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Zuridah Merican

Asian Shrimp – A fork in the road

The Aquaculture Roundtable Series (TARS) 2025 will be the most important in the recent history of shrimp aquaculture in Asia because the industry has reached a fork in the road. Supply has exceeded demand, and prices have fallen below the breakeven point in many countries including Ecuador. Cost of production will continue to creep upwards. The eFishery debacle has given both the start-up and aquaculture industries a 'black eye'. This by itself is a disruption of the disruptors.

Borrowing a phrase from Bill Clinton's US presidential election campaign 'it's the economy,.. the catchphrase for shrimp aquaculture should be 'it's the farming,.. Just like how the earlier catchphrase is the primary concern of US voters, the latter catchphrase should be the primary concern of the entire shrimp industry because without farming, there cannot be any ancillary business and the whole value chain will shut down.

The intensive farming model in ponds started with specific pathogen free (SPF) genetics when *Penaeus vannamei* came to Asia. *P. vannamei* could be cultured in the water volume compared to just the pond bottom area with *Penaeus monodon* but greed and pride pushed stocking densities beyond the carrying capacity leading to disease outbreaks. This worked well when survival rates were 80% resulting in a low cost of production per kg but when disease ravaged survival rates to 50%, cost of production increased significantly. Gone are the days when errors in farming will still give good margins. Ponds have aged too. The industry needs to find a new and more efficient farming model.

The startup sector has mainly focused on real-time monitoring, alternative feed ingredients, feeding technology and simplifying the marketplace but very few have looked for a new farming model. The current practice of delivering 20-30% bonus post larvae is analogous to 'shooting oneself in the foot'. The measure of apparent survival rates – based on stocking 120%-130% of post larvae versus real survival rates must stop because overstocking can only lead to exceeding carrying capacity and disease outbreaks. We can learn from disease outbreaks. The data gathered can be very telling if only we make the effort to analyse and determine the trigger points of the outbreak. We need the 'canary in the coalmine' or an early warning of danger or failure.

TARS 2025 on Shrimp Aquaculture: Precision, Productivity, Profitability needs some explanation. Shrimp Aquaculture is such an inefficient sector today which is easily demonstrated by the poor survival rates. What we cannot measure, we cannot improve. Start with precision farming and productivity will improve. Once achieved, profitability will automatically follow. TARS 2025 will focus on the analysis of the whole value chain and propose models to augment the current inefficiencies. TARS will require the participants to think outside the box.

An area of opportunity is to start stocking strong juveniles (around PL35) in culture ponds. This would dramatically improve survival rates at harvest, reduce days of culture in ponds and increase the number of cycles per year. These SPF juveniles will be much stronger and robust in the face of pathogens. This model requires nursery systems similar to hatcheries and a hybrid RAS could be ideal. The cost of juveniles will be higher than for PL12 but the improved survival rate will justify the cost. Being more expensive would inherently eliminate the practice of supplying 20-30% bonus animals and move from apparent survival to real survival rates.

This is a wake-up call as pursuing status quo is no longer an option but is it still too comfortable for many of us to seek change?

If you have any comments, please email: zuridah@aquaasiapac.com

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Shrimping up Indonesia at Shrimp Outlook 2025

Liris Maduningtyas, CEO and Co- Founder of JALA shared the Shrimp Outlook 2025 report on Indonesia's shrimp industry performance in 2024.

JALA, the Indonesian startup, continues to support the shrimp farming industry through its annual Shrimp Outlook event. This year's Shrimp Outlook 2025, hosted by JALA and the US Soybean Export Council (USSEC), was held on February 27 in Yogyakarta. The theme was "Shrimping Up Indonesia: Navigating Local Challenges with Global Insights". The focus varied from diseases, price fluctuations, low productivity and global market competition. According to Aryo Wiryawan, Chairman and Co-Founder of JALA, the fifth edition was highly successful, attracting 350 participants, including shrimp farmers, industry players, and experts.

"The original intention behind Shrimp Outlook is to provide an all-inclusive platform for shrimp farmers, industry players, and stakeholders to come together, share insights, and collaborate on addressing the shrimp industry's challenges and opportunities. It serves as a forum for staying informed on global trends, market demands, and best practices on shrimp farming," said Aryo.

The event, underlined Aryo, was planned to focus on key issues, such as the current state of the Indonesian shrimp industry, global market projections, shrimp health management, and innovative farming techniques, primarily aiming to foster strategic discussions and solutions for future growth and sustainability.

Indonesian shrimp in global markets

In his opening speech, Budi Sulistiyo, Director General of Marine and Fisheries Product Competitiveness, highlighted the market-driven focus of fisheries and aquaculture products. Shrimp led seafood exports in 2024 with 214,000 tonnes worth USD 1.68 billion, despite a 2.9% decline year-on-year. The target for 2029 is 269,000 tonnes valued at USD 2.6 billion.

The message by Lukas Manomaitis, the Southeast Asia Technical Director for Aquaculture of USSEC was to expect more disruptions due to climate change, including challenges with ingredients. Indonesia must build into approaches to carbon footprint and sustainability.

Haris Muhtadi, Associate Director of CJ Feed & Care Indonesia, stated that the industry relies on the US market for approximately 65% of its total exports, with 64.5% being frozen shrimp. Of this, 97.5% is affected by US antidumping tariffs. Currently, only one processor, BMS, has a zero tariff, while the others face a 3.90% antidumping tariff. Indonesia did not qualify for exports to the EU due to unmet AMR requirements and the use of specific antimicrobial products per EU 2022/1255. The EU market makes up less than 10% of Indonesia's exports.

For the future, Haris proposed focusing on niche markets, enhancing value-added products, and reducing dependence on commodity markets. He suggested adopting certification, traceability, and sustainability measures to meet global market standards. Budi suggested shifting to more breaded shrimp, which are not subjected to US antidumping tariffs, and incorporating CBIB certification as part of the requirements for exporting to EU markets.

While discussing global shifts in trade for shrimp, Willem van der Pijl, Director of Global Shrimp Forum, said that Indonesia also faces several challenges in the global shrimp market, such as potential tariff increases to the US and difficulty accessing the EU market.

" Although, in 2024, cooked and breaded shrimp accounted for almost 40% of US imports from Indonesia, it needs to increase its competitive edge and diversify its markets for both raw and value-added shrimp. The EU is a promising market, but it is also important to strengthen the domestic shrimp market to provide more stability and reduce dependence on exports."

Industry in 2024

Liris Maduningtyas, CEO and Co-Founder of JALA shared aspects of JALA's Shrimp Outlook 2025 report, which evaluates Indonesia's shrimp industry performance in 2024. In 2023, farmed shrimp production was 265,834 tonnes and rose 8.27% to 287,962 tonnes in 2024. Liris explained this production volume was calculated from feed sales data provided by the Indonesian Feedmills Association or GPMT. In general, the industry saw productivity increase from 10.35 tonnes/ha in 2023 to 11.55 tonnes/ha in 2024. Bali-Nusa Tenggara showed the most impressive improvement in productivity doubling from 24.4 tonnes/ha to 43.4 tonnes/ha in 2024.

A top concern is price. Sharing the price trends from JALA's shrimp portal, she showed that in 2024, the highest price fluctuations were for shrimp in the 100/kg size range, while prices for size 70/kg were the most stable. Liris listed what to expect in 2025: maintain sustainability and regulatory compliance, have collective certifications to ensure credibility for Indonesian shrimp and branding and promotion.

Ecuador's strategies towards global success

Gerry Gilang, Kamahara led a discussion on learning from Ecuador, the leading global shrimp producer. In her presentation, Yahira Piedrahita, Executive Director of the National Aquaculture Chamber of Ecuador (CNA), credited the success in Ecuador to the best quality post larvae, feed and technology to increase production in the same land area.

"Feed companies provide the best quality conventional and functional feeds to match the varied farming conditions. Local genetic improvement programs are based on the selection of all pathogen-exposed (APE) broodstock, and there are strict regulations on imports of broodstock. Additionally, it is the industry characteristics of closed production and processing cycles."

In terms of production costs, 66% is feed, 14% is diesel and 7% is labour. She added that new technologies (aeration, automated feeding, automated monitoring and control and AI) and the use of probiotics improve productivity, efficiency and sustainability, although only 35% of farms are partially or fully automated. "We have the advantage of having a single voice in Ecuador. In 2013, we launched the campaign "The best shrimp in the world for the domestic market" and producers were very proud. We promoted consumption globally based on quality and now, we are working on sustainability," said Piedrahita.

Regarding CNA, Piedrahita explained that it represents the entire industry and brings together companies involved in post larvae production, farming, suppliers, feed mills, processing plants and exporters. Its activities are industry-funded while the government focuses on regulations.

Lessons for Indonesia

Some speakers and panellists gave their take on moving forward Indonesia's farmed shrimp industry.

Yahira Piedrahita: Stakeholders coming together to analyse problems is critical. In order to improve shrimp productivity, all parties must analyse risks and seek solutions together.

Willem van der Pijl: Continue to focus on building a positive image among shrimp buyers for Indonesian shrimp through certification and other sustainability initiatives. This is not to get price premiums, as those are rare, but to have market access to the world's largest shrimp markets.

Haris Muhtadi: Indonesia needs to explore new markets like BRICS and Asian markets while increasing local consumption. We should follow Brazil's approach to boosting its domestic market.

Related article: Moving Indonesian shrimp in 2025, pages 13-15.

Aryo Wiryawan, Chairman and Co-Founder of JALA (third, left) and Erik Harjadi Lisnan, VP, Head of Aquafeed Operation, PT Suri Tani Pemuka (Japfa Group, centre), with participants at Shrimp Outlook 2025 held on February 27 in Yogyakarta.

Celebrating 15 years of partnership and innovation

In February, **BioMar** announced 15 years of its strategic partnership with **Lallemand**. This milestone marked the anniversary of the market launch of the first BioMar fish feeds containing Lallemand's Bactocell®, a unique probiotic which has played a key role in enhancing the efficiency and sustainability of aquaculture production, benefiting farmers and the industry as a whole.

A groundbreaking research initiative

Mathieu Castex, General Manager and President of Lallemand Animal Nutrition explained the beginning. "Our journey with BioMar actually began in 2004 with an ambitious R&D project under the OFIMER program (French National Inter-trade Office for Sea and Aquaculture Products), uniting BioMar, Lallemand, and French research institutes IFREMER and INRAE. It took five years to get the first approval in the European Union to apply Bactocell® in feed for salmonids and shrimp, and another three years to extend the approval to all species".

Two of the fathers of the collaboration between BioMar and Lallemand, the now retired Michel Autin and Mathieu Castex, now General Manager and President of Lallemand Animal Nutrition during the launch of the LARVIVA range with Bactocell® in 2012.

The research outcome was remarkable, as it not only secured the approval to use Bactocell® in feed for aquaculture but also earned approved functionality claims backed by well-documented and replicable results.

Obtaining EU approval to use such claim for a feed additive requires rigorous laboratory and field tests across various species, as European regulatory standards are among the strictest in the world.

Henrik Aarestrup, currently Vice President LATAM, Shrimp & Hatchery at BioMar, joined the project in 2007 shortly after joining the company, said, "In order to obtain EFSA approval, the results achieved in Lallemand's laboratories needed to be validated in the field, so we organised field trials with customers across Europe testing multiple species, and the results were consistent regardless of the species."

The approval of Bactocell® is based on extensive documentation, particularly its ability to reduce the risk of deformities in fish (Vertebral Compression Syndrome). Deformities represent a significant challenge in aquaculture, leading to reduced fish welfare, higher mortality rates, and economic losses due to waste during fish processing.

Further research programs on salmonids and marine fish show that promoting a stable and healthy gut microbiota do improve, performance, general robustness and stress tolerance. In shrimp, it has been documented to favourably affect growth and survival as well as to help reduce the level of Vibrio in the intestinal tract of shrimp.

Stephane Ralite, Aquaculture Product Manager, Lallemand said, "Bactocell® holds a unique position in aquaculture as the first and only probiotic authorised in aquafeed in the European Union for use across all aquatic species".

Since 2009, the probiotic has demonstrated consistent performance and effectiveness in promoting better gut health and enhancing immunity. This has enabled BioMar to implement it in feeds to multiple aquatic species and it is today standard in all larval diets and the majority of nursery diets sold by BioMar for shrimp and fish.

"Increasing fish and shrimp robustness should start in the early life stages, as these developmental phases establish the foundation for health and resilience, leading to better performance in hatcheries and then later at the farm. Furthermore, starting with first feeding and continuing throughout the initial growth stages ensures the full benefit of probiotic inclusion. Our LARVIVA and INICIO diets for marine fish and shrimp fully support this process," explained Aarestrup.

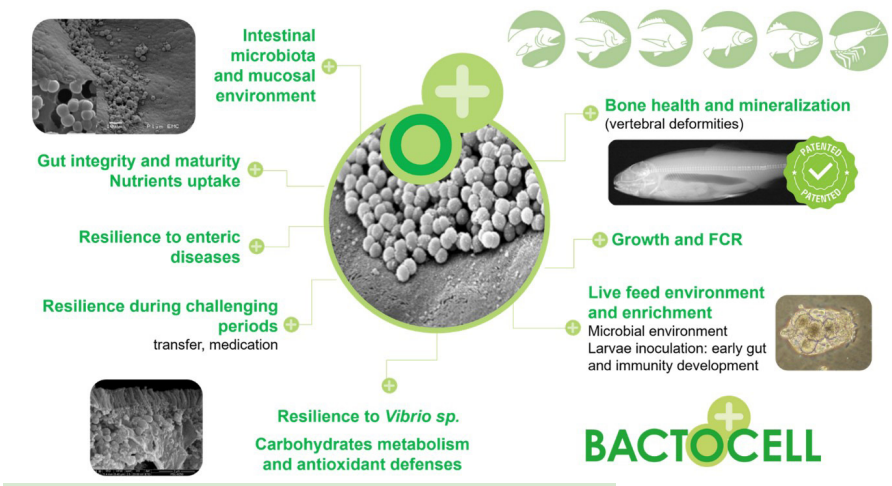
A unique partnership

This intensive collaborative effort forged a strong partnership between BioMar and Lallemand. Today, this partnership continues as they work together on multiple aspects to improve health and welfare on shrimp and fish species.

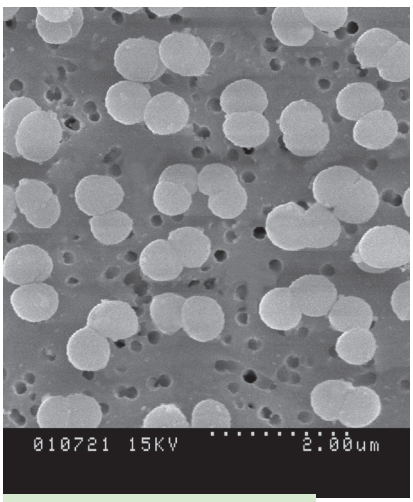
"During the first years of the partnership there wasn't even a formal contract between BioMar and Lallemand. This project was a result of collaboration between people in both companies like Paddy Campbell, Mathieu Castex, Bruno Rochet, and Michel Autin sharing a common vision and commitment to drive sustainable development in aquaculture and product development based on solid science," added Aarestrup.

BioMar and Lallemand have invested significant resources in understanding Bactocell's full potential and the mechanisms at play with today over 100 scientific publications validating its benefits in aquaculture.

Aarestrup concluded, "For us, it is important to provide proper documentation for our products, offering solutions that meet regulatory standards and have been shown to deliver measurable results. Our partnership with Lallemand will continue to grow, and we are exploring various solutions with several exciting projects underway."



Bactocell® applications in fish and shrimp (Credit: Lallemand)



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Thailand's shrimp farming industry: Navigating global market shifts

The changing landscape in Thailand demands growing domestic consumption

By Vinij Tansakul

The article titled "Shrimp: Continuous weak prices dampen growth", published in *AQUA Culture Asia Pacific* January/February 2025, highlights a significant correlation. It suggests that if global shrimp prices rise, global shrimp production could also expand accordingly.

However, during and after the COVID-19 pandemic, the global shrimp industry had to adapt to a new normal in shrimp prices. This includes reducing production volumes and lowering shrimp stocking densities. Thailand is no exception. The Thai shrimp industry faces challenges such as declining export volumes and values due to the higher production costs compared to competing countries (Table 1).

Since 2010, the industry in Thailand has seen a continuous loss of key export markets, including those in the US, European Union, China, and Japan (Figure 1). In some countries, such as China, domestic demand for shrimp consumption is exceptionally high. This can lead to domestic shrimp prices being higher than export prices, as producers may prioritise meeting local demand.

Country	Range for COP in USD/kg	References	Production 2024, tonnes*
Ecuador	2.2 -2.4	Tran Huu Loc, 2023	1,544,250
India	2.7-3.0	Tran Huu Loc, 2023	816,000
Indonesia	2.5-3.5	JALA, Indonesia, 2024	492,100
Vietnam	3.5-4.2	Tran Huu Loc, 2023	792,000
Thailand	3.7-4.5	DOF Thailand, 2024	303,900

Table1. Direct cost of production (COP) for size 50/kg in five producing countries. * Source: Global Seafood, 2025.

Vannamei shrimp. Photo credit: Tawatchai Jeangim, AquaBiz Magazine.

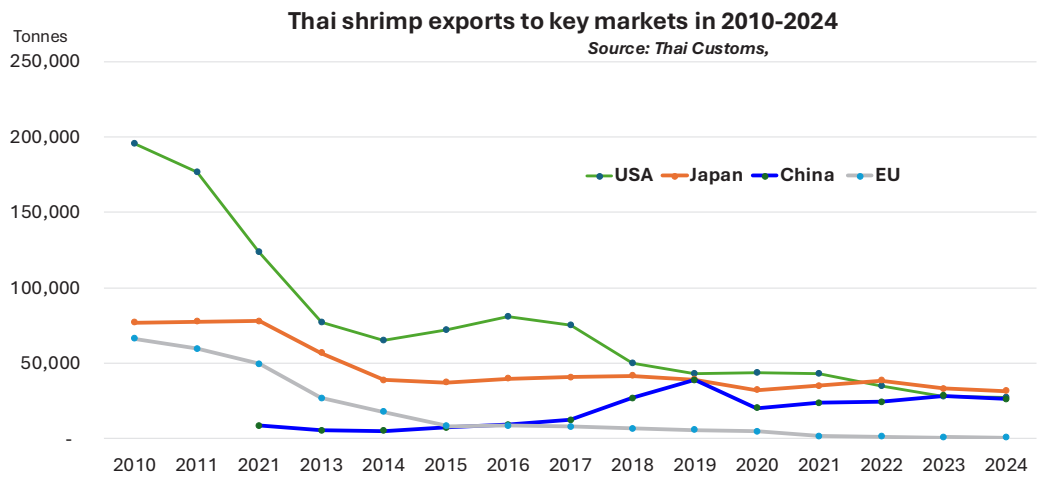

Figure 1. Thai shrimp exports to key markets in 2010-2024

The changing landscape of Thai shrimp aquaculture

The Thai shrimp industry is at a critical crossroad, facing unprecedented challenges that demand immediate and strategic transformation. Traditionally renowned as a global export powerhouse, Thailand is now confronting a significant shift in market dynamics.

Domestic consumption has surged 73% from 78,650 tonnes, since 2016 to an estimated 136,000 tonnes in 2024, while over the period 2016-2024, export volumes have declined almost 60% from 207,708 tonnes to 130,101 tonnes (Table 2, DOF, Thailand). This fundamental restructuring of the market requires a comprehensive reimagining of the entire shrimp aquaculture ecosystem.

This shift has led to farmgate shrimp prices in Thailand being less tied to export prices set by local cold storage facilities. Farmgate prices are higher and show a stronger upward trend compared to export prices. Over the past decade, global shrimp prices have consistently declined due to economic stagnation and reduced demand in major importing countries versus increased production by supplying countries.

Restructuring Thailand's shrimp aquaculture

Thailand's industry must undergo restructuring to respond to both domestic and international market changes and challenges. Domestic shrimp consumption has risen significantly, driven by higher consumer incomes, an expanding middle class, and shifting consumption patterns. This reflects opportunities for domestic market development.

Thailand continues to face export challenges due to stiff competition from major producers like Ecuador, India, Indonesia, and Vietnam, which benefit from much lower production costs. Rising logistics costs, driven by higher oil prices and shipping delays, further erode Thailand's global competitiveness. While higher domestic shrimp prices benefit farmers, they pressure local exporters who must compete on price in international markets.

In the long term, Thailand's shrimp industry must enhance production efficiency through technology and sustainable farming practices, such as automated feeding systems and precision disease management, to reduce costs and maintain competitiveness. For example, adopting smart

Harvesting vannamei shrimp at Thai Union TMK Farm in Trang province, Southern Thailand. Photo credit: Tawatchai Jeangim, AquaBiz Magazine.

Year	All production (tonnes)	(Shrimp imports (tonnes)	Total production (tonnes)	Shrimp exports (tonnes)	Domestic consumption (tonnes)	Per capita consumption (kg)
2016	260,683	25,675	286,358	207,708	78,650	1.19
2017	255,129	31,636	286,765	212,625	74,140	1.12
2018	272,804	27,819	300,623	185,351	115,272	1.75
2019	274,416	28,078	302,494	176,495	125,999	1.91
2020	257,262	24,950	282,212	149,482	132,730	2.01
2021	254,824	42,566	297,390	153,275	144,115	2.18
2022	256,822	28,795	285,617	143,467	142,150	2.15
2023	260,269	28,065	288,334	132,588	155,746	2.36
2024*	250,320	15,781	266,101	130,101	136,000	2.06
** Estimation on February 2025.*						

Table 2. Marine shrimp production in Thailand: Imports, exports and cconsumption in 2016-2024 in tonnes. Source: Fisheries Development Policy and Strategy Division, Department of Fisheries (excludes lobster and freshwater prawns)

farming technologies can lower feed costs, by improving feed conversion ratios (FCRs) and survival rates. Such changes can help ensure Thailand's competitiveness in both domestic and export markets.

In addition, the Department of Fisheries (DOF) forecasts that the farm-gate prices of Thai shrimp will continue to rise in 2025, compared to the previous year (Figure 2). This upward trend is driven by several factors, including the increased promotion of domestic shrimp consumption, particularly fueled by the growth of the tourism sector. Thailand, a renowned destination for seafood lovers, welcomed approximately 35.54 million foreign tourists in 2024, significantly boosting demand for shrimp. The expanding tourism industry has led to higher domestic consumption, as restaurants and hotels increasingly feature shrimp dishes on their menus to cater to both Thai and international visitors. The popularity of buffet-style restaurants offering fresh and ready-to-eat shrimp options, alongside the rise in shrimp exports to neighbouring countries, has further strengthened this trend. Additionally, cold storage facilities are shifting their focus to the domestic market for frozen shrimp, capitalising on favourable profit margins and lower logistics costs, compared to international shipping. Together, these dynamics are shaping a robust and growing domestic demand for Thai shrimp.

Production for rising domestic demand

If Thailand achieved the same level of shrimp consumption as the US, which stands at 2.2 kg per capita (National Fisheries Institute NFI, 2022), domestic demand would be more than double. This would require a significant increase in shrimp production or a reallocation of exports to meet local market needs. Thailand's target for shrimp production in the coming years is set at 400,000 tonnes, a volume that would be sufficient to cover both domestic demand and export commitments.

However, over the past five years, Thailand's shrimp production has consistently remained below 300,000 tonnes, highlighting the need for substantial efforts to scale up production and meet future targets. Achieving this goal will require advancements in aquaculture technology, improved farming practices, and effective resource management to ensure sustainable growth in the industry.

