

The Role of Synbiotics in Enhancing Growth, Immunity, and Disease Resistance in Shrimp Farming

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Abstract

Synbiotics, a combination of probiotics and prebiotics, have emerged as a promising alternative to antibiotics in shrimp farming, offering several benefits for shrimp growth and health management. This article explores the role of synbiotics in enhancing shrimp culture by improving growth performance, immune response, digestion, and water quality. Synbiotics work through mechanisms such as competitive exclusion, pathogen antagonism, and immune stimulation. Research indicates that synbiotics promote disease resistance, enhance gut microbiota, and reduce environmental stressors like ammonia and nitrite. As shrimp farming intensifies, the use of synbiotics presents a sustainable approach to improve production efficiency, mitigate disease outbreaks, and reduce the negative impacts of antibiotics. Further optimization of synbiotic formulations is essential for maximizing their benefits in shrimp culture.

Introduction

Aquaculture is one of the fastest-growing sectors globally, with shrimp farming and shrimp exports playing a significant role in the economic growth of India. Aquaculture provides livelihood opportunities, boosts the economy, and generates employment. However, the intensification of aquaculture for increased production efficiency often leads to the deterioration of water quality. This rapid development is accompanied by challenges such as disease outbreaks, poor growth, and high mortality in shrimp populations. Traditionally, antibiotics have been used to treat bacterial diseases, which primarily target gut microflora to improve growth and feeding efficiency. The major negative impacts of antibiotic use include the development of antibiotic resistance, immune suppression, and the transfer of antibiotic residues to humans. Additionally, antibiotics are costly and sometimes unavailable in shrimp farming. To address these challenges, feed additives such as synbiotics have been developed. The use of synbiotics has shown positive effects on shrimp growth, with the primary goal of improving growth rates and overall health.

Synbiotics

Synbiotics are composed of non-digestible food ingredients (prebiotics) and live microorganisms (probiotics). They are nutritional supplements that combine both probiotics and prebiotics to form a synergistic relationship.

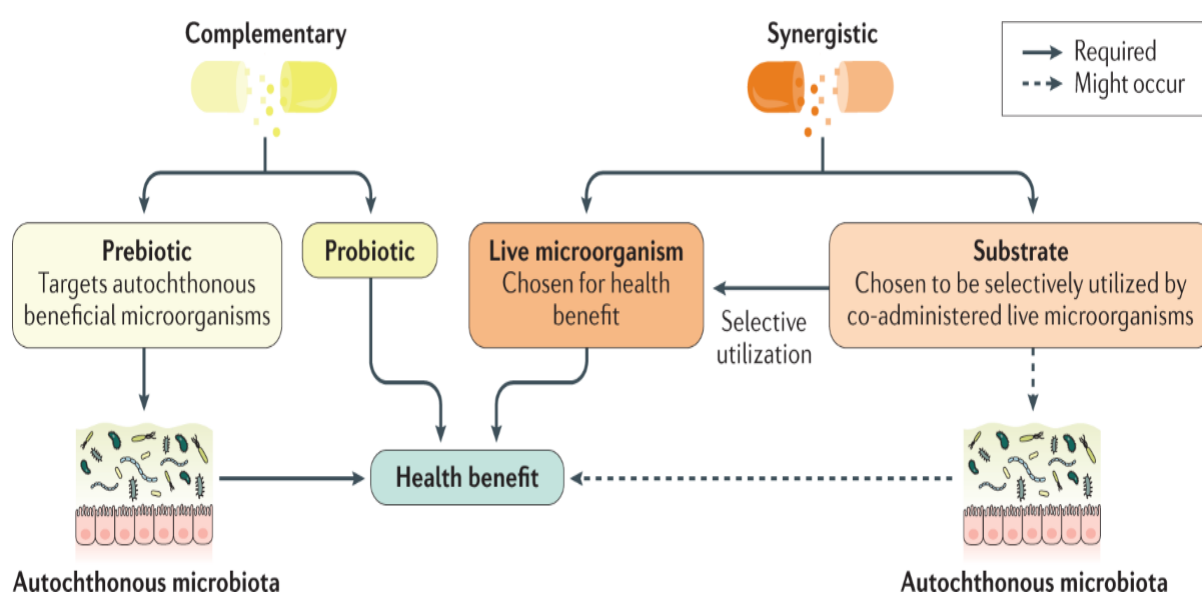
Components of Synbiotics

Synbiotics consist of both probiotics and prebiotics. Probiotics (derived from the Greek words *pro* and *bios*, meaning "for life") are beneficial microorganisms. Fuller defines probiotics

