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Zuridah Merican

2022: A new equilibrium post Covid

The year 2022 saw the opening and normalising of the economy in Asia. This meant back to in-person events such as AquaIndia 2022 and the Infofish Shrimp conferences in June. Towards the end of 2021, there was already a rebound in seafood consumption in the US and Europe – both retail for home consumption and food service, leading to a net increase. Unfortunately, in China, Asia's largest shrimp market, uncertainty still prevails. What we also learnt from the last two years is that Chinese buyers were not ready to keep stock. It was a case of once bitten twice shy with stocks for the festive Chinese New Year which was muted for two years.

At the end of Q1 2022, we saw the inflection point, a consequence of several factors - supply chain disruptions and effects of the Ukraine invasion, raising feed costs and higher shrimp prices leading to drop in consumption. Since Q2, high inflation and an increase in interest rates as well as the high US dollar were pain points for aquafeed producers, said Piet Verstraete during TARS 2022. Unable to hold margins, feed millers started to raise feed prices, passing along costs, albeit in stages, to farmers. This was exacerbated by astronomically high wheat prices for shrimp feeds, in addition to the continuing high prices for corn, soybean meal and plant oils.

We are reminded of higher shrimp production from almost all countries in South America. Ecuador recorded almost a million tonnes of shrimp exports in 2021 and is on track to add more supply in 2022. GOAL in October, projected 1.3 million tonnes production from Ecuador while Asia would experience lower production by 0.1% in 2022. In September, at the Global Shrimp Forum, Ravi Kumar Yellanki expected a slow growth in India, with production down by 11% in 2022, mainly because of weather and disease factors. Asian players rationalised by explaining the price factor in the US market. For Ravi, Indian shrimp sell at higher prices than Ecuadorian shrimp.

Robins McIntosh has often reminded us that Asia is losing out with lower survival rates leading to higher production costs. Asian production has been expanding with new culture areas while Ecuadorian farmers work on improving efficiency with nursery systems and marginal higher stocking density within the same infrastructure. What is also impressive is how Ecuadorian producers could pivot quickly, distributing its shrimp into the three markets (US, Europe and Asia, including China), as these markets change. Ecuador's National Chamber of Aquaculture (CNA) continues to attract attention with its efforts to differentiate its shrimp with Sustainable Shrimp Partnership (SSP) giving it better access into markets in Europe and the US.

Seafood Expo Global saw the first gathering of seafood players since 2019 and for the first time, the importance they are giving to sustainable feed ingredients and ESG (environmental social and governance) risk. Feed is a black box in the eyes of consumers who want to know what their fish and shrimp eat. The target is for a more sustainable food system and towards a 100% traceable and transparent supply chain. In addition, discussions also centered on the effects of climate change. Here Europe's large aquafeed companies show that they are already leading with sustainable sourcing targets.

Are stakeholders expecting a return to normal prices for feed ingredients? At TARS 2022, Karla Canavan, WWF stated, no, it will not. Volatility will be here to stay and industry needs to adapt to this new reality. With rising costs of traditional ingredients, there is an opportunity for novel feed ingredients like insect meals and single cell proteins. Despite there being many suppliers, they seem to be missing the points of price versus functionality and scalability.

Innovations in aquaculture are plenty and there was no doubt that investments abounded in 2022. However, as the salmon industry has taken advantage of the market demand and limited supply growth, the marine fish industry in Asia seems to be very slow. Despite the volatility, high inflation and looming recession, the recent Rabobank report (October 2022) predicts high hopes for premium aquaculture. Apart from shrimp, here in Asia, we have to ask, which other products we can develop?

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

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State of the aquafeed industry in Asia

Managing volatility in feed ingredients at an industry level

Asia's aquafeed industry is facing challenges arising not only from the pandemic but also global trends – rising ingredient and high freight costs, supply chain disruptions and the push for more sustainable feed ingredients. While inflationary cost affects all players along the supply chain, it is particularly difficult for Asian feed millers tasked with supporting its growth. There is a need to future-proof the industry for the next decade.

The above set the scene for aquafeeds in Asia at TARS 2022 (The Aquaculture Roundtable Series®) with the theme *Aquafeeds: A new Equilibrium*. About 250 industry stakeholders from 24 countries attended the event. This year, almost 34% came from Vietnam, followed by 18% from Thailand and 8% from Indonesia. Sponsors were INVE Benchmark Genetics, DSM Nutritional Products, BASF, Diamond V, BioMar, Phibro, Adisseo, Grobest, Symrise Aqua Feeds, Cargill and Jefo Nutrition. Held in Ho Chi Minh City, the event was supported by Vietnam's Ministry of Agriculture and Rural Development, Directorate of Fisheries. TARS 2022 was organised by Aqua Culture Asia Pacific and Corporate Media Services.

Dr Tran Dinh Luan expressed a need to develop aquaculture sustainably in response to climate change, critical for the Mekong Delta, the centre of aquaculture in Vietnam.

In his welcome address, **Dr Tran Dinh Luan,** Director at the Ministry of Agriculture and Rural Development, Directorate of Fisheries, said that Vietnam has expansion plans for its aquaculture industry with a target of 5.6 million tonnes by 2025, a 36% increase from that in 2021 and almost a million tonnes for shrimp. "We want to develop aquaculture sustainably in response to climate change, which is critical in the Mekong Delta, the centre of aquaculture in Vietnam. We have a dynamic aquaculture industry and want to continue improving productivity and the competitiveness of our farmed fish and shrimp. We are fortunate to have an equally dynamic aquafeed industry, with local players as well as several multinationals from Taiwan, China, Indonesia, Malaysia, Philippines and Europe setting up their regional base here in Vietnam."

TARS 2022 started with the state of the industry presentations "This year has been an unprecedented situation for aquafeed players. The program chair has scripted this session to cover four vantage points. The first is the rising costs of raw materials and the double whammy of a huge demand for sustainability which costs money. WWF's **Karla Canavan** will discuss the volatility in feed ingredients and the journey to sustainable commodities. **Piet Verstraete** will cover the second point on how this affects Asia's aquafeed players. For the third point, on how the industry needs to be more efficient in using raw materials in formulations, we look to the poultry industry, which has developed this into a science and not an art, with a presentation titled 'Formulation techniques for capturing the genetic potential of aqua species and optimising digestible amino acid content' from **Matthew Clark,** Feed Guys Resources. For the last vantage point, we look to a country as an example. Since we are in Vietnam, Grobest's **Dr Olivier Decamp** and **Nguyen Van Khanh** look at how the aquafeed industry in Vietnam has progressed in the past three years in meeting challenges in shrimp production, before, during and now after Covid," said Ronnie Tan, US Grains Council as he introduced the session.

Over two days, from October 6-7, there were 17 presentations in sessions on improving feed efficiency -more with less, functional feeds for health interactions, adoption of novel feed ingredients, smart feed management and future proofing and sustainability issues with aquafeeds. An industry panel discussed how can aquafeed millers in Asia "de-risk" themselves

Speakers in the session on State of the Aquafeed Industry in Asia and Growth in Vietnam. From left, Karla Canavan, Matthew Clark, Piet Verstraete, Olivier Decamp and Nguyen Van Khanh.

from increasing ingredient prices and how to attract investments. The 1.5-hour roundtable breakout session had group participation of all participants to discuss "Working along the value chain to improve efficiency, traceability and sustainability". This year the Hard Talk panel looked at challenges on early adoption of novel ingredients and on how to create the pull and push for their adoption by industry (see pages 37-40).

Current events and volatility in aqua feed ingredients

Karla Canavan, Vice President, Commodity Trade and Finance, Markets, World Wildlife Fund (WWF), US, said that three major events increased the uncertainties in the production, processing, packaging, transportation and even in the financing of feed ingredients. She grouped these into the 3Cs- Covid, Conflict in Ukraine and Climate change.

"Covid really affected the supply chain, especially with freight and increasing prices of feed commodities. This connects with the conflict in Ukraine, which is a large producer of raw materials like corn and sunflower oils. What happened in Ukraine has had a global effect on commodity prices across the globe, such as higher prices of corn in central America. There are disruptions in wheat supply. Wheat is so important in aquafeed formulations. The limited supply of sunflower oil from world trade affected the prices of palm and soybean oil, also important components in aquafeeds."

Climate change is a significant event. "We do not know how it is going to turn out. The food system contributes about a third of total GHG emissions. As part of the food chain, aquaculture and aquafeed stakeholders need to understand that an 80% decline in emissions comes from eliminating commodity-driven deforestation."

Karla added, "Managing risk in volatility and availability will be the key to transforming food systems to address food security and ensuring production becomes more resilient while respecting planetary limits. Aquafeed production is the backbone of aquaculture and understanding the implications that the afore-mentioned major events have on the price and availability of feed ingredients is critical to its success."

"It is no longer sufficient to cover the nutritional requirements at the best possible cost as feed design becomes a risk management exercise."
- Piet Verstraete

"Dynamic risk management and a deep dive into the supply chain are needed at the procurement and company levels", says. Karla Canavan.

Since many stakeholders may expect that post-Covid or after the conflict, the situation will return to normal, Karla commented, "No, it will not be the same and so we need to adapt to this new reality. In years to come, volatility will stay."

Resilient aquafeed landscape

There are several aspects which must be considered for a resilient aquafeed landscape. These are assessing gaps in supply chain control which increase risks; linking habitat conversion and scope 3 carbon; establishing full supply chain traceability and determining gaps; and finally, assessing the suppliers and supply. Karla also emphasised the importance of the triple bottom line sustainability - social, environmental and economic.

Takeaways for the industry included the need to have a long-term view and plan. "Quick solutions will not solve our problems. Dynamic risk management and a deep dive into the supply chain are needed at the procurement and company levels. Traceability is key and incentives should be aligned with farmers."

Status of Asia's aquafeed industry

In his presentation on "Dealing with the challenges and striving towards greater sustainability in Asia's aquafeed sector," **Piet Verstraete,** 4Sea Consulting Ltd, recounted how as of July 22, FOB soybean meal prices have risen by 74% (since January 2020), mainly because of supply-demand imbalances – supply due to weather conditions in the US and Latin America and demand by major importers such as China. Wheat rose by 124% because of the conflict in Ukraine. Although the situation may have stabilised, the fear is that prices will not come down in the short term. "This is impacting all our aquafeed types. Particularly vulnerable is the freshwater fish segment. Marine fish feed production is affected by fishmeal prices increasing by 30-40%, depending on the grade, as well as fish oil prices, especially those with higher HUFAs which have doubled in price. An alternative is the more sustainable algal oils."

Piet showed the real impact of rising ingredient prices with a snapshot comparing the rise in ingredient prices since the end of 2018 at a shrimp feed plant in India. "In 2021, some ingredients such as soybean meal and soy lecithin have tripled in price. The cost of standard shrimp feed increased by almost 50% during the same period. "Increases in feed prices have been lagging, but as of today, they have increased by about 30 to 35%," said Piet.

Besides rising energy, logistics and ingredient costs, the feed miller is also challenged by unfavourable foreign currency exchange rates for imported ingredients. "Margins are under pressure, but another serious problem is related to liquidity to finance an increase in production cost. Do we tighten credit terms and risk losing production or extend and support customers but run a higher risk of bad debts? Until recently, credit was relatively cheap, but the interest rates are rising to reign in inflation."

Impact on aquafeed production

Apart from Indonesia, all leading shrimp-producing countries showed significant drops in shrimp feed production in 2020. In India, where the pandemic interrupted the supply chain, the decline in shrimp feed production was 17% in 2020. "A recovery or even growth was seen in the 7 main shrimp feed producing countries to 4.6 million tonnes (possibly 5.3 million tonnes) in 2021 from 4.1 million tonnes in 2020. The fish feed sector underwent swings in demand over the pandemic. The example of China was given, with shifts towards farming high-value freshwater species for local markets, such as snakehead and largemouth bass, instead of tilapia and declines in export-oriented high-value species.

Impact on feed mill and formulations

While the current ingredient situation calls for diversification in purchases to reduce supply risks, it also forces Asia's feed companies to prepare for a more sustainable future. The focus is no longer on reducing fishmeal usage but on knowing and managing a wide range of ingredients.

"The most traumatic direct impact is on the finance and purchasing departments," said Piet. He showed an example of fishmeal purchases in Greece, characterised by many fishmeal suppliers, but fishmeal almost exclusively from sustainable sources. Engaging in long-term contracts partly covered supply into 2021. "Today, the call is for close interaction between purchasing, formulation and quality control to ensure supply of the right quality and price ingredients."

The current situation also impacts feed formulations. "It is no longer sufficient to cover the nutritional requirements at the best possible cost as feed design becomes a risk management exercise. For many Asian species, precise data is missing to develop profitable feed. A key asset is a feed formulation program, but these are not always fully exploited in our Asia aquafeed plants," said Piet.

