 and p75, which are produced by *Lactobacillus bacteria*, can help control immune responses. These compounds promote advantageous processes such as microbial aggregation and the synthesis of S-layer proteins, bacteriocins, and protective proteins that collectively aid in preventing the growth of harmful pathogens.

Different bacterial species and strains may respond differently to postbiotics' immune-boosting effects. These discrepancies are frequently associated with variations in the components of the bacterial cell wall, such as peptidoglycan and lipoteichoic acid, which have an important role in how the host's immune system recognizes and reacts to them.

Identification of postbiotics

According to several published articles, the use of Ultra-performance liquid chromatography (UPLC) is primarily to separate and identify postbiotics; it has been shown to be a superior analytical method due to its ability to separate complex mixtures into single components at a greater resolution and with more sensitivity than traditional methods (Choi et al., 2006).

Method of administration

Postbiotics can be added directly to culture tanks or incorporated into feed, making them easy to use in practical applications (Antunes et al., 2011).

Potential applications in aquaculture

The use of pre-and probiotics has been highly regarded within the aquaculture industry. However, the introduction of postbiotics is a newer and emerging field of research. Recent evidence suggests that the use of postbiotics may increase fish growth rate, improve resistance to stress, decrease the occurrence of viral disease, and promote overall fish health. As such, postbiotics are now being recognized as a valuable tool to support more widespread utilization within the aquaculture sector (Table 1).

Table 1. Application of postbiotics in aquaculture

Postbiotics	Microorganism producer	Aquatic species	Applications	References
Cell lysates	*Bacillus, Lactobacillus*, and yeast	River prawn (*Macrobrachium nipponense*)	Improve growth performance, survival rate, antioxidant capacity, non-specific immunity and gut health	Wang et al. (2023)
Inactivated bacteria	*Bacillus subtilis* (HIB)	Striped catfish *(Pangasianodon hypophthalmus)*	Improve growth performance and feed utilisation, increase immune and antioxidant responses	Shawky et al. (2023)
Cell-free supernatants	*Bacillus sp.* AK3	Harmful algal bloom (HAB)	Eradicate HAB species	Boonbangkeng et al. (2022)
Cell-free extract	*Enterococcus faecalis* F7	*Litopenaeus vannamei*	Promote growth and modulate the intestinal microbiota	Ai et al. (2022)

Exopolysaccharides	*Lactococcus lactis Z-2*	Common carp	Immunity enhancement Resistance against *A. hydrophila*	Feng et al. (2020)
Cell surface proteins	*L. pentosus*	*Litopenaeus vannamei*	Immune response improvement	Du et al. (2019)
Cell wall components (PGs and LTA)	*B. pumilus SE5*	Grouper *(E. coioides)*	Growth performance improvement, Innate and adaptive immunity amelioration	Yang et al. (2020)
Lipoteichoic acids	*L. plantarum LTA*	Silver pomfret *(Pampus argenteus)*	Against *V. anguillarum* causes vibriosis	Gao et al. (2016)

Conclusion

In aquaculture, postbiotics are becoming more well-known as a safe and efficient feed additive. Research indicates that they can boost immunity, support gut health, stimulate growth, and raise the level of quality and safety of farmed seafood. Postbiotics provide a useful tool for enhancing stock health by boosting the animals' natural defenses and lowering their vulnerability to infections. Farmers may be able to minimize disease losses, increase overall productivity, and improve management effectiveness by carefully incorporating them into aquaculture practices.

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