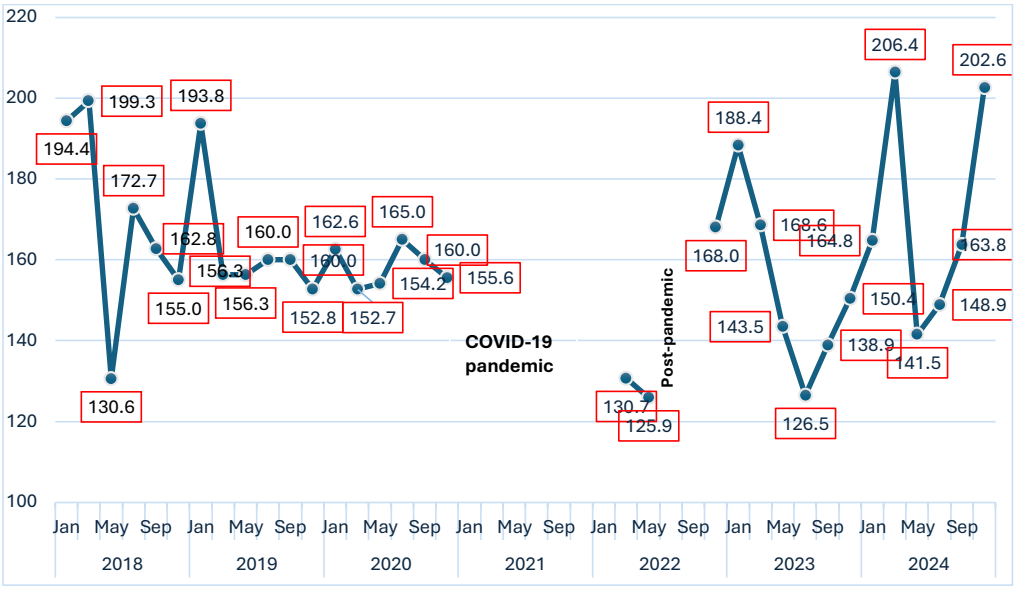

Figure 2. Farmgate price in THB/kg of vannamei in Thailand (size 50/kg) in 2018-2024, Source: Department of Fisheries, Thailand, 2025.

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Strategies to enhance competitiveness

The Thai shrimp industry must undergo structural adjustments to bolster its competitiveness both domestically and internationally. Within the country, it is essential to conduct consumer behaviour research, develop value-added products, and expand distribution channels. On the production side, advanced technologies should be adopted, such as auto feeding systems, real-time water quality monitoring, and precision disease management, to minimise losses and increase productivity. Additionally, exploring alternative feed ingredients can help reduce costs and environmental impacts.

Strengthening farmer support systems is crucial. Farmers should unite to form robust cooperatives to enhance bargaining power and efficiently share production resources. Training programs on sustainable farming practices and modern marketing knowledge will enable farmers to adapt to evolving market demands. Establishing a premium Thai shrimp brand that emphasises high quality, food safety through pre-cooling residue and drug testing, and environmentally friendly practices can further increase value and sustain market demand.

Black tiger shrimp in Thailand

Finally, diversifying export markets is vital. Focus should be on niche export markets that prioritise quality, such as organic or ethically farmed, environmentally friendly shrimp, and low-carbon Thai shrimp. Leveraging Free Trade Agreements (FTAs) and improving logistics efficiency will support these efforts. The Thai shrimp industry should promote research and innovation through collaboration with academic institutions and the private sector to develop technologies that enhance productivity, reduce costs, ensure shrimp quality, and guarantee long-term sustainability.

"The future of the Thai shrimp industry will not be measured by the quantity of production, but by quality, innovation, traceability and sustainability."

Conclusion

The domestic market will become an important segment for development. Diversifying risks by creating domestic consumption demand will help reduce the impact of export market volatility. Online trading platforms and digital marketing will be important channels to reach consumers directly, creating relationships and trust between producers and consumers.

Thailand's farmed shrimp industry is at a pivotal juncture, facing a tailwind of rising domestic demand and a headwind of declining export competitiveness. Prioritising the domestic market, enhancing production efficiency, and adopting innovative practices will help Thailand adapt to this new landscape while maintaining its status as a global shrimp producer. A strategic focus on quality, sustainability, and market diversification will ensure the industry's long-term resilience, benefiting all stakeholders—from farmers to consumers.

The future of the Thai shrimp industry will not be measured by the quantity of production, but by quality, innovation, traceability and sustainability. Compared to other major shrimp-producing countries in Asia, such as India, Vietnam, and Indonesia, Thailand's traceability system which covers the entire production process—from shrimp post larvae to harvest is considered one of the most sophisticated and reliable in the region. This allows Thai shrimp to meet the strict requirements of niche markets, including organic, health-conscious, and sustainability-focused segments. For example, consumers and retailers can verify that Thai shrimp are produced without harmful chemicals, using environmentally friendly methods, and with fair labour practices. This level of transparency builds trust and gives Thailand a significant competitive edge.

This transformation presents an opportunity to reshape the industry, create a strong ecosystem, and ensure Thailand stands proudly on the global trade stage.

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Note: This article draws from industry data and market analysis available as of February 2025.

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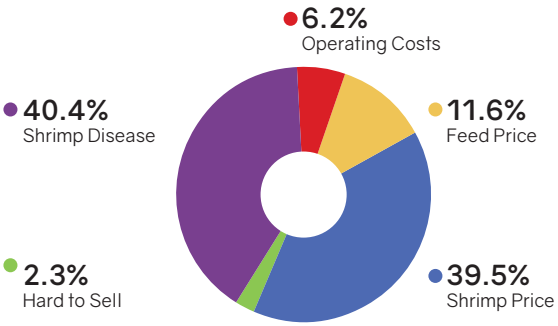
Moving Indonesian shrimp in 2025

Disease prevention strategies and marketing at Shrimp Outlook 2025

By Zuridah Merican

The top concern in shrimp farming in 2024, according to JALA's survey, is disease. This was closely followed by fluctuations in shrimp prices. Other concerns in order of ranking were feed costs, cost of production and difficulty selling shrimp. In presenting JALA's Shrimp Outlook 2025 report, CEO Liris Maduningtyas said that the greatest threat was acute hepatopancreatic necrosis disease (AHPND). Despite *Enterocytozoon hepatopenaei* (EHP) being the most common disease, Liris said, "AHPND strikes at early days of culture and the median survival reduces to only 45%." Other diseases, according to their effects on survival rates are white spot syndrome virus (WSSV), EHP, white faeces disease (WFD) and infectious myonecrosis virus (IMNV). Anecdotal information from industry at this conference was that AHPND is pushing farm owners to abandon farms in the west of the archipelago and move to the east.



The main concerns in shrimp farming in Indonesia in 2024, presented in the Shrimp Outlook report 2025. Source: JALA.

Disease management and mitigation

The CeKolam team of Sidrotun Naim and Lulu Nisrina discussed data on disease prevalence from sampling of ponds, post larvae, water and sludge in 2023 and 2024 in several locations in Indonesia. CeKolam is a disease detection service provided by Nusantara Genetics (Nusantics), specifically for vannamei shrimp. Outbreaks of AHPND, WSSV, EHP and IMNV were monitored using real-time (RT) PCR. Lulu is Head of R&D Animal Diagnostics and Sidrotun is Shrimp Health Specialist.

Their message was that farmers need to collaborate during the farming process, and to inform other farms on schedule of water exchanges to minimise water uptake after discharge of water with pathogens. Regular testing is encouraged. The costs for RT-PCR testing range from 0.5 - 1% of the total cost of production for each farm/cycle.

Sidrotun Naim and Lulu Nisrina discussed CeKolam's services for pathogen testing in ponds, shrimp, post larvae and water.

Genics Pty Ltd has been supporting industry in Indonesia for more than six years. CEO Dr Melony Sellars discussed pathogen testing and biosecurity practices in Indonesia, highlighting improvements and best practices for enhancing aquaculture health and productivity. Sellars emphasised that utilising multifactorial pathogen analysis for early pathogen detection before the shrimp is clinically sick, is the way forward. It is a comprehensive pathogen testing for post larvae to ensure that they are pathogen free.

In Ecuador and Australia, the shrimp multipath technology and knowledge have improved production by 10-15% and in Ecuador, more than 52% increases in nauplii production. The wish is for Indonesian producers to be able to achieve the same. Her recommendations included using tests that are fit for purpose, validated information with tested science and scientific publications, and expert advice from multiple reputable sources. Additionally, to include bacterial concordance with 16S profiling and detailed biosecurity planning and practices to prevent breaches.

Towards success with preventive measures

Txomin Azpeitia Badiola, Group Technical Manager, Grobest Group explained the effects of AHPND in farms in Indonesia, Thailand, and Vietnam. In general, AHPND has a high impact on farms with a basic farm design and environment management, while farms with advanced designs and management practices experience lower to medium impacts. AHPND-related costs can constitute a significant portion of total production costs, ranging from 5-19%.

"A preventive approach in health and feeding management is more effective in controlling AHPND compared to a corrective approach," said Azpeitia Badiola. "We can see a high risk of more recurrent disease outbreaks, especially AHPND, WFS and EHP, unless drastic mitigation strategies are implemented." He discussed integrating functional feeds with efficient pond management practices to reduce the incidence and impact of AHPND as well as other major diseases. However, he reminded that farming protocols must be tailored to the specific conditions of each farm to fully profit from the benefits of functional feeds.

Grobest Group's CTDO, Jennifer Kuo, (centre), Txomin Azpeitia Badiola (right) and Januar Pribadi, Aquaculture Technical Development Manager - Grobest Indonesia.

The next phase in marketing Indonesia's shrimp

Liris moderated a panel with Nicholas Leonard, Co-Founder of Haven Foods, and Dr George Chamberlain, President of The Center for Responsible Seafood (TCRS). Chamberlain related the roots of certification, how 20 years ago, each buyer had their own team to check environmental and social compliance but with so many suppliers and countries, this was unworkable. Today, certification programs with third party accredited systems are now mainstream. Buyers publish on their website their commitments, such as by a certain time, all their seafood will be sourced from responsible sources which are also defined.

"A challenge is getting the small producers certified. These small farms are invisible and there is no traceability. In India, we use digital technology from Aqua Exchange to get data on small farmers and we have complete traceability of small farms," said Chamberlain.

Leonard added that certification is required by all his customers, i.e. supply must be from certified farms. Traceability is critical and he encouraged producers to implement best aquaculture practices. Leonard added that he has not seen a price premium applied to certification, but it offers better market access. Certification is expensive and the recommendation is for producers to work together with factories.

Liris Maduningtyas (right) moderated the panel on "The Next Phase of Shrimp Market: How Consumer Trends and Sustainability are Reshaping the Global Market" with George Chamberlain (left) and Nicholas Leonard. Photo credit: JALA.

On improvements in marketing Indonesian shrimp, Leonard commented, "We must improve harvesting and handling to get the very best shrimp. Ideally, the time from harvest to processing plant should be no more than six hours, which in Indonesia can be up to four days."

The US market is price based, and specifications differ between food service and retail. It is B2B, working with the buyers. "Indonesia is unique with both commodity and value-added products. Buyers work on specifications and the real challenge is to get the right ones." Chamberlain added that certification does not deal with product quality at all. Therefore, he suggested industry set standards on the water addition through soaking and glazing. Liris concluded that this conversation has brought some optimism for 2025.

Shrimp farming in five years

Aryo Wiryawan, JALA Chairman and Co-Founder gave his wishlist on Indonesian shrimp farming in five years.

- I expect to see a more technologically advanced and sustainable Indonesian shrimp industry.
- There should be an increased focus on traceability and quality which will enhance the industry's competitiveness in the global market.
- We need to develop the domestic market which will provide a buffer against external shocks.
- Most importantly, the industry will need to remain vigilant in addressing disease risks, managing costs, and adapting to changing market dynamics.

"JALA can play a pivotal role in the growth and sustainability of the Indonesian shrimp industry by leveraging its vision of leading the global shrimp industry with innovation, sustainability principles, and trusted supply chain solutions. By aligning with its mission to consolidate the global shrimp supply chain, JALA can help lower the cost of producing fresh shrimp with implementations of technology like IoT, AI while ensuring quality, transparency, and sustainability across the entire industry."

Aryo added, "By developing technologies, providing hands-on farming assistance, access to high quality inputs and the shrimp market, we are empowering the entire ecosystem to adapt and thrive in the ever-changing shrimp industry."

Related article: Shrimping up Indonesia at Shrimp Outlook 2025, pages 4-5.

Gerry Gilang, Kamahara and Yahira Piedrahita, National Aquaculture Chamber of Ecuador in the panel on "Turning Challenges into Opportunities: Learning from Ecuador's Strategies towards Global Success". See pages 4-5.

Graded levels of hydrolysed yeast improved gut health and expression pattern of four candidate genes of tilapia

By Aung Tun Aye, Md. Lifat Rahi, Md Amzad Hossain, Rajib Dutta, Melina Bonato and Kabir Chowdhury

Various yeast-derived feed additives such as nucleotides, β-glucans and mannan-oligosaccharides (MOS) are recognised as important modulators for improving intestinal health and controlling pathogens by enhancing innate immunity of fish. Nucleotides are part of the intracellular fluid, while β glucans and MOS are the products derived from the wall of yeast cell.

Both nucleotides and β-glucans are considered as immunity modulators. Dietary supplementation of nucleotides has shown to influence physiological functions, morphological profile, and the microbiota composition of the intestinal tract of fish. Dietary inclusion of 1,3 and 1,6 β-glucans are known to stimulate phagocytic activity through producing cytokines (a chain reaction that induces innate immune response).

Dietary MOS is widely used in aquafeed to boost immunological and gastrointestinal functions of farmed animals. These complex carbohydrates can agglutinate pathogens and prevent pathogen colonisation in the gut by offering a binding site to harmful bacteria that possess type 1 *fimbriae*. The agglutinated pathogens are then excreted with the faecal material.

Hilyses® (ICC Animal Nutrition, Sao Paulo, Brazil) is a yeast-derived additive from *Saccharomyces cerevisiae*, utilised in the fermentation of sugarcane for ethanol production. During this process, the yeast undergoes cell autolysis and intracellular content hydrolysis. The final product is highly digestible, containing free nucleotides and nucleosides, amino acids, peptides and polypeptides, glutamine, MOS, and high levels of β-glucans. These end products are widely used in aquafeed for improving animal health, welfare, and eventually, production.

In this study, the effects of supplementation of graded levels of this yeast-derived additive were investigated on gut health, together with the expression of four important genes of Nile tilapia (*Oreochromis niloticus*).

Experimental protocols

This dose-response study was conducted at Maverick Innovation, Gazipur, Bangladesh following approved animal utilisation protocol of the organisation. The aquatic research facility consists of a recirculation system (RAS) complete with 64 circular fibre-glass experimental tanks (300L each) and five 1,000L holding tanks. In sequence, this RAS system comprises a settling tank, rotating drum filter, protein skimmer, ozone generator, biofilter, degassing chamber, ultra-violet system, and oxygen generator. This feeding trial was conducted over 98 days. During the duration of the trial, all environmental parameters were maintained at the optimum range for Nile tilapia.

Four high-fibre (7.7±0.3% crude fibre), isoproteic (29.8±0.09% crude protein) and isoenergetic (3415.5±31.1 kCal/kg) diets were formulated for the trial. The diets were supplemented with graded levels of Hilyses® at the following inclusions per kg of diet: 0.5g/kg (HL0.5), 1.0g/kg(HL1.0), and 2.0g/kg (HL2.0). There was no supplementation in the negative control. All diets were produced in a commercial feed manufacturing facility (Arman Feed Manufacturing Plant, Narsingdi, Bangladesh).

Spleen from three randomly selected fish from each tank were collected for gene expression study. Spleen tissues were used for RNA extraction, cDNA synthesis and real time PCR (RT-PCR) based gene expression profiling.

Histological analyses

At the end of the feeding trial, four fish from each treatment were randomly sampled and anesthetised with clove oil containing 90% eugenol. Intestinal samples were collected from each fish for the measurement of histological parameters using the image analysis application software Sigma Scan Pro5. Changes in the intestinal histomorphology were captured by a photomicroscope (AmScope 1000).

Gene expression

For gene expression, spleen from three randomly selected fish from each tank were collected. The spleen is the only secondary lymphoid organ present in all jawed vertebrates. However, most teleosts are devoid of any lymph nodes. Instead, the spleen is primarily responsible for immune surveillance of peripheral blood antigens. Spleen tissues were used for RNA extraction, cDNA synthesis and real time PCR (RT-PCR) based gene expression profiling

Improvements in feed efficiency

Despite numerical improvements in weight gain with the increasing levels of the yeast-derived additive, there were no significant differences among the treatments. However, feed efficiency improved linearly in a dose dependent manner ($P<0.05$). A similar trend was also observed in body protein deposition, and protein and energy retention efficiency.

The tanks at Maverick Innovation, Gazipur, Bangladesh where the 98-day dose response trial was conducted, following approved animal utilisation protocol of the organisation.

Gut Health

Villi length (VL, µm) and total surface volume (SV, mm^3) in fish fed HL2.0 diets were higher (P<0.05) compared to the control diet. A significantly linear trend with Hilyses® inclusion levels was also observed for these two parameters (Table 1).

Gene expression

The expression of all target genes, insulin like growth factor I (IGF-1), glyceraldehyde-3-phosphate dehydrogenase (G-3-P), ghrelin and hepcidin were upregulated with the addition of Hilyses® compared to the control diet (Table 2). This increasing gene expression trend was found to be significantly (P<0.05) linear with increasing dietary level of the yeast derived additive for all four genes. However, the increase in ghrelin expression was lower compared to the expression of the other three genes.

IGF-I is a key gene for regulating somatic growth of fish. Ghrelin stimulates growth hormones and prolactin release in tilapia. On the other hand, G-3-P gene helps to release glycolytic enzyme that plays a major role in cell metabolism and homeostasis of animals. Upregulation of these genes with the increasing level of Hilysis® in this study depicted the influence of yeast-metabolites on growth of Nile tilapia (Figures 2 A, B and C).

Hepcidin plays a major role in hepatic iron metabolism. It is a vital effector molecule in the innate immune reaction of vertebrates. Several studies have reported the antimicrobial role of hepcidin in response to infectious pathogens. For example, when injected with a pathogenic bacterium, a highly positive correlation was reported in the hepcidin expression levels with liver, brain, pituitary, and testis of Nile tilapia.

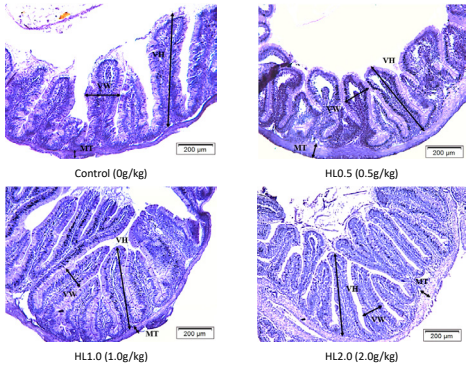


Figure 1. Cross-section of proximal intestine of fish fed the experimental diets with graded inclusion levels of Hilyses®.

Parameters	ANOVA					Regression vs HL (%)	
	Diets and inclusion of Hilyses®				*P*-value	'I'	*P*-value
	Control 0g/kg	HL0.5 0.5g/kg	HL1.0 1.0g/kg	HL2.0 2.0g/kg			
VL, µm	504^{b}±92.3	621^{ab}±169.7	679^{ab}±96.2	795^{a}±135.8	0.016	3.006	0.009
VW, µm	226±16.5	225.5±37.9	225.5±9.1	244.8±25.2	0.664	1.048	0.313
SV, mm^3	0.008^{b}±0.004	0.014^{ab}±0.006	0.012^{ab}±0.002	0.019^{a}±0.004	0.012	2.830	0.013
Note: VL – villi length, VW – villi width, SV – surface volume.							

Table 1. Intestinal histological parameters of fish fed the experimental diets.

Parameters	ANOVA					Regression vs HL (%)	
	Diets and inclusion of Hilyses®				*P*-value	't'	*P*-value
	Control 0g/kg	HL0.5 0.5g/kg	HL1.0 1.0g/kg	HL2.0 2.0g/kg			
IGF-1	2.96^{b}±0.03	2.97^{b}±0.03	3.00^{ab}±0.04	3.04^{a}±0.04	0.038	3.648	0.003
G-3-P	2.66^{b}±0.03	2.67^{b}±0.03	2.70^{ab}±0.04	2.74^{a}±0.04	0.038	3.648	0.003
Ghrelin	2.16^{b}±0.03	2.17^{ab}±0.03	2.20^{ab}±0.04	2.22^{a}±0.03	0.029	2.848	0.013
Hepcidin	2.57^{b}±0.03	2.58^{b}±0.03	2.61^{ab}±0.04	2.66^{a}± 0.04	0.047	3.494	0.004

Table 2. Expression levels of target genes in tilapia fed the four different experimental diets.

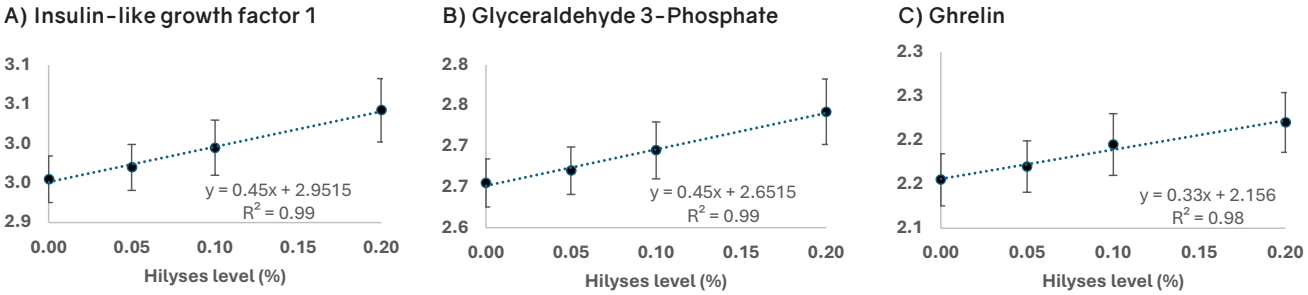


Figure 2. Regression of Hilyses® level (%) with the expression levels of target growth genes: A) Insulin-like Growth Factor – 1, B) Glyceraldehyde 3-phosphate, C) Ghrelin.

In this study, we found upregulated expression of hepcidin genes with increasing levels of Hilyses®. This elevated response could be in response to the increasing levels of β-glucan intake by the experimental fish (Figure 3).

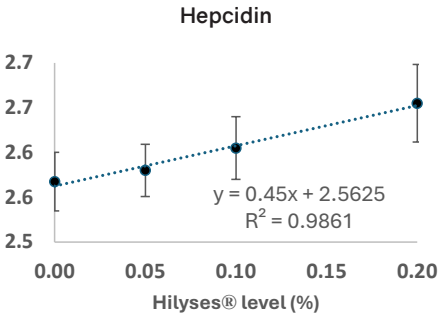


Figure 3. Regression of Hilyses® level (%) with the immune gene, hepcidin expression values.

Conclusion

This study shows a dose-dependent effect of yeast-metabolites rich additive on gut health, growth and immune genes of Nile tilapia. It has been shown that these metabolites are the major contributing factors towards improved gut microvilli morphology, relieved stress status, and reduced intestinal inflammation of Nile tilapia.

- The upregulation of the growth hormone and related genes in tilapia fed with graded levels of Hilyses® supplemented diets proved to be a key factor in promoting better growth or at least an improved homeostasis under stressful conditions.
- The upregulation of hepcidin gene with the increasing levels of the dietary Hilyses®, could be an important indicator of the immunomodulatory effects of yeast-metabolites. This has shown to be more important when the fish is infected with pathogenic bacteria.

Farmed animals are periodically subjected to stressful situations due to poor environment and diets, high density or crowding stress or stress during transportation of the live animals. Chronic exposures to one or more stressors not only affect growth, reproduction, and digestion, but also weaken the immune system. A weak immune system may lead to pathogenic infections and disease outbreaks, and as a result, economic loss to the farmers.

Yeast-metabolite rich additives such as Hilyses® can help mitigate risks from stressful conditions of farmed fish, therefore, reducing the potential economic loss from disease outbreaks and fish mortality under stress conditions.

Aung Tun Aye is founder at Agro Solution, Bangladesh and National Advisor at Maverick Innovation.

Md. Lifat Rahi is Professor at Khulna University, Bangladesh.

Md Amzad Hossain is Professor at the Gazipur Agricultural University, Bangladesh.

Rajib Dutta, DVM, MBA and **Melina Bonato** PhD, are Technical Business Manager-South Asia and Global Technical and R&D Manager, respectively at ICC Animal Nutrition, Sao Paulo, Brazil.

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Precision nutrition, palatability to health intervention

Precision nutrition is a key practice in modern livestock production. It is the cutting-edge approach to provide the animals with the exact nutrients required for optimal growth, health, and productivity. It also leverages with the right balance of nutrients at the right time. Where are we with precision nutrition in fish farming? The challenge is the number of species, the environment fish are farmed in (freshwater, brackish water, and seawater), culture models (ponds, tanks, cages, and controlled systems) and density. There are many permutations.