Feed and farm: Reducing FCR and sustainability

This requires technology and interaction between the feed, the farm and genetics. "The freshwater fish segment is entirely on safeguarding profitability for the farms. The challenge is to find the right equilibrium between feed cost and fish performance and avoid additional environmental problems caused by increased FCRs. An interesting evolution in tilapia breeding is the shift towards selecting more robust and resistant traits rather than focusing on growth," said Piet.

An example is China, where the alternative strategy is to focus on higher-value freshwater species. With environmental concerns and restrictions on floating net cages, the move is towards more controlled and sustainable production systems such as RAS.

"In Asia, the debate is on extruded shrimp feeds since it is not entirely clear if extruded feeds are giving better performance for the shrimp itself. But the definite advantages are the increased flexibility in raw material choice and reduced losses at the feed plant and when using auto feeders. Great progress has been made in shrimp genetics, but the link with an adapted feed design to support improved animal performance has not been established. I believe feed and improved genetics go hand in hand for optimal performance of shrimp."

A clear takeaway from this presentation is that "There is a great opportunity to make our ingredient costs more sustainable. Progress has been made with functional feeds for profitable applications at the farm level. Additives, such as palatability enhancers, aromas, emulsifiers, enzymes and amino acids can help us get more out of available ingredients. Still, there is a need for liquid application systems to incorporate them in the most efficient way."

The 1.5-hour roundtable breakout session had all participants discuss in groups on "Working along the value chain to improve efficiency, traceability and sustainability."

The panel discussion on the output from the Breakout Group 1 (Feedmillers and Farmers), was led by Chiow Yen Liew, DSM (left) and from the right, Karthik Masagounder, Evonik, Germany; Rui Alexandre Gonçalves, Lucta, Spain; Jarin Sawanboonchun, Cargill, Thailand; Joao Reis, Biomar, Ecuador; Ravikumar Bangarusamy, Growel Feeds, India; Si Mon Ong, Malaysia; Lay Nguyen, Cargill, Vietnam and Rizky Darmawan, PT Delta Marine, Indonesia.

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Prevention and control measures for EHP: An integrated approach

Prevention measures start at the hatchery with effectively managed and biosecure features, including ultra-filtration systems to exclude spores

By Mark Rowel Napulan, Ramir Lee and Craig Browdy

A hyper intensive nursery in Thailand, with average stocking density of 12.5 post larvae/L, demands complete nutrition and excellent water stability.

Enterocytozoon hepatopenaei (EHP) is an established microsporidian disease that causes slow growth in shrimp which continues to devastate Asian shrimp industries with USD billion losses annually. Effective control of EHP depends on understanding and adapting management protocols based on scientific data on the biological characteristics of the pathogen, its modes of infection and the effectiveness of methods of control.

EHP is a microsporidian pathogen producing spores that can remain dormant for up to 2 years. Once the environmental conditions become favourable, the spores start to activate and infect shrimp through polar tube extrusion. It is important to note that EHP spores are described as being clusters of elliptical to somewhat ovoid in shape (1.1±0.2 by 0.6-0.7±0.1 microns) through H&E stained hepatopancreas samples. Because of their small size, spores are difficult to detect under the microscope, requiring skilled, experienced microbiologists to find at 100x objective using oil immersion. The small size can bypass some commonly used filtration systems in the hatchery.

Due to the complexities of the diagnosis of EHP through microscopy, properly applied PCR techniques must be used throughout the production process to identify and eliminate the pathogen. When applied correctly, PCR testing is very sensitive. Nevertheless, efficiently identifying sources of infection depends upon the effectiveness of sampling. The number of samples needed to detect infection increases depending on the prevalence of the pathogen. Thus, the effectiveness of PCR diagnostic strategies for screening potential sources of infection must be carefully evaluated.

Recent studies on cohabitation suggest that spores can be transferred orally through ingestion of faeces and cannibalism. Spore densities are concentrated in filter-feeding animals such as mussels, oysters and polychaetes, and can also be ingested through sediments suspended in the water column. Hence, the approach to the prevention of EHP must be holistic, starting from the maturation systems in the hatchery through to the harvest and post-harvest pond treatments in the farm.

Commonly used wild live polychaetes in Asia can be depurated but they remain infective.

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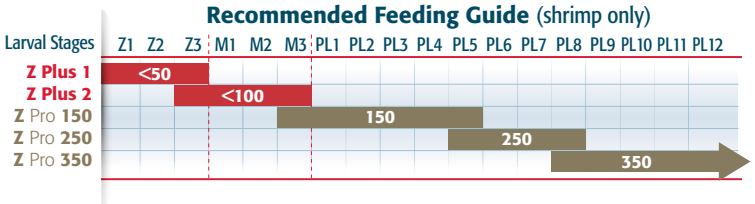

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Controlling EHP

In July, a Zeigler team toured three major shrimp-producing countries in Asia (India, Vietnam and Thailand) to support customers with practical solutions and technical approaches on controlling EHP. We conducted a series of technical seminars, in Phan Rang, Vietnam and in Kakinada, Nellore, India to support customers. The seminars were attended by a combined total of 229 shrimp hatchery owners, managers, technicians, consultants and nursery farmers. In Thailand, the team visited nursery farmers to identify areas for improvement and share techniques and experiences in shrimp nurseries. The team shared insights into its Precision Feeding Program (PFP) software. This is a program to support customers using Raceway 40-9 and PL Raceway Plus nursery feeds which provides an accurate feeding guide based on the carrying capacity of the system and the particular genetics of the animals. The most important feature of the program is its flexibility, enabling the manager to adjust and control feeding rates throughout the cycle. Properly managed, biosecure nursery systems have been successfully deployed as one part of the solution to prevent EHP.

Management of EHP in the hatchery

EHP can enter maturation systems with infected broodstock, through the water or in live or fresh feeds carrying viable EHP spores. Beginning with certified specific pathogen free (SPF) broodstock is the first step in prevention. Being filter feeders, wild live polychaetes, in particular, are potential carriers of EHP. Therefore, it is highly recommended to use only SPF live polychaetes in maturation systems. If using alternative diets, such as squid and other fresh feeds like mussels, these must first be subjected to -20°C, freezing for more than 48 hours to inactivate the spores. In this regard, we highly recommend the use of Redi-Mate maturation feed to start the conditioning stage and through active spawning. Redi-Mate is an inert, manufactured biosecure maturation diet that has been shown to adequately replace up to 50% of live polychaetes in commercial trials and up to 60% of fresh feeds (without live polychaetes).

Live polychaetes can be one of the most expensive and difficult to procure components of typical maturation feeding regimes. Nevertheless, hatchery managers in Asia are reluctant to significantly reduce inclusion rates as live polychaetes are purported to increase spawn size and nauplii production rates. In the Americas, live polychaetes are not used, maturation systems are larger, and broodstock costs are controlled by the use of local breeding programs and multiplication centres. Applying this model in Asia will require more investment in biosecure broodstock multiplication centres stocking PPL (parent post larvae) to reduce logistical costs and bottlenecks as well as ensure adequate supplies of genetically improved SPF broodstock.

We also recommend incorporating ultra-filtration systems for water in the hatchery with <0.1 micron filtration to exclude spores. Research has shown that EHP spores can be inhibited with various treatment methods. Thus, treatment of all incoming water in the hatchery with either 40ppm of 65% active chlorine or 15ppm $KMnO_4$ inactivates spores. Filling tanks with steam (water in gas phase) and rinsing equipment with water at a temperature of 75°C for up to 1 minute could also help to inactivate spores.

Additionally, hatchery technicians should select high-quality hatchery feeds formulated to optimise nutrition

The adoption of ultra-filtration systems is becoming a trend in Vietnam.

by incorporating highly digestible ingredients. Zeigler recently launched its Z Pro diet in Asia, specially designed for shrimp post larvae. This novel and advanced product was developed over 3 years of continuous R&D at the Zeigler Aquaculture Research Center in Florida. It is gaining popularity and market shares in many regions and was proven to reduce the usage of flakes and dry feeds in some current commercial protocols by up to 40%.

Improving feed utilisation efficiencies in the hatchery tank reduces waste and improves water quality by lowering ammonia and *Vibrio* levels. This results in robust, stronger post larvae with improved survival rates that are better able to resist pathogens such as EHP in hatcheries, nurseries and grow-out systems.

Management scenarios in ponds

Managing EHP in ponds is particularly challenging due to the much larger water volumes and culture areas that need to be treated. In areas with active EHP infections, water must be filtered or treated with the correct dose of the appropriate, approved product to inactivate spores. Also, EHP spores are typically embedded in pond bottom sediments, which can reduce the efficacy of chemical treatments. The use of well points and lined ponds that can be appropriately disinfected can improve the outlook for successful crops in areas with ongoing EHP outbreaks.

Moreover, stressors can trigger EHP infections in shrimp ponds. Nursed post larvae (0.5g to 2g) can produce more robust and faster-growing animals due to compensatory growth. A properly designed and managed nursery phase reduces the overall culture period and the exposure of the

The EHP focused seminar in Phan Rang, Vietnam was attended by major post larvae suppliers.

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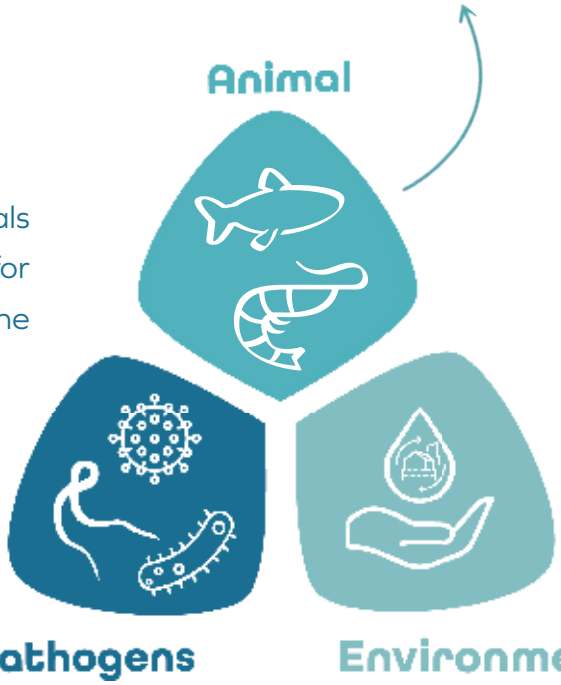

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shrimp to pathogens and stressors. As in the hatchery, similar water treatment procedures and physical exclusion with the use of ultra-filtration should be adopted. Efficiently feeding high-quality nursery feeds will help improve the feed conversion ratio (FCR) and thereby reduce organic waste in the system. Controlling FCRs in the nursery is critical to reducing stress resulting from overfeeding and the subsequent deterioration of nursery and pond water quality.

Performance data from 17 separate trials conducted in Asia for PL Raceway 40-9 product demonstrate the achievement of survival rates averaging 92.4±6.1%, with FCR values of 0.87. These trials clearly demonstrate that this nursery diet is cost-effective and improves animal health while reducing ammonia and nitrite inputs into the system.

Ponds with sandy loam soil and high sedimentation should be lined with high-density polyethylene plastic (HDPE).

For ponds known to be previously infected with EHP, farmers should treat them with the proper lime product. It is important to know your lime and pay attention to its solubility in water. Burnt lime, calcium oxide (CaO), magnesium oxide (MgO) and hydrated lime $Ca(OH)_2$ can increase pH up to 12 or higher and eliminate EHP spores when applied at a dose of 6 tonnes/ha. A simple way to assess a liming product is to put it in water and observe whether it will raise the temperature to 50°C. The product must be sieved through a 100-mesh net. It should be noted that for this hot lime to react, the soil must be moistened. The liming should cover the entire pond bottom to optimise its treatment impact.

Recently, researchers found that EHP-infected shrimp produce white faeces when there is co-infection with *Vibrio*. In this case, farmers should pay attention to controlling *Vibrio* throughout the entire shrimp culture cycle. We strongly recommend selecting probiotics proven to be effective in the hatchery and in grow-out ponds, properly demonstrated to colonise the shrimp gut and inhibit growth of *Vibrio* in the water.

To control EHP, farmers must demand healthy, EHP-negative post larvae from their hatcheries. These test results must be from a robust ongoing sampling program conducted by a properly accredited and independent laboratory certified by the government. Zeigler is committed to helping hatcheries maintain and enhance post larvae survival, growth and health to meet the scrutiny and higher post larvae quality necessary to maintain profitability in EHP-affected areas.

In Kakinada, India, Craig Browdy emphasised on the importance of EHP prevention by using clean diets for shrimp maturation.

