AGRI MAGAZINE
(International E-Magazine for Agricultural Articles)
Volume: 03, Issue: 02 (February, 2026)
Available online at http://www.agrimagazine.in
©Agri Magazine, ISSN: 3048-8656

Influence of Nutritional Additives on Growth Parameters of *Litopenaeus vannamei*

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The Pacific white shrimp (*Litopenaeus vannamei*) dominates global shrimp aquaculture due to its rapid growth, adaptability, and high market demand. However, intensive culture practices expose shrimp to environmental stress, disease outbreaks, and fluctuating water quality, often compromising growth performance. Nutritional additives have emerged as strategic dietary interventions to enhance growth, feed efficiency, immunity, and overall productivity. This review synthesizes current knowledge on the influence of probiotics, prebiotics, synbiotics, enzymes, organic acids, phytogenic additives, immunostimulants, and functional nutrients on growth parameters such as weight gain, specific growth rate (SGR), feed conversion ratio (FCR), survival rate, and protein efficiency ratio (PER) in *L. vannamei*. The article highlights mechanistic pathways, practical implications, and future research directions for sustainable shrimp aquaculture.

Introduction

Shrimp aquaculture has undergone remarkable expansion over the last two decades, with *Litopenaeus vannamei* contributing more than 50% of global shrimp production. The intensification of farming systems has increased productivity but also introduced challenges such as disease outbreaks, poor feed utilization, and environmental stress. Feed represents 50–60% of total production cost, making nutritional efficiency a critical determinant of profitability. Traditional reliance on antibiotics for growth promotion and disease prevention has declined due to concerns over antimicrobial resistance and food safety. Consequently, attention has shifted toward functional feed additives that enhance growth performance while maintaining environmental sustainability. Nutritional additives are now considered not merely supplements but essential components of precision aquaculture nutrition.

Growth Parameters in *Litopenaeus vannamei*

Growth performance in shrimp is commonly evaluated using:

- Weight Gain (WG)
- Specific Growth Rate (SGR)
- Feed Conversion Ratio (FCR)
- Survival Rate (SR)
- Protein Efficiency Ratio (PER)
- Average Daily Gain (ADG)

These indicators collectively reflect the efficiency of feed utilization, metabolic health, and overall farm productivity. Nutritional additives primarily influence growth through improved digestion, enhanced gut microbiota balance, immune modulation, and stress mitigation.

Types of Nutritional Additives and Their Influence on Growth

Probiotics

Probiotics are beneficial live microorganisms that improve intestinal microbial balance. In *L. vannamei*, commonly used genera include *Bacillus*, *Lactobacillus*, *Enterococcus*, and *Saccharomyces*. Studies have demonstrated that probiotic supplementation significantly improves SGR and reduces FCR by enhancing digestive enzyme activity (protease, amylase, lipase). Probiotics also suppress pathogenic bacteria such as *Vibrio* spp., reducing energy loss due to subclinical infections. Improved nutrient absorption and intestinal morphology contribute to better growth rates. For instance, dietary inclusion of *Bacillus subtilis* has been shown to improve weight gain and survival while enhancing feed efficiency (Wang et al., 2019).

Prebiotics and Synbiotics

Prebiotics such as mannan oligosaccharides (MOS), fructooligosaccharides (FOS), and inulin serve as substrates for beneficial gut microbes. They selectively stimulate microbial populations that improve gut health and nutrient absorption. Synbiotics, combinations of probiotics and prebiotics, provide synergistic benefits. Research indicates that synbiotic supplementation significantly improves SGR and PER while lowering FCR in intensive culture systems. The mechanism involves improved gut integrity and enhanced digestive enzyme secretion (Ringø et al., 2010).

Digestive Enzymes

Exogenous enzymes such as proteases, phytases, and carbohydrases improve nutrient digestibility, particularly in plant-based diets. As aquafeeds increasingly replace fishmeal with plant proteins, anti-nutritional factors may reduce digestibility. Enzyme supplementation enhances protein and phosphorus availability, leading to improved weight gain and reduced nutrient wastage. Studies report improved growth performance when phytase is added to soybean-based shrimp diets (Cao et al., 2007).

Organic Acids

Organic acids such as formic acid, citric acid, and butyric acid lower gut pH and inhibit pathogenic bacteria. Acidifiers improve mineral absorption and digestive efficiency. In *L. vannamei*, dietary organic acids have been associated with improved SGR and survival rate, especially under high-density culture conditions (Ng & Koh, 2017).

Phytogenic Feed Additives

Plant-derived bioactive compounds such as garlic extract, turmeric, oregano oil, and neem contain antimicrobial, antioxidant, and immunomodulatory properties. Phytogenic additives enhance digestive enzyme activity and reduce oxidative stress, thereby improving growth performance. Garlic supplementation, for example, has been linked to improved feed intake and FCR in shrimp culture.

Immunostimulants

β-glucans, nucleotides, and chitosan are widely used immunostimulants. While primarily targeting immune enhancement, improved health status indirectly enhances growth performance. β-glucan supplementation has been shown to improve survival and weight gain by reducing disease-related growth suppression (Meena et al., 2013).

Functional Amino Acids and Lipids

Certain amino acids (e.g., arginine, glutamine) and fatty acids (e.g., DHA, EPA) play regulatory roles in metabolism and immunity. Supplementation improves nutrient utilization efficiency and enhances SGR. Optimized amino acid profiles reduce metabolic stress and improve protein deposition efficiency, directly influencing growth parameters.

Mechanisms Underlying Growth Enhancement

The beneficial effects of nutritional additives on growth in *L. vannamei* are mediated through:

1. **Improved Digestive Enzyme Activity**
2. **Modulation of Gut Microbiota**
3. **Enhanced Intestinal Morphology**

4. **Improved Immune Competence**
5. **Reduced Oxidative Stress**
6. **Better Nutrient Absorption and Retention**

These mechanisms collectively improve feed efficiency and energy allocation toward growth rather than stress responses.

Practical Implications for Shrimp Farming

In commercial aquaculture, the inclusion of feed additives must consider dosage optimization, cost-effectiveness, and compatibility with feed processing conditions. Over-supplementation may not proportionally improve performance and can increase production costs. Integrated use of probiotics, enzymes, and phytogenic compounds appears to provide the most consistent improvements in FCR and SGR. However, environmental factors such as salinity, stocking density, and water quality significantly influence outcomes.

Future Perspectives

Future research should focus on:

- Precision nutrition based on life stage-specific requirements
- Microbiome-driven feed formulation
- Nano-encapsulation of additives for improved bioavailability
- Evaluation under commercial farm conditions rather than laboratory trials

Advancements in molecular biology and metagenomics will enable deeper understanding of host–microbiota–diet interactions.

Conclusion

Nutritional additives significantly influence growth parameters of *Litopenaeus vannamei* by enhancing digestive efficiency, improving gut health, modulating immunity, and mitigating environmental stress. Probiotics, prebiotics, enzymes, organic acids, phytogenics, and functional nutrients have demonstrated measurable improvements in SGR, FCR, and survival rates. As shrimp farming continues to intensify, strategic incorporation of scientifically validated feed additives will be central to achieving sustainable, profitable, and antibiotic-free production systems.

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