A session at TARS 2024 on Finfish Aquaculture, covered a good start towards a framework on precision nutrition for fish farming as addressing this is critical towards developing species-specific feeds for improved efficiency and at all life cycle stages. Four presentations set the stage, starting with information on standardised processes for ingredient assessments. Another industry demand is reducing cost/kg fish produced which requires nutritional modulation for better feed efficiency and for health intervention to increase survival rates.

"Precision nutrition requires understanding the dietary needs of different animal sizes and essential nutrients. It is important to manage diet palatability and sensory perception in fish to enable some capacity to manage their feed intake."
- Brett Glencross

It all starts with the right approach to ingredient assessment

"The evolution of ingredient assessment: a feed is still only as good as its ingredients," said Dr Brett Glencross, Research Director at IFFO and Honorary Professor at the University of Stirling, Scotland.

He discussed the evolving strategies for ingredient assessment in feed formulation, noting that modern diets focus more on nutrients than ingredients. As such, ingredient assessment also needs to increase its objectivity in line with those demands.

Precision nutrition requires understanding the dietary needs of different animal sizes and essential nutrients. It is important to manage diet palatability and sensory perception in fish to enable some capacity to manage their feed intake. Diet formulation involves two information sets: understanding the animal's needs to design the feed, and knowing the ingredients, their constraints and how to manage them.

"We focus on nutrients - not ingredients, and how to manage them effectively," said Glencross. "With modern diets, we aim for precision nutrition, focussing on digestible energy (DE) and digestible protein (DP) rather than crude measurements. It is this digestible supply that impacts performance."

The panel discussion was led by Romi Novriadi (left) with, from right, invited industry player, Piet Vertstraete, Abung Simanjuntak, Sofia Morais, KP Chan and Brett Glencross.

He emphasised the importance of understanding how requirements change with fish growth stages and animal sizes. "Without this knowledge, precision approaches are impossible. We know that requirements change with fish size, so we need to accommodate this in our formulations. Furthermore, formulating based on crude nutrients alone is inadequate without understanding digestibility."

Glencross outlined a structured four-step approach for ingredient assessment ensuring a thorough evaluation of each ingredient's value and suitability for inclusion in animal feed. The stages are:

Characterisation: This stage involves identifying and documenting the fundamental properties and composition of the ingredient. TDS or technical data sheets are commonly used at this stage, to provide detailed information about the ingredient's characteristics. This stage is often a desk-top based preliminary evaluation.

Digestibility and palatability: This stage is an evaluation on how well the ingredient can be digested and its appeal to animals. Digestibility measures the proportion of the ingredient's nutrients that can be absorbed, while palatability assesses the likelihood of the animals consuming the ingredient.

Utilisation and growth: This stage investigates the effectiveness of the ingredient in supporting the growth and overall health of the animals. It includes studying the ingredient's impact on growth rates and other performance metrics.

Omics responses, immunological responses, meat quality, and functionality: This final phase is largely the ancillary studies that may add value when added to steps 1 to 3. It aims to examine the broader biological responses to the ingredient, including omics responses such as changes in gene expression (transcriptomics), and metabolites (metabolomics), and immune system reactions, as well as the quality of the meat produced and the functionality of the ingredient within the diet.

More details are available here: The power of nutrition for the industry in Asia, *Aqua Culture Asia Pacific*, January/February 2023, pages 38-41.

Glencross concluded that all ingredients have strengths and weaknesses, and the key is to find the complementarity among them. Sustainability and the environmental footprint of feed ingredients are also becoming increasingly important. In many cases these criteria are now included in the stage 1 characterisation step.

The science of taste

In the nutrition process, intake is the number one driver of variation in performance. **Sofia Morais**, Innovation AQUA Team Leader at Lucta S.A., Spain, explained how taste impacts aquaculture productivity and its application in creating effective fish feed. She highlighted, "It is important to note that food recognition in fish involves the identification of nutrients rather than specific ingredients. Fish possess many unique, special, and highly developed sensory systems."

Three of these systems are directly involved in feed intake: smell, taste, and solitary chemosensory cells (SCCs). These systems use chemical signals to help fish locate food sources, with taste being key in the final decision to consume food.

Olfaction, or smell, and SCCs are the first to respond in the feeding behaviour process. They are the long-distance sensing systems which the fish uses to detect the food far away and to orientate itself towards it. Taste is the only sensory system that is exclusively used for feeding. It is a short-distance sensing system which finally determines consumption.

Taste modalities in vertebrates help identify food quality, guiding dietary choices. There are five taste modalities (Figure 1). Morais explained that bitter compounds often signal toxicity, sour indicates microbial degradation and spoilage and warns the fish that the source of food is no longer fresh. Umami and sweet receptors detect vital nutrients like amino acids and carbohydrates.

Morais stated that taste sensing continues after feed ingestion in fish, involving enteroendocrine cells (EECs) along the gastrointestinal tract (GIT). These receptors play a crucial role in sensing food chemostimulants as they travel through the GIT, regulating satiety, gut transit, digestion and absorption.

Stimulants that attract or make food palatable usually have low molecular weights, such as free amino acids and small peptides. These water-soluble substances disperse easily and are found in high concentrations in attractive foods (or ingredients). They leach from pellets, signalling food to animals. Mixtures of these stimulants in specific combinations are more effective than single compounds.

Taste preference varies by species. Recently, fishmeal has been reduced in diets, causing palatability issues. To achieve positive feeding cues, formulators are now using specialty ingredients like hydrolysates and krill meal, and additives, rich in stimulants.

Sensory additives can be applied to enhance the palatability of feeds with reduced fishmeal levels. The supplementation with a palatability enhancer (PE) had a significant positive impact in specific growth rate, feed intake and feed conversion, as shown in a barramundi trial in Thailand. The performance of the control diet containing only 15% fishmeal was suboptimal, despite being reinforced with krill and squid meal. More details: Taste matters: Exploring the fish gustatory system for overcoming aquaculture challenges by Morais, S., 2025. *Aqua Culture Asia Pacific*, January/February 2025, pages 25-29.

These additives may become useful tools for nutritionists in developing future aquafeed formulations with emerging ingredients. For example, single cell proteins, fermentation products of various waste streams, or insect meals are often not recognised as food or are avoided by many farmed species.

"Umami and sweet receptors detect vital nutrients like amino acids and carbohydrates" – Sofia Morais

Finally, Morais stated that using specialty ingredients and additives, boosts feed intake and efficiency, thus enhancing profitability. Reducing feed waste also supports sustainability in aquaculture.

A molecular perspective on astaxanthin in finfish aquaculture

While astaxanthin is vital for pigmentation, it also plays key roles in reproductive fitness, overall survival, and as an antioxidant, it reduces oxidative stress and lipid peroxidation in fish, according to **Dr KP Chan**, Regional Technical Team Lead for Vitamins & Carotenoids, Asia Pacific, BASF Animal Nutrition. Carotenoids differ by their oxygen molecules; astaxanthin's four oxygen molecules dictate its chromophoric and antioxidant properties.

Chan described the metabolic characteristics of carotenoids. Red carps convert lutein/zeaxanthin to astaxanthin and store it, while seabream cannot convert beta-carotene and require a dietary source. Astaxanthin is used in integument for aesthetics and reproduction, and in the liver for cellular functions and antioxidation; it is also vital for ovary development, fertilisation, hatching, larval growth, and egg quality.

Focussing on stressors in fish, Chan described how astaxanthin works in stress management. "Its molecular structure allows it to intercalate into the lipid bilayer very effectively and sequester the reactive oxygen species (ROS). A study by Qiang et al. (2022) demonstrated that fish fed with 150mg/kg feed astaxanthin exhibited considerable enhancements in terms of growth, feed utilisation, as well as viscerosomatic and hepatosomatic indices."

In terms of dosage, as shown with the tilapia, an inclusion rate of 150mg/kg feed produced optimal performance for the tilapia. "Beyond this level, we see that the performance equals that of the negative control meaning that the astaxanthin functions as a pro-oxidant i.e. it induces oxidative stress. It becomes a metabolic load for the fish and affects the performance of the fish. For shrimp pigmentation, dosage depends on farming conditions, stress, growth and feed. There is no fixed rule but typically around 50-100ppm."

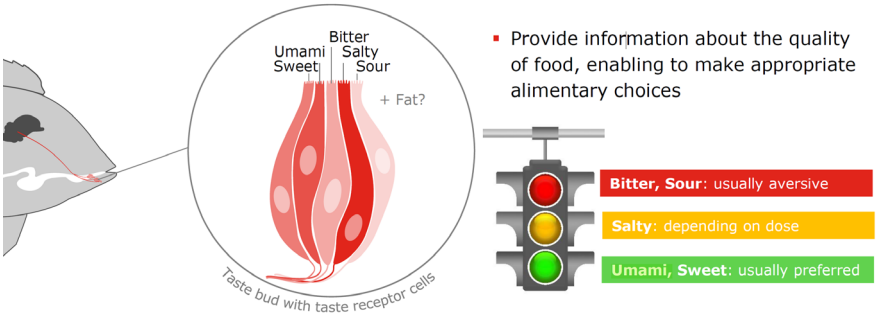


Figure 1. The five taste modalities explained. Source: Taste Matters: From Science to Application by Sofia Morais, Lucta S.A., Spain, presented at TARS 2024 Finfish Aquaculture, August 14-15, Bangkok, Thailand.

Why micro-encapsulate astaxanthin?

The compound has a large molecular weight close to 600mg and in the native form, is crystalline. "Nothing is going to happen if fed as crystalline astaxanthin since it is not soluble in water and in itself, is very susceptible to oxidation. We need to convert this from a crystalline into an amorphous form, breaking them into smaller particles and microencapsulate."

"Overall, the choice of astaxanthin formulation can determine its effectiveness in enhancing pigmentation, growth, and reproductive performance in aquaculture species". - KP Chan

Micro-encapsulation of astaxanthin improves its stability, bioavailability, and ease of handling, making it more effective in aquafeeds. It improves bioavailability, ease of handling and allows for rapid dispersibility in cold water which is ideal for post-pelleting liquid applications (PPLA).

Two technologies stabilise astaxanthin through microencapsulation. Beadlet technology traps finely dispersed astaxanthin in a solid matrix like silica, making the beadlets stable and dust-free for extreme processing. Granulation technology creates cold water dispersible granules, suitable for post-pelleting liquid applications and quick dispersal in water. Both methods aim to improve the stability, bioavailability, and handling of astaxanthin in aquafeeds.

Chan noted that synthetic astaxanthin deposits more in fish muscle than natural astaxanthin, suggesting that it is more effective for enhancing pigmentation. Although effective, natural astaxanthin shows lower deposition levels when used at the same dosage.

Overall, the choice of astaxanthin formulation can determine its effectiveness in enhancing pigmentation, growth, and reproductive performance in aquaculture species.

Feed additives to reduce mortality in tilapia farming

"Indonesia's farmed tilapia faces challenges from stress and diseases. High stocking densities over 200 fish/m² increase stress and disease susceptibility, impacting productivity and profitability," said **Abung Simanjuntak**, Technical Expert Manager – Aqua Region Greater APAC, dsm-firmenich. Stress also arises from handling, transportation, disease treatment, and feeding regime.

To mitigate these challenges, it is crucial to focus on controllable aspects such as genetics, feed, and farming methods while adopting sustainable practices and innovative solutions. The targets are higher survival rates (current averages are 60-70%), fast growth and feed efficiency, considering, the uncontrollable aspects, diseases, and the environment. In feeds, use of more plant meals brings in another dimension as these meals have 10-45% indigestible fractions.

Abung discussed how essential oils at different dosages and combinations of organic acids reduce mortality. "When the feed is enhanced with organic acid, there

"The use of more plant meals brings in another dimension as these meals have 10-45% indigestible fractions". - Abung Simanjuntak

are added benefits such as increases in feed efficacy. Exogenous enzymes increase nutrient utilisation and improve the digestibility of the raw material. Phytase reduces the phosphorus in the environment as well as in the feed formulation. The overall effects are lower nitrogen in the water environment, less eutrophication and harmful algal bloom (HAB). Ultimately, in high density tilapia farming, we reduce the pathogen load."

However, Abung cautioned that it is important to understand the challenges within the whole farm ecosystem. "Our feedback from tilapia farms show benefits from feeds supplemented with feed additives go hand in hand with farm practices. For example, we need to find the best dosage of additives in the different farming systems (cages or flow through systems) to see any benefits."

More on palatability

Dr Romi Novriadi from Jakarta Technical University of Fisheries moderated the panel and Q&A. Piet Vertstraete, Managing Director of 4SEA Consulting in Thailand, emphasised the significance of palatability in marine fish feed formulations. He discussed stabilising feed composition during raw material changes and using palatants to improve feed intake under stress or to enhance performance.

Vertstraete explained that one example is the initial feeding after transferring fish from the hatchery to grow-out cages. Palatants are frequently used during stressful conditions or when there is a need to produce larger fish to meet market demands.

Palatability enhancer and disease mitigation

Morais explained that it is hard to simulate experimentally the role of palatability enhancers during disease outbreaks. "When fish face mortality and pathogens, they often stop feeding as their metabolism prioritises survival. Diseases exploit stress, and prolonged or repeated stress can cause immunodepression in fish. At this critical stage, improving feed and energy intake levels is essential for coping with stress."

She noted that farmers are aware of the conditions that lead to the development of pathogens and often use functional feeds or add their own functional ingredients to feed. These functional compounds, such as phytogenics, may be bitter and unfamiliar to the fish. This situation can result in reduced appetite and an adverse response to the feeds. While it is possible to enhance palatability at this critical point, proving its effectiveness might be challenging.

Vertstraete gave an example of marine fish farming in the Mediterranean with an overwintering cycle. When temperatures drop, digestion, the immune system and membrane fluidity are affected, and fish eat less. At the same time, opportunistic bacteria get a chance to challenge the fish. "Using functional ingredients and

palatants can encourage fish to eat and stay healthy, even if they don't grow much," he said.

Measuring palatability

Several methods exist, such as adding palatants to feeds and evaluating performance on lab scale. Verstraete noted that the real test is feeding under farm conditions and evaluate feed intake. A robust software system can track various cages under different conditions and formulations based on lab trials. This is efficiently implemented in large fish farming companies. Powerful information systems can connect feed formulations and ingredient choice to farm performance.

For Abung, it is important to test in both controlled and uncontrolled environments. "After testing, we focus on environmental factors and actions. It is essential to understand both factors. We should know the differences between uncontrollable environmental factors and controllable aspects. The decision based on these tests will be made accordingly." Many factors influence palatability, sinking rate, and pellet quality. Chan said, "I prefer to evaluate feed performance (FCR) and growth under each condition to see what works best for the farm."

Morais highlighted the difficulty in gathering data to support perceptions, especially on farms. "Creating experimental models is nearly impossible, even in labs. Evaluating fish feeding behaviour is complex compared to shrimp, which feeds slowly. Few consider attractability when feeding fish. Fish typically eat quickly, focussing mainly on total feed intake is a rough measure of palatability." She added that underwater cameras and AI aid precision feeding by detecting fish hunger. This is effective in clear waters but difficult in low visibility conditions, such as in tilapia or pangasius farming.

Glencross explained that measuring palatability involves making nutrition adjustments, which can introduce inaccuracies. The goal is to find the least disruptive path, typically involving nutrition adjustments.

"On methodology, I would combine palatability and digestibility. For digestibility assessment, there is an acclimation period and feed intake is measured each day to assess the response of the animal. There are two key drivers controlling appetite - the hedonic response (seconds, minutes, hours) and the homeostatic response (days). When doing the digestibility study, acclimating for 2 weeks, we pick up hedonic responses which is relevant in terms of palatability."

Digestible protein

Formulating diets based on digestible protein (DP) rather than crude protein (CP) means that the CP value is higher. According to Glencross, "Formulating on DP basis is crucial as DP is what really matters, not CP. While CP can vary within a range, there is a specific DP:DE ratio that must be maintained for optimal growth. In formulations, DP can derive from various sources."

Vertstraete added that formulation is on DP and digestible amino acids which the animal needs for optimal growth. However, labels on bags still require CP values as per registered specifications. "But by selecting the most digestible ingredients, you narrow that gap between digestible and crude protein," said Verstraete.

"Rise" in Asia's shrimp farming and aquafeeds

The dsm-firmenich team and guests from Vietnam. From right, Abung Simanjuntak, Technical Expert Manager; Phan Thuc Lieu, GreenFeed; Nguyen Tan Doan, Viet Thang; Nguyen Thi Kim Phuong, Feed One; Chiow Yen Liew, Aqua Marketing Asia; Khoi Huynh Man, Manager for Distributors, dsm-firmenich Vietnam and Dr Rutchanee Chotikachinda, Aqua Technical Expert Manager.

This is the second part of the report on dsm-firmenich's annual Asia Pacific Aquaculture Conference. The 29th conference was hosted in Nagoya, Japan, bringing together an exclusive group of participants from 14 countries on October 15. The theme "Rise" highlighted resilience achieved from experiences and lessons. Part 1 in the January/February issue (pages 34-38) covered excerpts from presentations on global shrimp supply and demand outlook, marketing shrimp from Asia, pond management and countering melanosis at post harvest.

This article provides information on research related to nutritional therapies conducted by Dr Kyeong-Jun Lee, at the Jeju National University, South Korea, and on shrimp immunity based on research led by Dr Ikuo Hirono, Professor and current Advisor (Science) to the President at Tokyo University of Marine Science and Technology (TUMSAT). dsm-firmenich's Adolfo Fontes, Head of Business Intelligence Animal Health and Nutrition followed up with a presentation on global trends in raw materials relevant for aquafeed production in the Asia Pacific region.

Nutritional therapy for shrimp

This is for performance, immunity and environment. After discussing the use of nucleotides, glucans and carotenoids as dietary supplements, **Dr Kyeong-Jun Lee** described the role of functional additives in stress management. Environmental and management factors, such as stocking density and water quality, can act as stressors. Of interest are prebiotics which are non-digestible fibre components that increase beneficial microorganisms in the host's gut,

Kyeong-Jun Lee said, "By integrating these enzymes into aquafeeds, we can promote more sustainable and efficient aquaculture practices."

and probiotics, which are live microorganisms, offering health benefits by improving or restoring the gut microbiota of the host animals.

Lee discussed the use of fishmeal in aquafeeds and the constraints on the growth of aquaculture due to its reliance on fishmeal in these feeds. "Definitely we must reduce the use of fishmeal in aquafeeds. When replacing fishmeal with plant sources, the limitations such as the presence of anti-nutrient factors, deficiency in essential amino acids, poor digestibility and low palatability have to be addressed. Enzymes have been extensively used in poultry and swine feed but still remain low in use in aquafeeds. They offer several benefits to the nutritional quality of the feed, such as increasing bioavailability of nutrients, improving shrimp health, and reducing environmental impacts," said Lee adding that, "Improving gut health will improve shrimp growth and resilience."

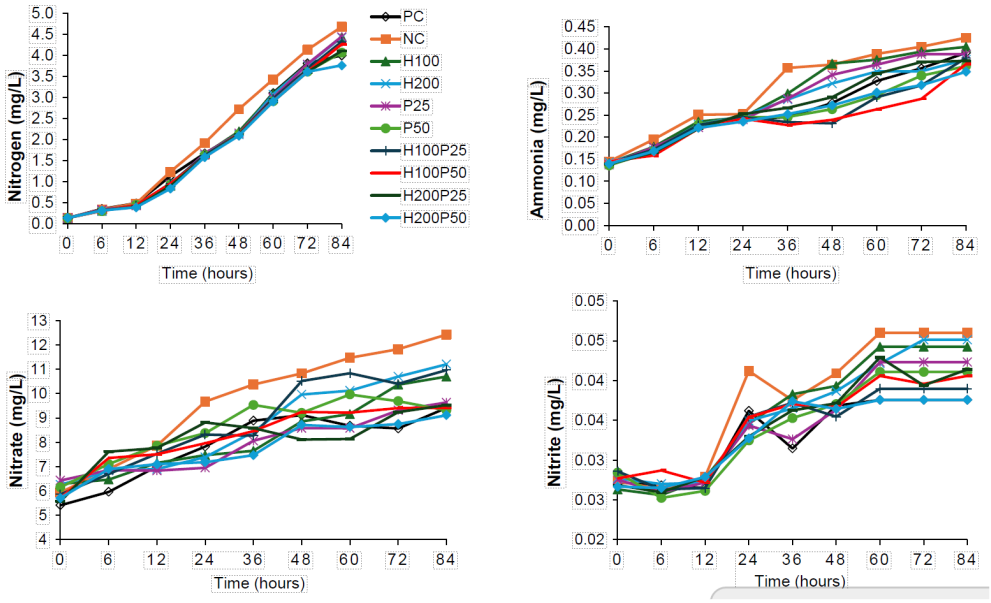


Figure 1. Research conducted at the Department of Marine Life Sciences, Jeju National University, Korea, to demonstrate application of enzyme technology to reduce nitrate, nitrite, nitrogen and ammonia excreted into the environment. Source: A nutritional therapy for the shrimp performance, immunity and environment, Kyeong-Jun Lee, presented at the dsm-firmenich Aquaculture Conference, Nagoya, Japan, October 15, 2024.

Biopeptides can be produced through the hydrolysis of proteins by enzymes such as protease. The potential benefits include improved digestibility and absorption of nutrients, leading to better growth and feed efficiency in shrimp. Biopeptides may also enhance the immune and anti-inflammation responses in shrimp, making them more resistant to diseases and infections. Additionally, they have antioxidant and antimicrobial properties, which can inhibit the growth of harmful bacteria and pathogens in the gut, promoting a healthier microbiome.

Enzyme technology to solve sustainability challenges

The enzymes in aquafeeds listed included protease, carbohydrase, phytase, cellulase, β-glucanase and xylanase. Lee discussed the outputs from research at Jeju National University over the past four years (Figure 1). "Enzymes enable the use of more plant-based ingredients without compromising performance, and they also help to reduce the environmental footprint of aquaculture.

"Enzyme technology, including the use of protease, phytase, and other enzymes, offers multiple benefits for sustainable aquaculture. These include enhanced nutrient utilisation, cost-effective feeding strategies, reduced environmental impacts, and improved gut health and immunity. By integrating these enzymes into aquafeeds, we can promote more sustainable and efficient aquaculture practices."

There was a discussion on results from trials to study the effects on growth, feed conversion ratio (FCR), survival and nutrient digestibility with the combinations of enzymes - protease and phytase as well as with a combination of phytase, protease and multigrain (xylanase, glucanase and cellulase).

Related to shrimp immunity, Lee described studies on the impact of protease supplementation on non-specific immune responses in shrimp. The study tested three dosages of a protease supplementation: 0, 400, and 800 mg/kg diet. Two levels of fishmeal were used for the diets: 200g/kg (a high fishmeal, HFM diet) and 100g/kg (a low fishmeal, LFM diet). In shrimp fed with protease-supplemented diets, higher gene expression levels of proPO (prophenoloxidase) were observed indicating an enhanced immune response while increased crustin expressions suggested an improved antimicrobial activity.

Shrimp microbiome

Protease supplementation was observed to have an impact on the shrimp microbiome, particularly in the hepatopancreas. The experimental design included different dosages of a protease supplementation tested at 0, 400, and 800 mg/kg. The results indicated that the protease supplementation in shrimp diets can positively influence the shrimp microbiome by increasing beneficial bacteria and reducing harmful pathogens. This leads to improved gut health, better nutrient absorption, enhanced immunity, and overall better growth performance and health status of the shrimp. Specifically, the abundance of various microbial populations in the shrimp hepatopancreas showed increases in *Lactobacillus* spp. The populations of gram-positive and gram-negative bacteria varied across different groups. *Vibrio* spp populations generally decreased in the protease supplemented groups, suggesting a possible reduced pathogenic infection.

In summary, the feeding trials demonstrated that protease, phytase and their combination performed well in both HFM and LFM diets fed to shrimp. Protease supplementation at 800mg/kg in the LFM diet could improve the performance to the levels comparable to HFM diet enhancing the nutritional quality of the plant proteins. A combined supplementation of xylanase, glucanase, phytase with protease could be a good choice for shrimp growth, health and resistance to diseases.

Lee's take-home message was that a careful selection of nutritional supplements should be made due to variability in feed ingredients and enzyme stability.

