



## Emerging Trends in Plant-Based Aquafeed Formulation for Aquaculture

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### DESCRIPTION

Plant-based aquafeed formulation has gained increasing attention as aquaculture continues to expand and the availability of traditional marine-derived ingredients becomes more limited. The shift toward plant-derived resources is driven by economic considerations, sustainability concerns and the need to reduce pressure on wild fish stocks. As a result, feed manufacturers and researchers are actively exploring innovative ways to develop nutritionally complete diets using plant-based ingredients without compromising fish growth, health or product quality. One of the primary components in plant-based aquafeed is protein derived from crops such as soybean, pea and rapeseed. Soybean meal, in particular, has become a widely used ingredient due to its relatively high protein content and availability. However, plant proteins often lack certain essential amino acids required for optimal fish growth. To address this limitation, feed formulations commonly include a combination of different plant protein sources along with supplementation of limiting amino acids such as lysine and methionine. This approach helps create a more balanced amino acid profile that meets the nutritional needs of various aquatic species.

Another important consideration in plant-based aquafeed is the presence of anti-nutritional factors. Compounds such as phytates, tannins and protease inhibitors can interfere with nutrient digestion and absorption. Processing techniques including heat treatment, fermentation and enzymatic treatment are used to reduce these compounds and improve feed quality. Fermentation, in particular, has shown positive effects by enhancing protein digestibility and increasing the availability of beneficial bioactive compounds. Lipids in plant-based aquafeed are typically derived from vegetable oils such as soybean oil, sunflower oil and canola oil. While these oils provide a good source of energy, they differ from fish oil in their fatty acid composition, particularly in the levels of long-chain omega-3 fatty acids. To maintain the nutritional quality of farmed fish,

strategies such as partial inclusion of marine oils or the use of algae-based lipid sources are being explored. Algal oils are especially valuable as they can provide essential fatty acids similar to those found in fish oil.

Carbohydrates play a more prominent role in plant-based aquafeed compared to traditional diets. Ingredients such as wheat, corn and rice bran are commonly included to supply energy and improve pellet binding. Proper processing of these ingredients enhances digestibility and ensures that fish can effectively utilize the available energy. However, the level of carbohydrate inclusion must be carefully controlled, particularly for species with limited carbohydrate metabolism. The incorporation of functional additives is another important aspect of plant-based aquafeed formulation. Probiotics, prebiotics and phytochemicals are used to improve gut health, enhance nutrient absorption and support immune function. Plant extracts containing natural bioactive compounds have also been studied for their potential to improve disease resistance and overall performance in aquaculture systems.

Palatability is a key challenge in plant-based aquafeed development. Fish accustomed to diets containing fishmeal may initially show reduced acceptance of plant-based feeds. To overcome this issue, attractants such as amino acids, nucleotides and natural flavor enhancers are added to improve feed intake. Gradual adaptation and careful formulation help ensure that fish readily accept the new diets without compromising growth rates. Environmental sustainability is one of the major advantages of plant-based aquafeed. The use of renewable plant resources reduces reliance on marine ingredients and contributes to more sustainable aquaculture practices. Additionally, improved feed efficiency and reduced nutrient waste help minimize the environmental impact of fish farming operations. Selecting locally available plant ingredients can further reduce transportation costs and support regional agricultural systems. Technological advancements have played a significant role in

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improving plant-based aquafeed formulation. Extrusion processing enhances feed digestibility, pellet stability and nutrient availability. Modern formulation software allows precise balancing of nutrients, ensuring that plant-based diets meet species-specific requirements. These technologies enable feed manufacturers to produce high-quality feeds that are both efficient and economically viable. Economic factors also influence the adoption of plant-based aquafeed. While some plant ingredients are cost-effective, others may require additional processing, which can increase production costs. Therefore, achieving a balance between cost and nutritional quality is essential for widespread adoption. Continuous research is

focused on identifying new plant sources and improving processing methods to enhance cost efficiency.

The future of plant-based aquafeed lies in the continued exploration of novel ingredients and improved formulation techniques. Advances in crop breeding, biotechnology and feed processing are expected to enhance the nutritional value of plant ingredients and reduce limitations associated with their use. As the aquaculture industry continues to grow, plant-based aquafeed will play an increasingly important role in meeting global demand for seafood in a sustainable and responsible manner.