Reducing Formulation Costs During Challenging Times

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INTRODUCTION

Known as the king of ingredients for feeds in intensive aquaculture worldwide, fishmeal is made from wild capture and fish by-products. Aquaculture remains highly dependent on marine capture fisheries to supply key dietary nutrients, such as fishmeal and fish oil. Due to its composition and amino acid profile, the inclusion of fishmeal in aquaculture feed is a standard practice. Fishmeal contains all the nutrients aquatic species need, typically 60-72% crude protein, 10-20% ash, 5-12% fat, and high levels of omega-3s EPA and DHA (Hatch, 2024). Nevertheless, many different products with different specifications are sold under the name of fishmeal. For example, looking at the IAFFD website (https://www.iaffd.com), there are almost 72 different products registered under the name of fishmeal without considering the specific types such as tuna or salmon meal. Obviously, all these products have very different compositions and amino acid profiles.

Parallel to aquaculture growth in the past three decades, the proportion of global fishmeal supplies used by the aquafeed industry rose from 10% to over 70% of the total fishmeal quantity supplied to all species feed (Barrows & Sealey, 2015). Approximately 86% of fishmeal was used in aquaculture in 2020, with the remainder used in livestock feed production (Gatta, 2022). Currently, the shrimp farming sector employs more than a million tons of fishmeal per year, making it one of the largest users of fishmeal in 2020. This means that about 25% of all fishmeal used in aquaculture is now for shrimp, given that global fishmeal production is around 5 million tons and aquaculture uses close to 4 million tons (Glencross, 2022).

On the other hand, the availability of wild stocks, regulations, and authorized fishing seasons are critical factors in the price of fishmeal. The recent cancellation of Peru's fishing season resulted in a price increase of $2,571 to $2,585 per ton, 40% higher than in 2022, and a 70% year-on-year decline in Peru's production (IFFO, 2023). In anticipation of a lack of supply, China is stocking up on fishmeal, further increasing costs and reducing market availability.

Nowadays, fishmeal has become a major concern in aquaculture feed due to its unsustainable supply, high percentage of formulation cost, and urgent shortage in the market, especially for high-quality fishmeal. Two main nutritional strategies for solving this problem are reducing fishmeal consumption and adopting a protein-saving diet.

Tran-Ngoc et al. (2019) pointed out that, in fish, the reduction of fishmeal and compensation by other protein sources face a challenge of protein digestibility. Similarly, protein digestibility is the main challenge when trying to reduce high-quality fishmeal and compensate with different protein sources, especially non-marine proteins (Vieira et al., 2022).

Table1: Digestibility of different protein sources in Tilapia

ADC_{diet} of nutrients	Basal diet (Fish diet)	+ 30% Feather meal	+ 30% Soybean meal	+ 30% Rice bran meal	+ 30% Canola meal	+ 30% Sunflower meal	+ 30% DDGS meal
Dry matter	80.8±0.10[a]	78.15±0.30[a]	78.31±1.75[a]	71.34±0.81[bc]	71.31±0.56[bc]	69.86±3.35[c]	73.66±0.82[b]
Crude protein	92.29±0.49[a]	87.44±0.47[d]	92.14±0.98[a]	88.99±0.86[c]	88.68±0.40[c]	90.87±0.75[b]	88.90±0.76[bc]
Crude fat	94.11±0.91[a]	84.78±2.30[d]	93.47±0.64[ab]	86.85±1.35[d]	90.39±0.41[c]	91.44±0.82[bc]	92.93±0.85[ab]
Phosphorous	56.36±2.60[a]	55.76±0.53[a]	54.83±5.20[a]	36.72±1.70[c]	46.16±5.30[b]	48.82±4.61[b]	60.09±3.50[a]
Ash	47.05±2.10[a]	38.34±4.50[b]	50.73±0.76[a]	28.84±1.30[c]	36.75±1.62[b]	40.15±7.33[b]	50.57±2.67[a]
Energy	85.14±0.23[a]	81.64±0.79[b]	83.39±0.64[ab]	70.70±1.14[cd]	76.82±0.75[cd]	74.85±2.57[d]	77.99±0.97[c]

Tran-Ngoc et al., 2019

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Crude protein content, the profile of essential amino acids, and their digestibility shall be measured to determine the quantity and quality of proteins in feed and ingredients. It is necessary to ensure that the nutritional requirements of individual farm species are matched by the content of key amino acids and total crude protein in compound feed. The ability to break down protein into peptides for absorption is also the key to measuring feed quality and ingredient effectiveness. Improving the nutrient efficiency in plant-based proteins for aquafeed by adding exogenous enzymes has been proven beneficial for many aqua species. Eventually, the use of enzymes is important for the development of a sustainable aquaculture industry that is less dependent on fishmeal content (Ravindran & Son, 2011). In addition, to address the problem of sustainability of protein sources in aquaculture, two main nutrition strategies are used: reducing fishmeal consumption and adopting protein-saving diets that offer cost-saving advantages and reduce dependence on fishmeal. However, these approaches have been linked to negative effects on growth performance, feeding efficiency, and disease resistance of aquatic animals. To mitigate these challenges, exogenous protease has been used to improve the quality of diets with lower fishmeal content or protein levels, thereby improving the bioavailability of nutritional ingredients (Chen et al., 2023).