Stress management and infectious disease control in aquaculture

Dr Ikuo Hirono focussed on the use of beneficial bacteria to support shrimp health and immunity. He started his presentation with a quote from Selye (1950) -, "Stress is 'the sum of all the physiological responses by which an animal tries to maintain or re-establish a normal metabolism...'. "Stress increases susceptibility to diseases in the shrimp, which unfortunately, with its innate immune system, often lose the battle against pathogens," Hirono added.

Beneficial microorganisms

Fortunately, there are several beneficial microorganisms that protect shrimp from pathogenic infections through various mechanisms. These include the inhibition of pathogens in shrimp, activation of the shrimp's immune functions, and the release of metabolites by beneficial bacteria. There are groups of commercial beneficial bacteria for aquaculture such as several species of *Bacillus*, acid lactic bacteria or LAB, and photosynthetic bacteria or PSB which are present in ponds or within shrimp itself. However, Hirono stressed that there are many species and strains which vary in the ability to support health.

It is important to understand the functional structure of shrimp. Hirono referred to a study which showed that in shrimp, a thin film of chitin forms in the midgut, creating a physical barrier known as the peritrophic membrane (PM, Figure 2).

"We need to understand the relationship between bacteria in the gastrointestinal tract and shrimp. The pH of shrimp at 5.5 is ideal for growing bacteria." However, he stressed that there are many species and strains which vary in their ability to support health.

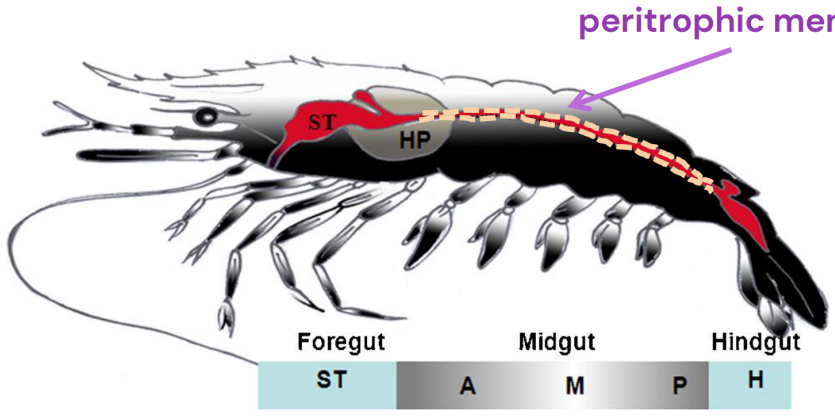
Anti-microbial activity

This was demonstrated with *Bacillus amyloliquefaciens* TOA5001, a commercial bacterium in Japan which has been shown to inhibit growth of *Vibrio parahaemolyticus* (Vp). Another three *Bacillus* spp do not have the capability to inhibit *Vibrio* spp.

Feeding the probiotic to shrimp and then monitoring the survival post challenge with *Fusarium*, showed that the probiotic can reduce *Fusarium* activity. The probiotic-fed shrimp also showed significantly higher survival compared to those of the control when challenged with Vp. Over the 2-4 weeks of feeding, the number of *Vibrio* (CFU/mL) continued to decrease in the stomach and intestine. The diversity of species in the microbiota of the stomach was higher than for the midgut.

"Through metagenome analysis of bacterial flora in shrimp after feeding TOA5001, we also saw that the bacterial flora in the stomach changed a lot. But the gene expression of shrimp before and after feeding the probiotic did not change. We suggested that feeding these bacterial strains did not stimulate the shrimp immune system and that maybe the bacteria strains produce some metabolites to combat pathogens," said Hirono.

PSB produces 5-aminolevulinic acid (5-ALA) which are non-protein molecules of amino acids. In the trial, the first screening involved 50 different PSB strains, and subsequently, three strains were selected for feeding trials and then one strain was fed as a feed additive to shrimp. Feeding PSB cultures reduced shrimp mortality by white spot syndrome virus (WSSV). The challenge tests showed that this strain showed disease resistance against acute hepatopancreatic necrosis disease (AHPND) and WSSV. Hirono referred to the work by Ivane R. Pedrosa-Gerasmio



(modified from Soonthornchai et al., 2010)

Figure 2. A description of the physical barrier in the gastrointestinal tract of shrimp. Source: Practical approach to stress management in aquaculture: Infectious disease control in shrimp farming using beneficial bacteria, Ikuo Hirono, Tokyo University of Marine Science and Technology, Japan, at the dsm-firmenich Aquaculture Conference, Nagoya, Japan, October 15, 2024.

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from Mindanao State University, Philippines suggesting that dietary 5-ALA enhanced the immune response of *L. vannamei* to *V. parahaemolyticus*, upregulated immune- and defense-related genes, and enhanced aerobic energy metabolism, respectively.

The research extended to field trials to study the effects of using a combination of *B. amyloliquefaciens* TOA and 5-ALA. These trials were conducted in 100m^2 circular ponds and shrimp were stocked at 300 PL/m^2. With outbreaks of AHPND occurring 2 weeks into the culture, followed by WSSV after 40 days, researchers reported that survival rates in the 16 ponds ranged from 4.8~52.11% in control ponds where shrimp were fed a commercial feed. In the ponds where shrimp was fed *Bacillus* and 5-ALA, the range was 33.2~77%.

"We need to understand the relationship between bacteria in the gastrointestinal tract and shrimp. The pH of shrimp at 5.5 is ideal for growing bacteria."
- Ikuo Hirono

Hirono had this message, "Beneficial microorganisms inhibit pathogens but are not medicines. They should not be expected to act like antibiotics or vaccines. Using good beneficial microorganisms is better than vaccines but it depends on the costs. Overall, they serve as an antimicrobial prophylaxis strategy."

Raw material trends for Asia-Pacific users

Adolfo Fontes shared data on the grains and fishmeal markets. "Firstly, it is very important to include uncertainties when we discuss raw material markets and trends. A major factor is geopolitical tensions impacting logistics and oil prices and disruption of supply chains between Asia and Europe." Listed were diseases such as Covid and African swine fever (ASF); economic issues (inflation and consumer behaviour); climate change and production costs which are related to grain prices.

In 2022, grain prices were at record highs due to consecutive years of La Niña in 2021 and 2022, with crop losses in south Brazil and Argentina. "It was the perfect storm, together with the Russian invasion of Ukraine, post Covid and inflation. In 2023, even with El Nino, seasons were good, and in 2024, we saw fantastic yields in the US. Grain prices showed lower levels. But when there is a delay planting of soybeans in South America, it can affect the planting of corn," commented Fontes.

Long term landscape in animal protein

Production volumes for animal proteins (seafood, poultry, beef etc) are expected to increase from 2023 to 2033, to meet the growing global demand which will grow at 1.1%/year, from 546 million tonnes in 2023 to more than 610 million tonnes in 2033. Aquaculture shows the highest compound annual growth rate (CAGR) of 1.6%, from 96 million tonnes in 2023 to more than 100 million tonnes in 2033.

Raw material trends and outlook

The focus was primarily on grains used in animal feeds. In 2023, soymeal represents almost 71% of oilseed meal in feed use (373.2 million tonnes). Corn and wheat represent 71% and 13.9%, respectively, of grains, in feed use (1,084.5 million tonnes, Figure 3).

Fontes said that grain use in Asia-Pacific (APAC), apart from India, depends on local production but also significantly on imports from USA, Brazil and Argentina. China has local annual production of soybeans of 21 million tonnes, while her imports total 108 million tonnes. India produces around 13 million tonnes and does not import. Other countries, Indonesia, Japan, South Korea, Thailand, Vietnam and the Philippines import a total of 13 million tonnes of soybean and 21 million tonnes of soybean meal annually. The message here is, "There is trade within Asia but the main suppliers are US, Brazil and Argentina. What happens in these countries have a huge impact on prices in APAC."

Price trends

Looking at the fundamentals of demand and supply, Fontes gave the following trends on Chicago prices for corn, soybean and wheat.

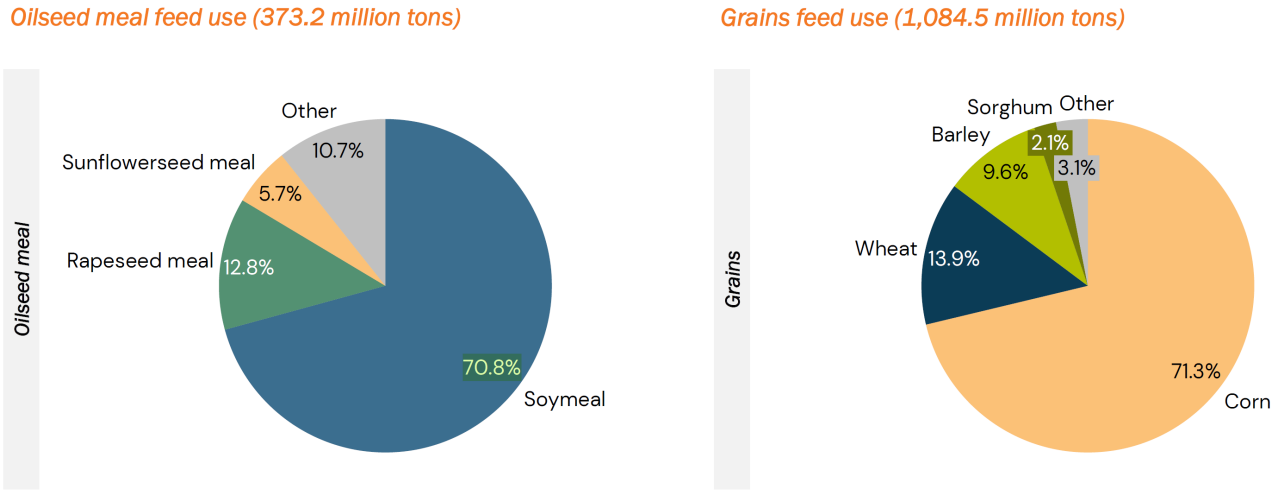


Figure 3. Oilseed meal and grain feed use in 2023. Data from USDA, FAO and DSM analyses, from Key & Emerging Raw Material Trends in APAC by Adolfo Fontes, dsm-firmenich Aquaculture Conference, 2024, Nagoya, Japan, October 15, 2024.

"There is trade within Asia but the main suppliers are US, Brazil and Argentina. What happens in these countries have a huge impact on prices in APAC."
-Adolfo Fontes

In October 2024, corn prices were down to around USD4/bushel as market reacted to good supply. Global corn production was expected to decline by 0.5% in the US. In October, the expectation was a price rise to USD4.50/bushel in May 2025. However, in February 2025, given additional volatility coming from geopolitical tensions and adverse weather, future prices predicted for May 2025 were again above USD5.00/bushel, with production projected to decline by 1.3%.

Global wheat production is expected to reach record volumes again in 2024/25 - up by 0.8% but consumption is also increasing. Prices show slight increase over the last quarter of 2024. In February 2025, it was expected that May 2025 prices will remain below USD6.00/bushel.

Soybean production is expected to increase by more than 8.7% in 2024/2025, with significant gains in Brazil, Argentina and the USA. The May 2025 price is predicted at USD10.67/bushel from around USD11.5/bushel in May 2024.

In response to increased soybean availability and rapid expansion of crushing capacity, soybean meal prices are projected at USD324.10/tonne for May 2025. "With La Niña, two years ago production in Argentina was half of the expectation for 2024/2025. Argentina is the biggest soymeal exporter; depending on what happens there, global soybean meal availability and global prices will be impacted," added Fontes.

With regards to global stocks, stock to use ratios for 2024/2025 showed: an increase to 33% for soybean and 26% for corn, from 32% and 25%, respectively, for 2023/2024. In the case of wheat, it is less at 32% versus 33% in 2023/2024 because of the food market although production is increasing.

Long- term supply situation

Of interest to industry in APAC, is the long-term soybean supply situation. By 2032, US will increase supply by 10 million tonnes and Brazil 33%, with almost 30 million tonnes. However, deforestation is an issue in Brazil and Fontes explained the happenings there. "Some 65% of Brazil land area (550 million ha) is native vegetation. Pasture lands total around 180 million ha and half is underused. Over the last 10 years, around 10 million ha of pasture lands have been used for grain production, albeit taking four years for high productivity. The potential to increase soybean production comes from these underused areas. Illegal deforestation is small compared to these numbers, but it dominates news."

By 2032, the APAC region is projected to import over 145 million tonnes of soybeans and 67 million tonnes of corn. "Vietnam will increase imports by 10 million tonnes of corn. Overall, there will be enough grains for APAC," said Fontes.

Fishmeal

Information came from Rabobank. Fishmeal prices have declined from USD2,200/tonne to the current USD1,300/tonne due to the good first season in Peru. Peruvian fishmeal producers are expecting a strong second season with a solid fishing quota at or above 1.7 million tonnes. Overall, the increased supply from Peru is likely to keep fishmeal prices relatively lower in the short term.

Left to right: Jay Chen, General Manager, dsm-firmenich Taiwan, Supamat Tantipaswasin, General Manager, dsm-firmenich Thailand, and Khoi Huynh Man, Manager for Distributors, dsm-firmenich Vietnam.

Addressing dark pigmentation in shrimp post larvae

Dark pigmentation is associated with better nutrient absorption and utilisation, improved growth rate, and increased resistance to disease

By Babu Rathinam, Grace Angel and Arul Victor Suresh

Post larvae (PL12) fed with a single meal of pigmented feed.

Dark pigmentation is a desirable trait to increase market value of shrimp post larvae. Farmers prefer dark hepatopancreas and gut because they can observe the shrimp size and activity more clearly. Dark pigmentation is associated with better nutrient absorption and utilisation, improved growth rate, and increased resistance to disease. Some hatchery operators and farmers, however, believe that the opposite is true: growth and survival of shrimp post larvae are negatively affected when their hepatopancreas and gut are pigmented.

In this article, we present results on a trial to answer some of the prevailing questions related to dark pigmentation.

Ways to achieve dark gut and hepatopancreas

The trial was conducted at the Growel Shrimp Hatchery Feed Trial Center (GSHFTC) to evaluate the effect of Growel's feed variant, Origin® 300D, on the post-larval rearing of white leg shrimp *Litopenaeus vannamei*.

The aim of this study was to determine ways to achieve dark gut and hepatopancreas colouration by offering this pigmented feed as a single feed and in combination with other feeds. The following five treatments, each with five replicates, were tested as shown in Table 1.

Essentially, post larvae were fed a cocktail diet of non-pigmented feeds, Growel Origin, and another hatchery diet from PL4 to PL7. Subsequently, feeds were changed to the dark pigmented Origin 300D either by itself for the rest of the cycle as a single feed or in a cocktail for the entire duration or just for two days.

Specific pathogen free (SPF) post larvae of the "Growth" genetic line of *L. vannamei* were obtained from in-house commercial larval rearing tanks (LRT). The shrimp post larvae (PL3) were stocked at a density of 60 PL/L in 25 tanks (approximately 8,400 post larvae per 140L tank) and reared over 10 days using a protocol widely practised in commercial hatcheries in India.

Post larvae were fed six to eight times a day. Before PL7, four meals of live *Artemia* nauplii and six meals of commercial dry feeds were given. After PL7, the dry feed meals were increased to eight meals and *Artemia* was decreased to two meals. Once post larvae reached PL 9, *Artemia* feeding was stopped completely and the feeding protocol was followed as per the experimental design.

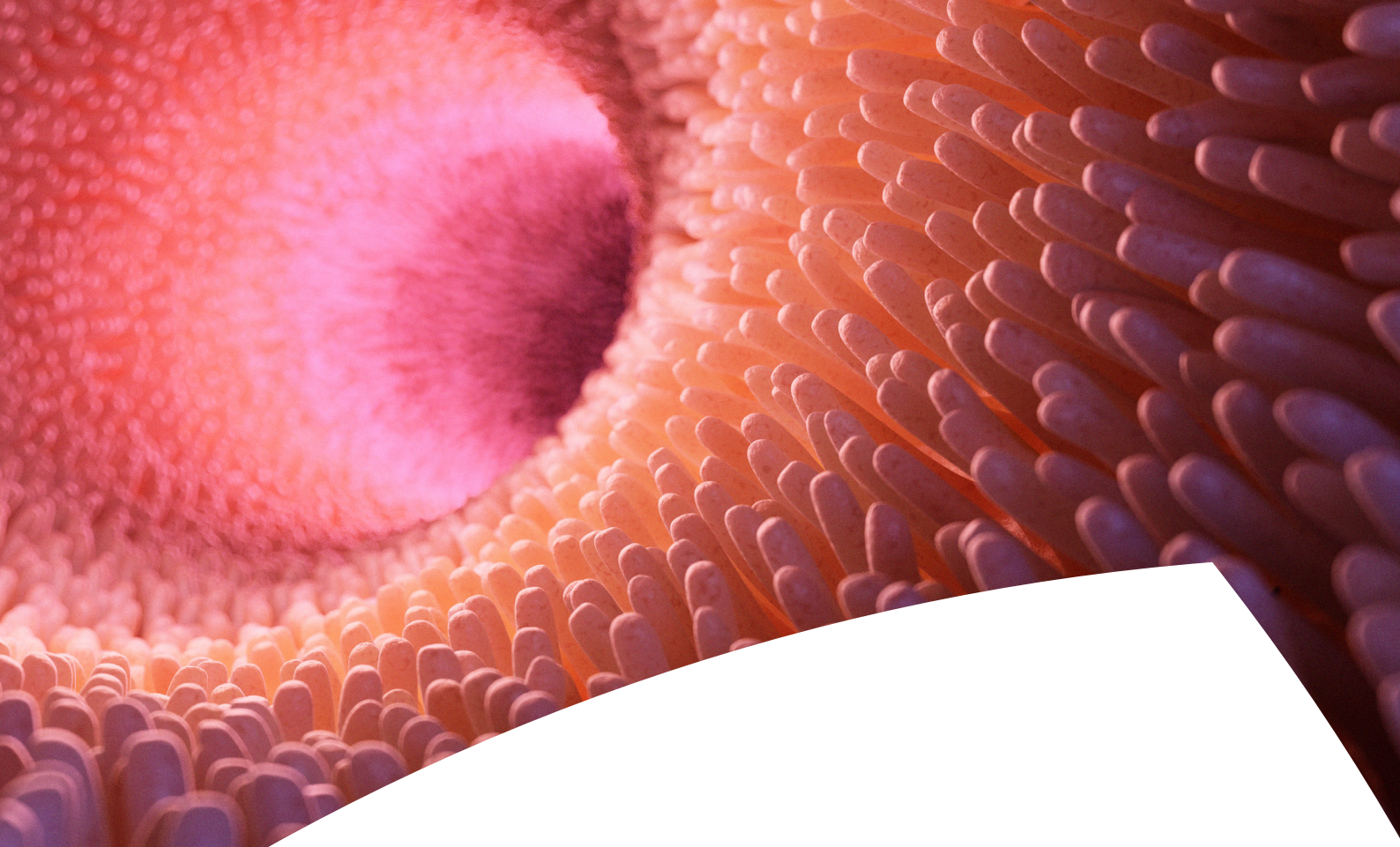
Growth and survival of post larvae

Water quality parameters such as salinity, pH and alkalinity in all treatments remained unchanged from the beginning to the end of the trial. Total ammonia nitrogen (TAN) was below 3ppm in all treatments throughout the trial. However, the TAN of water in the tanks receiving Origin 300D was lower when compared to other dietary treatments.

Post larvae performance was statistically similar across the treatments (Table 2); however, results showed a generally higher average survival for post larvae fed the pigmented feed variant.

Treatments	Description of feeds	Diet	Size range
T1	Non-pigmented control	Origin	PL8-PL12
T2	Pigmented	Origin 300D	PL8-PL12
T3	Pigmented: Non pigmented	Origin 300D: Origin (50:50)	PL8-PL12
T4	Pigmented: Non pigmented	Origin 300D: Origin (50:50)	PL8-PL10
	Pigmented	Origin 300D only	PL11 to PL12
T5	Non-pigmented	Origin only	PL8 to PL10
	Pigmented: Non pigmented	Origin: Origin 300D (50:50)	PL11 to PL12

Table 1. Treatment diets comprised various combination of non-pigmented feeds, Growel Origin and its pigmented version, Origin 300D to post larvae.



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increase gut microvilli length and height, improving protein and fiber digestibility

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Treatments	Survival (%)	Final PL Length (mm)	Final Biomass (g)	Final PL weight (mg)
T1: Origin Only (PL8-PL12)	80.91	10.62	30.97	5.6
T2: Origin 300D only (PL8-PL12)	83.25	10.79	31.63	5.8
T3: Origin & Origin300D in 50:50 ratio (PL8-PL12)	83.02	10.84	31.51	5.6
T4: Origin 300 only (PL8-PL10) followed by Origin 300D only (PL11-12)	83.74	10.95	34.99	5.8
T5: Origin 300 only (PL8-PL10) followed by Origin & Origin 300D in 50:50 ratio (PL11-12)	84.03	10.62	32.07	5.6

Table 2. Performance of shrimp post larvae fed diets with and without dark pigmentation.

The data revealed that Origin 300D does not negatively affect post larvae performance and may actually improve it slightly.

Observations on pigmentation

Phase 1 (PL3- PL7):

The shrimp post larvae's key stage is the early post larval stage. During this stage, post larvae consume both live and formulated feeds. Additionally, the consumption rate of formulated feed is relatively low. As a result, the post larvae's gut and hepatopancreas pigmentation appeared pale in colour, which was consistent across the treatments.

Figure 1. Combination of live and formulated feeds during PL4-7 resulted in pale colour of the hepatopancreas and gut.

Phase 2 (PL8-PL10)

During this phase, the diets were switched to the dark feed variant, either singly or as a cocktail feed along with the unpigmented variant Origin 300. The pigmentation results revealed that post larvae fed the dark feed variant (T2) acquired the darkest gut and hepatopancreas, followed by those fed the cocktail feed in T3. The gut colouration was the lowest in treatments 1, 4 and 5 which continued to be fed with Origin only. So, the desired gut colouration was obtained when the post larvae were fed the dark feed variant alone for two days. Combining it with the unpigmented feed for two days resulted in a moderately dark colour of the hepatopancreas.

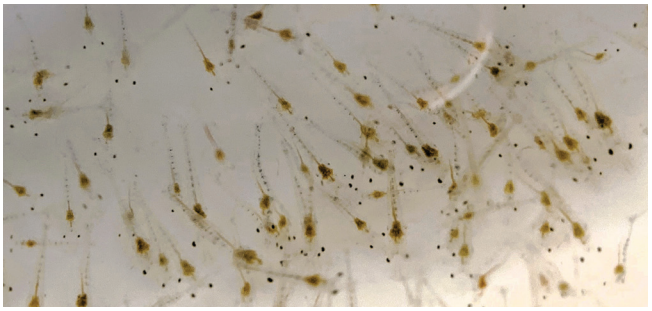

Figure 2. Post larvae fed cocktail feed showed moderate gut and hepatopancreas colour.

Phase 3 (PL11-PL12):

During the final stage of post larvae rearing, dark colouration of the gut and hepatopancreas appeared in post larvae fed Origin 300D alone, followed by cocktail meal in those that were not previously given the dark pigmentation feed. However, the darkest pigmentation was seen in T2 and T4, which were offered the dark feed from PL8 onwards.

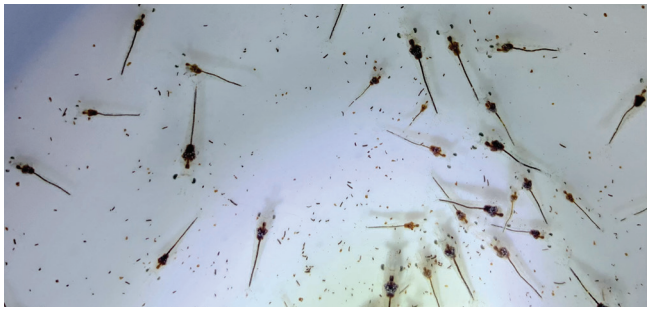

Figure 3. Dark pigmentation of shrimp post larvae during the final harvest which meets farmer preference.

Summary

Feeding with the dark pigmented Origin 300D feed did not negatively impact post larvae performance, regardless of the length of the feeding. Higher growth and survival of the post larvae fed the dark pigmented feed may indicate better nutrient absorption and utilisation, improved growth rate, and increased resistance to stress and pathogens. The trial results show that the dark pigmented feed should be applied either partially or fully throughout the late post larvae rearing to get the best results in terms of pigmentation. If the hatcheries are unable to provide the dark pigmented feed throughout the late post larvae rearing stages, they should provide it at least in the last two days prior to harvest. Exclusive administration of the dark pigmented feeds in the last 3-4 meals is highly recommended.



