



Design Strategies for Nutritionally Balanced Aquafeed in Modern Fish Farming

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DESCRIPTION

Aquafeed formulation is a fundamental aspect of modern fish farming that directly influences growth performance, feed efficiency and overall production outcomes. The increasing demand for fish as a protein source has intensified the need for carefully designed feeds that meet nutritional requirements while maintaining economic viability. A well-formulated aqua feed provides all essential nutrients in appropriate proportions, ensuring that cultured species can achieve optimal growth without compromising health or water quality. The process of developing balanced aquafeed begins with a thorough understanding of the nutritional needs of the target species. Different fish species exhibit varying dietary requirements based on their feeding habits, digestive physiology and environmental conditions. Carnivorous species such as seabass and salmon require higher protein levels, whereas omnivorous species like tilapia and carp can efficiently utilize a combination of plant and animal-based ingredients. Additionally, life stages play a significant role, with larvae and juveniles requiring more nutrient-dense diets compared to mature fish.

Protein is often considered the most critical component in aquafeed due to its direct role in tissue development and growth. Selecting suitable protein sources involves evaluating digestibility, amino acid composition and cost. Fishmeal has traditionally been valued for its high nutritional quality, but limited availability and rising prices have encouraged the use of alternative sources such as soybean meal, sunflower meal and insect-based proteins. Combining different protein sources helps achieve a balanced amino acid profile, which is necessary for efficient protein utilization. Supplementation with specific amino acids like lysine and methionine is sometimes required to correct deficiencies in plant-based ingredients. Lipids are included in aquafeed as concentrated energy sources and carriers of essential fatty acids. These fatty acids are vital for maintaining cell structure, supporting immune function and enhancing reproductive performance. Fish oil has long been used due to its

richness in omega-3 fatty acids, but alternative lipid sources such as vegetable oils are increasingly being incorporated. Achieving the right balance between different fatty acids is important to ensure both fish health and the nutritional quality of the final product intended for human consumption.

Carbohydrates serve as an economical energy source in aquafeed formulation, although their utilization varies among species. Omnivorous and herbivorous fish can digest carbohydrates more efficiently than carnivorous species. Including appropriate levels of carbohydrates helps reduce the reliance on protein as an energy source, thereby improving feed efficiency and reducing costs. However, excessive carbohydrate inclusion can lead to poor growth and metabolic complications, making it necessary to maintain controlled levels based on species-specific tolerance. Vitamins and minerals are required in small quantities but play essential roles in metabolic processes, skeletal development and disease resistance. Deficiencies in these micronutrients can result in poor growth, deformities and increased susceptibility to infections. Premixes containing essential vitamins and minerals are commonly added to aquafeed to ensure consistent nutrient supply. Stability during storage and resistance to leaching in water are important considerations when selecting these supplements.

The physical characteristics of aquafeed significantly affect feeding behavior and nutrient utilization. Pellet size must be appropriate for the mouth size of the fish to ensure efficient consumption. Feed texture, water stability and buoyancy also influence feeding patterns. Floating feeds allow farmers to monitor feeding activity and adjust feeding rates accordingly, while sinking feeds are suitable for bottom-dwelling species. Maintaining pellet integrity in water reduces nutrient loss and prevents water pollution. Feed additives have gained attention for their ability to enhance performance and health in aquaculture systems. Probiotics, prebiotics and enzymes are commonly used to improve gut health and nutrient absorption. Probiotics introduce beneficial microorganisms into the digestive

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system, while enzymes assist in breaking down complex feed components, increasing nutrient availability. Immunostimulants and natural extracts are also used to improve resistance against diseases, reducing the need for chemical treatments.

Water quality management is closely linked to feed formulation and feeding practices. Poorly formulated feed or overfeeding can result in excess nutrient discharge into the water, leading to reduced oxygen levels and accumulation of harmful substances such as ammonia. Balanced aquafeed minimizes waste output by ensuring efficient nutrient utilization. Economic considerations play a significant role in aquafeed design. Feed costs typically account for a major portion of total production expenses in aquaculture. Therefore, selecting cost-effective ingredients

without compromising nutritional quality is essential. Utilizing locally available raw materials can reduce transportation costs and support regional agricultural systems. Efficient feed formulation ensures that farmers achieve maximum returns on investment through improved growth rates and feed conversion efficiency.

In summary, designing nutritionally balanced aquafeed involves a comprehensive approach that integrates knowledge of fish nutrition, ingredient properties, feed technology and environmental considerations. Continuous research and innovation are essential to meet the growing demand for aquaculture products while ensuring long-term sustainability and economic viability.