Perspectives

As the shrimp farming industry continues to face challenges to increase production, due to outbreaks of EHP, the team at Zeigler will continue to improve its products and technical support by strengthening R&D efforts, improving manufacturing processes as well as reaching out to clients. Finally, we recognise the role of various research institutions and the importance of collaborative efforts to find real-world solutions to support the needs of our customers worldwide.

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The Global Shrimp Forum

Leadership platform for the global shrimp industry takes off

During the grand opening, led by Chair Melanie Siggs (centre), Willem van der Pijl and Esther Luiten set the stage with overviews on developments in farmed shrimp production and markets, respectively.

The inaugural edition of the Global Shrimp Forum held from September 6-8 in Utrecht, the Netherlands, had more than 430 participants from 35 countries. Other statistics given by Willem van der Pijl, Conference Chair, on the first day during the plenary "Setting the stage" included 33 sponsors from across the shrimp value chain and 225 companies of which 35 are technology companies.

The Global Shrimp Forum is spearheaded by an independent not-for-profit foundation set up by the Aquaculture Stewardship Council (ASC), Shrimp Insights and Contango. The purpose of the Global Shrimp Forum Foundation (GSFF) is to establish a global platform for knowledge sharing, innovation, and industry value-chain collaboration to drive a sustainable future for the industry. The forum will meet on an annual basis over a 3-day period in early September in Utrecht, the Netherlands. This location is at the heart of the European markets, and functions as a hub for tech companies and investors.

Willem van der Pijl, Owner of Shrimp Insights, and Founder, Board member and Managing Director of Global Shrimp Forum, said "This is a leadership platform for the shrimp aquaculture industry, bringing together all stakeholders to discuss, and to share insights and issues. This is a joint journey to build a better future for the industry. GSFF is a nonprofit foundation and profits will go towards supporting non-competitive activities such as research, mangrove reforestation, improvement programmes and awareness.

A changing landscape

"Why are we gathered here? " said Willem. " Farmed shrimp will continue to grow; it is already the fastest growing animal protein industry. But the landscape is changing very rapidly, whether due to COVID-19, innovation, or consolidation," Using export data rather than production data, he showed that Latin America is moving ahead much faster than Asia - not only Ecuador but also Venezuela and Honduras. "Within Asia, shrimp exports from India and Indonesia are growing but those from Vietnam and China are flat. China, on the other hand, is a net importer."

There are different drivers of growth, such as from extensive to semi-extensive systems in Ecuador and expansion to new areas in India. Vietnam is moving toward super intensive culture systems. "Governments have ambitious plans on shrimp production and even if half of the targets are realised, there will be a lot of shrimp in the market." Willem added that while the industry grows, there are problems and challenges to overcome - booming production volumes putting pressure on prices, increasing production costs lowering margins, limited ability to overcome disease and environmental issues, and social and animal welfare concerns. "Ablation will be a hot topic over the next few years. The fragmented industry involves thousands of small-scale farmers. Luckily, there are solutions, from feed management and genetics to innovations. There is a new generation of companies which are levelling the playing field, bridging the gap between large corporations and small-scale farmers."

In the shrimp marketplace

Willem asked, "What will be the future with Ecuador moving from HOSO (head-on and shell-on) to value adding, the latter traditionally held by Asian producers and Ecuador producing so much shrimp? What will be the global dynamics for this industry?"

Esther Luiten, Co-founder and Board member, GSFF gave some insights on the shrimp market. While shrimp remains a key seafood ingredient, markets have been changing. "Recent growth (CAGR 2018-2021) showed a rise in China at 12% to USD4 billion and in the US at 9% to USD8 billion. The market in Japan is stable while the EU market is steady. The global volume did bring prices down. Many producers are in competition trying to find their edge."

Esther asked, "Covid brought challenges and there is the macroeconomic trend of inflation and how it affects prices. With rising feed and energy costs driving up production costs, will producers react with higher prices?"

Retail sales occupy significant volumes, from more than 80% in France, Spain, Italy, Germany and the Netherlands to 65% in China. Another dimension in market dynamics is the rapid changes in ecommerce which will impact trade and production. Additionally, there are also regulatory demands specific to each market. For example, there are import checks in the US and EU, and Covid related checks in China. Esther added that a key trend is food safety and traceability across markets including in China. Not to be underestimated is the impact of due diligence regulation in Europe. "Europe is demanding on sustainability which will not go away."

To set the scene, Esther said, "I am convinced that imports of shrimp will increase. We are here together to make a resilient future. Producers will need to position themselves to be competitive. Growth will be there but restrained; inflation may bring the reality of increasing costs and uncertainty."

Setting the stage

During the grand opening, **Melanie Siggs,** Plenary chair set the stage with the production status from some countries. **Dr Victor Suresh**, Technical Director at Growel Feeds Private Limited and President of the Society of Aquaculture Professionals, recounted how India's production moved from the 750,000 tonnes pre-Covid in 2019, to drop by 20% in 2020 and went up to 900,000 tonnes in 2021. India benefitted from the retail demand during the pandemic years and today, while prices are acceptable, the challenge is high cost of production from much higher input costs. India is the leading shrimp exporter to the US and Victor said, "We need to diversify markets - export to China and have more market access into Europe. We also need to develop our domestic markets. With ecommerce, we expect this market to develop fast." On the production side, he said that India needs to work with shrimp breeding companies. Industry is not changing to the Ecuadorian model but needs to ensure that broodstocks are appropriate for Indian farming conditions.

Similarly, **Dr Rokhmin Dahuri Ismail**, Advisor and President of Indonesia Aquaculture Society is convinced that some of

The panellists reviewing L. vannamei production, Gabriel Luna (left), Ravi Kumar Yellanki (middle) and Julius Roland Sebastian.

Ravi Kumar Yellanki (middle) with Marc Indigne, KYTOS, Belgium (right) and Frank Indigne, I&V Bio, Thailand.

Indonesia's production of 550,000 tonnes, comprising 80% vannamei shrimp can be consumed locally. The challenges are high costs of production and disease outbreaks, but Rokhmin expects recent technology to help solve issues from genetic selection to water quality.

Carlos Miranda, Board President at Ecuador's Cámara Nacional de Acuacultura (CNA) described its industry as "resilient, innovative and proud." In the last 7 years, the shrimp industry has been growing at double digits. Production is based on genetic selection for resistance. "Industry is led by large professional, motivated and highly innovative companies with long-term vision and ready to invest, creating a strong base for smaller and medium scale producers to grow together. Twenty companies are producing more than 60% of production volumes due to their capability to invest and consolidate in the value chain," said Carlos, adding, that today, Ecuador has 40% of production area under technification. The possibility to grow depends on the ability to sell more shrimp in markets such as China and the US.

"Vannamei shrimp comprises 75% of shrimp production in Vietnam, but equally important is black tiger shrimp," said **Nguyen Hoai Nam**, Deputy Secretary General of Vietnam Association of Seafood Exporters and Processors (VASEP). There are ambitious plans to increase the value of production to USD5.8 billion by 2025 from USD4.3 billion in 2021. It has a free trade agreement with the European Union. Critical for the future is improving quality and processing technology to scale up value added products.

L. vannamei production review and outlook

Seminar Chair **Travis Larkin**, President and Owner of Seafood Exchange guided panel discussions and updates on *L. vannamei* production in Ecuador, India, Vietnam and Indonesia, the four leading producers. The remarkable exports from Ecuador in 2021 was 841,722 tonnes and **Gabriel Luna**, Business Owner and Seafood Procurement Specialist estimated that by the end of 2022, the exports will total more than one million tonnes. The increase in production came about from encouraging situations in the Ecuadorian industry; high prices in 2011 at around USD3.70/kg when cost of production was only USD1.80/kg and farmers were paid USD3.10/kg. Abandoned post-WSSV ponds were rejuvenated. "Ecuadorian farmers seized the chance to grow. While early mortality syndrome

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BioMar

The team from PT Suri Tani Pemuka, the aquaculture subsidiary of Japfa Comfeed, Indonesia, from left, Sandy Eka, Julius Roland Sebastian, Erik Harjadi Lisnan, Dr Erwin Suwendi, with Allan LeBlanc, Calysta, USA (right).

(EMS) outbreaks were lowering production all over Asia, it was our opportunity to expand production, said Gabriel." In 2012-2016, exports went to China, initially with headless shrimp for reprocessing. Later, exporting head-on shrimp into China was a boom for the industry.

Although prices dropped in 2018-2022, producers were not deterred and increased production with the same infrastructure. Gabriel added, "There were increases in stocking density but merely from 8PL/m^2 to 12PL/m^2 and then to 15PL/m^2. Feed mills developed better quality feed and the use of automatic feeders and aeration led to better growth from 1.1g/week to 2.5g/week. With nursery phases, there were less days in the ponds. From now on, it will be efficiency with continued improvement in feed quality, and the use of acoustic feeders to target a growth rate of 2.9g/week. In terms of markets, Gabriel described how in 2014, it was equal shares of three markets (China, US and Europe) at 30-34% each. In 2019, China's market share rose to 67%. Then markets changed in 2020-2021, with more exports to Europe (+35%) and the US (+56%) while the Asian market expanded to include more countries.

On how long Ecuador can continue at this pace, Gabriel said that eventually there will be a limit to growth; in Ecuador, technification will lead to better conditions to grow, produce more at low cost and to be profitable. Country-wide the average productivity for 220,000 ha of ponds is low at 4.5 tonnes/ha which is actually the 3-month production of leading producers. Feed conversion ratio (FCR) is low at 1.2 to 1.65 at low density.

Ravi Kumar Yellanki, Managing Director of Vaisakhi Bio-Marine Private Limited, India, told of the incredible growth of India's vannamei shrimp production which started at 100,000 tonnes in 2010 to more than 900,000 tonnes in 2021. The only blip in production was in 2020 because of supply chain disruptions. Expecting a slow growth in the second part of 2022, he estimated lower production at 800,000 tonnes. The culture duration has changed to only 3 months with new genetics. Ex-farm prices are higher in 2022 as compared to 2021.

In terms of exports, the US is India's major market at 47%, followed by China. Ecuador is trailing India in exports to the US but India trails Ecuador with exports to China. "Furthermore, in 2021, at 728,000 tonnes, our export volumes were lower than Ecuador's but in terms of value, we were higher at USD5.8 billion versus USD5.08 billion for Ecuador. Our average price was USD7.96/kg versus USD6.03/kg for Ecuadorian shrimp. All these are attributed to modern technology with value adding.

Although production peaked in 2021, Ravi said that with inflationary pressures, higher input costs as well as poor demand from China, no sector was profitable. The major disease problem was *Enterocytozoon hepatopenaei* or EHP which some farmers managed to overcome by switching to farming black tiger shrimp for niche markets. Many farmers reduce stocking. "There is more awareness on genetics and farmers demand balanced and tolerant lines - shifting to hardy lines for the summer crop and growth lines for the winter crop." To address the slowdown in production, Ravi said that industry is working with shrimp breeding companies on sentinel trials, with selection to match the environment in India and to develop lines in the US. Ravi also projects that with the ecommerce trend in India, its 1.35 billion population can become a leading consumer of farmed shrimp in 10 years..

"Since 2017, Indonesia's shrimp production grew 46% to 250,000 tonnes in 2021," said **Julius Roland Sebastian**, Head of Marketing and Sales at Japfa Aquafeed's business in Indonesia. "Production remained unchanged over the last 4 years due to diseases and pressure from rising input costs. Productivity of 9,000ha of intensive ponds is 15 tonnes/ha while productivity of semi-and extensive farms covering 300,000ha is less than 0.6 tonnes/ha. There are plenty of issues which need solutions," said Julius. "Aside from the commonly occurring disease, infectious myonecrosis virus or IMNV, production challenges are with diseases such as WSSV, EHP and most recently AHPND.

From left, Anton Immink, ThinkAqua, Dane Klinger, Conservation International (CI) and Retno Nuraini Yayasan Sustainaqua Indonesia (YSAI).

Therefore, we do not see much growth in production. Since 50% of success is with the post larvae quality, the hatchery association is requesting the government to create zoning for shrimp hatcheries," said Julius. Logistics is an issue with processors centred in East Java, Makassar, Lampung and Jakarta. There is a difference of USD0.7/kg with offer prices for shrimp from farms in Aceh versus those in Lampung.

Julius is optimistic that production can be scaled up to 350,000 tonnes by 2026, particularly with government initiatives such as revitalisation of ponds. The company is developing solutions for WSSV and AHPND and has sustainable feed with less than 8% fishmeal. "There is, however, a need to access new markets. We want to export to Europe and China and move away from our major markets - US and Japan. There are expansion plans by the cold storage segment, to build operations close to farms in Central Sulawesi and Bangka Island."