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Email: nutrition@growelfeeds.com

Field demo of a new feed solution to mitigate EHP prevalence in Thailand

Thai field trials consolidate the positive impact of a new functional solution for shrimp challenged by EHP and allow farmers to maintain a good economic situation

By Stephane Frouël, Wipavee Thongpiam and Maxime Hugonin

The first trial in a farm in Nakhon Sri Thammarat province was in a 5,600m² pond where stocking density was 125 shrimp/m².

Since 2009, *Enterocytozoon hepatopenaei* (EHP), a now well-known microsporidian, jeopardises global shrimp production in Asia. First characterised in the black tiger shrimp *Penaeus monodon* in Thailand, this endoparasite is responsible for huge economical losses. Restricted to the shrimp hepatopancreas (HP), EHP does not appear to cause high mortality but mostly severe growth retardation and depressed feed conversion ratio (FCR) forcing farmers to salvage their crops and to harvest at early stages. Moreover, as primary infection, EHP is associated with other pathogens such as *Vibrio parahaemolyticus*, which causes high mortality, and diseases such as white faeces syndrome.

For two decades, farmers must deal with EHP threats. Being difficult to eradicate, the main solution remains to implement a strong biosecurity program to keep it under control and limit its impact on shrimp growth.

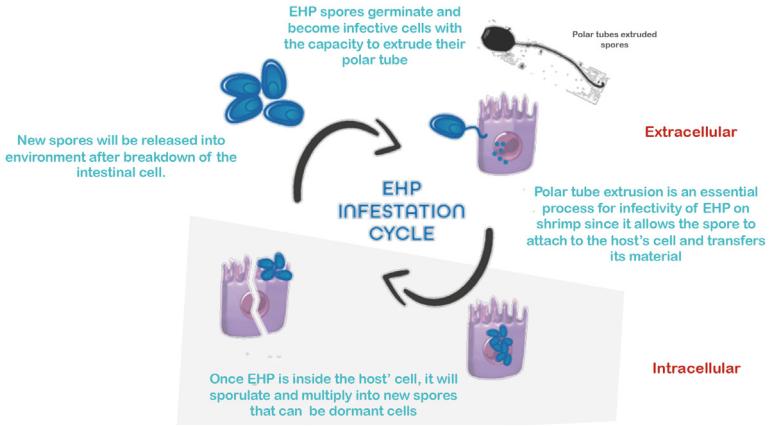


Figure 1. Illustration of *Enterocytozoon hepatopenaei* (EHP) infestation cycle. Adapted from Chaijarasphong et al., 2021.

Reminder: The EHP cycle

The life cycle of this microsporidian parasite can be divided into three phases: the infective, the proliferative and the spore-forming phase (Figure 1).

The infective phase is the only phase that can survive without the host since spores are outside of the host's cells in a dormant and more resistant form. Once in the host, the dormant spore will become an infective one through the key phase of the cycle: the germination. This phase is marked by the expression of an essential tool for the spore to replicate: the polar tube. Thanks to it, the germinated spore will puncture the plasma membrane of the host's cell, releasing sporoplasms (infectious material) inside the cytoplasm of the cell. The sporoplasms start to replicate and produce many copies which are released into the environment after killing the cells; they then infect other shrimps until the level of infection reach the critical limit where growth stops.

Based on the cycle of infection of EHP, the preventive approach remains our recommendation to ensure that spores are killed or inactivated during their free phase out of the hepatopancreas cells.

Field demo of a new feed solution

In this article, we describe some field trials and feedback conducted and obtained in Thailand after the launch of a new biosecurity tool that helps farmers to break down the dynamics of EHP infection and reduce its kinetics allowing the shrimp to reach commercial sizes.

All these results consolidate and validate the effectiveness through a lab trial of this new prophylactic feed solution developed by MiXscience (France). They are the continuation of a research program started 3 years ago when it was proven that this solution reduces the germination of the EHP spores and controls its replication.

Our previous works demonstrated how the product limits this essential step - thanks to three main mechanisms (Frouël et al, 2021, 2023 and 2024):

a. It changes the shape of spores (Figure 2)
b. It changes the behaviour of spores (Figure 2)
c. It disturbs the global physiology of EHP spores to finally kill them (>70% of spores killed at the recommended dosage of 4kg/tonne of feed) (Figure 3)

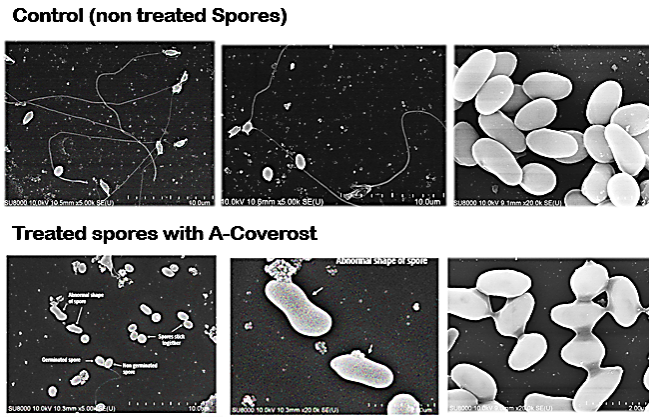


Figure 2. SEM (Scanning Electronic Microscopy) study of the impact of A-Coverost on the germination and morphology of EHP spores (Frouël et al., 2024)

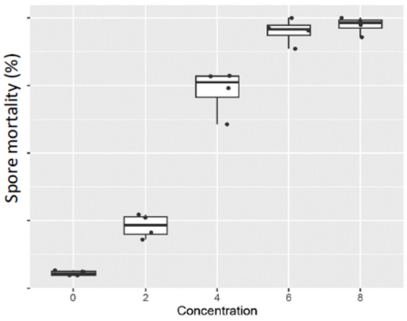


Figure 3. Dose-response effect for A-Coverost concentrations ranging from 0 to 8g/L

Used as a preventive treatment and at the recommended dose, the product will control the EHP load to maintain shrimp performance which has been confirmed in the field.

Field approaches

New field data have been collected under commercial conditions in shrimp farms in Thailand, after the commercialisation of the product by Unify Aquatic Innovation (Thailand).

Layouts of trials

The first trial was a demo trial conducted in Nakhon Sri Thammarat province, to assess the return of investment (ROI) of the product application. The trial was run under intensive stocking density (125 shrimp/m^2). The duration of the trial was 7 weeks, and the initial weight of shrimp was 0.5g. Pond size was 5,600m^2 and salinity was 30ppt.

The control (CTRL) was from a pond where the product was not used. The results were compared with a pond where the product was applied at 4 kg/tonne of feed (EXP). It was applied from the stocking date (week 0) until the end of culture (week 7). The EHP infestation was unpredictable and the first EHP occurrence started 4 weeks after the beginning of the trial. Based on the zootechnical results, a ROI was calculated.

A second trial was a commercial trial conducted in Surat Thani province to consolidate the effect of the product. The trial was carried out at a stocking density of 75 shrimp/m^2. The duration of the trial was 12 weeks, and the initial weight of shrimp was 0.5g. Pond size was 8,000m^2 and salinity was 20ppt.

Results from a pond without the product A-Coverost (CTRL) were compared with a pond with the product applied at 4kg/tonne of feed (EXP). It was applied from the stocking date (week 0) until the end (week 12). The first EHP occurrence started a few weeks after the beginning of the trial.

Determination of EHP load

In the demo trial, shrimp hepatopancreas was collected individually from 30 shrimp/pond for DNA extraction. DNA template for qPCR was obtained by homogenising hepatopancreas tissue in DNA lysis buffer. The 20µL of qPCR reaction mixture contained 1x SYBR green-qPCR, 0.2µM SWP primers and 10ng of DNA template. To calculate the EHP load, the samples were compared with the standard obtained from plasmid DNA at a concentration of 1.0x10^6 copies/µL.

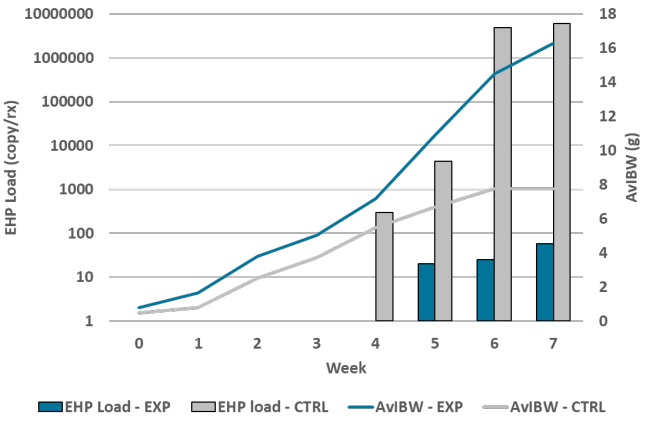
Parameters studied

In both trials, the shrimp growth performance indicators including initial weight, final weight, weight gain, average daily growth (ADG), FCR, final pond yield and survival rate were determined. Complementary microscopic analyses were conducted to observe the EHP spores' behaviour and their impact on gut histology.

Reduction in EHP spores

Results of the demo trial conducted in Nakhon Sri Thammarat province, showed that A-Coverost significantly reduced (>99%) the shrimp load of EHP spores with a stable and rapid control after first EHP occurrence (Figure 4). Moreover, the farm faced a challenging situation with WFS around week 5 after stocking but treated pond with A-Coverost was less impacted. This information confirms the hypothesis that EHP is a primary cause, which opens windows for secondary pathogenic infestations or metabolic disturbances.

This reduction and the disease protection induced a significant positive impact on feed efficiency and consecutive weight gain. Final yield of the pond was improved by 45% (Figure 4 and Table 1). Consequently, the absence of growth retardation demonstrated that A-Coverost improved shrimp farming, with a highly satisfactory ROI) with a huge differential of 58% (Figure 5).



	CTRL	EXP	Relative gain (%) EXP vs CTRL
Initial weight (g)	0.5	0.5	
Final individual Body weight (g)	7.74	16.26	110
Average daily gain (ADG, g)	0.165	0.344	108
Feed conversion ratio (FCR)	1.48	1.18	-20
Final pond yield (t)	7.45	10.82	45
Final survival rate (%)	99.83	97.84	-2

Figure 4 and Table 1. Final EHP load kinetic with associated average individual body weight (AvIBW) and final zootechnical results of the Demo trial #1.

A·Coverost

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Unique combination of chemical and physical actions

Acts directly at the EHP level

Prevents performance degradation

GUT
Controls the parasite load

FARM
Maximizes yield in challenging conditions

ANIMAL
Reduces parasites impact on host performance

SUSTAINABILITY
Animal welfare and environnemental friendly

mixscience
INNOVATE FOR LIFE
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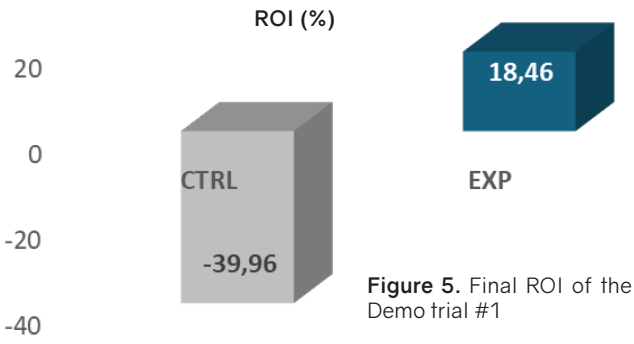

Figure 5. Final ROI of the Demo trial #1

Results of the second commercial trial in Surat Thani province, showed that treatment with A-Coverost maintained the global performance parameters in the presence of a pathogenic pressure.

This reduction and disease protection induced a significant positive impact on feed efficiency and consecutive weight gain. Final yield of the pond was improved by 98% (Table 2). This protection means that the duration of the crop was prolonged by 27% until 80 days to meet the market demand for commercial size whereas it was stopped at 63 days without the product.

	CTRL	EXP	Relative gain (%) EXP vs CTRL
Final individual Body weight (g)	12.82	20.83	62
Average daily gain (ADG, g)	0.2	0.26	30
Feed conversion ratio (FCR)	1.43	1.35	-6
Final pond yield (t)	4.8	9.5	98
Final survival rate (%)	62	76	14
Duration of cultivation (Days)	63	80	27

Table 2. Final zootechnical results of the commercial trial #2

Complementary studies on histology of hepatopancreas demonstrated that, with A-Coverost, it was in good condition, with no constriction and with full content of lipid droplets (Figure 6).

Microscopic observations of EHP spores (Figure 7) confirmed our previous results (Figure 2). The A-Coverost product interacted with the membrane of EHP spores, causing disruption; abnormal morphology of the spores and clumping, and they were no longer able to germinate.

Conclusion

These field studies, conducted in Thailand, reinforced previous studies and the conclusions obtained through lab trials. Following these two trials, the product has been applied over a whole year in more than 500 shrimp ponds in Thailand. An average of 80% of them encountered EHP infestation, but with the product application, production was maintained to reach a commercial size.

The take home messages with regards to the positive effects of applying A-Coverost during a culture cycle are as follows:

- Physically altering the spores, killing them, preventing germination and consequently, reducing replication.
- Breaking the dynamics of infection and slowing down its kinetics.
- Helping to keep under control the EHP load in the hepatopancreas and maintaining a normal and functional organ.
- Maintaining an acceptable level of pathogenic pressure which means that beyond EHP, secondary infections are kept under control.
- Maintaining feed efficiency and its associated performance.
- Helping farms to reach harvest of commercial sizes and maintain profits.

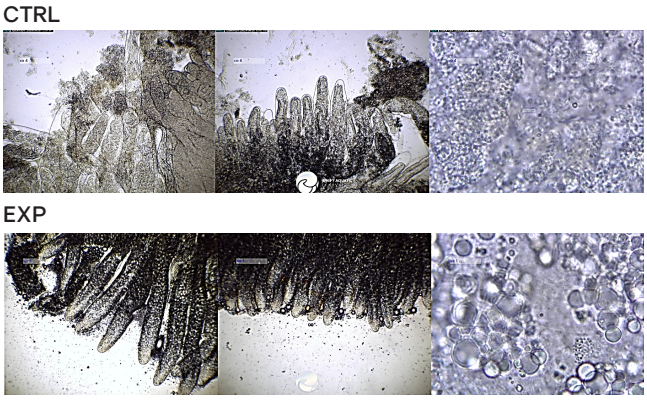

Figure 6. Representative microscopic picture of shrimp hepatopancreas without A-Coverost (CTRL) or with A-Coverost (EXP) under light microscope with 100X objective lens. Courtesy of Unify Aquatic Innovation.

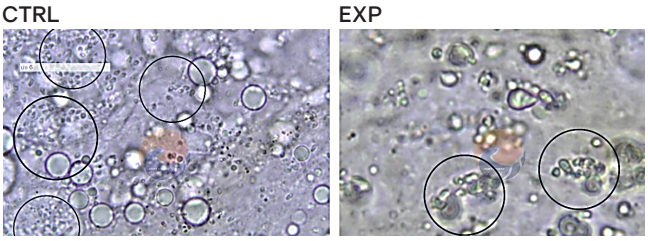

Figure 7. Representative microscopy study on the morphology of EHP spores without A-Coverost (CTRL) or with A-Coverost (EXP) under light microscope with 100X objective lens. Courtesy of Unify Aquatic Innovation

In the fight against EHP, prevention remains the key recommendation and farmers must rely on strict biosecurity and disease surveillance for an efficient control of the parasite in shrimp farming systems.

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Thai Fish Project: Creating feed formulations for Asian seabass and banana shrimp

The focus of this Japan-Thailand joint aquaculture research project is sustainable farming of these two native species

By Pakpitchaya Borvonsin, Izumi Tsurita, Yutaka Haga, Pitchaya Chainark, Nawanith Klongklaew, Montakan Tamtin and Ikuo Hirono

Harvesting high-DHA Asian seabass. The cage was donated by Japan International Cooperation Agency (JICA) to the Coastal Aquaculture Research and Development Regional Center 5 (Phuket), Department of Fisheries, Thailand.

Species diversification in aquaculture is vital for a resilient and sustainable food system. Despite some level of species diversity, Thailand's aquaculture production still primarily consists of the Nile tilapia *Oreochromis niloticus* and Pacific white shrimp *Penaeus vannamei*. Against this backdrop, the Thai Fish Project—a Japan-Thailand research collaboration titled "Utilisation of Thailand Local Genetic Resources to Develop Novel Farmed Fish for Global Market" was initiated in 2019.

This project aims to promote the domestication of two native aquatic species in Thailand – the Asian seabass *Lates calcarifer* and banana shrimp *Penaeus merguiensis* to advance sustainable aquaculture and food security. This six-year project is funded by Japan International Cooperation Agency (JICA) and Japan Science and Technology Agency (JST). Research activities are jointly led by Tokyo University of Marine Science and Technology (TUMSAT), Thailand's Department of Fisheries, and several other academic institutes from both countries.

Side by side, researchers from Thailand and Japan involved in the Thai Fish Project at the 9th Research Update Meeting held on July 16, 2024 in Bangkok, Thailand.

Addressing common challenges

The project has been conducting comprehensive research encompassing various topics to address common challenges in the aquaculture sector. After five years of work, some of the successful achievements include the development of feed formulations tailored for farming the Asian seabass and banana shrimp. The feeds were developed to promote sustainability, improve productivity and create added value within the industry.

Feed formulation for the Asian seabass

The project's research on feed formulation for the Asian seabass focused on two major objectives:

1) to develop low-fishmeal and low-fish oil feed formulas and
2) to utilise a functional feed additive to enhance the level of docosahexaenoic acid (DHA) in the seabass.

Due to the increasingly unstable global supply of fishmeal and fish oil, which causes price volatility, combined with the resource-intensive production process of catching wild fish to feed farmed fish, it is important to reduce the reliance on fishmeal and fish oil for a sustainable development of aquaculture, particularly for carnivorous species. Therefore, researchers sought to identify suitable alternative protein and lipid sources for seabass and ensure the fish can maintain adequate growth performance.

Low fishmeal and fish oil diets

The project researchers have successfully developed a low-fishmeal and low-fish oil grow-out feed. In this formulation, up to 75% of fishmeal was replaced with various land-based protein sources. According to the research, the alternative protein sources suitable for the fish include soybean meal, Protam protein (bacterial meal), black soldier fly meal, and poultry by-product meal. Meanwhile, the alternative lipid sources are palm and flaxseed oil. These alternative sources have been proven to effectively replace fishmeal and fish oil without affecting the fish growth and biological performance.

Diets	High FM	High FO	Low FM & FO
Feed ingredients (g/100 g)	100% FM	100% FO	25% FM & FO
Fishmeal	58.00	14.50	14.50
Soybean meal	-	12.00	12.00
Protam protein	-	10.00	10.00
Black soldier fly meal	-	5.00	5.00
Poultry by-product meal	-	18.00	18.00
Wheat flour	10.00	10.00	10.00
Wheat starch	5.00	5.00	5.00
Broken rice	17.40	13.30	13.30
Fish oil	1.00	5.00	1.25
Palm oil	4.00	-	1.75
Flaxseed oil	-	-	2.00
Choline chloride (50%)	0.50	0.50	0.50
Vitamin premix	2.50	2.50	2.50
Mineral premix	1.50	1.50	1.50
Ascorbic acid (active 35%)	0.10	0.10	0.10
Calcium monophosphate	-	0.75	0.75
DL-methionine	-	0.75	0.75
Taurine	-	0.50	0.50
Fish source	-	0.50	0.50
Enzyme complex	-	0.10	0.10

Table 1. A comparison of the composition of standard 100% fishmeal feed and a 100% fish oil feed with the new formulation developed by the team with 25% FM and FO (low-fishmeal and low-fish oil) for Asian seabass.

In December 2023, the Thai Fish Project organised its first "Seabass Tasting Event" at Centara Grand Ladprao, Bangkok, Thailand. To disseminate the research outcomes, researchers served DHA-enriched seabass sashimi to around 200 participants, including representatives from Japanese business groups in Thailand, who later expressed their interest in sourcing the DHA-enriched Asian seabass. This reflected the market potential of this project.

Enhancing DHA content

To increase the appeal of Asian seabass for both production and consumption, the project focused on adding value to the fish by enhancing its DHA level. With several health benefits of DHA, this project output responded to the growing focus on health and wellness in seafood, directly addressing a crucial aspect of food security which is nutritional quality.

Therefore, after developing formulations with low fishmeal and fish oil diets, the researchers introduced dried *Schizochytrium sp.* (a marine microalgae species) as a feed additive to boost the DHA content of seabass. A subsequent study proved that feeding Asian seabass with the above-mentioned diets supplemented with 2% dried *Schizochytrium sp.* for 3 weeks effectively increased the DHA level by 20%, ensuring good growth and sensory properties.

Feed formulation for the banana shrimp

The banana shrimp is popular with consumers, but most of the shrimp available in the Thai market is wild-caught. This is partly due to the limited knowledge and know-how on banana shrimp farming within the country. To effectively promote its farming, the first step is a feed tailored for the species. Feed is key to successful aquaculture by directly affecting the animal's growth and survival.

The primary goal of the project's research on banana shrimp feed formulation was to develop an artificial feed suitable for each stage in banana shrimp farming. Another goal was to add value to fishery waste by using it as a feed ingredient. Other key research activities included developing a maturation diet for banana shrimp broodstock and utilising marine by-products, such as crab waste-derived chito oligosaccharide and fish hydrolysate, as functional feed ingredients.

While some aspects of the research on banana shrimp feed formulation is still ongoing, researchers have achieved some notable outcomes. One of these is the successful application of marine fish hydrolysate (MFH) in larval diets for banana shrimp.

MFH as an alternative to fishmeal

For some time now, protein hydrolysates have attracted attention as an alternative protein source in aquafeeds, which is as effective and perhaps even richer in other nutrients and is more digestible. The project's researchers thus attempted to include protein hydrolysates obtained from fish waste into the diet formulation for the banana shrimp. According to research by Krongpong et al. (2021), MFH fermented with *Lactobacillus plantarum* TISTR No. 541 could replace up to 50% fishmeal and still lead to the highest survival rate and growth in terms of RNA/DNA ratio of the post larvae (PL3).

In this experiment, banana shrimp from mysis 1 (M1) to post larvae (PL3) were fed four diets; a typical shrimp larvae feed (T1), a fishmeal-based diet (T2), a diet with 25% MFH (T3) and a diet with 50% MFH (T4, Table 2).

Feed ingredients (%)	T1	T2	T3	T4
Fishmeal (69.38% CP)	Artificial shrimp larvae feed	36.00	27.00	18.00
Marine fish waste hydrolysate (48.18% CP)		0.00	25.20	50.40
Squid meal		12.00	9.00	6.00
Soybean meal		10.00	7.50	5.00
Wheat gluten		10.00	7.50	5.00
Wheat flour		8.00	8.00	4.00
Tapioca starch		13.47	5.27	1.07
Soybean oil		2.00	2.00	2.00
Choline chloride (50%)		0.20	0.20	0.20
Vitamin premix		1.50	1.50	1.50
Mineral premix		1.50	1.50	1.50
Vitamin C (ascorbic acid 35%)		0.20	0.20	0.20
Butylated hydroxytoluene (BHT)		0.02	0.02	0.02
Cholesterol		0.05	0.05	0.05
Vitamin E (50%)		0.06	0.06	0.06
Carboxymethyl Cellulose (CMC)		1.00	1.00	1.00
Monocalcium phosphate		2.00	2.00	2.00
Lecithin		2.00	2.00	2.00
Total		**100**	**100**	**100**

Table 2. The composition of each experimental diet used in the project's research feed formulation for banana shrimp larvae. Diets were T1 - a typical shrimp larvae feed; T2 - FM-based diet; T3 - 25% MFH mixed diet; and T4 - 50% MFH mixed diet. (Krongpong et al., 2021).

