Enhancing shrimp farming productivity through feed palatability

Applying chemosensory science to improve feed palatability has the potential to enhance the productivity, profitability, and resilience of shrimp farming systems

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Experimental nets installed in the shrimp production unit of commercial farm, CV Adi Sarana Permai in Patas Village, Gerokgak, Buleleng, Bali, Indonesia

The global shrimp aquaculture industry faces pressing challenges in optimising feed utilisation, production efficiency, environmental sustainability, and shrimp health. Shrimp are naturally slow and selective feeders, typically reared in turbid aquatic environments, which limit visibility and disperse chemical cues. These conditions seriously complicate feeding management and increase the risk of feed wastage and nutrient leaching, which in turn reduce feed quality and contribute to pond environmental degradation. Together, these factors impair feeding efficiency and decrease farm profitability.

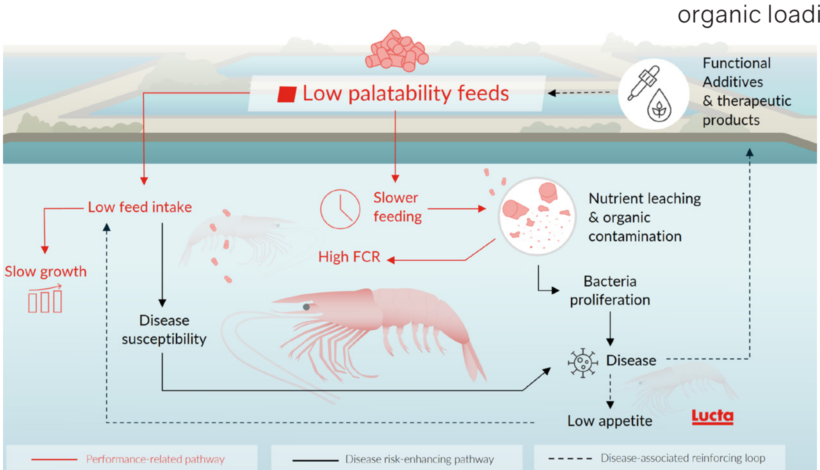
Consequences of reduced feed palatability in shrimp aquaculture

Sustainability and cost-saving trends have driven progressive reductions in fishmeal inclusion in commercial diets. While necessary, these shifts towards plant-based or lower-palatability protein sources are well known to negatively affect shrimp performance by reducing feed intake and slowing growth.

Feeds lacking sufficient concentrations of chemo-stimulants are detected more slowly and elicit weaker feeding responses. As a result, pellets remain in the water for longer periods, increasing nutrient leaching and diminishing their nutritional value. This contributes to a deterioration in feed conversion ratio (FCR) and, ultimately, in growth performance.

In parallel, uneaten feed and leached nutrients increase the organic load in the pond. Excess organic matter promotes the proliferation of heterotrophic and opportunistic bacteria, including *Vibrio* spp., thereby increasing microbial pressure and challenging shrimp health. Shrimp experiencing inadequate energy and nutrient intake while being exposed to unstable water quality become immunologically compromised and more vulnerable to disease.

Together, these factors create a performance-reducing pathway that becomes interconnected with a disease risk-enhancing pathway, as shown in Figure 1. Finally, if opportunistic diseases break into the system, shrimp appetite is further reduced, and the use of functional additives or therapeutic products, many of which can themselves lower palatability, further enhances a downward spiral in farm productivity. Improving chemosensory stimulation breaks this negative cycle by enabling faster feed detection, greater feed intake, more efficient nutrient utilisation, and a reduction in pond organic loading.



"When incorporated into feeds, these additives enhance the chemical "signature" of pellets, facilitating quicker detection, faster ingestion, and more consistent feed intake."

Figure 1. Potential consequences of low palatability feeds in shrimp farming, including conceptual interrelations between performance-related, disease risk-enhancing and disease-associated reinforcing loops.

