



## Enhancing Fish Performance through Functional Feeding Strategies in Aquaculture Systems

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### Abstract

Aquaculture has emerged as one of the fastest growing food production sectors globally. However, increasing intensification has led to several challenges, including disease outbreaks, reduced growth performance and environmental stress. Functional feeds have gained attention as a sustainable nutritional strategy to improve fish growth, health status and immune competence. These feeds are supplemented with bioactive compounds such as probiotics, prebiotics, synbiotics, phytonutrients, immunostimulants and essential nutrients, which go beyond basic nutrition. Functional feeds include specific components, their mechanisms of action and their role in enhancing fish growth and immunity. They also reflect recent advances and research findings supporting their application in aquaculture. Functional feeds represent a promising tool for sustainable aquaculture by reducing dependence on antibiotics and improving productivity.

**Keywords:** Functional Feed, Growth, Immunity, Aquaculture, Probiotics, Prebiotics, Synbiotics

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### Introduction

Aquaculture plays a significant role in global food security, providing a major source of protein to the growing human population. With increasing demand for fish production, intensive aquaculture practices have become common. However, intensification often leads to stress, disease susceptibility and reduced growth in cultured fish species. Traditionally, antibiotics and chemicals were used to control diseases, but their excessive use has resulted in antimicrobial resistance and environmental concerns.

In this context, functional feeds have emerged as an innovative and sustainable approach to improve fish performance and health. Functional feeds are diets that contain specific ingredients capable of enhancing physiological functions beyond basic nutritional requirements. These feeds aim to improve growth performance, immune responses, disease resistance and overall well being of fish. Functional feed additives can modulate gut health and immune mechanisms, thereby improving survival and productivity (Dawood and Koshio, 2016).

### Concept of functional feeds in aquaculture

Functional feeds are designed to provide additional health benefits, apart from meeting nutritional needs. They include a wide range of bioactive compounds such as probiotics, prebiotics, synbiotics, herbal extracts, vitamins, minerals and immunostimulants. These components work synergistically to improve digestion, nutrient absorption and immune function. Functional feeds are particularly important in intensive aquaculture systems, where fish are exposed to various stressors.

### Types of functional feed additives

#### Probiotics

Probiotics are live microorganisms that confer health benefits when administered in adequate amounts. Common probiotics used in aquaculture include species of *Bacillus*, *Lactobacillus* and *Saccharomyces*. These beneficial microbes improve gut microbiota balance, enhance digestion and inhibit pathogenic bacteria. Studies have shown that probiotic supplementation can significantly improve growth rate and feed conversion ratio in fish species such as tilapia and carp (Dawood and Koshio, 2016).

#### Prebiotics

Prebiotics are non digestible feed ingredients

that promote the growth of beneficial gut bacteria. Examples include inulin, fructooligosaccharides and mannan oligosaccharides. Prebiotics improve gut health by enhancing microbial diversity and stimulating immune responses. Prebiotic supplementation enhances disease resistance and improves intestinal morphology in fish (Ringø *et al.*, 2010).

### **Synbiotics**

Synbiotics are combinations of probiotics and prebiotics that work synergistically to enhance gut health. The combined effect leads to improved microbial balance and enhanced immune responses. Research indicates that synbiotic supplementation results in better growth performance and higher resistance to pathogens compared to individual use of probiotics or prebiotics.

### **Phytogenics**

Phytogenic additives are plant derived compounds such as essential oils, herbs and spices. These compounds possess antimicrobial, antioxidant and immunomodulatory properties. Garlic, ginger, turmeric and neem are commonly used phytogenics in fish diets. Phytogenics improve appetite, digestion and immune response, leading to better growth and survival rates.

### **Immunostimulants**

Immunostimulants are substances that enhance the innate immune system of fish. Common immunostimulants include beta glucans, chitosan and nucleotides. These compounds activate immune cells and increase resistance against pathogens. Immunostimulants play a crucial role in enhancing disease resistance in aquaculture species (Sakai, 1999).

### **Essential nutrients and functional lipids**

Certain nutrients such as omega three fatty acids, vitamins and minerals also act as functional components. These nutrients improve physiological functions, including immune response and stress tolerance. For example, vitamin C and vitamin E act as antioxidants, protecting fish from oxidative stress.

### **Mechanisms of action of functional feeds**

Functional feeds exert their effects through multiple mechanisms. They improve gut health by modulating intestinal microbiota and enhancing nutrient absorption. They stimulate immune responses by activating immune cells and increasing production of antibodies and

cytokines. Functional feeds also reduce oxidative stress, by providing antioxidant compounds. Furthermore, they enhance metabolic efficiency, resulting in better growth performance.

### **Role of functional feeds in improving fish growth**

Functional feeds significantly contribute to improved growth performance in fish. By enhancing digestion and nutrient absorption, they increase feed efficiency. Probiotics and enzymes improve breakdown of feed components, leading to better utilization of nutrients. Phytogenics stimulate appetite and digestive enzyme activity. Studies have demonstrated that fish fed with functional diets exhibit higher weight gain and improved feed conversion ratio, compared to control groups.

### **Role of functional feeds in enhancing immunity**

Fish rely heavily on innate immune mechanisms for disease resistance. Functional feeds strengthen these mechanisms by enhancing phagocytic activity, lysozyme production and complement system activity. Immunostimulants such as beta glucans activate macrophages and neutrophils, increasing their ability to combat pathogens. Probiotics also produce antimicrobial substances, that inhibit harmful bacteria. Dietary immunostimulants improve resistance to bacterial and viral infections in fish (Nayak, 2010).

### **Reduction of disease incidence**

The use of functional feeds reduces the incidence of diseases in aquaculture systems. By improving immune responses and gut health, fish become more resistant to pathogens. This reduces the need for antibiotics and chemicals, thereby promoting sustainable aquaculture practices. Functional feeds also help in maintaining water quality, by improving feed utilization and reducing waste output.

### **Environmental and economic benefits**

Functional feeds offer several environmental and economic advantages. Improved feed efficiency reduces feed costs and minimizes nutrient discharge into the environment. Reduced disease outbreaks lead to lower mortality and higher profitability. Additionally, the use of natural feed additives aligns with consumer demand for safe and sustainable seafood.

## Conclusion

Functional feeds represent a promising strategy for improving fish growth and immunity in aquaculture systems. By incorporating bioactive compounds such as probiotics, prebiotics, phytogenics and immunostimulants, these feeds enhance digestive efficiency, immune responses and disease resistance. The adoption of functional feeds can reduce reliance on antibiotics, improve sustainability and increase productivity in aquaculture. Continued research and innovation will further strengthen their role in achieving sustainable fish farming.

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