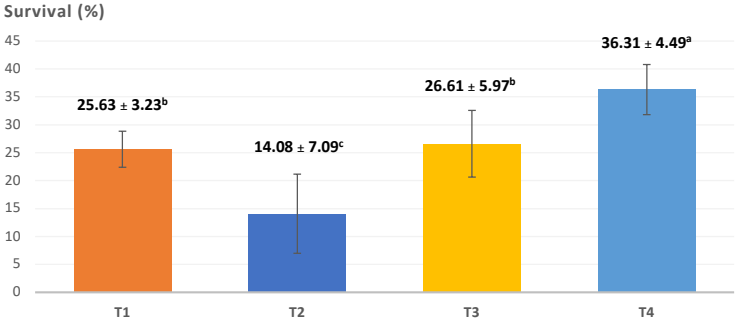

Figure 1. The survival of PL3 banana shrimp fed with the four experimental diets. Diets were T1 - a typical shrimp larvae feed; T2 - FM-based diet; T3 - 25% MFH mixed diet; and T4 - 50% MFH mixed diet. Source: Krongpong et al., 2021.

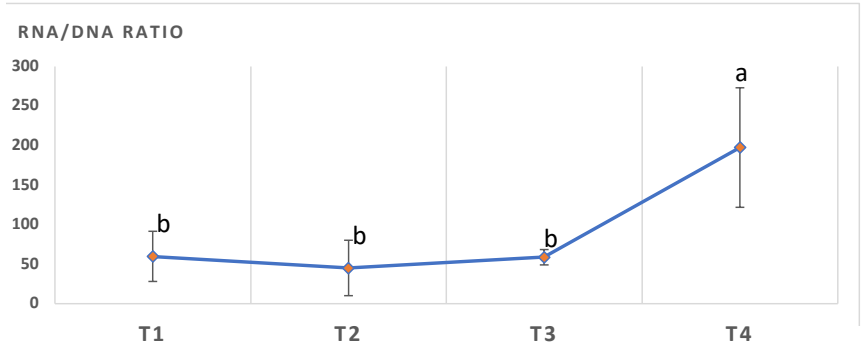

Figure 2. RNA/DNA ratio in banana shrimp post larvae (PL3) fed with the four experimental diets. Diets were T1 - a typical shrimp larvae feed; T2 - FM-based diet; T3 - 25% MFH mixed diet; and T4 - 50% MFH mixed diet. Source: Krongpong et al., 2021.

Project-reared high-DHA Asian seabass harvested on December 6, 2023, off the coast of the Phuket, Thailand. The fish was later served as sashimi at the project's Seabass Tasting Event in December 2023.

Overall, the objective of utilising marine fish waste hydrolysate (MFH) as a feed ingredient for banana shrimp has proven to support high productivity farming while promoting the development of a sustainable industry. This approach also helps to reduce reliance on fishmeal and adds value to fish waste.

Next steps

Creating added value and promoting the wise and sustainable use of available resources in Asian seabass and banana shrimp farming through efforts such as utilising black soldier fly meal and fish waste as alternative protein sources for feed, are not the only research focuses of the Thai Fish Project. As mentioned in the introduction, the project covers a range of research topics, with the principal aim of developing a comprehensive aquaculture package for the two target species for Thai farmers.

Under the Thai Fish Project, research topics can be classified into four major outputs: genetic improvement, disease prevention, added value and wise use of resources (as discussed in detail in this article), and preservation of genetic diversity.

Based on the project's timeline, all outputs will be finalised and published by May 2025. More information and future updates can be found on the 'Thai Fish Project' Facebook page, (https://www.facebook.com/thaifishproject/?locale=zh_HK&_rdr).

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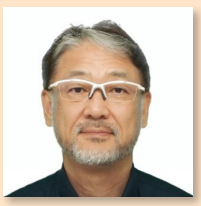

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Asian seabass or Malabar red snapper for Singapore's consumers

Between the two, red snapper has higher levels of EFAs, including DHA and EPA

By Shubha Vij and Kathiresan Purushothaman

Transferring sedated red snapper from a large tank at the Marine Aquaculture Centre, Singapore Food Agency.

Malabar red snapper Lutjanus malabaricus.

Aquaculture production is an important pillar in helping Singapore to meet its government's targets to boost the country's self-reliance and reduce the dependency on imported seafood. The Asian seabass *Lates calcarifer*, known for its mild flavour and thin, flaky textured flesh, is Singapore's most commonly farmed fish, and it is widely regarded as the "poster fish" of the country's aquaculture industry.

Farmed Asian seabass is usually sold in supermarkets between SGD8-11 (USD6.11-8.40) per 450–500g portion. A close runner-up to the Asian seabass is the Malabar red snapper *Lutjanus malabaricus*, an important high-value marine finfish in Singapore, often used as an ingredient in fish head curry, a popular local dish.

Comparatively, a 400–500g red snapper typically costs around SGD15 (USD11.45). Unlike the Asian seabass, which benefited from decades of R&D funding from national agencies, it is only in 2021 that two of the projects funded by the Singapore Food Agency (SFA) focussed on research into the red snapper, aimed at improving knowledge on its farming in Singapore.

These projects aimed to develop genetic resources for the red snapper and optimise feeds for its aquaculture, contributing to the understanding and sustainable production of this important marine food fish.

Nutritional profile

As part of one of these projects, we were keen to understand and compare the nutritional profiles of these two important fish species in Singapore. In 2023, one of the local farms farmed both the red snapper and the Asian seabass under similar husbandry conditions, including feed. This presented a useful opportunity to make an objective comparison. Both groups of fish were fed the same commercial feed containing 44% crude protein (Uni-President, Vietnam).

The research, led by Dr Kathiresan Purushothaman, at the School of Applied Science, Republic Polytechnic and James Cook University, Singapore, presented a comprehensive analysis of the nutritional profiles of these two species (Purushothaman et al., 2024).

".. valuable insights on the nutritional profile of the two species, which are regarded as most important for Singapore aquaculture."

Fatty acids

A comparison revealed a similar profile of the two food fish species with slight differences. When comparing fillet content of the two fish, red snapper had much higher levels of essential fatty acids (EFAs), including docosahexaenoic acid (DHA) at 13.4% and eicosapentaenoic acid (EPA) at 3%, while seabass had 11.2% DHA and 2.8% EPA. The DHA/EPA ratio was also higher in the red snapper at 4.5 versus 4.0 in the Asian seabass.

Additionally, the total saturated fatty acids (SFA) and polyunsaturated fatty acids (PUFAs) of the red snapper were slightly higher than for the seabass. Palmitic acid (C16:0) was the dominant SFA in both fish. In addition, the red snapper had a higher PUFA/SFA ratio of 1.1 and a lower omega-6/omega-3 ratio of 1.1 as compared to 1.0 and 1.3, respectively, for the seabass. Therefore, the red snapper is nutritionally superior in terms of fatty acid composition and lead to better health benefits. The total monosaturated fatty acids (MUFAs) were higher in the seabass. Additionally, the contents of the majority of fatty acids within the three groups (SFA, PUFA and MUFA) in the red snapper were significantly higher than those in the seabass.

Authors Shubha Vij (second row, left) and Kathiresan Purushothaman (first row, right) with the team at a red snapper mass sampling exercise at Marine Aquaculture Centre, Singapore Food Agency.

Fillet proximate analysis

A comparison of the protein level showed that the crude protein content in red snapper fillets was slightly higher at 24.6% of dry matter than in the seabass at 23.5%; however, the difference was not statistically significant. The red snapper was found to have a higher ash content (6.23% of dry matter) compared to the seabass at 4.92%, pointing to a higher mineral composition, including magnesium, calcium, potassium and zinc. No significant difference was observed in the moisture content of the two species.

GIT morphological and histological features

The research team also undertook a comprehensive analysis of the morphological and histological features of the gastrointestinal tract (GIT) which plays a crucial role in the nutrition, growth, and survival of fish across diverse environmental conditions. The GIT is instrumental in protein and lipid accumulation, which determines the nutritional quality of the fish fillets. Thus, a comprehensive analysis of the micromorphology of the GIT can offer insights into the dietary requirements of fish.

The intestine length and intestinal coefficient (IC) of teleost fishes can provide insights into their feeding patterns and habits. This study showed that the Asian seabass and red snapper had relatively low ICs of 1.1±0.04cm and 1.29±0.17cm, respectively, confirming their classification as predominantly carnivorous species.

As consumers are increasingly concerned about the health benefits of seafood, the findings from Purushothaman et al. (2024) provide valuable insights on the nutritional profile of the two species, which are regarded as the most important for aquaculture in Singapore. Studies on the GIT and their findings enhance our understanding of the dietary adaptations and nutritional quality of the seabass and red snapper, offering important implications for aquaculture practices and their dietary management.

Acknowledgements

This research was funded by the Singapore Food Agency and led by Republic Polytechnic, in close collaboration with Tropical Futures Institute, James Cook University Singapore, the Singapore Food Agency, and several local fish farms, including The Fish Farmer, Singapore Aquaculture Technologies, the Aquaculture Centre of Excellence, and Blue Ocean Harvest.

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Asian seabass farming in Andhra Pradesh, India

This fastest-growing single-species aquaculture, in ponds and cages, continues to gain momentum with market demand

By Laxmappa Boini, Suresh Pudi and Ravinder Rao Bakshi

Farming Asian seabass in ponds in Andhra Pradesh. Farmers stock large-size seabass fingerlings (80-100g) at 3,000 to 5,000/ha in ponds.

In India, the Asian seabass *Lates calcarifer* has several local names, such as *kalanchi* in Kerala, *koduvai* in Tamil Nadu, *bhetki* in West Bengal, *pandugappa* in Andhra Pradesh and Telangana. While the Indian major carps (IMC) account for about 50% of the country's farmed freshwater fish production, seabass production ranks fourth after carps, pangasius and pacu. Seabass farming was introduced under an Aquaculture Diversification plan in several regions in India.

There has been a steady rise in seabass monoculture farming at low density in ponds and cages, primarily by small, marginal and progressive farmers. Farming became popular among farmers and aquaculture entrepreneurs due to its culture traits, i.e., hardy nature, resilience to diverse habitats and high demand in the domestic and export markets. Seabass farming flourished over the years in coastal districts, particularly Andhra Pradesh, West Bengal and Kerala.

The fish is euryhaline, therefore it can survive in freshwater and marine environments, making it an ideal species to expand finfish production. The intensive production of this species through cage and open-water culture is also gaining momentum in India as the fish is popular because of its taste and white meat.

History, technology transfer and commercialisation

In 1999, hatchery technology was transferred to the Rajiv Gandhi Aquaculture Centre (RGCA), the research arm of the Marine Products Export Development Agency (MPEDA). In 2012 and 2013, this technology was further transferred to Sankar Rao Hatcheries in Andhra Pradesh and M/s Suryo Foods in Odisha. Nursery rearing and grow-out farming techniques of seabass were extensively shared with several small farmer groups and entrepreneurs in all maritime states. ICAR-CIBA and RGCA together produced approximately 4 million seabass fry per annum.

Historically in India, seabass has been cultured in brackish and freshwater by stocking wild fry in Andhra Pradesh, West Bengal, Tamil Nadu and Kerala. Several cage culture techniques have already been established by RGCA in ponds and CMFRI in open waters, leading to its farming, in Andhra Pradesh, West Bengal, Odisha, Tamil Nadu, Kerala, Karnataka and Maharashtra over the past five years.

Monoculture farming

This is the common practice where well prepared ponds are stocked with 5-10cm juvenile fish at a density of 5,000-6,000/ha. Fish grows to 800–1200g after 8-12 months of culture, producing 3-5 tonnes/ha.

Markets

One kg and above seabass sells at better prices since this is the preferred size by consumers in domestic markets. Market prices vary based on individual fish weight: fish weighing above 1.0kg sells at INR350/kg (USD4) and above, while fish less than 1.0kg sell for INR250-350/kg (USD2.9-4.0). The domestic market for seabass is mainly in the coastal districts of Andhra Pradesh. Fish is also transported to other states, including Tamil Nadu, Maharashtra, West Bengal, Kerala and Telangana.

Seabass farming in Andhra Pradesh

Seabass farming in Andhra Pradesh is the fastest-growing single-species aquaculture recorded so far in India. The species is cultured across 2,694ha, covering West Godavari, Krishna, Eluru, Konaseema and Bapatla in Andhra Pradesh. In 2024, production was around 34,000 tonnes. The primary sources of fry and fingerlings are RGCA, CIBA, MSR Aqua, Anand Hatcheries and wild sources (Table 1 and Figure 1). Machilipatnam in the Krishna district is the hub for seabass fry production, where farmers rear seabass fry to 100 to 250g sizes, to meet the specific demands of farmers throughout the state.

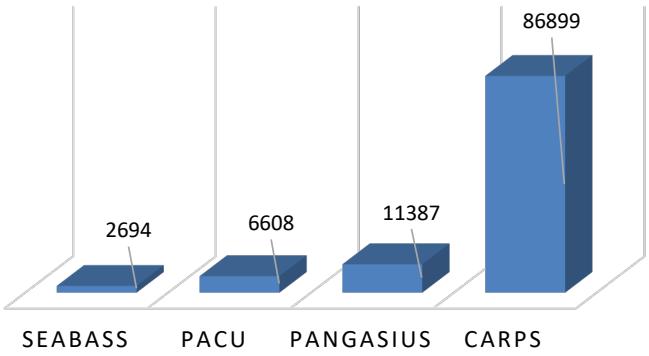

Figure 1. Major finfish aquaculture area (ha) in Andhra Pradesh.

Farming districts	West Godavari, Krishna, Eluru, Konaseema and Bapatla
Source of fry and fingerlings	RGCA, CIBA, MSR Aqua, Anand Hatcheries and wild sources.
Total production	34,000 tonnes
Value	INR12,240 million (USD 141,307 million)
Markets	Tamil Nadu, Maharashtra, West Bengal, Kerala, Telangana, etc.

Table 1. Production of the Asian seabass in Andhra Pradesh.

Farming attributes

Farmers in Andhra Pradesh usually stock large-size seabass fingerlings (80-100g) at 3,000 to 5,000/ha in ponds to achieve a productivity of 10 to 15 tonnes/ha over 15-18 months. The goal is to achieve premium prices in local markets. Currently, seabass are primarily fed live fish, such as tilapia and sardines, and also chopped fish once or twice daily. As a carnivorous fish, seabass requires high protein feeds.

Seabass is highly sensitive to changes in their environment. Therefore, it is essential to maintain optimal water quality to ensure their health and growth. Feed is an obstacle, as farmers are feeding about 6-8kg of live fish to produce one kg of live seabass. Some farmers are using pelleted feed. The cost of production ranges from INR240-280 /kg (USD2.76-3.22), while farmgate prices vary from INR360-400/kg (USD4.14-4.60). Prices fluctuate depending on the market and season (Table 2).

Parameters	
Stocking density	3,000-5,000/ha
Stocking size	80-100g
Culture duration	15-18 months
Survival rate	90-95 %
Feeding rate	4-6% body weight
Feed type	Live tilapia/trash fish and pelleted feed
Harvest type	Total harvest
Harvest weight	3-5kg
Total production	10-15 tonnes/ha
Farmgate price	INR360-400/kg(USD4.14-4.60)

Table 2. Common practices in seabass farming in Andhra Pradesh.

Seabass cage culture in Andhra Pradesh.

Conclusion

There are opportunities to increase seabass production in India. However, to increase productivity, farmers must have access to appropriate technology. After a decade of work in this area, techniques for feeding, maintaining healthy fish, and breeding are now available. ICAR-CIBA is innovating the feeding approach with specialized formulated feeds known as "Seabass Plus". These are high-protein, high-energy specially designed feeds are for the various stages of the grow-out and farming systems, such as RAS and open-water cages. Seabass Plus is a feed proven to be the best, with a feed conversion ratio (FCR) of 1.5 to 1.6.

In conclusion, seabass fish farming in India is a lucrative and sustainable sector, providing investors and business owners with many advantages. However, seabass farmers must focus on key factors that affect fish growth and health, including nutrition, fry quality, disease prevention and treatment, culture management, and marketing. Farmers can increase revenue and lessen their environmental impact by ensuring the best culture conditions and creating a powerful brand and marketing plan.

Asian seabass farming in India is set to become a more alluring investment option as the demand for seafood keeps rising. With meticulous planning and effort, investors and entrepreneurs can thrive in this fascinating industry.

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Future proofing fish aquaculture in Asia

The future needs a secure, stable, and sustainable seafood supply. A panel at TARS 2024 addressed three challenges: food security, alternative ingredients, and feed efficiency.

View of the pilot hatchery at the Marine Aquaculture Centre, Singapore Food Agency (SFA). Photos courtesy of SFA.

As global food demand continues to rise, securing a stable, sustainable seafood supply that can withstand oncoming challenges is critical. Furthermore, markets demand sustainable production models with scalable and cost–efficient production of premium quality fish. The future lies in controlled production with automation and building up support industries for the long-term sustainability of the entire industry.

Dr Daranee Sequin, Consultant, Thailand, led a panel of speakers and industry leaders to dive into selected areas in future proofing fish aquaculture. Food security is a concern and Dr Rui Gonçalves, Singapore Food Agency (SFA) shared about Singapore's aquaculture industry, where local hatcheries, nurseries and grow-out farms strengthens Singapore's food supply resilience against food supply disruptions. Linda Chen, Hatch Blue, looked at alternative ingredients to expand the aquafeed ingredient basket and Herve Lucien Brun, JEFO Nutrition, discussed concepts on future feed efficiency, environment and certification. TARS 2024 on Fish Aquaculture was held in August in Bangkok, Thailand.

Strengthening Singapore's food security

Singapore has taken strides towards strengthening food security through innovative strategies, particularly in fish supply via aquaculture. Dr Rui Goncalves, Deputy Director at SFA's Aquaculture Department, spoke on the key challenges and solutions in food security and aquaculture.

The need to increase local marine fish production

Singapore's reliance on imports makes it vulnerable to food supply disruptions, geopolitical risks, and climate change. Only 7.3% or 4,100 tonnes of its seafood demand is from local production. With only 1% of its land allocated to farming, the nation must develop advanced, space-efficient solutions such as vertical farming and aquaculture technology. Aside from land constraints, high operational costs (energy, labour, and infrastructure), rising temperatures and erratic weather impact farming conditions. "We wish to transform the current seafood industry into a highly productive, resource-efficient, and science-based industry. SFA's Marine Aquaculture Centre (MAC) overcomes this gap in Singapore as well as in the region by building up scientific expertise and strategic partnerships to develop capability for productive, climate resilient, sustainable and productive solutions in tropical aquaculture. It is mostly focussing on two species, Asian seabass *Lates calcarifer* and red snapper *Lutjanus malabaricus*."

Towards a future with focussed R&D

Singapore has a diversity of production systems in marine fish farming, such as close containment systems and high tech vertical land-based recirculation aquaculture systems, mainly for farming groupers and Asian seabass.

"In general, we work to identify the technical challenges along the production cycle and solve these directly or indirectly by academia and industry." Amongst these are improving egg and fry quality, spawning diets, and protocols. In systems optimisation, it is regarding carrying capacity in eutrophic ecosystems, and monitoring and managing nutrient discharges from farms."

Species-wise, there has been the closing of the reproductive cycle of Asian seabass and red snapper. It is F4 for the selectively bred seabass in the 20-year-old genetic selection program. Selection is for growth and disease resistance such as big belly, viral nervous necrosis (VNN) and iridovirus. In 2024, it is developing omega-3 lines to increase the value proposition for the fish. A future target will be the optimisation of fish spawning with oral delivery of encapsulated hormone in broodstock diets for the seabass and snapper.

Gonçalves commented, "The commercialisation of fast-growing Asian seabass strains is progressing but requires time. The next three to four years will be crucial for scaling up these initiatives, ensuring that genetic advancements translate into tangible industry benefits."

Advances in hatchery included the change from extensive outdoor culture systems with survival of 5% to intensive flow-through indoor system with 50% survival rates. "Nowadays, it is a standard with our protocols to have at least 50% survival in either indoor flow through systems or in RAS stocking at 30,000 fry/m^3. Note that we still consider this survival as low. In 2024, we managed to increase density to 60,000 fry/m^3 with the same survival rate." This work at the joint SFA-INVE Hatchery Technology Centre is on the optimisation of larvae, fry

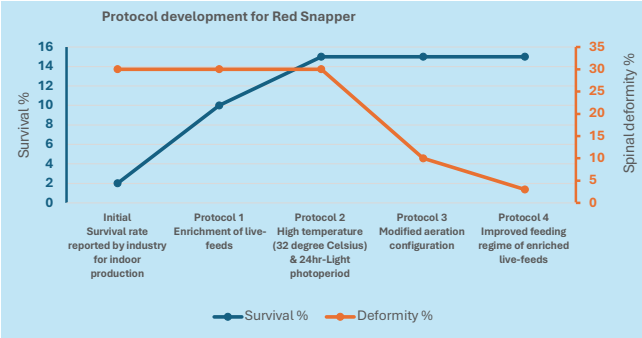

Figure 1. Some outputs in development rearing protocols for the red snapper *Lutjanus malabaricus* at the Marine Aquaculture Centre, SFA. Source: Sustainable Aquaculture Production in Singapore: A Vision towards Food Security by Rui A Gonçalves at TARS 2024, August 14-15, Bangkok, Thailand.

and weaning protocols which Gonçalves emphasised, is learning from practices in Europe and applying them to tropical species like the Asian seabass.

In the development of hatchery technology for the red snapper, a restriction is shock syndrome occurring at 15 – 25dph (days post hatch) and cannibalism at >18dph. "We achieved accelerated growth and reduced shock syndrome through managing water temperature and light regime during the critical phase. It is not only genetic selection, which is time consuming but also optimisation of hatchery protocols. It has taken us two years to achieve up to 15% survival from 1-2%, and reduce spinal deformity from 25% to 2-3 % through managing water environment and feeding regime," said Gonçalves, adding that the next steps will be on broodstock improvements, rearing protocols to further improve fry survival rates, increase density and namely live feed in early nutrition (Figure 1).

"The message was that there is a large market for various marine species and in parallel, huge economic opportunities."
– Rui Gonçalves

Investments in R&D

Gonçalves introduced AquaPolis, an aquaculture R&D programme to support Singapore's ambition of becoming a leading research and innovation hub for sustainable tropical aquaculture. AquaPolis brings scientists and industry together to develop solutions to real challenges faced by Singapore's farms, so as to enhance their productivity and fish quality.

The message was that there is a large market for various marine species and in parallel, huge economic opportunities. There is considerable work to be done, requiring large investments. Therefore, the focus on two species, and within them, in three main areas, genetics and hatchery technology, and in nutrition and production.

"I believe the secret to our success thus far is collaborating on R&D with academia and industry, instead of just working in a silo. Singapore aims to build a resilient and self-sufficient food system that can withstand future challenges. Working together is key to boost local food production."

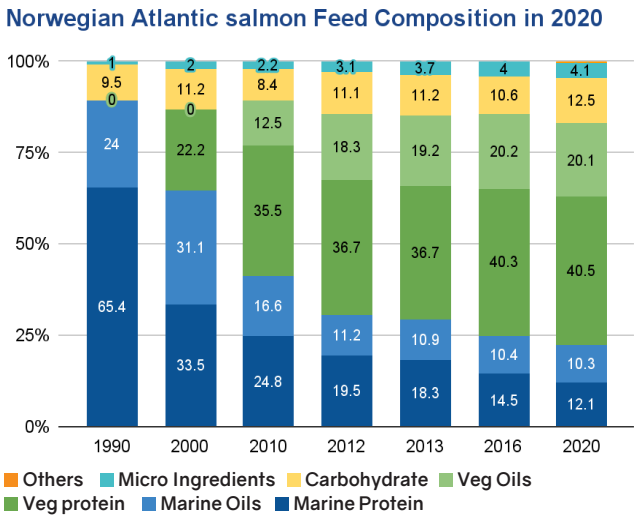

Figure 2. Sources of feed ingredients (% of feed) in Norwegian salmon feed in 2020 compared to previous years (Aas et al., 2019, Ytrestøyl et al., 2015). Source: (modified from) Synnøve T, Åsgård T, Ytrestøyl T. Utilisation of feed resources in the production of Atlantic salmon (*Salmo salar*) in Norway: An update for 2020. Aquaculture Reports. 2022; 26:101316.

Dr Daranee Seguin, Consultant, Thailand (left) led a panel of speakers and an industry leader to dive into selected areas in future proofing fish aquaculture. From right, Robert Redman, Market Development, Veramaris; Cameron Maclean, Aquaculture Management, Singapore; Dr Rui Gonçalves, Singapore Food Agency; Linda Chen, Hatch Blue and Herve Lucien Brun, Jefo Nutrition. TARS 2024 on Fish Aquaculture was held in August in Bangkok, Thailand. Maclean discussed empowering Indonesia's small scale tilapia farmers with market access and group certification.

