Feeding for success: Unravelling the key principles of optimal larval shrimp nutrition

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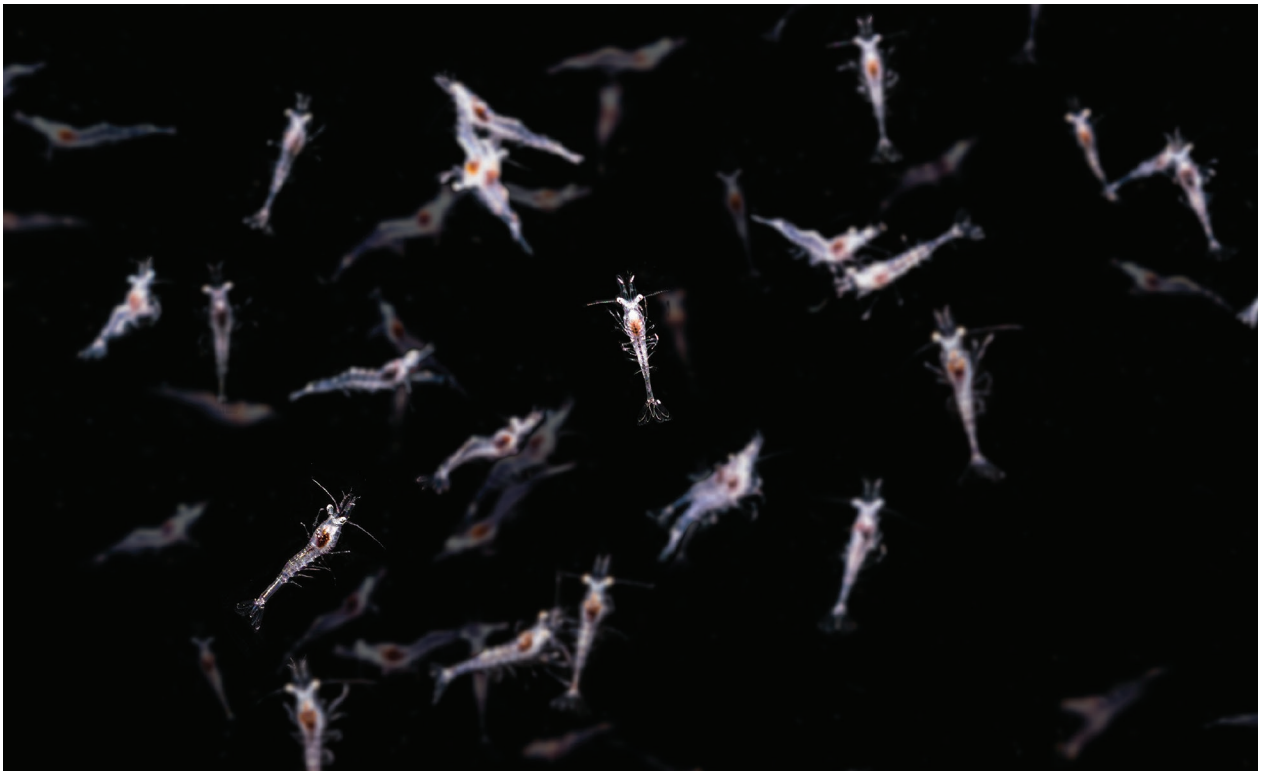

In the dynamic world of aquaculture, where innovation propels the industry forward, one crucial aspect remains paramount to the success of shrimp hatchery – nutrition. With the escalating demand for high-quality shrimp, the pursuit of unlocking the secrets of optimal nutrition has become a central focus for researchers, scientists, and shrimp farmers alike. In this expedition, SyAqua embarks on a journey into the intricate tapestry of shrimp nutrition, striving to decipher the code governing the health, growth, and sustainability of these aquatic marvels.

Shrimp larvae, known for their delicate yet resilient nature, require a precise balance of nutrients to thrive. Recent breakthroughs in scientific understanding, coupled with technological advancements, have opened new avenues in the quest to provide larvae with the perfect diet. From innovative feed formulations to a deeper comprehension of macronutrient and micronutrient value, digestibility, and absorption, the realm of larval nutrition is undergoing a transformative shift.

Come along with us as we uncover the secrets to providing the best nutrition for shrimp larvae — a journey that delves beyond the surface and into the heart of aquaculture innovation. From cutting-edge research to on-the-ground success stories, this

exploration aims to illuminate the nutritional factors and their balance. As we navigate the complexities of this nutritional code, a clearer picture emerges, promising not only healthier and more robust shrimp but also a sustainable and thriving industry.