Protease Improves Protein Digestibility and Amino Acid Profile of Protein Sources

Recent research shows that protease can significantly increase protein digestibility in common raw materials (Jefo, internal data). In rainbow trout (Oncorhynchus mykiss), the protein digestibility of soybean meal and canola meal can be enhanced by 3.5% and 6.3%, respectively, by adding protease (Lee et al., 2020). On the other hand, animal proteins, such as poultry meal, meat and bone meal, and feather meal, also gain higher protein digestibility by applying protease. Protease has also been proven to increase the protein digestibility of feather meal in European seabass (Dicentrarchus labrax).

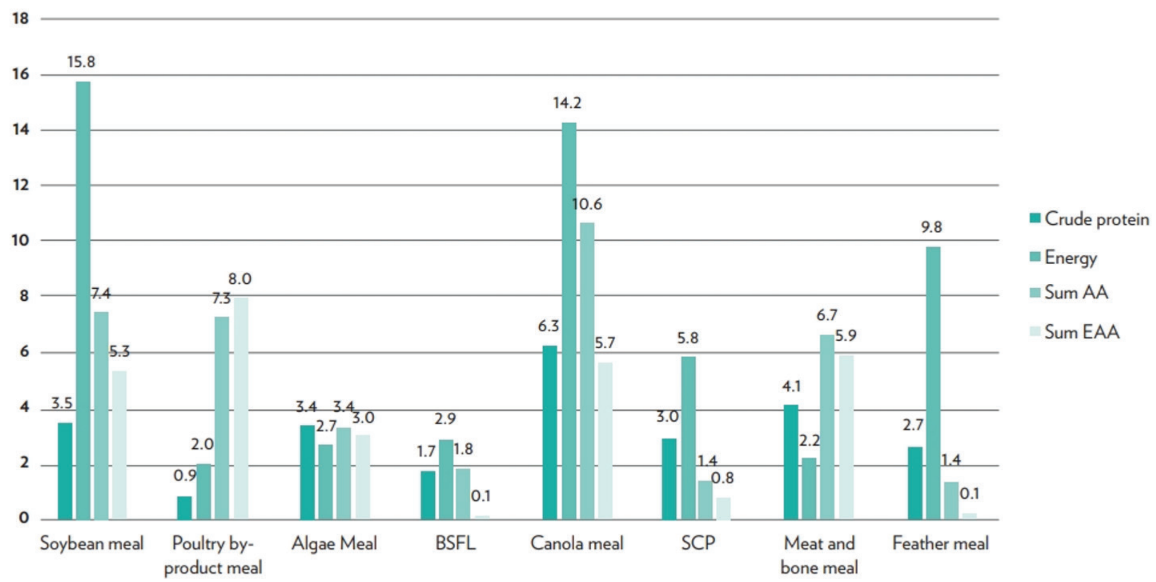

Figure 1: Improvement of nutrient Apparent Digestibility Coefficient from several ingredients (%) (BSFL: Black soldier fly larvae meal; SCP: Single cell protein)

Jefo internal data

Imbalance in the nutrient compositions is another disadvantage of plant ingredients, as it appears in the amino acid profile. For example, soybean meal is higher in lysine but deficient in methionine and cysteine, while corn gluten is low in lysine and arginine. Combining many plant ingredients can compensate for the deficient amino acid requirements but is also challenged by the interaction of different anti-nutritional factors (Bandara, 2018). Protease is responsible for breaking down complex proteins into smaller units through hydrolysis (Rawlings, 2013). Lee et al. (2020) examined the impact of dietary protease, which led to an improvement in ADCs for essential amino acids in rainbow trout fed 17 different feed ingredients. The findings validated a boost in ADC of essential and non-essential amino acids.