Innovating aquafeeds with emerging protein rich ingredients

As demand for sustainable and high-quality aquafeed grows, innovating emerging ingredients as they become available into formulations are becoming crucial. Based on a recent market report, "The Emerging Protein-rich Ingredients for Aquaculture Market," **Linda Chen**, Associate at Hatch Blue, shed light on current trends, challenges, and opportunities in aquafeed development and alternative protein sources. "To meet the 109 million tonnes of aquafeed production projected by 2030, we will need to accelerate the inclusion and commercialise some of the aquafeed ingredients. This was the basis of this year long research. We wanted to understand what is currently out there, what new ingredients are coming to market, and how mature the production is."

The shift in aquafeed Ingredients

Historically, fishmeal was the primary protein source for aquafeed. However, sustainability concerns and cost constraints have led to a dramatic shift towards plant-based and alternative protein sources. In farming the Atlantic salmon, fishmeal inclusion in feeds dropped from 65% in 1990 to just 12% in 2020, while plant-based proteins increased to 40.5% (Figure 1). The inclusion of novel ingredients is on the rise. Skretting increased inclusion rate of novel ingredients from 0.064% to 1% in 2022. By 2030, BioMar predicted a utilisation of around 30% of novel ingredients in Norwegian aquafeeds. According to Nofima, Norway introduced 8,126 tonnes of insect meal, single-cell proteins, fermented products, and microalgae into 1.98 million tonnes of salmon feed, marking a small (0.4%) but significant step toward sustainable feed solutions.

Emerging ingredients in the market

Chen explained that the goal was to understand what the most competitive ingredients are, and which have high potential for aquafeeds at volume in recent years. "Underlying inclusion are four criteria - digestibility and palatability, sufficient volume of ingredients for grow-out feed production, low environmental footprint, and lastly, it's all about price," said Chen. "It is not advocating replacing of existing ingredients but having ingredients in the basket which are complementary to produce the optimal feed for a farm species."

The report assessed nine different ingredients which are currently in market for aquafeeds, and some are coming online into aquafeeds (Figure 3). The top three with highest potential are all plant-based: corn fermented protein, fermented soybean meal, and barley protein concentrate at production levels of 900,000 tonnes, 200,000 tonnes and 55,000 tonnes (Figure 2). Chen mentioned insect meal and methanotrophic bacteria meals (single cell proteins) which require capital and efforts to ramp up production. This shift has prompted research into competitive, protein-rich ingredients that balance cost, nutrition, and environmental impact.

Innovation trends in aquafeed

The emerging ingredient market follows three primary trends:

- Improved protein extraction which is converting low-quality raw materials into high-value ingredients by reducing anti-nutritional factors.
- Repurposing existing processes by utilising commercial processes from the 1990s to develop new feed ingredients.
- Genetic enhancement by modifying crops to increase protein yields for aquafeed applications.

Challenges in market-wide adoption

Despite the potential of these emerging ingredients, widespread inclusion in aquafeed has been slow due to several factors such as engineering and biological limitations making large-scale production difficult. Securing investment for alternative proteins remains a challenge due to high risk and limited capital, and lastly, farmers and feed producers require extensive research, growth trials, and demonstrated consistency before adopting new ingredients.

"Underlying inclusion are four criteria - digestibility and palatability, sufficient volume of ingredients for grow-out feed production and lastly, it's all about price," said Linda Chen.

Ingredient	Current Volume	Volume Potential	Cost/T	Capex/T	Price/T	Crude Protein	Digestibility
Definitions	"1 – <1,000 MT/yr 2 – 1,000–10,000 MT/yr 3 – 10,000–100,000 MT/yr 4 – >100,000 MT/yr"	"1 – < 100,000 MT/yr 2 – 100k–1m MT/yr 3 – 1m – 5m MT/yr 4 – > 5m MT/yr"	"1 – $100–500 2 – $500–1,000 3 – $1,000–2,000 4 – >$2,000"	"1 – $100–500 2 – $500–1,000 3 – $1,000–2,000 4 – >$2,000"	"1 – $500–1,000 2 – $1,000–1,500 3 – $1,500–2,000 4 – >$2,000"	"1 – 50–55% 2 – 56–60% 3 – 61–65% 4 – 66–70% "	"1 – <85% 2 – 85–88% 3 – 89–92% 4 – >92%"
Corn Fermented Protein	4	4	1	2	1	1	2
Fermented Soybean Meal	4	2	NA	NA	3	2	1
Barley Protein Concentrate	3	3	1	2	2	2	4
Insect Meal	3	4	4	4	4	3	1
Methanotrophic Bacteria	3	4	3	4	3	4	2
Mycelium	2	4	NA	NA	3	3	2
Grass Protein Concentrate	1	4	2	2	1	1	2
Canola Protein Concentrate	1	3	2	NA	2	4	3
Mixed Nut Meal	1	1	3	2	3	2	3

Figure 3. Comparison between ingredients of interest. Source: The Emerging Protein-rich Ingredients for Aquaculture Market Report, Hatch Blue and Hatch Innovation Services, Ireland, 2024. Presented by Linda Chen on Emerging Protein-rich Ingredients for Aquaculture, TARS 2024, August 14-15, Bangkok, Thailand.

Future feed efficiency, environmental issues and certification

Aquafeed nutritionists aim to optimise feed efficiency, reduce costs, and ensure fish growth and health while considering the environmental impact of feeds. Consumers in the US and Europe are particular about the latter aspect, and this trend may extend to consumers in China in the future. **Herve Lucien Brun**, JEFO Nutrition Inc, Canada, said that fishmeal is the ideal protein, although it is one of the most expensive feed components and is deemed unsustainable. "Land animal proteins in feeds face poor consumer acceptance. Our alternative sources are plant protein meals."

Digestible protein

Often the crude protein content is the main concern among feed millers. Lucien Brun emphasised that non-digestible proteins are not metabolised during digestion; they are expensive and pollute aquatic ecosystems. "What is important is the digestible protein ratio and the amino acid profile. We use protease, an exogenous enzyme, as a solution for improving protein utilisation, which then reduces the percentage of non-digestible protein and minimises environmental impact."

The benefits of protease addition into feeds include the use of cost-effective alternative protein meals, and optimisation of crude protein within them, which then leads to improving feed conversion ratio (FCR) for better fish growth rates and profitability. Reduction in nitrogen output minimises environmental impact.

Optimising feed efficiency

Studies on trout, tilapia, and striped catfish demonstrated significant benefits from protease supplementation, including improved growth performance, cost savings, and better water quality. Protease allows feed producers to optimise plant-based protein inclusion while maintaining efficiency and sustainability. Lucien Brun discussed highlights from these studies.

Trout *Oncorhynchus mykiss* was fed diets containing 30% of a test ingredient and 70% reference diet. The broad range of improvements in apparent digestibility coefficients (ADC) of nutrients such as soybean meal and canola meal showed the capacity of the protease enzyme to break down proteins to peptides and amino acids and allow formulators to substitute fishmeal.

A trial in Vietnam with the snakehead showed that by adding the protease to a 14% fishmeal diet, the weight gain was equivalent to fish fed a 40% fishmeal (FM) diet. This was related to better protein efficiency ratio (1.17 for fish fed the 40% FM diet versus 1.15 for those fed14%FM+protease). The fish fed with 14%FM +protease were also more homogeneous in terms of average individual weight. "The absence of small size fish at harvest in the group fed the 40%FM + protease diet gave significant cost savings for both feed manufacturers and farmers," said Lucien Brun.

Certification for the tilapia

"Particularly for the tilapia, protein retention efficiency (PRE) and feed fish equivalent ratio (FFER) are important criteria for certification bodies such as the Aquaculture Stewardship Council (ASC) and Best Aquaculture Practices (BAP). ASC sets the FFER limit of 0.81 for the tilapia. This is to minimise environmental impact of fish production and use of fishmeal in feeds," said Lucien-Brun. In trials with tilapia, PRE of diets with protease supplemented to diets with no fishmeal was close to diets with 60% fishmeal.

The challenge for tilapia farmers in Colombia's Lake Betania is environmental degradation and diseases. Trials with the tilapia showed that supplementation of commercial feeds with protease improved PRE, from 68.3% to 74.0%, and optimised the feed conversion ratio (FCR) to 0.80 from 0.92, thereby lowering production costs. "This lowers the level of non-digestible protein in the feed, which in turn significantly reduces the level of nitrogen released into the aquatic environment, improves farm water quality, and complies with the certification standards as demanded by consumers."

"The absence of small size fish at harvest in the group fed the 40%FM + protease diet gave significant cost savings for both feed manufacturers and farmers," said Herve Lucien Brun.

Kim Tran, Grobest, Vietnam questioned data on digestibility used for alternative ingredients since there are many fish species.

Okdivina Sitepu, Logistics and Transportation Manager from Regal Springs, Indonesia, expressed concerns about whether alternative protein sources would affect feed palatability.

Adam Naylor, Sales Director, Jefo Nutrition (fifth, left) and participants.

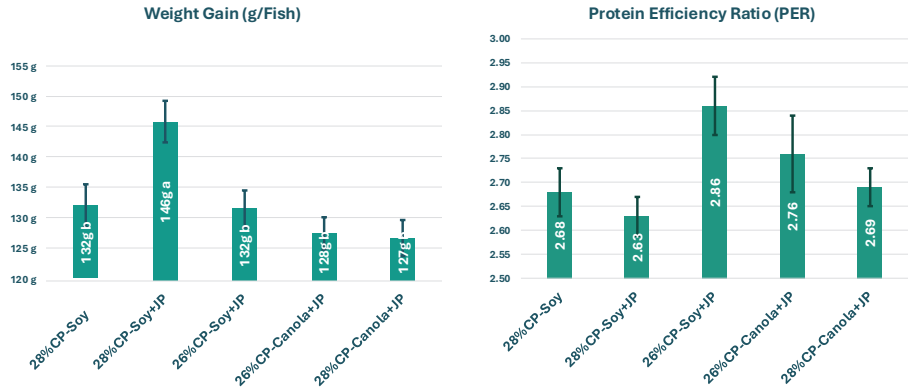

Figure 4. Results from trials to assess the benefits of protease enzyme supplementation toproduce more economic fish diets by reducing dietary protein content of feeds. Source: Future Feed Efficiency, Environmental Issues and Certification by Herve Lucien Brun, TARS 2024, August 14-15, Bangkok, Thailand.

Lastly, a trial with the pangasius in Vietnam, replaced soybean meal with the cheaper canola meal. Based on the growth performance and feed utilisation, catfish fed a 28% crude protein diet from soybean meal with added protease outperformed other treatments. A 26% CP diet with soybean meal, canola meal and protease gave growth comparable to the 28% CP-Soy diet (Figure 4). Overall results suggested that canola meal could be used at 5% in diets supplemented with protease enzyme; this allows a significant reduction in production costs without impacting performances.

The panellists commented on various topics, including digestibility in feed ingredients. Collaboration opportunities between research centres and private companies, and advances in protease applications for improved protein efficiency. They also addressed the broader ambitions of SFA and challenges within the Asian market.

Digestibility profiles of feed ingredients

Nutritionist Dr Kim Tran, Grobest Vietnam questioned how digestibility is calculated for alternative ingredients, given that different species such as pangasius and shrimp may exhibit varying digestibility profiles. Chen had used digestibility values based on the salmon as there is limited data available for shrimp and acknowledged the variability in digestibility across species and emphasised the need to take averages when presenting data to avoid bias. “Actual digestibility values could be much higher on a case-by-case basis. This reinforces the importance of further research in this area.”

Profitability and sustainability

Lucien-Brun noted that the aquaculture industry is shifting from high-margin operations to cost-conscious production, similar to what occurred in the poultry industry years ago. While acknowledging that fishmeal remains the best protein source, he said, “Alternative solutions, including amino acids for palatability, must be explored in collaboration with feed millers to ensure optimal feed formulations.”

While improved farm management could also lead to better protein efficiency, Lucien Brun commented, “ASC certification includes criteria related to the protein efficiency ratio, and protease applications can help meet these requirements. As certification standards evolve, efficiency improvements from protease use will likely become integral to certification processes.”

To be a centre of excellence for the region?

The discussion then shifted toward Singapore’s role in regional aquaculture. Will Singapore position itself as a centre of excellence for Southeast Asia, similar to how Italy supplies fingerlings to Malta in the Mediterranean? “While Singapore’s vision extends beyond its domestic needs, given its small land area and limited production capacity, the country’s priority is to import and share knowledge with the broader region,” said Gonçalves. “When we address knowledge gaps in species such as sea bass and snapper, such information will benefit our neighbours too.

Private investment in aquaculture

The panel delved into whether the organisation can step in to create a scalable production model that could attract private investors? The idea was that demonstrating a viable model would encourage investors to replicate it in Singapore and neighbouring countries. Gonçalves agreed that some areas within the aquaculture value chain require government intervention, particularly when they require high investment, such as broodstock development. While the private sector plays a crucial role, early-stage support is necessary to establish a foundation for sustainable production.

Insights from salmon farming

Robert Redman, Veramaris provided some insights into lessons from the salmon industry that could be applied to Asian aquaculture. “The salmon industry has navigated challenges that Asia will inevitably face. By analysing what are the challenges, where and how salmon producers overcame the hurdles, how salmon producers overcame hurdles, Asia’s aquaculture sector can accelerate its growth.” He highlighted some key areas of opportunity: marketing (either as a product or branded, utilisation of new materials, systems to improve transparency along the supply chain and support for small farmers to achieve scale. An example from salmon is a grouping of about 40 smaller salmon producers in Norway to form a cooperative to achieve economies of scale in areas such as feed supply.

However, he cautioned that integrating higher-value fish into Northern Hemisphere retail chains requires meeting new quality and certification standards.

How China's appetite for salmon could reshape global seafood markets – new research

By Dave Little and Mausam Budhathoki

A worker processing imported fresh salmon in a Beijing wholesale seafood market. Photo credit: Dave Little

China's demand for farmed salmon is growing at an unprecedented pace. In 2023, its imports grew by 46% year on year – with imports of fresh and chilled Atlantic salmon up 63%. According to the General Customs of China, China imported nearly 93,000 tonnes of Atlantic salmon in 2023 and for import of fresh and chilled Atlantic salmon, it was 80,126 tonnes (FAO Globefish, 2024). This remarkable growth is reshaping the global seafood trade. Exporters from Scotland, Norway, Chile, Australia, Faroe Islands, Canada, and Iceland are racing to supply the needs of this vast and rapidly evolving market.

At the same time, China's efforts to produce its own Atlantic salmon have faced significant challenges, highlighting the need for substitutes like rainbow trout to meet the country's growing appetite for seafood delicacies.

An important shift occurred in 2018, when the Chinese government permitted rainbow trout to be labelled and sold as salmon. This decision blurred the distinction between imported Atlantic salmon and locally farmed rainbow trout, creating a more accessible option for cost-sensitive consumers.

Trout is comparable to salmon in appearance and size, with firm and oily meat that has a similar orange-pink colour. Nutritionally too, the species are alike, as are the ways in which they can be cooked and prepared.

In our new research (Budhathoki, et al., 2024) which included taste tests, we found that many Chinese consumers could not distinguish between domestic rainbow trout and imported Atlantic salmon in blind testing. But when informed about the origin, testers' preferences shifted strongly in favour of imported Atlantic salmon, highlighting the power of provenance in consumer tastes.

Although people's willingness to pay did not vary initially in our blind tests, it became a decisive factor once the origin of the fish was revealed. But we found that origin alone was not enough. For our testers to be prepared to pay higher prices, they also had to like the look, smell and taste of the product more, or be persuaded by its ecolabel (indicating environmental standards).

Environmental costs

Transporting Atlantic salmon from Scottish lochs, Norwegian fjords or Chilean waters to Chinese markets involves complex logistics and significant environmental costs. The carbon footprint of this trade, combined with the resource-intensive nature of salmon aquaculture, raises critical concerns about sustainability.

These challenges are particularly pronounced in China, where consumers have a strong preference for freshness. This drives demand for quick delivery of imported salmon despite its environmental impact, and consumers are increasingly turning to online platforms to buy their seafood.

E-commerce has reshaped seafood retail in China, offering quick delivery and products that cater to consumer demand for quality and freshness. Salmon stands out in this market due to its perceived high value, premium quality, and price point. Unlike other expensive seafood that often needs to be sold live to maintain its value, salmon retains its appeal when chilled or frozen.

This makes salmon particularly suited to modern retail models, where sophisticated cold-chain logistics ensure its freshness without the complexities of live transport. However, these innovations come at a cost. The energy-intensive storage and rapid transportation required for imported salmon contribute significantly to environmental harm. As China's seafood market continues to grow, addressing the sustainability challenges associated with this trade will be critical to balancing consumer demand with environmental responsibility. Current international certification schemes aiming to improve the sector's sustainability have had limited impact in China so far.

China has made significant efforts to establish a domestic Atlantic salmon industry, but these attempts have largely been unsuccessful due to technical challenges and environmental constraints. This has left a gap that domestically farmed rainbow trout is poised to fill.

In 2022, China produced 37,000 tonnes of rainbow trout (Budhathoki, et al., 2024). This is a relatively small amount compared with international production levels, but still notable considering that rainbow trout is a new farmed species in China, unlike traditional species like carp.

However, rainbow trout farming in China is geographically constrained, as the species thrives in cooler freshwater temperatures found in higher-lying lakes and reservoirs, as well as in "raceways" (channels supplied continuously with fresh water diverted from rivers).

Advances in aquaculture systems offer a potential pathway to expand China's production. Trout farming is a more sustainable, locally sourced alternative to Atlantic salmon that reduces the carbon footprint associated with imports and ensures fresher options for Chinese consumers. Developing a robust domestic trout industry could enhance food security, reduce dependence on imports, and create economic opportunities in rural areas.

China's evolving seafood market offers valuable lessons for the global industry. Emphasising quality, freshness and sustainability will resonate with the increasingly sophisticated Chinese consumer.

At the same time, investment in eco-friendly aquaculture practices, both domestically and internationally, will be essential to balance the growing demand for premium seafood with environmental responsibility. These could include reducing feed waste and recirculating aquaculture systems (which filter and reuse water) to minimise water use. Recycling waste nutrients by using them elsewhere in food production could also be key.

As rainbow trout gains prominence in China's seafood landscape, the relationship between consumer preferences, environmental concerns and economic opportunities could in turn shape the future of the global salmon trade.

If domestic fish captures a larger share of the Chinese market, salmon producers in Europe, Canada and other exporting regions may face significant challenges. This could ultimately force them to rethink their strategies in order to adapt to shifting market dynamics. Although the goal of creating a domestic Atlantic salmon industry has proved difficult for China, trout farming presents a practical and sustainable solution for its luxury seafood sector.

The article was first published online in The Conversation (https://theconversation.com)

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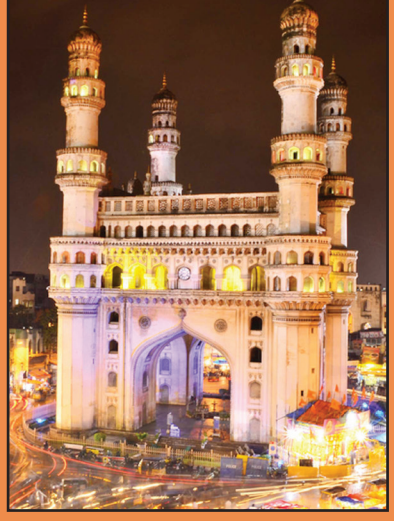

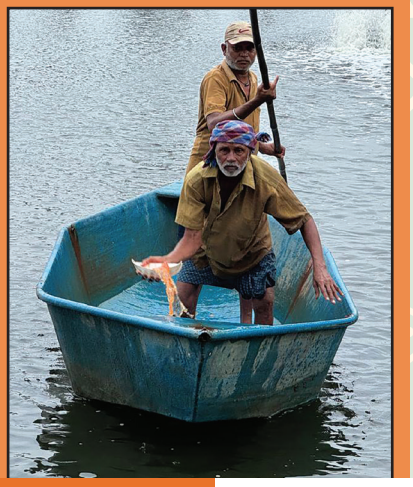

Aquaculture: Opportunities, Options, and Optimism

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Sustainable bioactive peptides for enhanced aquaculture nutrition

Marine Biotech Vietnam in Long Anh province is a state-of-the-art facility producing dry hydrolysate protein powders for the Asian feed and pet food sectors.

In pursuit of innovation, **Aquaproducts** recently introduced PEPTITOM, an advanced shrimp hydrolysate powder designed for both aquaculture and livestock markets. This product redefines the use of marine resources in feed formulations, aligning with the company's core values of quality, sustainability, and efficiency. Derived from underutilised shrimp by-products, it offers a unique source of functional peptides, and a highly digestible, nutrient-rich feed solution for aquatic animals and livestock, helping to reduce waste while boosting animal nutrition.

Aquaproducts is a leading specialist in marine bio-extracts and a pioneer in sustainable seafood by-product processing. Through strategic alliances with global industry leaders, Norway's Scanbio SAS and Indonesia's Maqpro Biotech, the company has built a strong, environmentally responsible supply chain for functional marine proteins.

In 2022, Aquaproducts expanded its operations by launching Marine Biotech Vietnam (MBV) in collaboration with the Mirova Sustainable Ocean Fund. Officially inaugurated on June 11 2024 at Vinh Loc 2 Industrial Park, Long An, this state-of-the-art hydrolysate facility specialises in producing dry hydrolysate protein powders for the Asian feed and pet food sectors, reinforcing its position as a key provider of sustainable, high-quality marine ingredients in the region.

Functional benefits in aquaculture

This novel functional ingredient is designed for marine fish species, supporting nursery and early developmental stages. Beyond basic protein supplementation, it provides essential functional benefits that enhance feed intake, digestion, and nutrient absorption, leading to efficient growth during critical early stages.

Its rich composition of bioactive peptides and free amino acids acts as biological regulators within the gastrointestinal tract, intestinal epithelium, and systemic circulation. However, bioavailability and physiological impact depend on precise hydrolysis conditions, including enzyme selection, pH, temperature, and time. The degree of hydrolysis and molecular weight distribution directly influence their bioactivity, ensuring PEPTITOM delivers optimised nutritional and functional benefits.

The uniqueness of its peptide profile provides strong antioxidant and antimicrobial properties, reducing oxidative stress and protecting fish from bacterial infections. This dual roles in boosting immune defence and improving overall health make it an excellent option to increase functionality in aquaculture diets.

Fish fed shrimp hydrolysate have shown improved digestibility and nutrient absorption linked to better intestinal health, seen in improved intestinal morphology, enterocyte height, villi length, and goblet cell number. In addition, high digestibility ensures optimal nutrient utilisation, supporting faster growth while helping aquatic animals cope with environmental stress and feed transitions.

PEPTITOM's formulation aims to increase survival rates, stimulate feeding responses, improve productivity, and boost overall feed performance through a balanced mix of low molecular weight compounds, with over 90% of peptides measuring below 1,000 Da.

Palatability

Palatability and feed attractiveness are crucial in aquaculture nutrition, enabling higher and consistent feed consumption to improve nutrient utilisation, support optimal growth, and reduce feed waste.

PEPTITOM has balanced mix of low molecular weight compounds, with over 90% of peptides measuring below 1,000 Da.

This not only enhances water quality in culture ponds by minimising nutrient leaching but also lowers feeding-related stress, thus improving overall well-being. Given that feed costs represent almost 60% of variable expenses in aquaculture, ensuring high palatability and efficient feed utilisation are vital for cost savings, better feed conversion ratios, and overall profitability. PEPTITOM contains key attractants such as free amino acids (glycine, arginine, glutamic acid, and alanine), organic acids, and small peptides, all of which play a role in enhancing feed intake and digestion efficiency.

Quality and sustainability at its core

PEPTITOM reflects Aquaproducts' larger mission to up-cycle seafood by-products using cutting-edge technologies. The hydrolysate powder is produced through a controlled batch hydrolysis process using selected enzymes, which allows for precise peptide control and quality standardisation. This stands in contrast to continuous hydrolysis methods that may yield less consistent results.

Strict control over raw material freshness and supply chain allows to keep histamine and total volatile basic nitrogen (TVBN) levels low, thus extending product shelf life. Further ensuring the product's quality, it undergoes a pasteurisation step in compliance with hazard analysis and critical control points (HACCP) standards to guarantee food safety and maintain a high standard of freshness.

