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Short Communication

Digestive Enzyme Activity as a Foundation for Efficient Nutrient Utilization in Aquaculture

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DESCRIPTION

Aquaculture production depends on the ability of fish, shrimp, mollusks, and other cultured aquatic animals to convert feed nutrients into body tissue, energy, and physiological functions. Feed is one of the largest operational costs in many aquaculture systems, making efficient digestion an important area of research. Digestive enzymes participate in the breakdown of proteins, carbohydrates, and lipids into smaller molecules that can be absorbed through the intestinal tract. The activity, quantity, and distribution of these enzymes vary according to species, developmental stage, feeding habits, environmental conditions, and feed composition. Understanding these differences can support better feed formulation and improved animal performance [1].

Protease activity is particularly important in aquaculture because protein is commonly included at relatively high levels in formulated diets. Dietary proteins must be hydrolyzed before their amino acids can be absorbed and used for tissue formation, enzyme synthesis, immune functions, and other metabolic processes. Proteases such as trypsin, chymotrypsin, pepsin, and various peptidases contribute to this process. Their activity can change with age, feeding status, temperature, and dietary composition. Young animals may show substantial changes in digestive enzyme production as their digestive organs develop, making early-life nutrition an important area for enzyme-related studies [2].

Digestive enzyme activity is closely associated with feed composition. Changes in protein source, lipid level, starch content, fiber concentration, and feed additives can influence enzyme production and activity. Ingredients containing plant-based proteins may contain compounds that affect digestive processes, while processing methods can alter the availability of nutrients and reduce or modify certain undesirable components. Fermentation, extrusion, heating, and other feed-processing approaches may change the physical and chemical properties of feed ingredients. Researchers can compare enzyme activity alongside growth, feed conversion, nutrient retention, and intestinal condition to evaluate the biological response to different diets [3].

Age is another major factor affecting digestive enzyme profiles. Larval fish often begin external feeding during a period when their digestive organs are still developing. During this stage, endogenous enzyme production may be limited, and the nutritional characteristics of live feeds can become particularly important. As larvae develop into juveniles, the digestive tract becomes more functionally mature and enzyme patterns change. Monitoring these changes can assist in selecting suitable feed types and feeding schedules for different developmental stages [4].

The study of digestive enzymes can also contribute to the evaluation of feed additives. Probiotics, prebiotics, phytogenic compounds, organic acids, enzymes, and selected microbial products have been investigated for their effects on digestion and intestinal function. Some additives may influence the intestinal microbial community or modify digestive enzyme activity. However, responses are often species-specific, and results obtained under laboratory conditions may not always correspond to commercial production systems. Controlled experiments with suitable sample sizes and appropriate biochemical methods are needed to establish reliable relationships [5].

Modern analytical techniques have expanded research on digestive enzymology. Traditional enzyme assays remain useful for measuring specific activities, while molecular approaches can examine the expression of genes associated with digestive enzymes. Proteomic and metabolomics methods can provide additional information about changes in digestive and metabolic processes. Combining enzyme activity data with growth performance, nutrient digestibility, intestinal morphology, and molecular measurements can provide a more complete assessment of how aquatic animals respond to different diets [6]. Digestive enzyme research is also relevant to sustainable feed

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development. As aquaculture increasingly uses alternative protein and lipid sources, researchers need to determine how effectively cultured species can digest these materials. Ingredients derived from insects, algae, single-cell organisms, agricultural by-products, and plant sources may have different nutritional profiles and physical characteristics. Evaluating enzyme activity together with nutrient digestibility can help identify suitable inclusion levels and processing methods. This approach can support the development of feeds that provide adequate nutrition while reducing unnecessary nutrient losses [7].

Accurate interpretation of digestive enzyme measurements requires careful experimental design. Enzyme activity can be affected by tissue sampling location, extraction procedure, storage conditions, assay temperature, pH, substrate concentration, and analytical method. Results from different studies may therefore be difficult to compare when methodologies differ substantially. Standardized procedures and clear reporting of experimental conditions are important for producing meaningful datasets [8].

Digestive enzyme activity serves as a primary foundation for efficient nutrient utilization in aquaculture, directly influencing animal growth, feed conversion efficiency, nutrient retention, and overall operational cost-effectiveness. Because feeds represent one of the largest financial investments in aquaculture systems, understanding how aquatic species including fish, shrimp, and molluscs break down dietary proteins, carbohydrates, and lipids into absorbable molecules is essential for optimizing feed formulation [9]. Proteases like trypsin, chymotrypsin, pepsin, and peptidases are especially vital due to the high protein demands of aquatic diets, yet their production and functional distribution fluctuate according to developmental stage, feeding habits, ambient environmental conditions, and feed composition [10].

CONCLUSION

Aquaculture digestive enzymology connects nutrition, physiology, microbiology, feed technology, and animal production. Research in this area can improve understanding of how cultured species process nutrients and respond to changes in diet and environmental conditions. By examining enzyme activity alongside growth, feed utilization, intestinal health, and nutrient retention, researchers can develop a clearer picture of digestive performance. Continued investigation of digestive enzymes across species and life stages can support improved feed strategies and more efficient aquaculture production while reducing nutrient waste and unnecessary feed expenditure.

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