Vietnam's shrimp exports, reported in terms of value reached USD3.9 billion in 2021 and is expected to reach USD4.2 billion, according to VASEP. Prices have been high due to supply shortages. Grobest's **Dr Olivier Decamp**, Group Technical Director, said that vannamei shrimp production has been growing at 1.5% annually from 125,000ha of ponds. "Production trends for 2017- 2022 (up to July) showed the highest vannamei production at 400,000 tonnes in 2021 but based on monthly production trends, we can estimate 2022 production to be higher. There was an early start in stocking in 2022."

Olivier discussed industry trends by looking at broodstock and post larvae production. In 2021, a total of 100-150 billion post larvae was produced by 125 hatcheries, and 80% were from those in central Vietnam. Hatcheries focussed on growth lines. Large volumes of broodstocks are imported. Viet Uc is the only local breeding company. "In 2022, we see that broodstock imports were high in the January-April period and down in May- July period. Sales of post larvae for the January-August period in 2022 were 14% lower than in the same period in 2021." According to Agromonitor, high prices fuelled early stocking in January and February, but disease outbreaks and poor weather resulted in crop failures. "The high production in March and April was followed by decreases in the following months in 2022. Information on disease outbreaks gathered by the Grobest team indicated white faeces syndrome, EHP and AHPND in all regions and in addition, WSSV in the northern region."

Ana Carolina de Barros Guerrelhas (right) and Maria Claudia Ferreira, Aquatec Aquacultura Ltda, a vannamei shrimp hatchery in Brazil.

The team from Charoen Pokphand Thailand, from left, Suphol Phantumaphas, Arphakorn Petthong and Parinda Kamchum.

Olivier added, "In Vietnam, we see that with intensification – intensive systems producing 25 tonnes/ha and super intensive producing 40 tonnes/ha, profits increase 28%. Intensive multiphase system and quality feeds together increase profits."

Travis asked for a comparison of number of cycles in these countries. "In Ecuador, the industry average is 3.5 cycles/year, but some farmers can do 7 cycles/year producing 17-19g shrimp by manipulating well the nursery cycles," said Gabriel. In Vietnam, it is 3.5-4 cycles and more with multiphase systems whereas it is only 2.2 cycles/year in Indonesia. Ravi said that in Andhra Pradesh, there can be 2.5-3 cycles/year but harsh winters limit cycles to only 1 cycle/year in Gujarat and 1.5-2 cycles/year in West Bengal and Odisha.

Monodon shrimp, feed and genetics, innovation, to market retail outlook

The above are some topics covered by the nine concurrent seminars conducted during this Global Shrimp Forum (www.shrimp-forum.com). New and upcoming shrimp producers including Sri Lanka's Taprobane Seafood Group, Spain's Noray Shrimp and Nigeria's Primstar were on stage to describe their technology and farming businesses. In issue September/October 2022, we published a report on the panels discussing *Penaeus monodon* and *Macrobrachium rosenbergii* production and market outlook which was chaired by Willem van der Pijl.

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Some challenges in a shrimp farm in north Bali

In Gerokgak, an exchange with farm technician, Komang Widiasa

By Gesang Katmoko

Ponds at UD Putra Gunung Sari Bahari during pond preparation for the next crop. Left, cement ponds and (right) ponds lined with 0.5mm HDPE liners.

During a post PMI (Petambak Muda Indonesia) conference farm visit in July 2022 in north Bali, a group of young farmers and industry entrepreneurs compared experiences with farm technician Komang Widiasa at this 10-year old farm, UD Putra Gunung Sari Bahari. The discussion included issues with farm management as well as rising costs of production.

Located in Gerokgak, north Bali, this farm is one of two farms of Shrimp Club Indonesia's Secretary General, Bp I Nengah Sarjana. There are five ponds, four of them 2,000m^2 and one of only 1,200 m^2. They all share a common reservoir pond. Some ponds are now fully lined with 0.5mm HDPE liners, which cover the bottom layer of sandy soil. "During the initial water preparation process, we use seawater. Then, after stocking until the end of the culture cycle, we use underground water of 5ppt for daily water exchange," said Pak Komang. There is a Pura or temple at the entrance to the farm, a Balinese tradition.

Pak Komang said that he has to be careful in cleaning the HDPE liners. He uses trichloride. This visit was during pond preparation for the next cycle and ponds were filled with clear water. However, even with 100cm transparency, stocking post larvae will continue. Similarly, Rizky Darmawan, PT Delta Marine Indonesia and also Secretary General of SCI and PMI President said that at his farm in Sumbawa, the practice is also to stock when the water transparency is high. Additionally on the practice of transferring post larvae, Ning Widjaja, Diamond V said, "Some 5 to 10 years ago, it was common to acclimate post larvae in fully aerated pond water in a tank. The aim was to adapt post larvae to pond water temperature and pH. Post larvae were also fed with *Artemia* provided by the hatchery. The condition of post larvae was observed closely and active post larvae were transferred into the culture pond. However, in recent years shrimp farmers have gone back to the old way of acclimating post larvae directly in the culture pond because they see that these days post larvae are much stronger and are faster to adapt to any changes."

Pak Komang Widiasa and Ning Widjaya

Usually the farm buys post larvae (PL8-9) from three hatcheries in Situbondo (Agape Hatchery, Ndaru Laut Hatchery, CPB Hatchery) and from Prima Larva Bali Hatchery and stocks at 150 PL/m^2. However, Pak Komang said that for the next cycle, they will use post larvae only from the CP Prima hatchery in Situbondo. Within 90 days, 37-38g shrimp will be harvested from two partial harvests. "With an average survival of 64%, our total crop was 28 tonnes from two farms. The other farm is in Negara," said Pak Komang. "Post larvae quality depends on the hatchery and farmers do not have a choice. I am not a fanatic when it comes to the source of post larvae. I depend on information from friends within the association. I also do not count post larvae when I receive them but know that when I order 1 million post larvae, I get more. But later when I do my sampling, I see that there is 10% extra." He added that the survival rate maybe considered low at this farm but in other farms, survival rates are even lower such that the farmer sells the shrimp as bait."

The PMI group of young farmers and industry entrepreneurs during the farm visit, pictured with the author (seated, left) and Pak Komang (second left), Rizky Darmawan (seated, centre). Standing are Ning Widjaja (back, middle) and Ronnie Tan, US Grains Council (back, right). Front, standing from left, Agung Purnawan, PT Bahtera Adi Jaya, Dr Wee Kok Leong, Diamond V, Thailand and Dr Boris Hinz, Stockmeier Chemie, Germany.

The conversation moved to farm and disease management. At the farm, dissolved oxygen (DO) is maintained at a minimum of 4ppm at night. In terms of water quality checks, pH is tested daily as well as nitrite and nitrate until days of culture (DOC) 70. When the DO is below 4ppm, partial harvest will be done. At his farm, he has experienced outbreaks of acute hepatopancreatic necrosis (AHPND) at 30 days into the cycle and followed

by infectious myonecrosis virus (IMNV) at 60 days. His subsequent action is to kill all of the shrimp with chlorine and then wait for total disintegration before disposal. With regards to health diagnostic services, Pak Komang said that in Bali, SCI members use commercial laboratories.

Rising feed costs

Familiar to all in the group is the rising costs of feeds. "Prices rose twice this year," said Pak Komang. "First it was IDR1,000/kg bringing up the feed price to IDR16,000/kg (USD1.02/kg). The second was IDR600/kg. In 2021, prices also went up twice." Earlier during the PMI conference, Haris Muhtadi, PT CJ Feed Jombang, explained how rising costs of ingredients by as much as 30% have forced feed millers to raise prices by an average 5%.

Although he also gets feeds and post larvae from a feed miller, here in Bali, bundling of post larvae with feed is not the norm. Pak Komang said that this practice happens in other regions. He is happy with various crude protein levels, from 28% to 30% of different feed brands (Irawan from CP Prima; Samsung SI from CJ Feeds Jombang and SGH from PT Suri Tani Pemuka). Pak Komang is not choosy with the protein content of the feed and said, "I accept various feeds, as long as I can achieve my target ADG of 0.4g at 90 days for each cycle and the final size range is 37-38g."

Blind feeding is carried out for 22 days and the first sampling at 40 days into the cycle. During blind feeding, for each 100,000 post larvae, 1,000g feed is used. The average daily growth (ADG) is 0.3g for the first 20 days and rising to 0.5g for the rest of the cycle. However, because August is the cold season with water temperatures down to 24°C, shrimp appetite decreases and consequently, the farm will also reduce the amount of feed normally fed. During this season, Pak Komang said that he cannot determine the ADG for this crop.

The group discussed energy costs. A recent rise in July brought costs to IDR1,114.00/kWh (USD0.07/kWh). Previously it was IDR1,035/kWh. In terms of prices, farm location influences prices. While the selling price of shrimp at this farm is IDR56,000/kg for size 100/kg and IDR80,000/kg for size 50/kg, Rizky said, "In Sumbawa, the offer prices are lower by IDR1,500/kg (USD0.9/kg). In general, it is 2% less for shrimp originating from Sumbawa compared to Bali. This is related to the distance to the processors."

Despite rising costs of production and expectations of lower shrimp prices, Pak Komang is confident that profit margins will be at an acceptable range. The farm is operated by a team of 10, including himself. There is a minimum labour wage but more attractive is the bonus payment when the farm does well.

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Debut of vannamei shrimp farming in Morocco

A pilot project with RAS and biofloc to test feasibility amidst climate and logistics challenges

By Zuridah Merican

Mly M'hamed Loultiti (third left) flanked by his sons, Ayoub and Youssef with USGC consultant in Morocco, Mustapha El Youssoufi (left); Aquaculture consultant Ronnie Tan (fifth left), Mohamed Salah Bouthour, Assistant Director for Africa (sixth left), Francisco Miranda Gutierrez (right) and visitors.

The Moroccan government has an aquaculture development plan that is in its early stages. The aim of the newly created National Agency for Aquaculture Development (ANDA) is to take advantage of the 3,500km coastline. At the same time, members of the agriculture cooperative, COPAG, have been looking at aquaculture to valorise reservoir ponds for the irrigation of farmlands spread all over the country. The idea is to use the ponds efficiently prior to their use for irrigation. COPAG, established in 1987, is the largest agglomeration of producers involved in agricultural and commercial activities for plant and animal products, including milk and its derivatives. Leading the way is its President, Mly M'hamed Loultiti who recently decided to run a pilot vannamei shrimp farming project.

His first investment to demonstrate the feasibility of vannamei shrimp farming is a one ha project in domaine Mazaria. Loultiti has also designated more areas to expand this pilot project before moving to the planned commercial farm, near Moulay Bousselham.

Recognising the interest of Morocco's agriculture players to diversify into aquaculture, the US Grains Council (USGC) sponsored the first mission of aquaculture experts in 2017. For land-based aquaculture, the expert advice is to farm Nile tilapia and vannamei shrimp. "Morocco has a privileged market with its main economic partners, benefiting from its proximity. Spain imports 185,000 tonnes of vannamei shrimp, mainly from Latin America. Tilapia will be for the local market but an export potential depends on the production of quality products. Most of the water resources are destined for agriculture but prior to this, we can valorize these resources for aquaculture," said Dr Mustapha El Youssoufi, USGC's consultant in Morocco. In August, Mustapha organised another mission, this time including USGC's aquaculture consultant, Ronnie Tan. Together with Loultiti and his team, they discussed approaches for the project's next steps.

Pilot farm

The planning of this pilot farm is the responsibility of a group of aquaculture professionals comprising Fernando Huertas from Ecuador, Florida-based Dr Darryl Jory and Spanish Colombian aquaculture entrepreneur Francisco Miranda Gutierrez, fondly known as Paco. Other than which culture system to adopt, the main consideration is temperature – during the day, the ambient temperature is 26°C declining to 16-17°C at night. Paco said, "This is the biggest challenge to overcome because we do not use electricity or gas to keep the water temperature at 30°C. In winter, the temperature is very cold at 4°C at night and 14°C in the daytime."

There are six ponds covered by 1mm thick HDPE liners with water flowing via gravity to a treatment pond positioned in between them in an inflated 8000m^2 greenhouse. Biofloc and recirculating aquaculture system (RAS) technology was chosen. Paco explained that this is a hybrid system, biofloc and MBBR biofilters. Floc volume is kept at 12ml/L. Female tilapia is cultured in the treatment ponds to control larvae of midge flies which are present in the organic matter mud in the digester. The digester in the treatment ponds

View of the several inflated greenhouses enclosing ponds and laboratory facilities for water quality and disease monitoring.

Grow-out ponds (left) and right, the treatments ponds with barriers to slow water flow and settle solids. Tilapia is stocked to control larvae of midge flies which are present in the organic matter in the digester.

helps to clarify the water, stabilise pH at 7.5 to pH8 and alkalinity at 160-220ppm. Denitrification accomplished in anoxic conditions frees alkalinity. Therefore, we do not need to add $NaHCO_3$. Water returning to the ponds is clear of suspended solids," added Paco.