Chemosensory science to the rescue: Using chemical cues to drive intake

Shrimp possess highly sensitive sensory receptors distributed across their bodies, enabling them to detect chemical cues and locate food from considerable distances. Extensive research into chemo-stimulants and their role in chemosensory-driven feeding behaviour enable the identification of substances that reliably trigger attractability and feeding responses in shrimp. From a chemical point of view, they are low molecular weight and water-soluble substances, which are commonly present in high concentrations in shrimp's preferred prey. These molecules dissolve rapidly in water and form chemical plumes that can be detected through long-range (antennule-driven) and short-range (legs and mouthparts) chemosensory pathways.

This knowledge has enabled the development of sensory additives as mixtures of active ingredients and chemicals that target the activation of the shrimp's chemosensory systems. When incorporated into feeds, these additives enhance the chemical "signature" of pellets, facilitating quicker detection, faster ingestion, and more consistent feed intake. Ultimately, chemosensory-targeted palatability strategies can increase feed utilisation efficiency while reducing nutrient losses to the water.

Efficacy of a palatability enhancer in low fishmeal diets

To validate the concept illustrated in Figure 1, a comprehensive 81-day trial was conducted at the shrimp production unit of a commercial farm, using juvenile *Penaeus (Litopenaeus) vannamei* with an initial mean body weight of 2.27 ± 0.10g. Shrimp were stocked at 300 shrimp per pen into 3 × 2 × 1m net pens. Environmental conditions remained stable throughout the trial, with an average water temperature of 30.6°C, salinity of 25.8ppt, and dissolved oxygen of 7.5mg/L. A standard fixed feeding rate protocol was applied, decreasing from 7% to 5% of biomass as shrimp grew.

Six dietary treatments were evaluated, each assigned to six replicate pens. The positive control (PC) diet contained 15% high-quality Peruvian fishmeal, 15% poultry by-product meal and 25% soybean meal as main protein sources. In the negative control (NC), fishmeal was reduced to 7.5% and soybean meal increased to 34.9%; lysine and methionine were supplemented to maintain essential amino acid balance, and corn starch was reduced.

Four additional treatments were formulated by supplementing the NC diet with 0.075%, 0.1%, 0.125% or 0.15% of a palatability enhancer (PE; Luctamax® AQ, Lucta). All diets were isoproteic (around 38.5% CP), while crude lipid levels ranged from 5.2–5.6% in NC and PE diets compared to 6.3% in the PC treatment.

Growth performance

Growth declined markedly in shrimp fed the NC diet relative to the PC, confirming the negative impact of reduced fishmeal inclusion (Figure 2A). However, supplementation with the PE restored growth in a clear dose-responsive manner. Inclusion levels of 0.1% or higher not only compensated for the 50% reduction in fishmeal but significantly improved growth beyond that of the PC group. The strongest response occurred at the 0.125% supplementation level. Feeding efficiency had a similar response as growth (Figure 2B). Survival remained high across all treatments (>90%) and was not influenced by diet.