as live microbial feed supplements that beneficially affect the host animal by improving microbial balance. Examples of probiotics include gram-positive bacteria such as *Arthrobacter* XE-7, *Bacillus subtilis* UTM 126, *B. subtilis* E20, *B. megaterium*, *Bacillus* P64 (in *Litopenaeus vannamei*), *Enterococcus faecium* MC13, *Streptococcus phocaea* P180, *Streptomyces*, *Tetraselmis suecica* (in *Penaeus monodon*), and *Lactobacillus sporogenes* (in *Macrobrachium rosenbergii*, freshwater prawn). Prebiotics are non-digestible food ingredients that benefit shrimp by stimulating the growth and metabolism of health-promoting bacteria in the intestinal tract, thus maintaining intestinal balance. The advantage of prebiotics over probiotics is that they are natural feed ingredients, reducing the need for additional feed. Prebiotics include carbohydrates, proteins, lipids, and peptides that reach the colon undigested. Examples of prebiotics are inulin, oligofructose, manno-oligosaccharides (MOS), transgalactooligosaccharides (TOS), glucooligosaccharides (GOS), isomalto-oligosaccharides (IMO), lactosucrose, xylo-oligosaccharides (XOS), soybean oligosaccharides, and lactulose. Prebiotics used for fish should be able to withstand acidic conditions, be hydrolyzed by digestive enzymes, and selectively stimulate the growth and fermentation of beneficial intestinal bacteria. Prebiotics are utilized by probiotics to promote the growth of beneficial bacteria.

Types of Synbiotics

1. **Complementary Synbiotics:** In these synbiotics, both probiotics and prebiotics work independently to achieve positive effects on shrimp.
2. **Synergistic Synbiotics:** In these synbiotics, the components, such as probiotics and prebiotics, work together to confer health benefits to shrimp. An example is the beneficial bacterium *Lactobacillus* and its preferred food, lactose.



Applications of Synbiotics

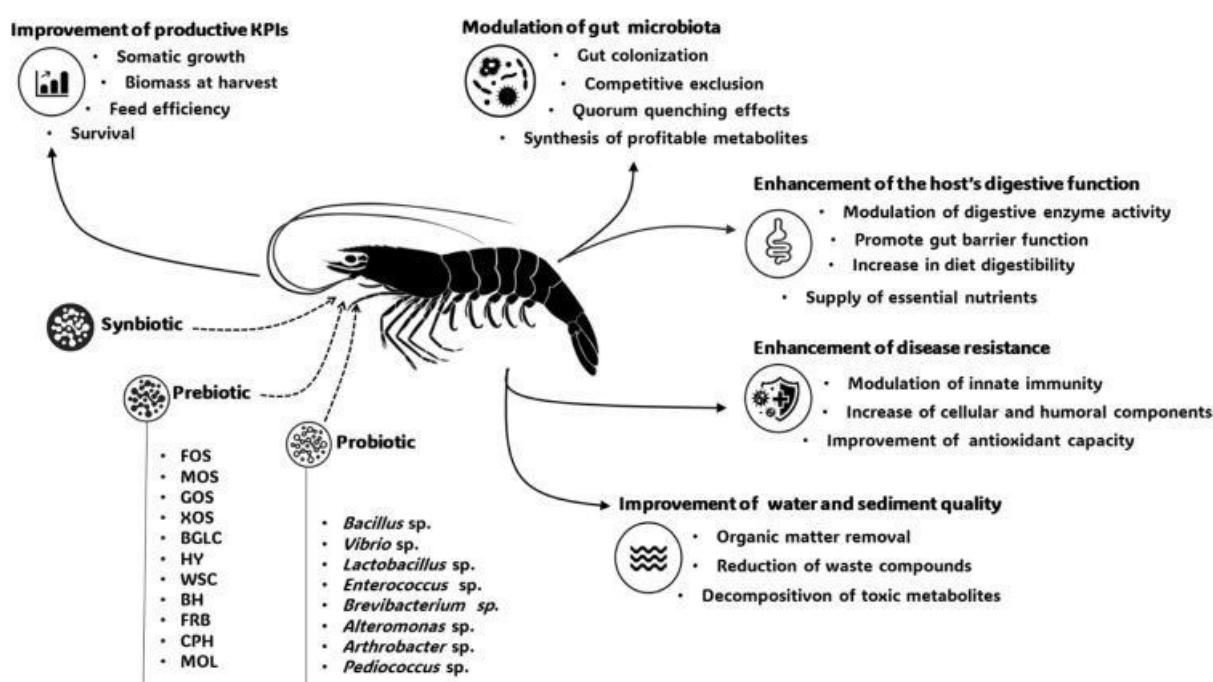
Synbiotics improve the gastrointestinal tract by promoting the fermentation and production of short-chain fatty acids, such as propionates, which lower the pH of the colon, preventing the growth of certain pathogenic microbes while stimulating the growth of beneficial bacteria like *Lactobacillus*. They directly or indirectly enhance growth by stimulating microbial growth or boosting the immune system. Synbiotics also promote water quality by removing environmental stressors like ammonia and nitrite, and reducing the prevalence of pathogens such as *Vibrio* or viral infections.