Protease Improves the Protein Digestibility of Aquafeed

Protease has been widely applied to aquafeed to improve protein efficiency ratio (PER), including in common carp (Carassius auratus), tilapia (Oreochromis niloticus), rainbow trout, coho salmon (Jefo, internal data). By applying protease, the PER can increase by 23% and 13.6% - 20% on carp and tilapia, respectively. A similar trend was found in salmon and trout, where protein digestibility can increase by 5% to 7%. For snakehead fish (Channa striatus), PER can go up by 21% in their high crude protein diet (40%). The study also indicates that protease enhances PER by up to 14.6% in white shrimp (Litopenaeus vannamei).

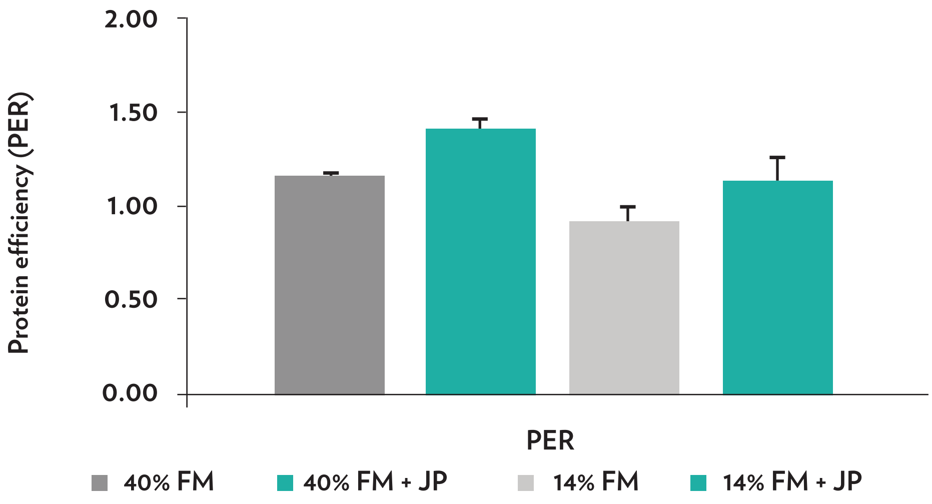

Figure 2: Protein efficiency ratio of snakehead-fed diets with and without Jefo Protease (JP)

Jefo internal data

Alternative Protein Sources Strategy

In recent years, protease has been widely applied in the aquafeed industry to address the problem of sustainable protein sources. Replacing first-grade fishmeal with local fishmeal is a common method used in shrimp feed and other high-end value species. The internal research indicates that protease can maintain the same performance for shrimp in the diet reducing the fishmeal level by 40% with the balance of other animal protein and plant protein sources (Jefo, unpublished data). In addition, substituting 5% soybean meal for canola meal in the Pangasius (*Pangasius hypophthalmus*) diet can maintain the growth performance at lower formulation cost by 0.6 – 0.9% (Jefo, unpublished data). Consequently, fishmeal levels can gradually reduce from 30% down to zero in fish diets depending on the species (Jefo, internal data). In white shrimp, growth performance and PER are maintained with fishmeal reduction from 10% to 50% in the diet (Jefo, internal data).

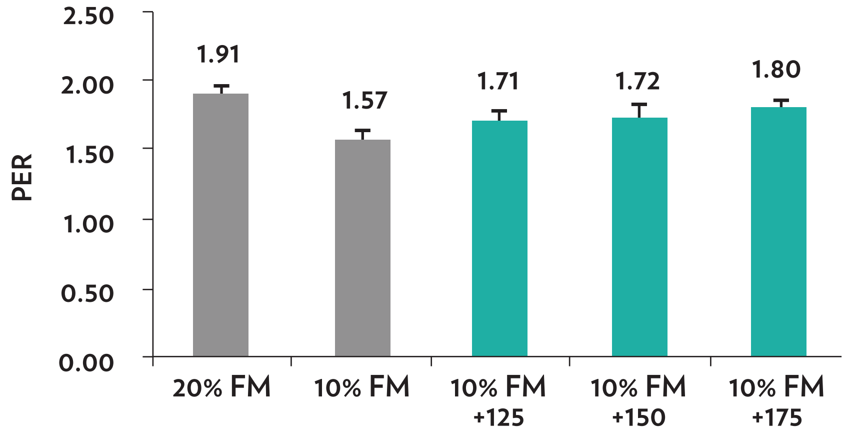

Figure 3: Protein efficiency ratio of shrimp fed experimental diets

Jefo internal data

Protein-Saving Diets Strategy

Nowadays, aquafeed mills respond to the economic challenges faced by farmers by optimizing raw materials, reducing feed costs, and enhancing feed efficiency. The super-intensive culture method is widespread in the industry, leading to a higher risk of environmental problems. For example, nitrogen is provided in high concentration in shrimp feed, but most of it added to the pond is not retained as shrimp biomass (Briggs and Funge-Smith, 1994). Reducing crude protein levels and increasing digestible protein in shrimp feed will help farmers achieve successful harvests while avoiding unabsorbed nutrients polluting the pond water. By applying protease, a 7% reduction in crude protein in the diet can bring better feed costs and maintain growth performance (E. Missale & al., 2017).