Balanced diets for shrimp: A focus on amino acid and fatty acid profiles

Traditionally, discussions surrounding shrimp nutrition have revolved around proteins, fats, and carbohydrates. However, the vulnerability of larvae necessitates a more tailored approach, with essential amino acids emerging as pivotal in ensuring proper development. Simultaneously, the role of fatty acids in energy metabolism and structural development takes on heightened importance, guiding the formulation of diets that transcend sustenance to promote thriving larvae populations.

Amino acids serve as substrates for protein synthesis, contributing to the growth of aquatic animals. They play essential roles in regulating feed intake, intermediary metabolism, cell signaling, immune response, and the overall health of farmed animals, including fish and crustaceans (D'Mello, 2003; Mai *et al*., 2022; Wu, 2021).

Categorized into nutritionally essential, conditionally essential, and non-essential amino acids, ensuring the balance of 10 essential amino acids (EAAs) is crucial (see the reference values in Table 1). Any imbalance is likely to disrupt protein synthesis and turnover, leading to adverse consequences, such as nitrogen loss into the environment. Alternative protein sources, animal byproducts and plant proteins are becoming popular to reduce cost in manufacturing, but those feedstuffs are usually less digestible and deficient in EAAs, especially methionine and lysine (Simon *et al*., 2021).

Methionine is very important to the physiology and metabolism of shrimp, and it is the most impacted EAA in low fishmeal diets (Chen *et al*., 2011). Lysine is one of the most limiting EAA in plant-based protein diet, which can significantly promote protein synthesis and growth performance of shrimp (Xie *et al*., 2012). In addition, both EAAs can support the application of other EAAs by eliminating the oxidation rate (Richard et al., 2010). The dietary methionine and lysine levels are 0.7-0.9% and 1.6-2.1% of the diets for cultured shrimp, respectively (NRC, 2011). The nutrition based-formulation approach with crystalline amino acids (CAAs) is widely recommended to provide a proper balance of EAAs in aquafeeds – CAAs are digestible amino acids, which are synthetically manufactured by bacteria through the fermentation process (Swanepoe *et al*., 2023). Therefore, the CP is not the only indicator to consider the feed quality, but the well-balanced amino acid profile and digestibility are also important to meet.

The lipid requirement of shrimp depends on their essential fatty acid profile and phospholipid content (Gonzalez-Felix *et al*., 2002). The increasing lipid level affected the increase of lipid deposition in hepatopancreas and muscle but without significant effect on growth. Notably, fatty acid profile, especially unsaturated fatty acids like linoleic acid (18:2n-6), linolenic acid (18:3n-3), eicosapentaenoic acid (20:5n-3, EPA), and docosahexaenoic acid (22:6n-3, DHA), is more meaningful in terms of nutrition value concern (see the reference values in Table 2). Maintaining the optimum levels of highly unsaturated n-3 fatty acids, EPA and DHA, at 0.5-1.0%, is crucial for achieving higher final weight and growth, as an imbalance, more than 2%, negatively affects nutrition and stunts shrimp growth

Table 1. Essential amino acid requirements by penaeid shrimp

Amino acid	Requirement for Penaeid shrimp (% diet)	Reference
Arginine	2.5%	Chen *et al.*, 1992
Histidine	0.42 - 1.17%	Millamena *et al.*, 1999
Isoleucine	0.52 – 2.02%	Millamena *et al.*, 1999
Leucine	0.95 - 2.95%	Millamena , 1999
Lysine	1.6-2.1%	NRC, 2011
Methionine	0.7-0.9%	NRC, 2011
Phenylalanine	0.62 – 2.12%	Millamena*et al.*, 1999
Threonine	1.4%	Millamena *et al.*, 1997
Tryptophan	0.2%	Millamena *et al.*, 1999
Valine	1.3-1.5%	Millamena *et al.*, 1996

(Gonzalez-Felix *et al.*, 2007). Additionally, an imbalance of lipids by over-supplementation exceeding 8% can depress protein digestibility, growth performance, and feed utilization (Chookird, 2010).

Optimum feed quality through digestibility

Understanding feed digestibility is a fundamental step in optimizing nutritional intake for shrimp. The composition and quality of feeds play a pivotal role in determining how effectively shrimp can break down, absorb, and utilize essential nutrients. A highly digestible feed facilitates the shrimp's digestive tract in absorbing macronutrients and micronutrients from feed to the bloodstream, leading to effective nutrient utilization for growth, energy, and overall physiological functions. Especially during the larval stage, digestion efficiency is limited due to early development. Higher digestibility in feed leads to greater nutrient utilization by larvae.