Enclosed within an inflated greenhouse, the water temperature is maintained at 30°C. "I continue to experiment with pond depths at 1.5m and 2.3m. In the 2.3m deep ponds, the volume is 900m^3 and I stock 250,000 post larvae (PL). According to Robins McIntosh, CPF, the ideal stocking should be 5kg/m^3 to take advantage of the whole water column. "Our goal is only a maximum of 4kg/m^3, basically because we are working with artificial seawater."

Logistics is a challenge for this project, both for post larvae and feed. The source of post larvae came from Charoen Pokhand's facility in Florida, USA, but poor flight scheduling in 2021 resulted in high mortality for the first consignment. With better planning, the second batch which came as PL4 was successful. Nevertheless, Paco is not happy with the high freight cost for post larvae supplies. Furthermore, there was also non-uniform growth when stocked directly in the ponds. He is now planning to import nauplii and grow to post larvae (PL25) before stocking.

In terms of disease and water management, Paco has not detected *Vibrio parahaemolyticus* but only the presence of *Vibrio alginolyticus*.

Commercial-scale production and markets

The 50ha commercial farm will be a modular design developed in 5 phases. Ponds will be covered and the projected productivity is 3kg/m^3. There will be 3-4 cycles/year. Loultiti has also planned the potential markets – the fresh and live shrimp market around Barcelona, Spain, the most accessible and nearest European country. The company is already well established in the export of fresh fruits to markets in Europe. The team discussed at length the logistics of exporting live and fresh shrimp as well as certifications to enter markets in Europe.

There is a thriving local demand for shrimp. A survey at a supermarket in Marrakech indicated a retail market for frozen peeled vannamei shrimp (size 31/40) imported from India priced at MAD 155/kg (USD14.1/kg) and MAD 60/kg (USD5.5/kg) for size 50/70. Imports of frozen HOSO black tiger shrimp (21/30) from Bangladesh retail at MAD140/kg (USD12.8/kg). Cooked locally caught shrimp size 50/kg is sold at MAD 149/kg (USD13.6/kg). Additionally, there are seafood restaurants with fresh raw peeled shrimp on the menu aside from salmon portions, whole bar, seabass and sole.

A harvest of 22g shrimp.

A seafood restaurant in Marrakech offers fresh seafood including peeled fresh vannamei shrimp at MAD100/kg (USD10/kg) and Argentinian shrimp at MAD 270/kg (USD24.6/kg).

A proactive approach on shrimp culture: A farm experience in central Philippines

In Iloilo, the NSB-NB5 farm is adopting science-based protocols for sustainable production

By Mary Ann C. Solis, Leobert de la Pena, Cary P. Andigan and Ryan Joseph Zamora

Application of probiotics for pond water to maintain good water quality and reduce Vibrio levels in pond water and in shrimp

Shrimp farming in the Philippines has never been more challenging than it is today; producers encounter many issues, from environmental degradation, climate change, emerging diseases, lower demand and lower market prices due to the current global economic situation.

Among these, diseases have been the most challenging, owing to the evolving nature of pathogens affecting shrimp stock. Disease-related crop failures have prompted shrimp farms to adapt to the changing culture environment and develop with strategies and protocols to improve shrimp survival rate and boost production. These strategies include adopting innovative technologies suited for site-specific farm conditions.

In this article, we describe how one such farm in central Philippines has succeeded in making *Penaeus vannamei* shrimp production profitable and sustainable despite these challenges.

Facing shrimp farming challenges

Similar to most farms, NSB-NB5 in Iloilo province has to deal with the prevalence of diseases and high shrimp mortalities. It faces high *Vibrio* levels as well as the white spot syndrome virus (WSSV), *Enterocytozoon hepatopenaei* (EHP) and acute hepatopancreatic necrosis disease (AHPND). Biosolutions International Corporation, an aquaculture solutions company providing shrimp health products and equipment, was called in to provide technical solutions to the recurring problems encountered by the farm. With this assistance, NSB-NB5 has managed to develop proactive culture techniques to address specific issues and problems in shrimp culture.

While diseases present a major risk in shrimp farming, it was even more so in this farm, where multiple disease infections occurred simultaneously during the same cycle. Co-infections by WSSV and vibriosis caused mass mortalities among cultured shrimp in past culture cycles resulting in crop failures. One key strategy adopted by the farm is to minimise and control the presence of *Vibrio* bacteria in the pond water and, subsequently, in shrimp stocks to protect shrimp gut and hepatopancreas from damage.

During periods with high levels of *Vibrios* ($3.1x10^6$ CFU/mL), the farm will implement remedial measures by applying an organic acid-based disinfectant in the pond water to reduce *Vibrio* levels. Highly concentrated probiotics are then applied to the pond water regularly High concentrations of probiotics are specifically used as they have been proven that higher numbers of good bacteria are more effective in reducing *Vibrio* levels through competitive exclusion and direct inhibition. Feeds are also supplemented with high concentrations of probiotics to minimise the *Vibrio* population in the shrimp gut; immune boosters and vitamins are used as well to help improve disease resistance and overall health condition and immune response of the shrimp.

Another key issue in high-density shrimp farming is organic waste accumulation and high toxic ammonia levels as more feed is being used in such culture systems. Feed is one of the most important inputs in shrimp production, providing the necessary nutrients for growth and survival. Since feed comprises 50-60% of the total production cost in shrimp culture, it is crucial that feed is administered as efficiently as possible. Shrimp that are stressed from the presence of high organic waste and toxic ammonia, even under sub-lethal levels, can experience slow growth, resulting in high feed conversion ratios (FCR), thereby increasing the cost of shrimp production. Finding the right balance between proper nutrition with adequate amount of feed while maintaining good water quality is also among the farm's key success factors.

A practical and site-specific approach

We recommend a science-based and practical approach to address shrimp culture issues and challenges faced by the farm; together with farm management, we derive a proactive and site-specific approach in farm operations. This combination specifically addresses shrimp health issues and the deteriorating pond culture environment. In addition, we enlist an in-house technician to help monitor the overall condition of shrimp stocks and the proper application of health products and proactive culture methods. This innovative approach has been adopted at the farm's 11 culture ponds and 4 reservoirs, spanning 10 ha. These strategies adopted by the farm resulted in a significant increase in production through better growth rates, higher survival and a more efficient FCR.

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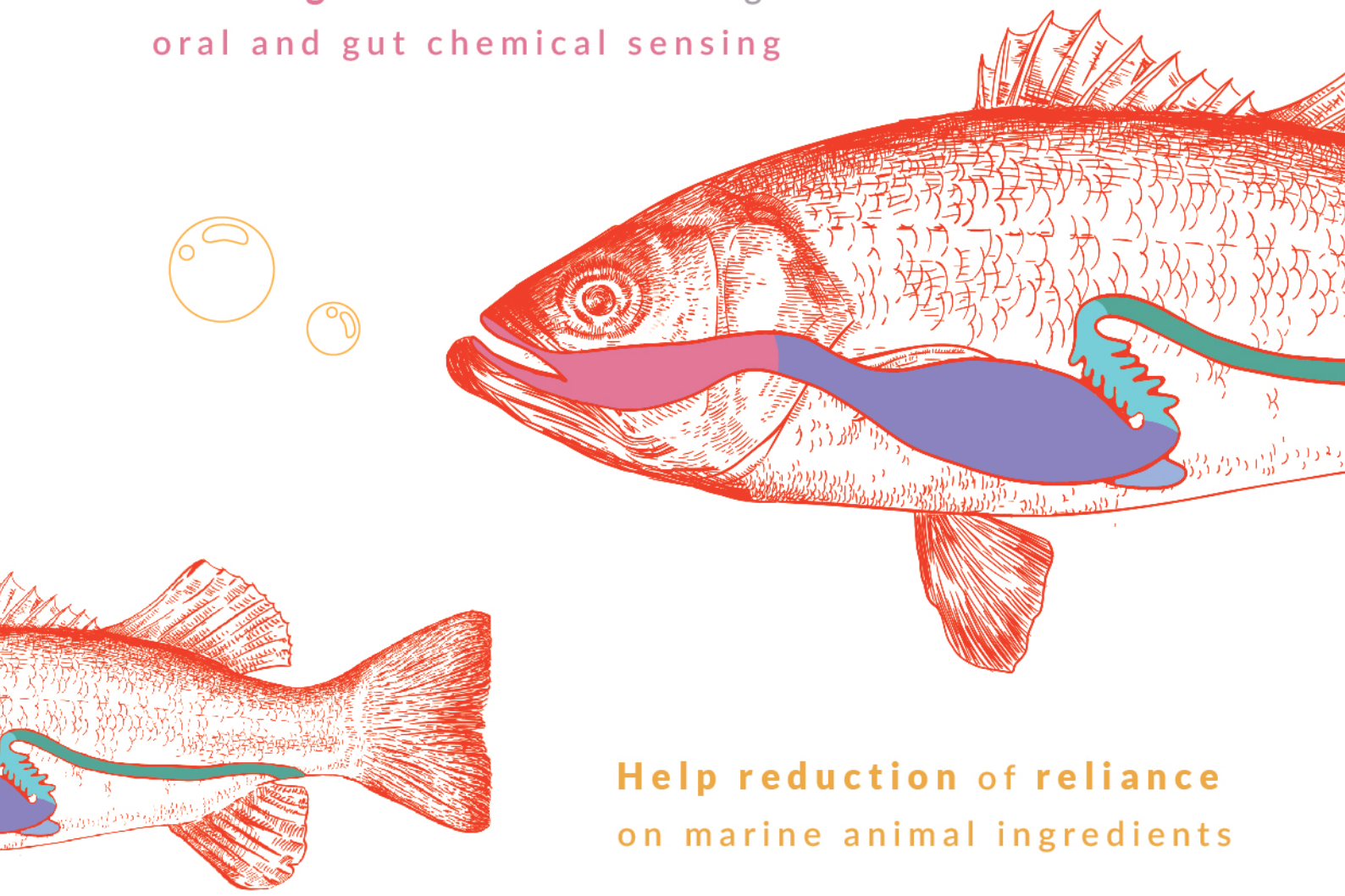

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Fry quality screening and handling

Only healthy post larvae from SPF (specific pathogen free) broodstock from accredited hatcheries are used in stocking culture ponds. Post larvae samples of PL7-PL8 are screened by the Southeast Asian Fisheries Development Center, Aquaculture Department (SEAFDEC-AQD) to test for potential diseases, such as WSSV, Infectious hypodermal and hematopoietic necrosis (IHHNV) and the microsporidian EHP. Tests are also carried out for total *Vibrio* counts and AHPND-causing pathogens. Only clean and healthy post larvae (PL9-PL10) with less than 1 x 10^2 CFU/mL *Vibrio* count that pass this stringent testing process are delivered to the farm for stocking directly into culture ponds.

Strict biosecurity

Biosecurity measures are strictly implemented, including the movement of personnel and vehicles, to minimise and prevent the entry of pathogens into the farm. Water in the reservoir and culture ponds undergo disinfection prior to stocking of post larvae. Disinfection is correctly applied to all materials used in the ponds. Personnel working at the farm use rubber boots that are regularly disinfected, Foot baths are located at the entrances of all ponds. Net and crab fences are installed around each pond to prevent potential disease-carrying organisms from entering the pond area. Regular disinfection is done in the culture ponds before stocking and during the culture phase to control pathogenic bacteria build-up inside the pond environment. Prevention is the key to minimising the risk of diseases.

Proper pond preparation

Before the start of each crop, technicians carry out the necessary pond and farm preparations. Water samples from the seawater source are tested for *Vibrio* and AHPND. Crustaceans such as crabs in the pond vicinity are tested in the laboratory for WSSV as these are major carriers of viral disease in shrimp farms.

Pond liners are also cleaned and disinfected, as well as equipment to be used during the culture cycle, such as paddlewheels, root blowers, aerator hoses and diffusers. When everything has been cleaned and prepared, the reservoir is filled with seawater and disinfected using 30ppm chlorine. This treated water is then pumped to the disinfected culture ponds. The pond water is then treated with probiotics, as well as silicate-based mineral fertilisers to allow plankton to bloom with natural food and to stabilise the water in preparation for stocking.

"Our collaboration with Biosolutions enables us to respond holistically and overcome the threat of emerging diseases in our farm. Using evidence-based monitoring together with high quality products that work, this allows us to have a consistently healthy and optimal harvest yield."
– Nestor Bretaña

A day before stocking, the pond water is again disinfected using organic-based disinfectants to control pathogenic bacteria. Culture ponds of 4,000-5,000m^2 are then stocked with 120-140PL/m^2.

