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Review Article

EFFECT OF CHITOSAN OLIGOSACCHARIDE ON FEED UTILIZATION EFFICIENCY IN SHRIMP

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ABSTRACT

Because of its prebiotic, antibacterial, antioxidant, and immunomodulatory qualities, chitosan oligosaccharide (COS), a low molecular weight derivative of chitosan, has grown in significance as a functional feed ingredient in shrimp aquaculture. By increasing digestive enzyme activity, nutrient absorption, protein consumption, and feed conversion ratio (FCR), dietary supplementation of COS increases feed usage efficiency. By controlling beneficial microbial communities and enhancing gut integrity, COS also supports intestinal health, which improves shrimp development and survival. By enhancing digestion, immunity, and resilience to environmental stress, its synergistic application with probiotics further promotes sustainable aquaculture. The importance of COS in enhancing nutrient metabolism, feed efficiency, and sustainable shrimp production is highlighted in this review.

Keywords: Chitosan oligosaccharide, Shrimp, Feed utilization, Growth performance, Digestive enzymes.

INTRODUCTION

The hepatopancreas and intestinal tissues, which generate enzymes essential for nutrient digestion, are the major regulators of digestive capacity in shrimp species such as *Litopenaeus vannamei*. Proteases, amylases, lipases, and other hydrolytic enzymes that convert dietary proteins, carbohydrates, and lipids into absorbable nutrients play an important role in efficient feed utilization. In aquatic animals, chitosan oligosaccharide (COS) supplementation has been reported to stimulate digestive enzyme secretion and improve nutrient digestibility. Since dietary protein is the primary nutrient required for shrimp growth, muscle development, molting, and immune responses, protease activity plays a crucial role in protein digestion. Enhanced protease activity improves amino acid availability and promotes protein deposition in tissues. Similarly, increased amylase activity improves carbohydrate utilization by providing metabolic energy, whereas enhanced lipase activity facilitates lipid digestion and absorption of essential fatty acids required for membrane formation and physiological development. Rahimnejad *et al.,* (2018) reported that dietary COS supplementation significantly enhanced digestive enzyme activities and growth performance in *Litopenaeus vannamei*. The authors suggested that increased protease, amylase, and lipase activities contributed to improved nutrient digestion and feed utilization efficiency. Lin *et al.,* (2019) also observed enhanced digestive capacity and metabolic performance in shrimp fed diets supplemented with functional oligosaccharides.

Because feed contributes a major proportion of production costs in intensive farming systems, feed utilization efficiency is a critical factor determining productivity and profitability in shrimp aquaculture. Poor feed utilization results in increased feed wastage, organic matter accumulation, deterioration of water quality, and physiological stress, ultimately affecting shrimp growth and survival. Therefore, the application of functional feed additives to improve nutrient utilization has become an important strategy in sustainable shrimp farming. Chitosan oligosaccharide (COS), a low molecular weight derivative of chitosan, has gained considerable attention due to its prebiotic, antimicrobial, immunostimulatory, and antioxidant properties (Kumar, 2000; Aranaz *et al.,* 2009; Ngo *et al.,* 2015). Due to its shorter polymer chains and higher availability of amino groups, COS exhibits greater solubility and biological activity compared with high molecular weight chitosan. Dietary supplementation of

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COS enhances feed utilization by increasing digestive enzyme activity, maintaining gut microbial balance, improving nutrient absorption, and regulating metabolic pathways. These combined effects promote growth performance and efficient conversion of dietary nutrients into body biomass in cultured shrimp (Zhang *et al.,* 2012; Li *et al.,* 2013).

Improvement of Feed Conversion Ratio (FCR)

Feed conversion ratio (FCR) is an important indicator of feed efficiency in shrimp production. Lower FCR values indicate improved conversion of feed nutrients into shrimp biomass. Functional feed additives such as COS enhance FCR by improving intestinal health, nutrient absorption, digestion, and metabolic efficiency. The improved FCR observed in COS-fed shrimp is associated with increased digestive enzyme secretion and favourable modification of intestinal microbial composition. COS promotes beneficial microorganisms while suppressing opportunistic bacteria, thereby increasing nutrient availability and reducing competition for dietary resources. Consequently, a greater proportion of ingested nutrients is utilized for growth rather than being lost as metabolic waste. Li *et al.,* (2013) reported that dietary COS supplementation improved feed efficiency and growth performance in aquatic animals by enhancing digestion and nutrient metabolism. Similarly, Mohan *et al.,* (2023) highlighted that chitooligosaccharides act as multifunctional feed additives by improving intestinal microbial stability, antioxidant status, and feed conversion efficiency in aquaculture species.

Influence of COS on Protein Utilization and Protein Efficiency Ratio (PER)

Protein is the most expensive and nutritionally important component of shrimp feed. Efficient utilization of dietary protein determines growth rate, muscle development, molting success, and immune competence. COS supplementation improves protein utilization by enhancing digestive efficiency and amino acid absorption. The positively charged amino groups of COS interact with intestinal epithelial surfaces and improve mucosal integrity, thereby enhancing nutrient transport across intestinal membranes. Improved intestinal health facilitates efficient absorption and utilization of amino acids for tissue development and protein synthesis. Studies have demonstrated that dietary COS increases protein retention and improves protein efficiency ratio (PER) in shrimp. Enhanced protein utilization also reduces nitrogen waste release into culture water, contributing to better environmental management and sustainable aquaculture production (Zhou *et al.,* 2012).