In light of this, our exploration delves into factors contributing to feed digestibility, including ingredient selection, processing techniques, and the role of enzymes in aiding nutrient release during digestion. For instance, different types of protein sources, such as fish-based protein and plant-based protein, or varying grades of protein sources, premium or standard, can significantly impact feed digestibility. Research has shown that premium fishmeal, with a balanced amino acid profile, exhibits higher apparent crude protein digestibility and promotes greater growth compared to lower-grade fishmeal with similar amino acid values (Chookird, 2010). This underscores the direct positive correlation between good digestibility, nutrient absorption, and growth feasibility.

Moreover, the quality of raw materials significantly impacts feed utilization, influencing digestion, absorption, and overall growth efficiency. SyAqua explores how premium-grade, enriched, and easily digestible feed promotes higher rates of digestion and absorption, resulting in lower feed consumption and a reduced feed conversion ratio. This not only minimizes organic waste in the water column but also enhances water quality, necessitating less management in the culturing tank.

SyAqua's internal trials reveal an exciting breakthrough in optimizing larval nutrition through enhanced feed digestibility. Our findings demonstrate a clear advantage in protein digestibility between high- and low-digestible feeds, showcasing the potential for significant improvements in larvae growth and development.

Table 2. Essential fatty acid requirements by penaeid shrimp

Fatty acid profile	Requirement for Penaeid shrimp (% diet)	Reference
EPA (20:5n-3)	0.50%	Gonzalez-Félix *et al.*, 2003
DHA (22:6n-3)	0.50%	Gonzalez-Félix *et al.*, 2003
Total HUFA	Max 2%	Gonzalez-Felix *et al.*, 2007
Total n-3	Min 1%	Kanazawa *et al.*, 1979

Table 3. Comparison of *in vitro* protein digestibility between high digestible feed and low digestible feed used for culturing shrimp larvae

Group	Protein digestibility (mM DL-alanine/g feed/Trypsin activity)
High digestible feed	55.41 ± 8.25 [b]
Low digestible feed	39.27 ± 3.29 [a]
p-value	0.035

The different superscript letters mean statistical differences ($p < 0.05$) (a < b).

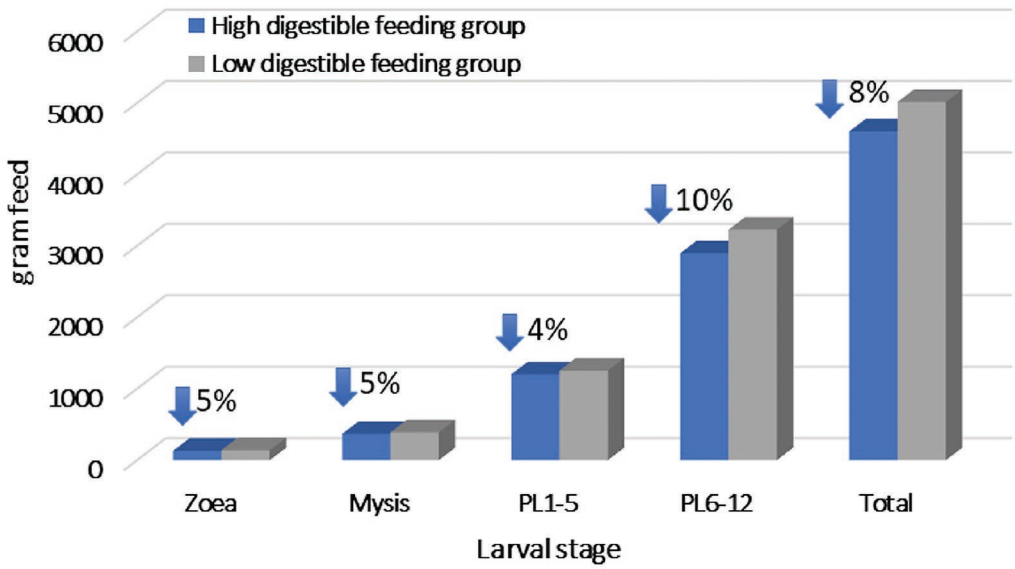

Figure 1. Feed consumption of high digestible feeding group and low digestible feeding group for culturing 1 million PL12

Notably, larvae fed highly digestible feed consume approximately 8% less, meaning low FCR and leading to reduced feed costs and increased profitability for hatcheries (Fig. 1). These results underscore the critical importance of prioritizing feed quality and digestibility in larval nutrition strategies, not only for enhancing performance but also for maximizing economic gains.

SyAqua's commitment to elevating the nutritional value of each feed pellet underscores its dedication to ensuring a consistent and high-quality nutrition source, from machine to hatchery. Join us in the revolution of shrimp nutrition, where science and technology converge to shape the future of aquaculture.

References available on request.

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