Water and waste management

Water parameters are regularly measured to keep track of water quality and organic waste levels. Suspended solids settling at the centre of ponds are removed by pumping after every feeding and placed at the central sludge collection pit. These procedures prevent the abnormal and drastic increase in levels of toxic ammonia, nitrite, and hydrogen sulphide in water and remove organic waste from uneaten feed, decaying plankton, shrimp faeces and moulted shells.

The wastes from the central sludge pit are pumped out and passed through a sludge collection pond where the organic waste is allowed to settle while only clear

NSB-NB5 Farm owner Nestor Bretaña (third from right) during a farm visit with teams from Biosolutions International and INVE Aquaculture.

Marlon Z. Cuarte, the in-house technician from Biosolutions holds large 45g shrimp harvested at NSB-NB5 farm.

and treated wastewater is drained back to the sea. This ensures that the immediate coastal environment is not polluted by the farm.

During the culture cycle, water parameters, particularly pH, salinity, temperature and dissolved oxygen (DO) are strictly monitored to minimise stress to the shrimp due to sudden changes in these parameters.

As part of its environmentally-friendly approach to water management, the farm uses only organic-based treatments for the pond water during the culture phase; these include organic-based disinfectants for water treatment and probiotics for bioaugmentation. The periodic treatment of pond water is done by applying disinfectants in the morning, after which probiotics are introduced 6 hours later to allow beneficial bacteria to multiply and proliferate in the pond environment and become one of the dominant species.

This combination treatment of pond water is highly efficient in controlling the levels of pathogenic *Vibrio* in the pond water and shrimp, thus, controlling the occurrence of AHPND brought about by *Vibrio parahaemolyticus*.

Feed supplementation

Proper feeding ensures that the feed is evenly distributed throughout the pond in adequate amounts. Good quality feed that provides the correct nutritional requirement results in good growth and survival. Good feed management and feed consumption monitoring result in better feed conversion, thus, lowering the overall cost of production and increasing profitability and cost efficiency.

Early in the culture phase, feeds are supplemented with probiotics, immune enhancers and vitamins by top-dressing the feeds to boost shrimp immune response to stress and disease. This is an important part of the proactive protocol in shrimp farming - not just to focus on maintaining a better pond water environment, but also to prioritise shrimp health and nutrition. A strong and healthy shrimp is a resilient shrimp that will survive challenges.

Disease surveillance and shrimp health management

As mentioned earlier, the farm has had its fair share of disease outbreaks, particularly WSSV, AHPND, and EHP. Due to the presence of these widespread diseases, proactive and close monitoring of shrimp stocks must be done throughout each crop cycle. During culture, pond water and shrimp samples are regularly sent to SEAFDEC's Fish Health Laboratory for testing. This proactive approach to disease monitoring helps the farm detect the presence of pathogens at the onset of a disease outbreak. Early detection allows for the prompt implementation of remedial measures to prevent mortalities and crop losses.

During multiple disease outbreaks a more aggressive remedial measure will be adopted. Water in the culture pond is treated in the morning with 1ppm of an organic acid-based disinfectant. After 6 hours a double dose of concentrated probiotics will be applied and thereafter on the following days until *Vibrio* levels drop. Feeds are mixed with a double dose of probiotics, together with vitamins as immune enhancers.

A more intensified disinfection process is employed to prevent further contamination that may affect other

	Crop 1		Crop 2	
	Pond 4	Pond 5	Pond 4	Pond 5
Area (m^2)	5,550	4,745	5,550	4,745
Stocking density (PL/m^2)	74	76	130	129
Days of culture (DOC)	114	121	83	92
Average body weight (ABW)	45.8	51.7	23.8	32.7
Biomass/pond (kg)	11,281.0	10,131.0	14,691.0	14,989.0
Yield/ha (kg)	20,327.0	21,352.0	26,470.0	31,589.0
Survival rate (%)	87	88	95	96
Feed conversion ratio (FCR)	1.22	1.25	1.15	1.16

Table 1. Production data for the latest two crops in two ponds showing better results. The farm can now grow larger white shrimp of 45g and 51g.

ponds with healthy stocks and shrimp post larvae to be stocked in the next cycle. After harvest and full draining, the pond liners are cleaned and disinfected with 1ppm an organic acid-based disinfectant. Then chlorine is used at 60ppm; it is injected below the pond liner to disinfect the underside portion of the plastic liners.

Improved production with innovative strategies

The above measures are key to the farm's success in production, and are defined by the following:

- Improved survival rates of 87%-96%
- Better growth rates – the farm is now able to harvest larger-size shrimp 32 to 51g (ABW) in 92 days and 121 days, respectively
- Lower FCR at 1.15 to 1.25
- Improved production/ha to 31 tonnes/ha compared to previous crops (Table 1)

These science-based and proactive approaches resulted in a healthy pond environment, with pathogens under control and shrimp with enhanced overall health and nutrition, profitability and sustainability.

Wealth in learning and sharing knowledge

Since 2018 with the full application of the Biosolutions Technology, this farm despite facing numerous challenges not merely survived but experienced superior shrimp production performance. Today, NSB-NB5 is not deterred from finding aquaculture solutions for a more sustainable and profitable shrimp production.

This innovative shrimp aquaculture approach was shared with many other shrimp farmers in Cagayan Valley (North Luzon), Mindoro (South Luzon), Negros Occidental (Visayas), South Cotabato (Mindanao), and Sarangani (Mindanao). These farmers have seen for themselves the advantage of using quality health products, innovative technology and best aquaculture practices to achieve better growth and survival. As a result, they have since adopted the Biosolutions methodology.

In fact, NSB-NB5 Farm owner Nestor Bretaña said, "Our collaboration with Biosolutions enables us to respond holistically and overcome the threat of emerging diseases in our farm. Using evidence-based monitoring together with high quality products that work, allows us to have a consistently healthy and optimal harvest yield."

The key factors contributing to the successful application of this technology involve the selection of high-quality health products and their proper and timely application customised to the culture circumstances unique to the farm. It also includes the stringent screening process for post larvae, regular laboratory testing during the culture period, and the presence of competent and trained farm personnel.

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Krill meal proves to be an impactful source of protein in Pacific whiteleg shrimp diets

In a new study on digestibility of crude protein and essential amino acids, krill meal exhibited the highest apparent digestibility

By Chaiyot Rawekchom

The Pacific whiteleg shrimp *Penaeus vannamei* has emerged in recent decades as one of the most important farmed shrimp species worldwide, accounting for 82% of global shrimp production (Liao and Chien, 2011). Native to the Pacific coast of Latin America, whiteleg shrimp was commercially introduced to the Asian market in the 1990s. Since then, its production across the continent has grown exponentially, with demand rising.

One of the costliest and most critical elements in raising whiteleg shrimp is protein (Allen Davis and Miles, 2021). It is an essential part of the shrimp diet and can be the deciding factor when it comes to shrimp growth. But finding the right source and amount of protein as a dietary ingredient has become somewhat of a balancing act for farmers. Too little limits growth and too much is costly and may not be fully absorbed by the shrimp (Lee and Lee, 2018).

This means that shrimp farmers must find an optimal source and amount of protein for their feeds, while taking their costs into consideration and not compromising the growth and development of the shrimp. As cost pressure increases on this industry, farmers will have to turn to ingredients that ensure the greatest possible nutritional impact on culture performance.

Krill meal stands out as an optimal source of protein

Krill meal has been identified as an optimal source of protein and proven to improve feed efficiency and growth performance, which have direct economic effects on the shrimp farms. Because of its growing reputation as an impactful ingredient in aquafeeds, krill meal (under the QRILL Aqua brand provided by Aker BioMarine) recently came under the lens of the marine scientists at Labomar, the Marine Sciences Institute in Northeast Brazil.

"While we did not participate in the study, on behalf of Aker BioMarine, we were pleased to supply the researchers with our QRILL Aqua product. We fully understand that independent research and academic interest in the effects of krill meal on aquaculture species are key to building a better understanding of the full potential of this Antarctic crustacean and how it can affect growth performance," said Lena Burri, R&D Director for Animal Nutrition and Health, Aker BioMarine.

Research is a key part of the Aker BioMarine strategy to build more knowledge around krill and its role in human and planetary health. Harvested in the pristine waters of the Southern Ocean, krill meal from Aker BioMarine is sustainably sourced and closely monitored by international bodies. These efforts have helped support the growth of krill biomass.

Krill feeds on phytoplankton and algae, which in turn boost its nutrient-packed nature. Over the last few decades, there has been increased attention on krill as a key ingredient in animal feeds, particularly as a potential gamechanger in the aquaculture industry," added Burri. "Krill is known to be rich in omega-3 phospholipids and now, thanks to Labomar and their scientists, more is known about krill as a source of crude protein and amino acids."

The hunt for the ultimate source of protein for shrimp diets

The quest for the ultimate source of protein for shrimp diets is what led the Labomar scientists to embark on their new study, published in 2022. The research, "Apparent digestibility of protein and essential amino acids from commonly used feed ingredients in Brazil for juvenile shrimp *Litopenaeus vannamei*", aimed to uncover the digestibility of crude protein and essential amino acids in various types of ingredients, including krill meal, for Pacific whiteleg shrimp diets. The major drawback, according to the Labomar team, is the lower availability of important nutrients and poorer attractability of these ingredients, making these protein sources less likely to attract the shrimp to consume the feed, as well as lower digestibility.

"Shrimp farmers today are feeling the cost pressure, and they are in need of more reliable sources of protein in their feeds," said Burri. "One of the ways to ensure reliability of the ingredients is to evaluate whether the shrimp are getting the full benefits of that ingredient. This requires a deeper investigation into whether the ingredient exhibits high digestibility, meaning more nutrients being absorbed and used in the body, as well as high attractability, meaning the shrimp are enticed by the ingredient and consume more of it."

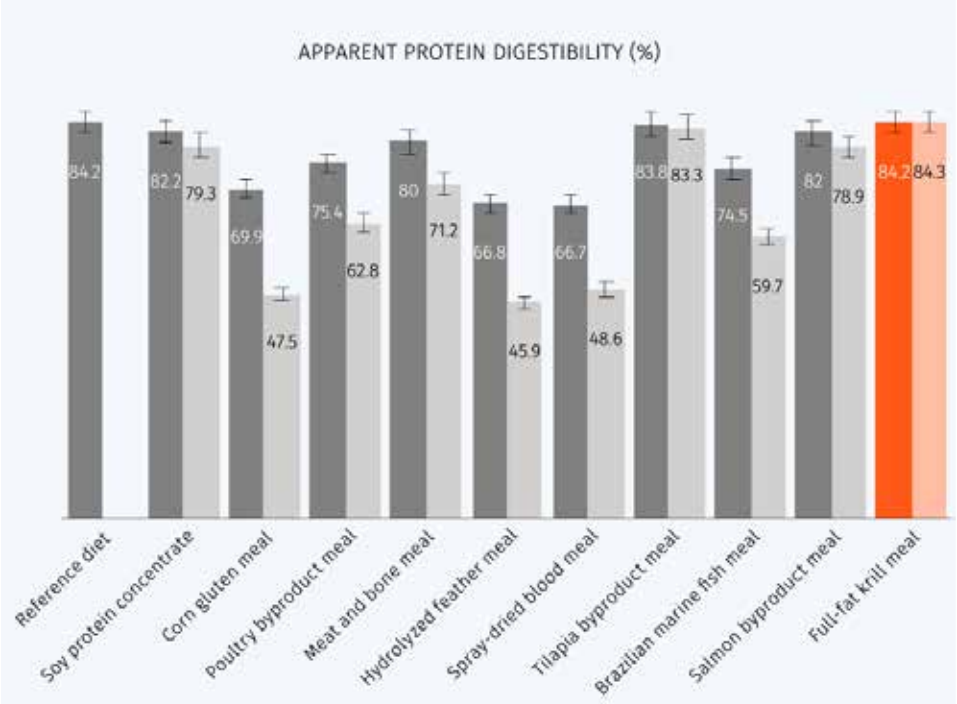

Figure 1. Apparent crude protein digestibility (ACPD) of test diets and ingredients for juvenile *Litopenaeus vannamei*.

The scientific team at Labomar started with the premise that farmers are increasingly turning to lower cost terrestrial plant protein products, such as soybean, canola, corn and wheat, as well as animal meals.

Three-phase juvenile shrimp trial run in Brazil evaluates various protein sources

The Labomar study, conducted in the State of Ceará, NE Brazil, set out to evaluate the effects of a variety of conventional protein sources among juvenile Pacific whiteleg shrimp test subjects.

The team measured the growth performance, attractability and digestibility of the protein sources, over the course of three distinct phases, each lasting 29-30 days. The first phase included rearing the shrimp. During the second phase, the scientists compared the effects of individual ingredients in a two-by-two comparison. In the final phase, the apparent digestibility for crude protein and essential amino acids of selected ingredients was determined. Shrimp survival exceeded 96% at close of study and was unaffected by the test ingredients.