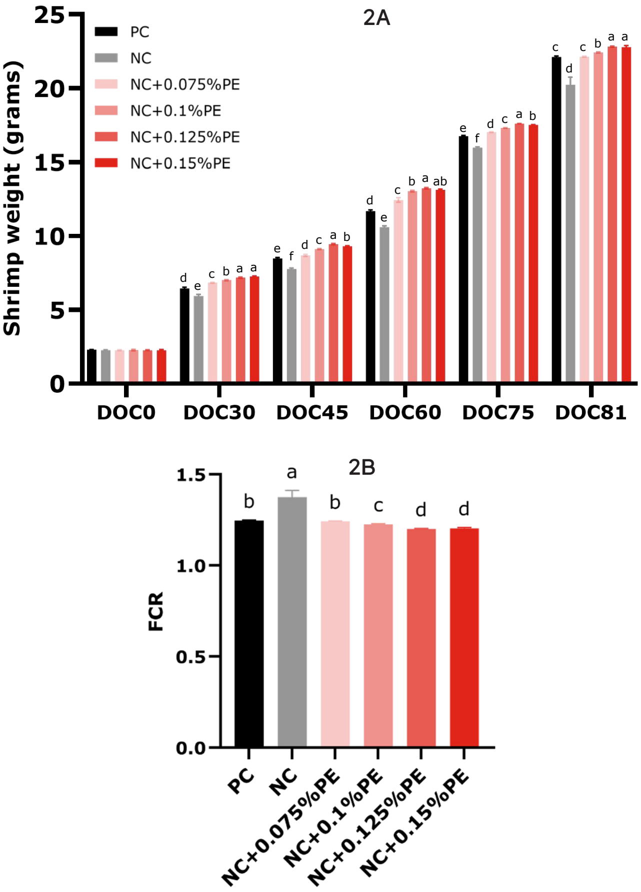


Figure 2. Performance of shrimp on a diet containing 7.5% fishmeal (NC), or a similar diet further supplemented with 0.075% to 0.15% of a palatability enhancer (PE) from Lucta (Luctamax® AQ). A diet containing 15% fishmeal was used as a positive control (PC). 2A shows shrimp weight (g) change during the experiment; 2B shows feed conversion ratio (FCR) at the end of the 81-day trial.

Shrimp find the palatability-enhanced feed faster

The trial included a behavioural attractability test that measured latency-to-contact, defined as the time required for 10 shrimp to approach and make initial contact with the feed. Shrimp offered the PE-supplemented diets exhibited markedly faster responses: latency decreased by up to 168% compared with the negative control and by 155% relative to the positive control. As with growth performance, attractability improved in a clear dose-dependent manner (Figure 3). This pronounced reduction in latency confirms that the PE effectively stimulated rapid chemosensory detection and stronger feeding motivation.

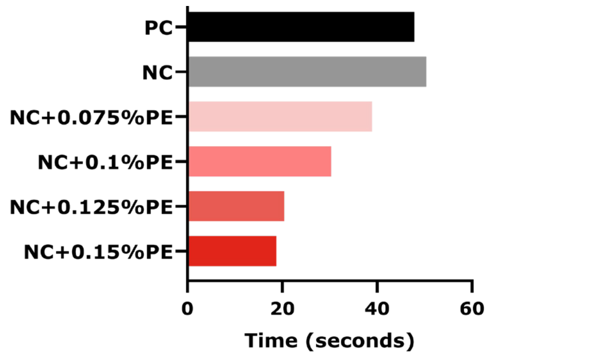


Figure 3. Attractability response (latency-to-contact time, seconds) to experimental diets. Diets were 7.5% fishmeal (NC), or a similar diet further supplemented with 0.075% to 0.15% of a palatability enhancer (PE, Luctamax® AQ). PC is a positive control with 15% fishmeal.

