Aquamimicry: The Key to Building Sustainable Water System

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In aquaculture, Biofloc is being acknowledged as an environmentally sustainable technology and a cost-effective means of managing waste generated within the system. Nonetheless, it is accompanied by certain drawbacks that dissuade shrimp farmers from adopting it. The primary limitation of this technology is the requirement for continuous aeration to suspend the generated waste, enabling active bacterial metabolism for protein production. Additionally, nitrification leads to a decline in pH and alkalinity, necessitating careful monitoring and the addition of adequate carbon, in contrast to conventional shrimp farming methods (Thong, 2014). Consequently, a new innovative technology, copefloc, has been developed to overcome these constraints. Copefloc relies on the natural production of copepods within the system, which the stocked shrimps subsequently consume. This approach eliminates the need for external feed sources or intensive agitation and oxygenation in the culture system (Romano and Kumar, 2017).

The copepods, acting as zooplankton, offer numerous advantages as they convert energy within the food chain, serve as a food source for marine animals, and effectively recycle nutrients (Christenson, 2016). Shrimps fed with these copepods demonstrate enhanced growth and improved survival rates due to the superior biochemical composition of the plankton. Shrimp farming is a booming industry that plays a vital role in meeting the global demand for seafood. However, traditional shrimp farming practices often lead to environmental degradation, including water pollution and habitat destruction. In the quest for sustainable solutions, aquamimicry has emerged as a game-changer. Emulating nature aquamimicry offers a promising approach to revolutionizing shrimp farming and building environmentally friendly water systems. In this article, we delve into the fascinating world of aquamimicry and explore how it holds the key to a more sustainable future for shrimp farming.

Understanding Aquamimicry

Aquamimicry represents a novel approach in shrimp farming that offers potential solutions to address the existing limitations associated with conventional methods. In recent years, various countries, such as Thailand, Australia, Bangladesh, Brazil, Brunei, China, Ecuador, Egypt, India, Korea, Malaysia, Mexico, Peru, Singapore, Sri Lanka, the USA, and Vietnam, have adopted this technique in their shrimp farming practices (Zeng et al., 2020). By simulating natural conditions, aquamimicry creates an environment that promotes microbial growth and enhances phyto and zooplankton populations, particularly copepods, which serve as valuable supplementary food sources while also contributing to in situ water quality management (Romano, 2017).

This approach effectively emulates the natural environment, fosters environmental stability, and reduces feeding costs. However, limited information is available regarding the specific details of this method, its associated benefits, and how it compares to other approaches, such as Biofloc Technology (BFT). By mimicking the efficiency and resilience of natural ecosystems, aquamimicry enables us to create sustainable solutions for various industries, including shrimp farming. It focuses on optimizing water usage, improving water quality, and reducing waste while ensuring the well-being of aquatic organisms.

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Advantages of the Aquamimicry in Shrimp Culture

- Stability Enhancement: The system offers a more stable culture environment than conventional systems.
- Improvement in Shrimp Health: The presence of bacterial secondary metabolites such as liposaccharides and peptidoglycans in probiotics can enhance farmed shrimp's immunocompetence, resulting in healthier individuals.
- Feed Conversion Ratio Improvement: The abundance of zooplankton, especially copepods, improves feed conversion ratios.
- Disease Prevention: Providing a more natural and welfare-focused environment reduces the likelihood of disease outbreaks in shrimp aquaculture.
- Applicability to Large and Semi-Intensive Systems: Aquamimicry can be utilized in large-scale and semi-intensive cultivation systems, leading to reduced feed consumption and water exchange rates.
- Improvement in Nutrition: The presence of live foods in the culture media improves the overall nutrition of farmed shrimp.
- Stress Alleviation and Biosecurity: The limited water exchange rate alleviates stress conditions in farmed shrimp and enhances biosecurity.
- Reduction in Pathogen Propagation: Aquamimicry creates unfavorable conditions for the propagation of harmful bacterial pathogens and reduces the formation of black soil.
- Rise in Production Yield and Profitability: Implementing will help to increase shrimp production yield, reduce expenditures, and enhance profitability. The reduced dependency on commercial feeds decreases biological oxygen demand and the need for intense aeration, leading to improved energy consumption efficiency.
- Better Growth Performance: Simulating natural conditions in this system can trigger better growth performance in shrimp.
- Simplified Implementation: This system requires less technology, infrastructure, and technical knowledge for establishment and operation. Aquaculture farmers can implement it with lower technical expertise.

Fermentation in Aquamimicry

Fermentation is a biotechnological process employed in aquamimicry systems to enhance the utilization efficiency of lignocellulosic materials. By breaking down complex compounds into simpler forms, fermentation increases the bioavailability of nutrients, improves digestion, and promotes animal growth rates (Razak et al., 2017). This microbial process is commonly used in aquaculture to improve the nutritional value and reduce anti-nutritional factors (ANF) in alternative protein sources and cereals incorporated into feed formulations. Cereals typically have low levels of essential amino acids, high fiber content, and ANF, which negatively impact digestion and growth. Through fermentation, undesirable substances are reduced, and the nutritional quality of plant proteins and cereals is enhanced by the activity of microbial-derived enzymes in an anaerobic environment (Qiu and Davis, 2018). During this process, bacteria and yeast use carbohydrates as an energy source and convert them into microbial proteins. Consequently, fiber and ANF levels are reduced, while amino acids, vitamins, minerals, and proteins are increased in fermented products. Studies have shown that the inclusion of fermented grains with probiotics in shrimp farming significantly improves digestion (Lara-Flores, 2011).