"Protein digestibility is an important factor that defines the quality and value of commercial raw materials. It allows formulating on a digestible protein and amino acid basis, while improving feed efficiency and shrimp growth performance," said the authors in their published findings. (https://www.rbz.org.br/wp-content/uploads/articles_xml/1806-9290-rbz-51-e20210177/1806-9290-rbz-51-e20210177.pdf)

The protein ingredients under evaluation during this trial included soy protein concentrate, corn gluten meal, poultry by product meal, meat and bone meal, hydrolysed feather meal, spray-dried blood meal, tilapia byproduct meal, Brazilian marine fish meal, salmon by product meal and krill meal from Aker BioMarine. Each test group was fed a specific diet to measure the distinct effects of each of the key protein and amino acid ingredients.

Following the experiment, the Labomar team made some key discoveries which demonstrate that not all protein sources are equally effective as a dietary ingredient. Here are three key findings from the study:

Finding 1: Aquatic ingredients yield high crude protein and essential amino acid digestibility

The apparent digestibility for crude protein for most aquatic proteins was high compared to plant and terrestrial animal byproducts. The salmon by product meal, soy protein concentrate, tilapia by product meal, and full-fat krill meal are preferable ingredients in feeds for the whiteleg shrimp since they carry a high crude protein and essential amino acid content (>600g/kg) combined with apparent digestibility coefficients near or in excess of 80%.

Finding 2: Krill meal was a top performing ingredient

Krill meal exhibited the highest apparent crude protein digestibility (84.3%) and apparent essential amino acid digestibility (86.5%) among all test ingredients. The shrimp consuming the krill meal diet also showed the best growth performance, the highest weekly growth, and the lowest feed conversion ratio.

Finding 3: Protein and amino acid digestibility is more important than their crude values

The crude protein and essential amino acid content in commercially available feed ingredients for whiteleg shrimp should not be taken as the sole indicator of their quality. Instead, apparent digestibility coefficients should be documented along with other parameters to judge quality and better predict shrimp culture performance.

Aquatic ingredients are the most effective shrimp feed additives

Overall, the Labomar research team concluded that the aquatic ingredients, in general, yielded higher crude protein and essential amino acid digestibility, making them

- QRILL Aqua is naturally packed with essential nutrients and feed attractants.
- Inclusion of QRILL Aqua reduces reliance on expensive marine protein sources.
- QRILL Aqua secures shrimp feed palatability, growth performance and health and at the same time optimizing feed cost.

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the more effective additives to shrimp feeds. Krill meal was a standout performer among the test groups, giving the best results in comparison to all other ingredients in the experiment.

In addition, Dr Alberto J.P. Nunes from Instituto de Ciências do Mar (Labomar) pointed out some key findings related to how farmers should evaluate their raw materials:

"This study shows that protein and amino acid digestibility of raw materials has a greater importance than their crude values and should be carefully considered during ingredient selection and feed formulation," said Nunes, upon the announcement of the study results.

"We see that aquatic protein sources and krill meal specifically have proven to increase feed efficiency and growth performance of juvenile shrimp, which will likely have direct implications on water quality and economic performance of shrimp farms," he added.

The complete article detailing the Labomar study is now available on Revista Brasileira de Zootecnia. (https://www.rbz.org.br/article/apparent-digestibility-of-protein-and-essential-aminoacids-from-commonly-used-feed-ingredients-in-brazil-for-juvenile-shrimp-litopenaeus-vannamei/). The experimental trial was part of the Master of Science thesis for Carolina Vieira, and was supervised by Dr Alberto J.P. Nunes, and co-authored by Drs Ricardo Pinto and Alexandre Diógenes.

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Long lasting effects of palatability enhancers on fish zootechnical performance are more visible in challenging conditions

The benefits of palatability enhancers have been demonstrated in several fish species and applications

By Mikael Herault and Paul Seguin

European seabass

Over the past 3 years, Diana Aqua, recently renamed Symrise Aqua Feed has published several articles demonstrating the benefits of protein hydrolysates-based palatability enhancers (PE) for aquafeeds. We have demonstrated a wide range of applications in marine carnivorous fish species where growth performance improved when using dietary PE: fishmeal replacement, medicated feed, environmental or husbandry stress mitigations (Seguin et al., 2020). Through top coating application and a specific PE formulation, including marine protein hydrolysate, we show there are cost reductions making it scalable to all fish growth stages, from larval to grow-out diets. Specific PE applications were successfully extrapolated to Asian seabass (Seguin et al., 2021) and also to Atlantic salmon, where the industry is already very well optimised (Fournier and Herault, 2021).

More recently, we showed that it was possible to increase feed acceptance of the tilapia and butter catfish (*Ompok bimaculatus*) by top coating dietary protein hydrolysate supplementations (Herault et al., 2022), hence resulting in much lower farm feeding costs. This is even though freshwater fish species are known to be much less demanding in terms of diet nutritional compositions or palatability enhancers. Currently, new results highlight the long-term benefits of dietary PE supplementations in marine carnivorous fish species, despite significant dietary changes.

Making fishmeal-free diet palatable to European seabass juveniles with PE

Feedback from the industry indicates that marine carnivorous fish juveniles are usually fed with 20-25% fishmeal (FM) diets while grow-out fish are fed with 10-15% FM diets. These figures are confirmed by a recent review made by Naylor et al. (2021).

In a recent study, Symrise Aqua Feed evaluated the long-term impact of a 2% liquid PE supplementation, when top-coated on practical diets for the European seabass *Dicentrarchus labrax* juveniles. There were six graded levels of fishmeal. The experimental diet formulations are presented in Table 1. All experimental diets were balanced to meet nutritional requirements of the European seabass and were iso-nutritional for dry matter, crude protein, crude fat and energy (CP 44±0.4%; CF 15.1± 0.2%; Energy 5.2±0.07 Kcal/g).

The six practical diets had graded fishmeal levels from 0 (fishmeal-free diet) to 25% (most conservative diet), top-coated with 2% liquid PE (Extrapal) or without. In the experimental design, these 12 dietary groups were randomly allocated to two tanks of 100L capacity, supplied with thermoregulated filtered seawater (20±1°C, 250% renewal rate). Fish were fed *ad libitum* with automatic feeders (Arvotech, Finland) for 37 days while feed waste were daily quantified to adjust feeding rates. Growth results are presented in Figures 1 and 2 while feed conversion ratio (FCRs) values are illustrated in Figure 3.

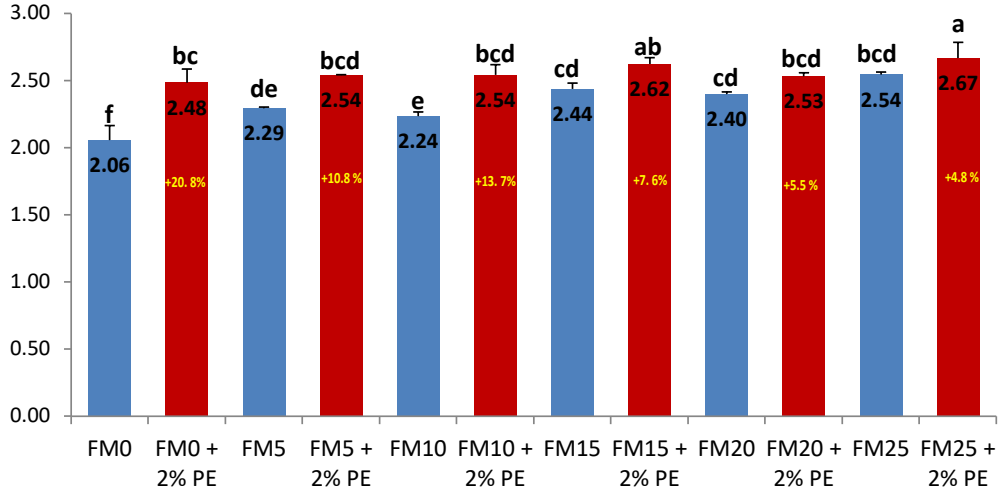

Figure 1. Specific growth rates (SGR) observed after 37 days of feeding trials in European seabass juveniles fed diets with graded levels of fishmeal (FM), supplemented with 2% liquid palatability enhancer (PE) and non-supplemented. Different letters above the bars indicate statistically significant differences at P<0.001 (1 way ANOVA & LSD post-hoc test).

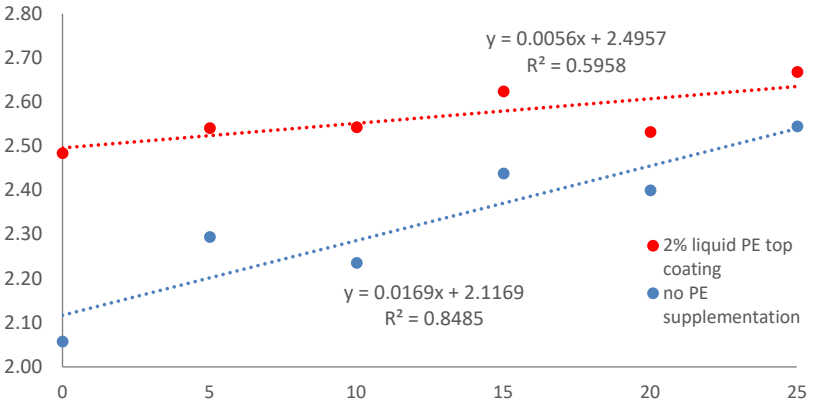

Figure 2. Modelled specific growth rates (SGR) observed after 37 days of feeding trials with European seabass juveniles fed diets with graded levels of fishmeal (FM 0 to 25%), supplemented with 2% liquid palatability enhancer (PE) and non-supplemented. ANOVA applied on linear regressions confirm significantly differences for modelled curve slopes constants ($p<0.01$).

Long lasting benefits of PE

These results show that a 2% liquid PE supplementation can significantly improve growth performance of European seabass juveniles at all tested fishmeal levels. Supplementing a fishmeal free diet with only 2% liquid PE allowed to yield the same growth performance as a 20% FM diet. This suggests promising possibilities in terms of cost savings and reduction of carnivorous fish diet environmental footprint and FIFO (Fish-In Fish-Out), particularly during the more demanding nursery phases.

The trial duration was 37 days, which means that these observed benefits are long lasting and are assumed to remain over the whole fish growth cycle. This statement can be supported further by the fact that FCRs were not negatively impacted over this duration for PE supplemented dietary groups. The poorest observed FCR average values for PE supplemented dietary groups was approximately 1.26, which corresponds to the FCR normally observed in laboratory conditions, for the non-supplemented FM20 dietary group.

As expected, modelled growth curves (Figures 2 and 3) confirm that the growth gain, resulting from the use of a palatability enhancer will be proportionally higher at lower dietary fishmeal levels. When extrapolated, we may assume this gain could be lower and less significant at above 27-30% fishmeal levels. We propose at these high fishmeal levels, using a mix of standard and premium fishmeal, diet palatability is already optimal, and therefore when reared under optimal conditions, the fish cannot eat or grow any further.

Interestingly, under challenging conditions, it seems possible to further enhance palatable diets containing high levels of quality fishmeal as we demonstrated in another trial with the European seabass reared under cold water conditions.

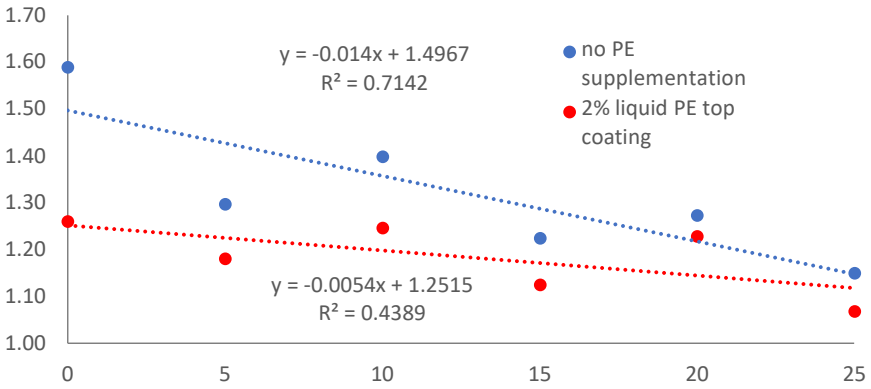

Figure 3. Modelled feed conversion ratio (FCR) observed after 37 days feeding trials in European seabass juveniles fed graded levels of fishmeal (FM) from 0 to 25%), supplemented, with 2% liquid palatability enhancer. (PE) and non supplemented. ANOVA applied on linear regressions confirm significantly differences for modelled curve slopes constants ($p<0.05$).