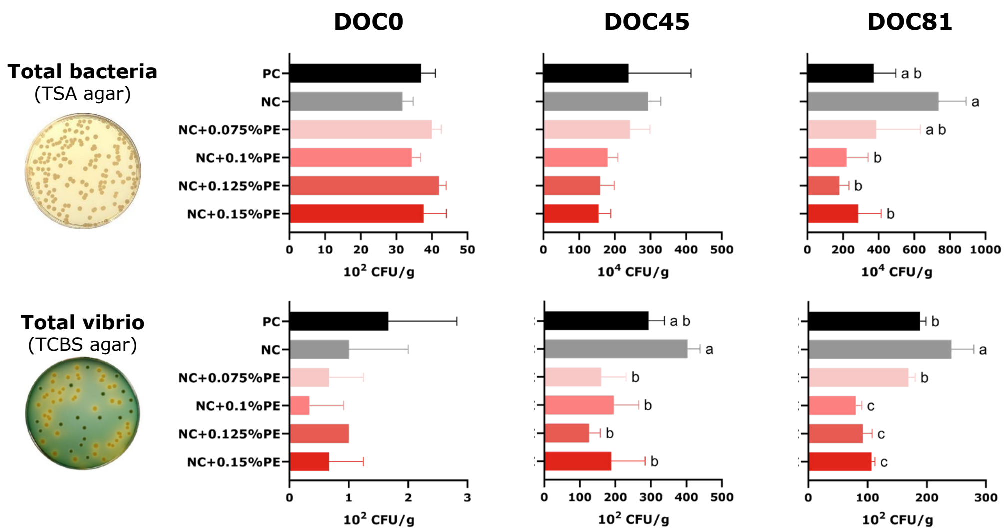


Figure 4. Total bacteria and total *Vibrio* spp. counts in shrimp hepatopancreas at day of culture (DOC) 0, 45 and 81 of the trial. Similar trends were observed in shrimp intestine (not shown). Diets were 7.5% fishmeal (NC), or a similar diet further supplemented with 0.075% to 0.15% of a palatability enhancer (PE, Luctamax® AQ). PC is a positive control with 15% fishmeal.

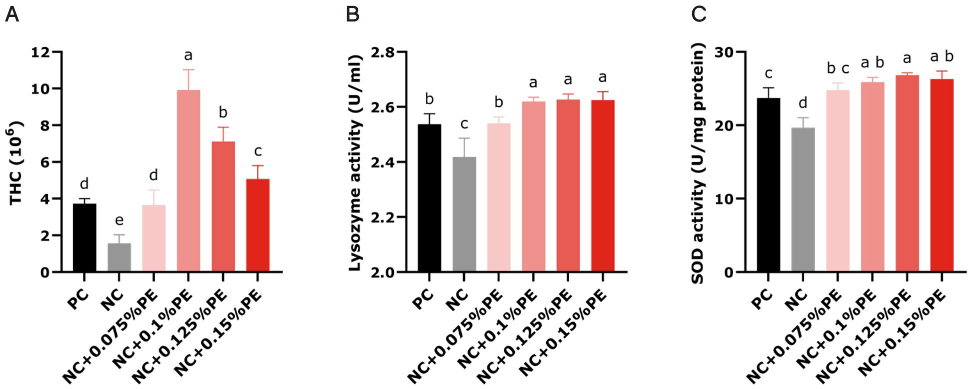


Figure 5. Health status indicators at the end of the 81-day trial. A - total haemocyte counts (THC) in haemolymph; B - lysozyme activity in plasma; C - superoxide dismutase (SOD) activity in hepatopancreas. Diets were 7.5% fishmeal (NC), or a similar diet further supplemented with 0.075% to 0.15% of a palatability enhancer (PE, Luctamax® AQ). PC is a positive control with 15% fishmeal.

Microbial load reduction and health biomarker responses

Microbiological analysis of the hepatopancreas and intestine revealed that, by the end of the trial, shrimp fed the PE-supplemented feeds had significantly lower total bacteria and *Vibrio* spp. counts compared to the NC, especially at ≥ 0.1% inclusion levels (Figure 4). These improvements likely reflect the combined effects of faster feed detection and consumption, which reduce nutrient leaching and lower organic loading in the culture system - conditions that limit bacterial proliferation and colonisation of feed pellets.

Shrimp physiological robustness was evaluated using several key health indicators, including total haemocyte counts (THC) in haemolymph (Figure 5A), lysozyme activity in plasma (Figure 5B), and superoxide dismutase activity in hepatopancreas (Figure 5C), representing cellular immunity, humoral defense, and antioxidant capacity, respectively. These parameters demonstrated significantly improved health status across all PE-supplemented treatments, and more substantially at ≥ 0.1% inclusion levels, which even exceeded the PC treatment.

Conclusion and implications for industry practice

Sensory feed additives such as palatability enhancers are emerging as essential tools supporting the use of alternative ingredients, with positive impacts on the industry's sustainability, productivity and profitability.

The trial presented here demonstrates how these strategies help break the negative cycles illustrated in Figure 1. In addition to stimulating feed intake and promoting growth, palatability enhancers contribute to lower organic waste burden and reduce microbial pressure in the feed and farming environment, by enabling a faster detection and consumption of feeds. As a result, they promote healthier, more robust shrimp, and contribute to more resilient farming systems.

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