Furthermore, this ingredient aligns with sustainable aquaculture practices as an environmentally responsible alternative to traditional animal protein sources. By utilising underutilised shrimp by-products, it helps reduce pressure on marine ecosystems while delivering a high-quality, functional feed ingredient for the industry.

Economic advantages

Aquaproducts' commitment to regional sourcing offers a reliable product supply for both local and regional markets. This consistent availability allows farmers and feed producers to depend on steady volumes and competitive pricing, leading to better planning and cost management.

Additionally, cost efficiency is at the heart of its product development. By adapting an innovative drying process for marine hydrolysate using a carrier, production costs are significantly reduced, and hygroscopicity is minimised, thus preventing caking. This presents a notable advantage over more expensive pure spray-dried hydrolysates, ensuring that this shrimp peptide concentrate remains an economically attractive option without sacrificing performance.

The future of functional feed ingredients

The company continues to play a pivotal role in reshaping the feed industry with its marine hydrolysate product range. By leveraging sustainable seafood by-products and transforming them into high-value, functional ingredients, the company is not only reducing waste but also contributing to the health, productivity, and sustainability of global food systems.

PEPTITOM exemplifies how Aquaproducts continues to lead the charge in marine bio-extract innovation, and how it advances the industry toward more sustainable and responsible resource use. The company's ability to innovate at scale, combined with its focus on local partnerships and supply chain stability, will ensure that it will remain a key player in the feed and pet food markets for years to come. (aquaproducts.org)

Thomas Levallois, Co-Founder & Director (third left), Teddy Nyoto (second right) and the team from Maqpro Biotech Indonesia at the Aquaproducts booth during VIV Asia 2025 in March.

Hydrolysates producers are joint winners of F3 Challenge on krill replacement

Marcel Sacco of BRF Ingredients (left) and Vincent Fournier of Symrise (right) accept their F3 Krill Replacement Challenge award for their top performing krill replacements during the Opening Plenary Session on March 7 at the World Aquaculture Society's Aquaculture 2025 Meeting in New Orleans, USA.

During the opening plenary session on March 7 at the World Aquaculture Society's Aquaculture 2025 meeting in New Orleans, USA, **F3 – Future of Fish Feed** announced BRF Ingredients and Symrise as joint winners of the top performing two global companies offering promising krill alternatives for aquaculture feed.

"The F3 Krill Replacement Challenge has highlighted the incredible innovation and potential within the aquaculture industry, demonstrating that there are multiple solutions to replace krill," said Kevin Fitzsimmons, chair of the F3 - Future of Fish Feed Initiative and professor and director of International Initiatives at the University of Arizona. "These alternatives will help protect our oceans while ensuring the continued growth of aquaculture."

Symrise won for their protein hydrolysate ingredients and BRF Ingredients for their chicken hydrolysate. The winning companies shared the USD100,000 grand prize. These two companies' products emerged as the top performing krill replacements in a 12-week feed trial on Atlantic salmon, demonstrating superior growth, feed consumption, and survival rates. The two winners were chosen from 10 finalists, who were themselves selected from 40 global companies that entered the F3 Challenge to test their krill meal alternatives to offer innovative solutions that could transform feed production and reduce the environmental impact of traditional krill sourcing. Testing was performed to confirm all products being used in the trial were free of marine animal ingredients.

Winning hydrolysates

BioActio Health & Performance is BRF Ingredients' chicken hydrolyzed protein, an ingredient rich in scientifically proven functional bioactive peptides. Produced through the enzymatic hydrolysis process of chicken raw material proteins (offal, giblets and chicken meat), it is an ingredient that promotes maximum performance and health, as well as being hypoallergenic.

"For us at BRF Ingredients, this recognition reinforces our commitment to feed the world with sustainable, high quality and global standard Ingredients. We congratulate all participants while celebrating our hydrolyzed products team's technical skills and talent," said Marcel Sacco, vice president of marketing and new channels at BRF Ingredients.

Symrise Aqua Feed leads the development of aquaculture feed ingredients, to reduce reliance on wild-caught proteins, including a functional hydrolysates support plant-based protein solutions for aquaculture, improving feed performance and sustainability.

"As a firm believer in the immense potential of byproduct valorization, I see this award as a testament to our ability to develop natural ingredients from circularly sourced raw materials," said Vincent Fournier, R&D Manager, at Symrise Aqua Feed. This innovation enables us to replace wild and endangered species like krill in feed formulations, contributing to a more sustainable global food production footprint."'

In addition, the F3 judges awarded honourable mentions to three companies for their exceptional performance as promising krill replacements: China-based Calysseo (single-cell protein), Netherlands-based Orffa Additives (amino-acid extract) and France-based Phileo by Lesaffre (yeast extract).

The F3 Krill Replacement Challenge, the fourth in a series of aquaculture-industry focused feed contests hosted by the F3 Initiative, was designed to spark innovation for alternatives to krill in aquaculture feed. This challenge was inspired by feed companies, particularly from China, who suggested finding alternative attractants and palatants would significantly assist in the transition to "fish-free" feed.

These krill replacement products have the potential to greatly benefit a wide range of farmed seafood producers seeking to improve the performance of "fish-free" feeds, making these alternatives a promising solution for enhancing feed quality and appeal. The environmental impact of sourcing marine ingredients for animal feed, pet food, and nutraceuticals has raised concerns among environmental advocates and the public, highlighting the urgent need for sustainable alternatives to wild-caught forage fish and krill, a critical priority as the global demand continues to rise.

Overfishing, climate change, and industrial harvesting have strained krill stocks, threatening their role as a key food source for many marine species. More sustainable alternatives are essential to reduce reliance on krill, protect ocean biodiversity, and ensure the future of aquaculture without further depleting ocean resources.

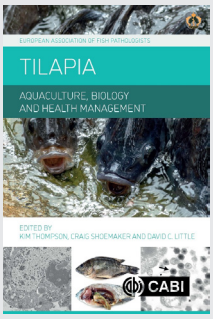
The F3 Initiative was founded on the belief that the ocean's current fish stocks are insufficient to meet the needs of a growing global population, and that the development of innovative aquaculture feed ingredients is essential to secure a sustainable, food-secure future. The first three contests focused on eliminating wild-caught forage fish in feed. krill.f3challenge.org

The F3 – Future of Fish Feed is set to announce its next competition, focused on whole fish farm production, in the summer of 2025.

Tilapia

Aquaculture, Biology and Health Management

By Kim Thompson, Craig A. Shoemaker, David C Little



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ePub: eISBN : 978-1-80062-945-5, 880 pages,2025

As a thorough exploration of tilapia aquaculture, this book emphasizes the significance of this group of fish and discusses the crucial elements of tilapia farming, including their reproductive and genetic characteristics, the various cultivation systems employed and the emerging governance of the practice. It also addresses important health management issues, focusing on nutrition, immunology, and animal welfare and extensively analyses the diseases affecting tilapia, how they are diagnosed and what potential zoonotic hazards exist.

The value of the book includes:

- Contributing to the wider understanding of tilapia aquaculture and the importance of the species to global food security.
- Providing an in-depth discussion on tilapia fish health, including major diseases, nutrition, immunology and disease prevention.
- Giving detailed insights into tilapia genetics, production systems, and reproduction.
- Written by an international team of experts to advance the long-term, sustainable growth of the global aquaculture industry, this book is a comprehensive and essential resource for anyone involved in or learning about tilapia farming.

Chapters are available for purchase at https://www.cabidigitallibrary.org/doi/book/10.1079/9781800629455.0000

There are 13 chapters:

- An introduction to the tilapias - Roger S. V. Pullin
- Tilapia as an aquaculture species - Junning Cai
- Reproduction and juvenile production - David C. Little, Warren A. Turner, Halina Sobolewska, Alastair Hamilton, Andrew P. Shinn
- Tilapia farming systems - Ram C. Bhujel
- Tilapia as human food - Ian Goulding
- Nutrient requirements of tilapia - D. Allen Davis, Darci Carlos Fornari, Waldemar Rossi Jr
- Tilapia immunology and immunostimulation - Kim D. Thompson
- Tilapia welfare - Carlos Garcia de Leaniz, Sonia Rey Planellas
- Tilapia bacterial diseases - Esteban Soto, Taylor I. Heckman, Gustavo Ramirez Paredes, Divya Rose, Matt J. Griffin, Thomas P. Loch, Benjamin R. LaFrentz, Alvin C. Camus
- Tilapia viral diseases - Saengchan Senapin, Janina Costa, Kim Thompson, Ha Thanh Dong
- Disease diagnosis for tilapia pathogens - Partho Pratim Debnath, Nopadon Pirarat, Kim D. Thompson, Channarong Rodkhum
- Concurrent infections of tilapia - De - Hai Xu, Craig A. Shoemaker
- Tilapia-borne zoonoses - Ruth Zadoks, Joke van der Giessen, Olga Haenen
- Histopathological maps of infectious diseases in tilapia - Ha Thanh Dong, Jorge del-Pozo
- Health management of tilapia from a farm perspective - Annette Simone Boerlage, Mona Dverdal Jansen
- Progress and challenges in vaccine development for farmed tilapia - Hetron M. Munang'andu
- Certification in tilapia health management - Francis Murray

CRO in Bangladesh for livestock and aquaculture

Maverick Innovation, located in the Gazipur district of Bangladesh, is a state-of-the-art research facility established in 2022.

Maverick Innovation, located in the Gazipur district of Bangladesh, is a state-of-the-art research facility established in 2022 by Dr Kabir Chowdhury, with the aim to evaluate novel ideas and technologies in the culture of aquatic and terrestrial animals. This is the only global contract research organisation (CRO) that facilitates the work on both terrestrial and aquatic animal research.

Chowdhury described his journey, "Seeking novel solutions to the existing problems or exploring unconventional ideas is in my DNA. I had travelled the world over the last 15 years and had the opportunity to visit many research facilities. In my previous job, my region of focus was the South Asian region, and I realised that there is a serious need for a well-established animal research facility in Bangladesh and the South Asian region."

He added, "In the absence of well-established and dedicated animal research facilities, local and regional nutritionists and formulators often need to rely on the information provided by the ingredient suppliers. Although in-vitro test of various ingredients may be possible by sending samples to an accredited laboratory in Singapore or Thailand, conducting reliable *in vivo* tests is almost impossible. I think at Maverick Innovation, with our dedication and expertise, and global network, we can fulfil this need by engaging and being a bridge between industry and academia."

Chowdhury has more than 30 years of experience in the field of aquaculture and aquaculture nutrition and is recognised internationally for his expertise. Upon completion of his PhD and a brief stint as post-doctoral fellow at the University of Guelph, Canada, he joined Jefo Nutrition Inc., a Canadian based global leader among non-medicated feed additive providers, where he worked as Global Technical Director for aquaculture. He is also a co-founder of Professional Aquaculture Nutritionists (PAN) previously Aquaculture Nutritionists Network (ANN) along with Dr. Albert Tacon.

With his varied expertise on, novel plant proteins, anti-nutrients and fibres on nutrient utilisation by aquatic animals, various functional feed additives on freshwater and marine species grown in both tropical and temperate climates, Chowdhury said that it is time for him to utilise all these experiences and venture into a research domain.

Future with ingredients evaluation

Maverick Innovation is already making breakthroughs on how ingredients are evaluated. It has completed evaluations of several ingredients in both fish and poultry. The work included trials with enzymes, gut health products, combination of various solutions targeting reduction of antibiotic use in animal feed, as well as effective management of stressful conditions.

Chowdhury said, "I always say, the best evaluators of an ingredient are the 'animals'. In Bangladesh and may be in most developing countries, animal trials are seldom conducted to test an additive or an ingredient. With dedicated facilities and trained personnel, Maverick is poised to lead the way on the selection of ingredients to be used in animal feed with the help of our industry leaders and advocates."

A complete aquatic system

The aquatic system boasts a comprehensive recirculating aquaculture system (RAS), which comprises 64 experimental tanks of 300L capacity, and five rearing tanks of 1,000L size. This RAS system sequentially incorporates a settling tank, rotating drum filter, protein skimmer, ozone generator, biofilter, degassing chamber, ultraviolet system, and an oxygen generator. Additionally, there are 16 faecal collection units, modelled after the modified Guelph system (each with four tanks), to support digestibility trials.

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The aquatic system at Maverick Innovation has a comprehensive recirculating aquaculture system (RAS), comprising 64 experimental tanks of 300L capacity, and five rearing tanks of 1,000L.

The facility also features a 5,000 ft² (464.5m²) pond equipped with 84 hapas of 2m³ each, arranged in seven separate series for pond-based feeding trials. A commercial-grade feed mill with a capacity of 200kg/hour, featuring a mixer, two double-phase conditioners, an extruder, and a modern feed dryer, is set to be commissioned this year.

The current poultry research infrastructure includes a broiler shed with 64 pens for feeding trials and 18 metabolic cages for digestibility studies. Plans are underway to establish a new poultry unit for layer chickens and a disease-challenge shed.

Importance of digestibility measurements

"When not conducting nutrient retention assays, performing *in vivo* nutrient digestibility trials is essential in conjunction with feeding trials when evaluating an ingredient. This is more important as nutritionists and formulators are formulating more and more on digestible nutrient basis instead of just from the proximate composition," said Chowdhury.

However, obtaining precise information on nutrient digestibility presents significant challenges. For instance, active methods of collecting digesta from the large intestine, such as stripping, may inaccurately display lower digestibility values, while passive faeces collection may yield higher than the actual values.

According to Chowdhury, there are three reliable passive collection methods – TUF Column system of Japan, St-Pee system of France, and Guelph system of Canada. The Guelph system was developed in early 1970 and is the most widely used system until today. Several variants of the system exist, but the basic set-up is a series of tanks (3-4) or a large circular tank where faeces are allowed to settle overnight and collected with minimal disturbance.

"No matter what system or what inert marker is used, researchers should focus on the following: collecting a 'representative' faecal sample free of uneaten feed; beware of leaching (to prevent leaching, care for the reference diet formulation is important); use the same technique consistently (same collection method, same reference diet, same inert marker); and finally, understand and accept the limitations of the techniques."

Part of the raison d'être at Maverick, is developing trained human resources. It offers internships to final year undergraduate and postgraduate students as well as industry professionals in need of an upgrade. The length of internships can be 1, 2 and 4 months.

"A primary objective of Maverick Innovation is to actively bridge the gap between academic research and industry, thereby facilitating collaboration between these two entities. To achieve this goal, the organisation is actively seeking partnerships with various academic institutions and multinational organisations," said Chowdhury.

Recently, Maverick signed a Memorandum of Understanding (MoU) and a Letter of Agreement (LoA) with Bangladesh Agricultural University (BAU) and Gazipur Agricultural University (GAU), respectively – two leading agricultural universities in Bangladesh. Additionally, the organisation is informally collaborating with various other academic institutions and local stakeholders in Bangladesh. Maverick has also initiated active collaborations with several international organisations based in Brazil, Canada, India, Singapore, and the USA. https://maverickinnovation.org

Kabir Chowdhury, Maverick Innovation (second left) signed a Memorandum of Understanding (MoU) and a Letter of Agreement (LoA) with Gazipur Agricultural University (GAU), a leading agricultural university in Bangladesh.

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www.was.org www.shellfish.org fishculture.fisheries.org www.nationalaquaculture.org

Aquaculture on the Rise!

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Speke Resort, Munyonyo, Entebbe, Uganda

For details: www.was.org

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For More Information:

Event Information: www.was.org

Conference & Registration: worldaqua@was.org

Tradeshow: mario@marevent.com

GSFF uncovers attitudes and behavior of US consumers regarding shrimp

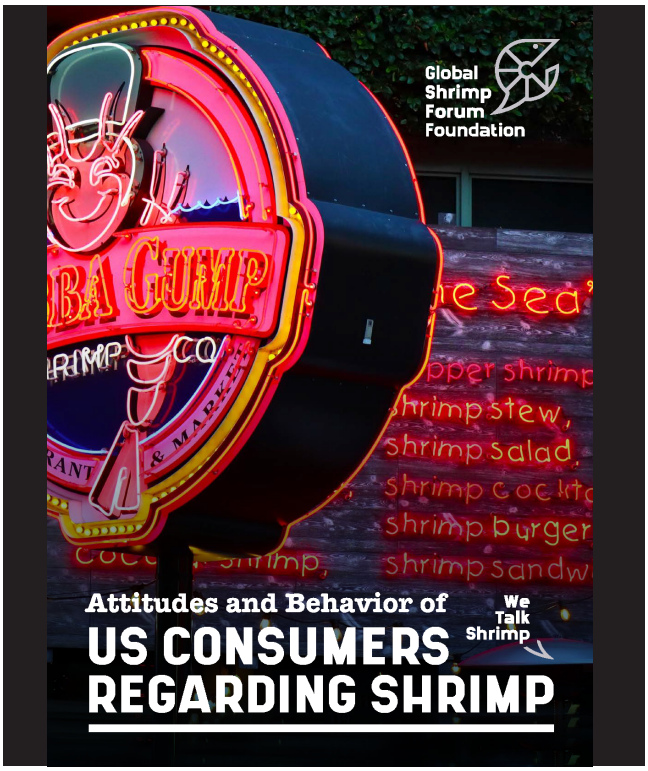
The **Global Shrimp Forum Foundation** (GSFF) has announced the publication of its latest study, Attitudes and Behavior of US Consumers Regarding Shrimp, which provides a comprehensive analysis of consumer perceptions, purchasing habits, and emerging trends in the US shrimp market, along with insights into how its findings can be applied in other markets.

Published on March 11, the report is available for free download on the Global Shrimp Forum website. Funded by GSFF, using the financial surplus from last year's Global Shrimp Forum, the study delivers valuable insights into U.S. consumer demand—critical knowledge for producers, retailers, and industry stakeholders looking to navigate the evolving seafood landscape.

The findings of the report are particularly timely as they directly inform the Global Shrimp Council's (GSC) first-ever marketing campaign, launched at the Boston Seafood Show in March. The campaign aims to engage consumers globally, promote the positive attributes of shrimp, and drive demand in one of the world's most significant seafood markets. Willem van der Pijl, Managing Director of the Global Shrimp Forum, emphasised the importance of this initiative:

"The US remains one of the most important markets for shrimp, and it is vitally important that we understand consumer preferences as well as possible. This report provides the industry with a much-needed understanding of what motivates US shoppers when choosing shrimp over other proteins. By reinvesting the surplus from last year's Global Shrimp Forum into this study, we are delivering on our commitment to creating valuable resources that benefit the entire shrimp sector. The insights gained will directly support the Global Shrimp Council's mission to boost shrimp consumption in the US through targeted marketing and promotion."

The author of the report, independent marketing and branding consultant, Arnd Jan Gulmans, commented on the significance of this launch:



"With the US being one of the world's largest shrimp markets, it is essential for the industry to stay ahead of shifting consumer attitudes. This study provides fresh data on how Americans perceive shrimp, what influences their purchasing decisions, and what barriers may be limiting consumption. These insights will help the industry better position shrimp in the market and ensure that marketing efforts, including the Global Shrimp Council's campaign, resonate with U.S. consumers."

The Global Shrimp Forum Foundation invites all industry stakeholders to explore the report and leverage its findings to support growth in the US market.
shrimp-forum.com

GLOBAL MEET

GIANT PRAWN 2025

Navigating Innovation and Sustainability in Giant Prawn Aquaculture

GIANT PRAWN 2025 EDITION

The GIANT PRAWN conference series, founded by Michael New, OBE, has been a cornerstone of *Macrobrachium* aquaculture since its inception in Bangkok in 1980. Subsequent conferences were held in Kochi, India (2003 and 2011), Bangkok, Thailand (2017 and 2023), and Shanghai, China (2019). The Aquaculture Program of Asian Institute of Technology (AIT), Thailand has been leading the GIANT PRAWN conferences since 2017, and subsequently collaborating with Shanghai Ocean University (SHOU), China. In 2025, GIANT PRAWN Conference will be held in Huzhou city in China's Zhejiang Province, which produces a lion's share of the improved prawn broodstock in China.

We are pleased to announce the seventh edition of this conference series.

CONFERENCE & EXHIBITION: 8-11 JUNE 2025

DONGWU NEW CENTURY GRAND HOTEL HUZHOU, HUZHOU, ZHEJIANG PROVINCE, CHINA

REGISTRATION
8 June 2025

MAIN CONFERENCE
9-10 June 2025

FARM TOUR
11 June 2025

This conference will provide a platform for global experts to exchange ideas and discuss the latest research advancements in the *Macrobrachium* industry. Participants will explore strategies for the healthy and sustainable development of the industry in the future. We also invite the global prawn industry to join and showcase their business at the Exhibition as part of GIANT PRAWN 2025.

Join us in Huzhou for this important event in the field of *Macrobrachium* aquaculture. Please visit our websites for further details

www.giantprawn.org
www.aitaquaculture.org

Organizers

Asian Institute of Technology (AIT), Thailand

Shanghai Ocean University (SHOU), China

Co-organizers

Zhejiang Institute of Freshwater Fisheries (ZIFF), China

Huzhou University (HU), China

Krishna R. Salin
Aquaculture Program
Asian Institute of Technology (AIT), Thailand
aarm@ait.ac.th

Huang XuXiong
Shanghai Ocean University (SHOU), Shanghai, China
xxhuang@shou.edu.cn

GIANT PRAWN Conferences are the premier global events dedicated to the farming of freshwater prawns, *Macrobrachium spp*. They were founded by Michael New, and the inaugural conference took place in Bangkok (Giant Prawn 1980). Subsequent conferences were held in Kochi, India (2003 and 2011), Bangkok, Thailand (2017 and 2023), and Shanghai, China (2019). Since 2017, the Aquaculture Program of the Asian Institute of Technology (AIT), Thailand, has led the organisation of these conferences. Beginning in 2019, AIT has collaborated with Shanghai Ocean University (SHOU), China, to host the conferences alternately in Thailand and China. In 2023, the 6th edition of the Giant Prawn Conference, brought together 160 participants from 17 countries.

The GIANT PRAWN 2025 is set to return to China, promising to showcase significant advancements in the farming and conservation of freshwater prawns in the Macrobrachium genus. The event will highlight China's pivotal role in producing a substantial share of improved prawn broodstock. Although the conference title may suggest a focus on the Giant Malaysian freshwater prawn (*M. rosenbergii*), the event encompasses all *Macrobrachium* species currently under cultivation.

It will be a great opportunity for the global freshwater prawn farming industry to review the latest research and development and to brainstorm what the priorities should be for its future expansion.

There will be two days of technical sessions and a field trip to prawn hatchery and nursery farms in Huzhou, Zhejiang Province on 11 June 2025. There will be an international trade show on aquaculture products and suppliers in the industry. More information: www.giantprawn.org

2025

March 26-28
VietShrimp International
Can Tho, Vietnam
vietshrimp.net

May 6-8
Seafood Expo Global
Barcelona, Spain
seafoodexpo.com

May 21-22
Shrimp Aquaculture Conference 2025
Bali, Indonesia
sac.pmindo.com

June 8-11
Giant Prawn 2025
Huzhou, China
giantprawn.org/aitaquaculture.org

June 22-25
Shrimp Summit 2025
Bali, Indonesia
responsibleseafood.org

June 24-27
World Aquaculture Safari 2025
Entebbe, Uganda
was.org

August 20-21
TARS 2025
Shrimp Aquaculture
Chiang Mai, Thailand
tarsaquaculture.com

August 20-22
Vietfish 2025
Ho Chi Minh City, Vietnam
vietfish.com.vn

September 2-4
Global Shrimp Forum 2025
Utrecht, The Netherlands
shrimp-forum.com

September 3-5
11th Aquaculture and Fisheries Expo Taiwan (IAFET) 2025
Taipei
taiwanagriweek.com/en/

September 22-25
Aquaculture Europe 2025
Valencia, Spain
aquaeas.eu

September 23-27
12th Symposium on Diseases in Asian Aquaculture (DAA12)
Chennai, India
daa12.in
World Aquaculture

October 6-9
LACQUA 2025
Puerto Varas, Chile
was.org

November 3-5
5th World Tilapia Trade and Technical Conference Trade Exhibition 2025 (TILAPIA 2025)
Bangkok, Thailand
info@infofish.org

November 10-13
World Aquaculture 2025
Hyderabad, India
was.org

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