Role of COS in Intestinal Health and Nutrient Absorption

The intestine of shrimp functions not only as a digestive organ but also as an important site for microbial regulation and immune interaction. Maintaining a healthy intestinal environment is essential for efficient nutrient absorption and growth. COS improves intestinal health by preserving epithelial integrity, regulating microbial populations, and reducing harmful bacterial colonization. COS acts as a prebiotic compound that selectively stimulates beneficial microorganisms such as *Bacillus*, *Lactobacillus*, and other lactic acid bacteria. These beneficial microbes produce vitamins, organic acids, extracellular enzymes, and antimicrobial compounds that improve digestion and maintain intestinal health. Gao *et al.,* (2012) reported that dietary oligosaccharides enhanced gut microbial balance and growth performance in aquatic animals. Similarly, Goh *et al.,* (2022) demonstrated that functional carbohydrates such as COS positively influence shrimp gut microbiota by increasing microbial diversity and promoting beneficial bacterial populations associated with nutrient utilization.

Effect of COS on Energy Metabolism

Energy utilization plays an important role in converting dietary nutrients into growth. COS supplementation improves energy metabolism by enhancing carbohydrate and lipid digestion and regulating antioxidant pathways. Improved carbohydrate digestion provides sufficient energy for physiological functions, allowing dietary protein to be utilized for tissue growth rather than energy production. Enhanced lipid utilization improves the availability of essential fatty acids and phospholipids required for cellular membrane synthesis, immune responses, reproduction, and molting. Choi *et al.,* (2014) reported that chitosan derivatives improved lipid metabolism and antioxidant responses in aquatic organisms, resulting in improved physiological performance and growth efficiency.

Interaction between COS and Gut Microbiota for Improved Feed Utilization

The gut microbiota plays an essential role in shrimp nutrition by supporting digestion, producing beneficial metabolites, and maintaining intestinal homeostasis. Dietary COS modifies microbial communities by increasing beneficial bacteria and reducing harmful microorganisms. Beneficial bacteria stimulated by COS produce short-chain fatty acids (SCFAs), which provide energy to intestinal cells and enhance nutrient absorption. They also produce extracellular enzymes that complement host digestive processes. Competitive exclusion by beneficial microorganisms reduces pathogen colonization and minimizes energy expenditure associated with immune activation. Ringø *et al.,* (2020) reported that functional feed additives such as oligosaccharides regulate intestinal microbiota and influence pathways related to digestion, immunity, and growth performance in aquatic animals.

Synergistic Effect of COS with Probiotics

The combination of COS with probiotics represents a promising nutritional strategy for improving shrimp production and feed utilization. COS acts as a prebiotic substrate that promotes probiotic colonization, while probiotic bacteria provide digestive enzymes, antimicrobial compounds, and immune stimulation. Synbiotic supplementation of COS with beneficial bacteria such as *Bacillus subtilis*, *Lactobacillus plantarum*, and *Pediococcus* spp. has demonstrated improved growth performance, FCR, digestive enzyme activity, and disease resistance compared with individual supplementation. Wang *et al.,* (2019) reported that combined supplementation of probiotics and functional feed additives significantly enhanced growth performance, feed utilization, and survival of Pacific white shrimp (*Litopenaeus vannamei*).

Effect of COS on Reduction of Feed Wastage and Environmental Impact

Improved feed utilization efficiency through COS supplementation contributes significantly to environmentally sustainable shrimp aquaculture. Enhanced nutrient absorption reduces nitrogenous waste production, including ammonia and nitrite accumulation, thereby improving water quality and reducing environmental stress COS supplementation minimizes organic waste accumulation by improving feed digestibility and nutrient retention in shrimp tissues. Therefore, COS-based functional feeds can reduce production costs, enhance farm sustainability, and decrease dependence on antibiotics and chemical growth promoters (Hai, 2015).

CONCLUSION

Dietary supplementation of chitosan oligosaccharide (COS) has emerged as an effective nutritional strategy for enhancing feed utilization and growth performance in *Litopenaeus vannamei*. COS improves digestive enzyme activities, including protease, amylase, and lipase, thereby enhancing the digestion and absorption of proteins, carbohydrates, and lipids. It also promotes intestinal health by maintaining gut integrity, stimulating beneficial microbiota, and improving nutrient uptake. Enhanced protein utilization and feed conversion efficiency contribute to faster growth, better physiological performance, and reduced feed costs. Furthermore, COS supports energy metabolism, antioxidant defense, and immune function, resulting in improved overall health and disease resistance. Its synergistic interaction with probiotics further enhances digestive efficiency and shrimp productivity. By reducing nutrient losses and minimizing nitrogenous waste discharge, COS also contributes to environmentally sustainable and economically viable shrimp aquaculture.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest

ETHICS APPROVAL

Not applicable

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AI TOOL DECLARATION

The authors declares that no AI and related tools are used to write the scientific content of this manuscript.

DATA AVAILABILITY

Data will be available on request

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