Furthermore, fermented cereal meals can partially replace dietary fishmeal in shrimp feed, exhibiting higher digestibility and improved nutritional content compared to non-fermented cereals. Among various cereals, rice bran, an agricultural waste, is commonly used as a carbon and energy source in aquafeeds. It is readily available and cost-effective, contains substantial nutrients, and has a relatively high fiber content (Deepak et al., 2020).

crustaceans with short lifespans and small sizes, play essential roles in nature, including serving as food for marine animals, facilitating nutrient recycling, and participating in energy conversion within the food chain (Chakravarty et al., 2018). Due to their favorable biochemical composition and ability to improve survival and growth in farmed shrimp at different life stages (including eggs, nauplius, pre-adults, and adults), the use of copepods in the aquaculture industry is increasing (Chakravarty et al., 2018). Compared to rotifers and Artemia, copepods offer higher nutritional value, particularly in terms of

Figure 1. Preparation of fermented rice bran. A: start of preparation (rice bran and probiotic). B: 24 hours after preparation. (Image: Catalani, 2020)

Figure 2. A: Anaerobic fermented rice bran maintained for 24 hours in an experiment on feed replacement. B: Application of fermented rice bran in pond during feed replacement experiment (Image: Gonçalves, 2022)

Live Food Importance

Aquamimicry technology utilizes natural organisms, particularly copepods, as a feed source for shrimp in a method known as copefloc technology (Deepak et al., 2020). In this approach, copepods become the dominant species, replacing other zooplankton species and indicating system maturity (Chakravarty et al., 2018). Copepods, which are

LC-PUFA (e.g., eicosapentaenoic, docosahexaenoic, and arachidonic acids), which are crucial for growth and development (Satoh et al., 2009). Additionally, copepods are rich in carotenoids, free amino acids (such as taurine), peptides, vitamins, and minerals (including selenium, iodine, copper, and manganese).

Moreover, copepods exhibit significant variation in protein levels, ranging from 52.4% to 57.6% of dry weight, surpassing the protein content of *Artemia franciscana* (41% in newly hatched nauplii and 34% after 24-hour enrichment). With nauplius sizes ranging from 50 to 60 µm, copepods are more suitable in size than rotifers and Artemia for the larval stages of various farmed aquatic species with smaller mouth gaps. Copepodites and adult stages, being larger, have been successfully utilized to feed larger larvae.

The stages of establishing an aquamimicry system

Step 1: Pond Preparation

- Fill the cultivation pond with filtered seawater using a filter bag (around 200-300 µm).
- Introduce probiotics (*Bacillus sp.*).
- Gently drag the sediments at the bottom of the ponds to facilitate mixing with the added probiotics and minimize biofilm development.
- Control aquatic weed growth by adding tea seed cake (20 ml L–1) along with fermented rice bran or wheat bran (without husk) at a rate of 50-100 mg L–1 to promote the zooplankton population. Proper aeration is important for nutrient and probiotic mixing while mitigating the negative effects of tea seed cake.

Step 2: Carbon Source Utilization

- Mix rice bran and wheat bran (without husk) with water at a ratio of 1:5 to 1:10, along with probiotics, and aerate the mixture for 24 hours. Slowly add the mixture to the pond once the bran is fully powdered.
- If the mixture has crumbled, add the upper layer to the pond. The pH of the mixed water should be maintained between 6 and 7.

Step 3: Stocking of Shrimp Post-Larvae (PL)

- Stock shrimp post-larvae (12-15) at a density of 30 to 40 m^{-2}.
- The inclusion of fermented carbon sources depends on water turbidity: 1.0 ml L^{-1} for extensive systems and 2.0 to 4.0 ml L^{-1} for intensive systems.
- Monitor and analyze water quality parameters daily.
- Perform gentle dragging every 15 days after stocking to minimize biofilm growth.
- Add probiotics monthly during the cultivation period to maintain water quality.
- In intensive rearing systems, excess sediment must be removed to sedimentation ponds through a central drainage system two hours after feeding. Sedimentation ponds should be regularly emptied to prevent the proliferation of pathogens like *Vibrio sp.*
- Sediment ponds are typically 4.0 m deep in the center and 2.0 m at the edges. Stocking low-density fish species such as milkfish and catfish can help control plankton and detritus, providing an additional income source for farmers. Sediments from cultivation ponds produce worms, which aquatic animals can consume.
- Overflow from sedimentation ponds is directed to another pond acting as a biofilter, with low-density species like tilapia. Water with minimal nitrogenous waste can be further overflowed into the grow-out pond.
- Thoroughly clean sediment ponds every three years.

Step 4: After Harvesting

- After harvesting, completely clean the pond of black soil and accumulated sediment. Add fermented rice and prepare probiotics for the next production cycle.

Conclusion

Aquamimicry represents the convergence of aquatic biology and technology to replicate the characteristics of natural aquatic ecosystems to cultivate healthy shrimp. This approach shares similarities with Biofloc Technology (BFT), although there are notable distinctions. Firstly, the aquamimicry system reduces the amount of carbon added and eliminates the reliance on nitrogen input ratios. Moreover, instead of allowing a large volume of flocs to form and remain suspended, aquamimicry employs more intensive systems to remove sediments, which other farmed aquatic species can recycle. In an ideal aquamimicry environment, the water closely resembles the composition and appearance of natural estuarine water, complete with microalgae and zooplankton. By achieving such a balance, dissolved oxygen and pH fluctuations are minimized. Additionally, chemical fertilizers are unnecessary as rice bran serves as a food source for zooplankton and a carbon source for bacteria. The aquamimicry system minimizes water exchange, ensuring biosecurity, and incorporates probiotics and FRB-derived oligosaccharides as synbiotics to stimulate immune responses in shrimp, ultimately yielding organic marine shrimp without the need for therapeutics. While challenges persist, further research and implementation are necessary to overcome these obstacles and facilitate the progressive development of this sustainable aquaculture technique.

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