The Fish World a Monthly Magazine
July 2024 Vol.1(4), 165-168

Popular Article

The Power of Next-Generation Probiotics in Fish Health

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doi.org/10.5281/Fishworld.12976742

Abstract

The use of antimicrobials and antibiotics in combating infectious diseases in fish has become increasingly undesirable due to their environmental impact and negative effects on the quality and consumer perception of farmed fish. Probiotics offer a superior alternative, as they do not contribute to environmental degradation and can enhance food conversion ratios while boosting disease resistance in cultured fish. Embracing next-generation probiotics represents a forward-looking approach, as they induce specific immunostimulatory effects against targeted pathogens. In this article, we delve into the pivotal role played by next-generation probiotics in revolutionizing disease management in aquaculture.

Introduction

In the evolving landscape of aquaculture, the proliferation of pathogens has posed a significant challenge. Historically, chemical agents and antibiotics have been the primary means of combating infections. However,. Vaccination and the utilization of probiotic strains have emerged as key strategies to address this issue (Torres-Maravilla et al., 2024). in maintaining gut microflora balance, contributing to overall host health. Their administration is commonly achieved through routine water applications or as feed additives (Torres-Maravilla et al., 2024).

Conventional probiotics:

Conventional probiotics, as defined by Havenaar et al. (1992), are unmodified live microbial cultures, either mono or mixed, aimed at enhancing the indigenous microflora's quality. These probiotics offer several desirable attributes, such as increasing the nutritional value of the host's feed and bolstering the nonspecific immune response against diseases (Hai, 2015). In aquaculture, a diverse array of microorganisms finds application, including Probiotics can be administered to the host as single strains or multiple strains, with combinations often yielding superior results compared to single-strain formulations. Additionally, probiotics can be administered alone or in combination with prebiotics, known as symbiotics. For example, the combination of *Enterococcus faecalis* probiotic with mannan oligosaccharide prebiotic enhances the food conversion ratio of the animal compared to administering probiotics and prebiotics separately (Rodriguez-Estrada et al., 2009). Probiotics may be administered to the animal in live or heat-killed (dead) forms, with live probiotics generally offering better protective effects than dead ones. Probiotics exert their beneficial effects primarily through two modes of action: competitive exclusion and immunomodulation. Desirable probiotics can degrade quorum sensing, thereby reducing infections caused by pathogenic bacteria (Hai, 2015).

Next generation (novel) probiotics:

Next-generation probiotics refer to advanced formulations of beneficial microorganisms designed to provide specific health benefits beyond those offered by traditional probiotics. It is the recombinant probiotics that is genetically engineered so that it produces the specific effect (Torres-Maravilla *et al.* 2024). While traditional probiotics primarily consist of live cultures of beneficial bacteria or yeasts, next-generation probiotics may incorporate various

THE FISHWORLD A MONTHLY MAGAZINE
Official Website
www.thefishworldmagazine.com
thefishworldmagazineindia@gmail.com
In Association with
The Science World a Monthly e Magazine
(ISSN:2583-2212)

innovations to enhance their effectiveness and versatility. These innovations can include:

Targeted Formulations: Next-generation probiotics are often formulated to target specific health issues or physiological functions. For example, probiotics may be tailored to promote digestive health, boost immunity, modulate inflammation, or improve nutrient absorption.

Multi-Strain Formulations: Instead of relying on a single strain of probiotic microorganism, next-generation probiotics may contain multiple strains that work synergistically to confer broader health benefits. Multi-strain formulations can enhance the resilience and adaptability of probiotic products.

Encapsulation Technology: single strain of probiotic microorganism, next-generation probiotics may contain multiple strains that work synergistically to confer broader health benefits. Multi-strain formulations can enhance the resilience and adaptability of probiotic products

Genetically Modified Probiotics: Advances in genetic engineering have enabled the development of genetically modified probiotic strains with enhanced functionality, such as improved adherence to intestinal epithelial cells, increased production of beneficial metabolites, or targeted delivery of therapeutic compounds.

Postbiotics: Postbiotics are bioactive compounds produced by probiotic microorganisms during fermentation. Next-generation probiotics may harness the health-promoting properties of postbiotics, which can include antimicrobial peptides, organic acids, vitamins, and enzymes.

Personalized Probiotics: Emerging technologies in microbiome analysis and precision medicine may enable the customization of probiotic.

Mechanisms of Next-Generation Probiotics:

Next-generation probiotics utilize advanced microbial formulations tailored to the specific needs of fish species and their environments. These probiotics typically consist of beneficial bacteria, such as Lactobacillus, Bacillus, or Pseudomonas species, which exert their effects through various mechanisms:

Competitive Exclusion: Probiotic bacteria compete with pathogenic microbes for nutrients and attachment sites in the fish gut, preventing the colonization of harmful organisms.

Immune Modulation: Probiotics can stimulate the fish's immune system, enhancing the production of immune cells and molecules that defend against pathogens.

Antagonistic Activity: Some probiotic strains produce antimicrobial compounds that inhibit the growth of pathogenic bacteria, fungi, and viruses.

Enhanced Nutrient Utilization: Certain probiotics help improve nutrient absorption and digestion in fish, leading to enhanced growth and vitality.

Next generation probiotic used in fish pathology:

and Muñoz et al. (2021) demonstrated enhanced immune responses against *Flavobacterium psychrophilum* and IPNV in rainbow trout and Atlantic salmon, respectively, using recombinant *Lactococcus lactis* expressing Interferon Type II and Type I Interferon. Additionally, Zhang et al. (2021) showed that probiotic pili-like protein anchored to the surface of recombinant *Lactococcus lactis* improved hepatic steatosis and intestinal health in high-lipid-eating zebrafish. Lastly, Zhao et al. (2019) found that recombinant *Lactococcus lactis* expressing HIRRV-G enhanced the immune response against hirame novirhabdovirus in flounder. These studies collectively highlight the potential of recombinant probiotics as innovative strategies for disease prevention and immune modulation in aquaculture.

Conclusion:

In conclusion, while conventional probiotics have long served as valuable tools in promoting microbial balance and host health, next-generation probiotics represent a significant leap forward in probiotic technology. With their advanced capabilities, including genetic modification, targeted functionality, and innovative formulations, next-generation probiotics offer a more precise, tailored, and effective approach to addressing health challenges in various fields, including aquaculture. By harnessing cutting-edge science and technology, next-generation probiotics hold the promise of revolutionizing disease management, improving animal welfare, and promoting sustainable practices, thereby ushering in a new era of probiotic innovation and application.

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