Mode of Action

- **Competitive Exclusion**
- **Antagonism to Pathogens**
- **Adhesion**
- **Immunity Stimulation**

Effects of Synbiotics in Shrimp farming

Synbiotics have positive effects on shrimp, including disease resistance, immune enhancement, and stress reduction.



Growth Performance

Synbiotics promote shrimp growth by improving the protein efficiency ratio (PER), energy retention, and feed efficiency. For instance, a combination of *Moringa oleifera* (2.5g/kg of body weight) and *Lactobacillus acidophilus* (1×10^7 cfu/g body weight) resulted in enhanced growth of *Penaeus vannamei* (Das et al.).

Digestion and Absorption

Synbiotics improve the growth of beneficial microbes, which in turn aid in fermentation, digestion, and nutrient absorption. They also compete for nutrients and attachment sites, interfering with quorum sensing to effectively decolonize pathogenic bacteria.

Immune Enhancement

Synbiotics act as immunostimulants in shrimp. When probiotics die, they release antigens

that enhance the immune response. The combined use of prebiotics and probiotics in synbiotics improves immunity more effectively than using each separately. Dietary supplementation with synbiotics has shown increased immunostimulatory effects against *Vibrio* infections (e.g., *V. alginolyticus*) and White Spot Syndrome Virus (WSSV) in *P. japonicus* and *P. vannamei*.

Studies on Synbiotics in Shrimp Culture

- A study on post-larvae of *Litopenaeus vannamei* (0.5g weight) fed with fermented rice bran and *Bacillus subtilis* promoted growth, enhanced immune response, antioxidant activity, and improved water quality (Eman M. Moustafa et al.).
- A study on supplementation with beta-glucan and microencapsulated probiotics (*Bacillus subtilis*) showed that beta-glucan alone improved hemolymph and osmolality, while synbiotic supplementation had a greater effect on the intestinal microbiota of *P. vannamei* (S. Boonanuntanasarn et al.).

Table 1. Synbiotics Used in Shrimp Culture and Their Effects

Cultured Species	Synbiotics Used	Findings	Reference
<i>P. vannamei</i>	<i>Vibrio alginolyticus</i> SKT-bR and sweet potato (<i>Ipomoea batatas</i> L.)-derived oligosaccharides	Growth ↑, immune responses ↑, resistance to co-infection of IMNV and <i>V. harveyi</i> ↑	Oktaviana et al., 2014
<i>Neocaridina davidi</i>	Probiotics (<i>Bacillus clausii</i> , commercial probiotics: <i>Enterogermina</i> , 1 mL) and prebiotics (GOS, 1–4 g)	Growth increases	Nababan et al., 2022
<i>Penaeus monodon</i>	<i>L. plantarum</i> at 10 ⁸ CFU/ml and <i>Sargassum polycystum</i> at 2% diet	Growth ↑, immune response ↑, disease resistance vs AHPND	Chin et al., 2024
<i>P. vannamei</i>	<i>Lactobacillus acidophilus</i> (1 × 10 ⁷ CFU/g) and <i>Moringa oleifera</i> leaf extract (2.5–5 g/kg body weight)	Gut microbiota abundance and composition ↑, Growth ↑, immune signaling and metabolic pathways upregulated	Das et al., 2024

Conclusion

As shrimp production increases, stress and disease outbreaks also rise, leading to significant production losses. Prophylactic measures using probiotics, prebiotics, or synbiotics can help mitigate the negative effects of antibiotics. Synbiotics act as growth promoters, immunostimulants, and alternatives to reduce disease by promoting gut homeostasis and improving water quality. It also absorbs environmental stressors like nitrite and ammonia, reducing the accumulation of organic matter. However, they are often species-specific and depend on the types of dietary ingredients used in feed preparation. Further improvements in synbiotics are needed to optimize their effectiveness.