Protease – A Practical Tool for Optimizing Feed Cost

One of the major fishmeal consumers worldwide continues to be the shrimp sector. Identifying and using alternative protein sources is essential to increasing production levels. Our research indicates that we can reduce fishmeal levels in aquafeed without affecting shrimp health or growth. Nevertheless, it is essential to formulate in compliance with the amino acid profile required for shrimp. It´s important to note that if one amino acid is required, crustaceans catabolize the others into energy, and they are no longer used for growth. This opens opportunities for using fishmeal more strategically alongside other effective protein sources. Jefo continues our research on reduced fishmeal content, supplementing it with the application of protease and other proteins. Our investigations have identified several viable alternatives, including poultry meal, soybean meal, canola meal, and other plant-based proteins, together with protease application to enhance protein utilization.

To maintain Jefo´s commitment to an environmentally friendly and economically viable aqua industry, research will continue to focus on these sustainable and efficient alternatives.

REFERENCES

Aas, T. S., Åsgård, T., & Ytrestøyl, T. (2022). Utilization of feed resources in the production of Atlantic salmon (Salmo salar) in Norway: an update for 2020. *Aquaculture Reports*, *26*, 101316.

Bandara, T. (2018). Alternative feed ingredients in aquaculture: Opportunities and challenges. *J. Entomol. Zool. Stud*, *6*(2), 3087-3094.

Barrows, F. T., & Sealey, W. M. (2015). Feed ingredients and the reduction of dependence on marine harvested products for aquaculture feeds. *Derived from http:// www. tidescanada. org/wpcontent/uploads/2015/03/Wendy-Sealey-White-Paper-Report-re-Feed-Ingredients-101232014. pdf*.

Chen, S., Maulu, S., Wang, J., Xie, X., Liang, X., Wang, H., ... & Xue, M. (2023). The application of protease in aquaculture: Prospects for enhancing the aquafeed industry. *Animal Nutrition*.

Missale, E., Wongsang, J., Lucien-Brun, H. & Chowdhury, K. (2017). Dietary Protease Improves Production Performance of Commercially Farmed Pacific White Shrimp Litopenaeus vannamei. Presented at Aquaculture America February 19 to 22, 2017, San Antonio, Texas, USA

Funge-Smith, S. J., & Briggs, M. R. (1998). Nutrient budgets in intensive shrimp ponds: implications for sustainability. Aquaculture, 164(1-4), 117-133.

Gatta, P. P. (2022). The State of World Fisheries and Aquaculture 2022. In *FAO eBooks*. https://doi.org/10/4060/cc0461en

Glencross, B.D (2022). Changing demands to global fishmeal use. *IFFO – The Marine Ingredients Organization, 2022*. https://www.iffo.com/changing-demands-global-fishmeal-use

HATCH BLUE (2024). Emerging protein-rich ingredients for aquaculture. *Hatch Blue & Hatch Innovation service*, 2024. www.hatch.blue

IFFO (2023). The Evolution Sustainability metrics for marine ingredients. *IFFO – The Marine Ingredients Organization, 2023*. https://www.iffo.com/role-marine-ingredients

Lee, S., Chowdhury, M. K., Hardy, R. W., & Small, B. C. (2020). Apparent digestibility of protein, amino acids and gross energy in rainbow trout fed various feed ingredients with or without protease. *Aquaculture*, *524*, 735270.

Ravindran, V., & Son, J. H. (2011). Feed enzyme technology: present status and future developments. *Recent patents on food, nutrition & agriculture*, *3*(2), 102-109.

Rawlings, N. D. (2013). Protease families, evolution and mechanism of action. In *Proteases: structure and function* (pp. 1-36). Vienna: Springer Vienna.

Tran Ngoc, K. T., Haidar, M. N., Roem, A. J., Sendão, J., Verreth, J. A., & Schrama, J. W. (2019). Effects of feed ingredients on nutrient digestibility, nitrogen/energy balance and morphology changes in the intestine of Nile tilapia (*Oreochromis niloticus*). *Aquaculture Research*, 50(9), 2577-2590.

Vieira, C. C. F., Pinto, R. C. C., Diógenes, A. F., & Nunes, A. J. P. (2022). Apparent digestibility of protein and essential amino acids from commonly used feed ingredients in Brazil for juvenile shrimp *Litopenaeus vannamei*. *Revista Brasileira de Zootecnia*, 51, e20210177.