	FM0	FM5	FM10	FM15	FM20	FM25
Fish meal SA Super Prime 68% CP	0.0%	2.5%	5.0%	7.5%	10.0%	12.5%
Fish meal NA Standard 70% CP	0.0%	2.5%	5.0%	7.5%	10.0%	12.5%
Corn Gluten 60%CP	17.4%	15.8%	14.3%	12.7%	11.1%	9.5%
Wheat Gluten 80%CP	22.9%	20.8%	18.7%	16.6%	14.5%	12.4%
Sunflower meal 35%CP	10.6%	10.3%	10.0%	9.7%	9.5%	9.2%
Soya Cake 48%CP	15.5%	14.8%	14.1%	13.4%	12.7%	12.0%
Wheat dehulled 10%CP	10.8%	11.3%	11.8%	12.3%	12.8%	13.3%
Methionine	0.6%	0.5%	0.5%	0.4%	0.4%	0.3%
Lysine	1.8%	1.6%	1.4%	1.2%	1.0%	0.9%
MCP	2.9%	2.6%	2.3%	2.0%	1.7%	1.4%
Fish oil	15.2%	14.8%	14.5%	14.1%	13.8%	13.4%
Micro-ingredients (Premix and antioxidants)	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%
Cellulose	1.2%	1.2%	1.3%	1.4%	1.4%	1.5%

Table 1. Experimental diet formulations for European seabass juveniles.

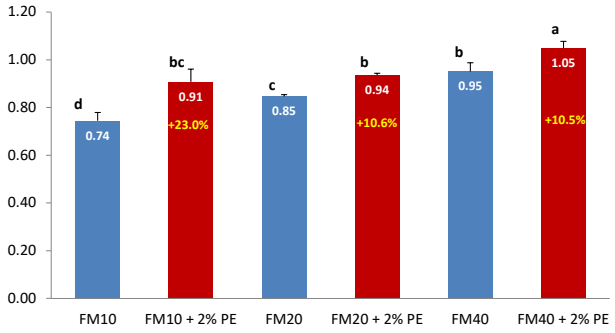

Figure 4. Specific growth rates (SGR) observed after 21 days of feeding in European seabass juveniles fed diets with graded levels of fishmeal (FM 0% to 40%), supplemented with 2% liquid palatability enhancer (PE) and non-supplemented in cold water conditions. Different letters above the bars indicate statistically significant difference at P<0.001 (1 way ANOVA & LSD post-hoc test).

Dietary palatability can mitigate stress perception and the resulting adverse effects

A 21-day feeding trial was implemented in Symrise Aqua Feed's testing facilities with European seabass juveniles (mean weight: 13.0g). Three graded fishmeal levels were tested (10, 20 and 40%), with or without 2% liquid PE supplementation, top-coated. Feed formulations were as in Table 1, with fishmeal mixes being partly replaced with a mix of plant protein and crystalline free amino acids.

The experimental design was very similar to the previous one, except that it was implemented at 11.7°C which is natural seawater temperature instead of 20.0°C (thermo-regulated). Each dietary group was randomly allocated to three tanks of 100L capacity. Fish were fed *ad libitum* to maximise dietary palatability performance and resulting growth performance are illustrated in Figures 4 and 5.

Symrise Aqua Feed (Aqualis) marine fish testing facilities

Fish growth rates were understandably impacted by the reduction in water temperatures as values were approximately 65% lower than in the previous feeding trial. Additionally, all PE supplemented groups yielded a significantly higher growth rate compared to their basal dietary benchmarks and again, the observed gap was higher for fish fed diets with lower dietary fishmeal levels as compared with fish fed diets with higher fishmeal levels. Nevertheless, contrary to what occurred at optimal rearing conditions of 20°C, at lower temperatures, feed acceptances were not at their physiological maximum for

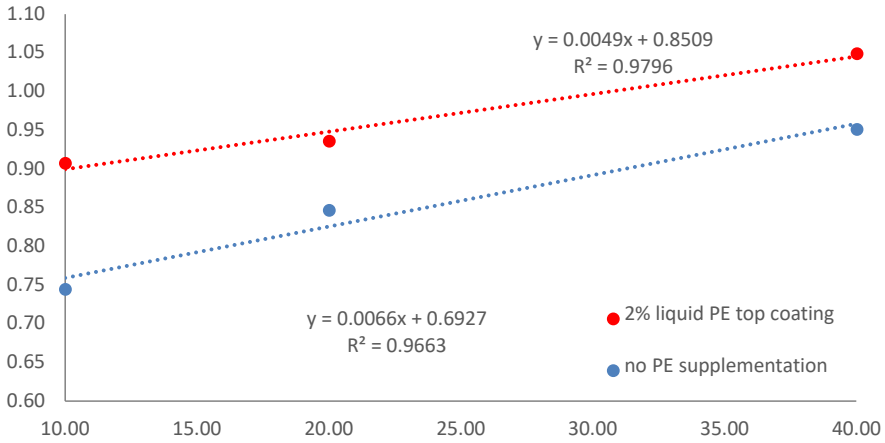

Figure 5. Modelled Specific growth rate (SGR) observed after 21 days feeding trials with European seabass juveniles fed diets with graded levels of FM (from 10 to 40%), supplemented with 2% liquid palatability enhancer (PE) and non-supplemented. ANOVA applied on linear regressions confirm significantly differences for modelled curve slopes constants ($p<0.001$).

higher dietary fishmeal levels and they could therefore still be further enhanced with PE supplementation.

Therefore, fish fed the FM40 diet showed growth rates 10.5% higher with PE supplementation ($p-v<0.001$). Modelled growth curves, illustrated in Figure 5, clearly show that, under challenging environmental conditions, a growth plateau was absent at higher dietary fishmeal levels and that 2% PE supplementation will result in approximately 0.15%/day more growth at equivalent dietary fishmeal levels (as calculated by the difference between two growth curves constants).

This feeding trial, combined with other unpublished results (available upon request), confirms that dietary PE, especially when formulated with marine protein hydrolysate and specific palatable ingredients, can play a significant role in mitigating environmental or husbandry stress perception by fish and reduce their adverse effects on zootechnical performance.

Conclusion

Marine carnivorous fish are generally the most profitable aquaculture products, but they also pose the greater challenges for feed formulators such as higher macro/micronutrient requirements, fishmeal replacement needs for a lower environmental footprint, possible palatability issues resulting from use of plant protein or that of novel proteins. Marine fish are highly susceptible to environmental or husbandry stressors, increasing disease outbreak risks.

These results from Symrise Aqua Feed demonstrate its liquid palatability enhancer, when used at low dosages (1 to 2% depending on pellet size), can be a cost-effective solution. Dietary supplementation with Extrapal, a palatability enhancer specifically designed for marine carnivorous fish species, resulted in long lasting enhanced growth and feed performance. The differential gains were even higher, proportionally, under challenging conditions, either dietary or environmental.

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The pull and push effect for the adoption of novel feed ingredients

At the Hard Talk programme during TARS 2022, a panel representing the supply chain searched for answers

The Hard Talk panel at TARS 2022. From left, Henrik Aarestrup, BioMar Group; Tony Dang Quoc Tuan, Tony Tuan Farm , Josh Goldman, Australis Aquaculture and Christopher Tan, Mida Trade Ventures Pte Ltd with moderator, Ronnie Tan . More on the panel **here**.

In recent years, we have seen the emergence of several novel feed ingredients, from single-cell proteins, insect meals to algal oils. The main marketing focus of these product developers is a sustainable alternative for fishmeal and fish oil in shrimp and marine fish feeds, the primary consumers. A few insect meal producers have made headway in salmon feeds by associating with some of the major feed millers. With today's rising prices of traditional feed ingredients, it is an excellent opportunity for these novel feed ingredients to be adopted. However, the process is taking a long time.

The conversation was on how to create the pull and push for the industry's adoption of novel ingredients and who in the value chain should bear the costs of the early introduction stages. This requires the participation of representatives along the supply chain.

Henrik Aarestrup is Vice President at BioMar Group, Denmark and heads BioMar's business units in the LATAM Division while driving BioMar's fast global expansion within the hatchery and shrimp segments.

Josh Goldman, Founder/CEO at Australis Aquaculture is a global leader in the production and marketing of the Asian seabass *Lates calcarifer*. Josh is an internationally recognised leader in sustainable seafood, developing some of the best ideas in aquaculture.

Tony Dang Quoc Tuan is a certified accountant and owner of Tony Tuan Farm, a 50ha farm in Bac Lieu, South Vietnam. He started this in 2019 after over 10 years of experience in operating and managing leading shrimp hatchery groups in Vietnam, including the Nam Mien Trung Group and Viet Uc Group.

Christopher Tan, Director, Mida Trade Ventures Pte Ltd, Singapore, a seafood brokerage and trading company, is servicing many of the largest importers in the USA, selling to major retailers like Walmart, Costco, Kroger and Albertsons, amongst many others.

"Why do we need to have the participation from the supply chain when rightly, we should consider just the feed ingredient supply and the feed miller?" posed moderator Ronnie Tan, Regional Aquaculture Consultant, US Grains Council, Malaysia. The answer, he said, is that today, there is a pull factor from retailers and consumers focusing on sustainability and what goes into the feed.

The slow adoption of novel feed ingredients into aqua feeds: Price and availability?

Henrik: We often hear that insect meals and algal oils are very expensive, but which is the bigger problem: price or availability? A 5% inclusion rate for an ingredient costing USD1,000/tonne more than a traditional ingredient will mean a 5% additional cost of the feed. But going further in the supply chain, we need to factor in farming and processing costs, logistics, etc, and the raw material based difference to the consumer will in the end be minimal.

I think that availability is probably a bigger problem and a limiting factor. If we calculate the demand increase for fishmeal for the increase in shrimp production in Ecuador in 2021, this was at least 40,000 tonnes of additional fishmeal just for Ecuador. The 3,000 tonnes offered by the insect meal producer will not help much with the current growth in Ecuador.

The economics of adoption

Can a novel feed ingredient supplier asking for USD2,500/tonne challenge the best quality fishmeal selling at USD1,800/tonne? Would a farmer be willing to pay a slightly higher price for a novel feed ingredient for the sake of sustainability?

Henrik: In reality, the issue is probably more about traceability. If the farmer who sees the initial bill of an extra USD50 on his feed price cannot pass that on to the following link, then it is a high cost that he will not be able to recover.

Josh: We are very optimistic on the role novel ingredients can play in supporting our brand and the broader ESG objectives, while helping to mitigate ingredient supply and cost risks. This gives us a strong motivation for adoption, but we still need to do our own research and collaborate with supply partners to gain a deeper understanding of how best to leverage these emerging ingredients.

Of course, the biggest challenge is economic. It is important to understand just how sensitive this can be for fish producers. For example, an ingredient that adds 5 cents per kg to our feed cost will increase the finished product by roughly 4 times that much - after factoring in the effect of FCR and processing yield. So, the conversation is going to be heavily focused on cost but also on whether an ingredient can deliver improved biological performance to offset any cost increase.

Tony: Firstly, shrimp farmers are very concerned with profits. Next is the economic sustainability of our business. The third concern is the efficiency of the feed. Shrimp farming is getting riskier with diseases, and as such, in Vietnam, we do a lot of top dressing of the feed at the pond side, which include additives that the feed miller does not want to add into the feed. Most of the additives leach into the pond, but we really do not have a choice. Feed millers are doing an excellent job with efficient feed, but we just wish they could supplement the feed with additives/ingredients that can help enhance or improve shrimp health. In Vietnam, shrimp feed prices have been a pain for farmers. In the past 18 to 24 months, the prices of shrimp feeds have increased by about 30% in the market.

Can there be a premium price for the final products?

Josh: Brands like ours need to manage a broad messaging architecture to create an authentic connection with our customers. Practically, this means that we have to think quite holistically about the story and message and so we cannot rely too heavily on any single "character" - such as insect meal or algal oil - in part because different consumers prioritise different concerns. Also, many products make sustainable claims, so we cannot expect the consumer to reward us for specific input, beyond of its role in supporting the brand values more broadly.

Bearing the extra costs

Who should bear the extra costs? Will the feed miller and farmer share the increase in feed costs between them or should they go down the supply chain to the processor or buyer?

Henrik: In the long term, the consumer will need to bear the costs. A feed miller can never continue a business if it is absorbing all the costs. Traceability is so important and it can go all the way to the consumer. The consumer can see that one product has a better profile than another. For the system to continue operating and be sustainable for the different parties in the supply chain to continue operating, the price has to be paid by the consumer.

Joss: We are willing to absorb the costs but at a very modest level. What we really need is the supply chain to be our partner and help us. In the end, what we are primarily looking for is an ingredient, like insect meal, not to be a pure protein replacement but to play a functional role as an attractant or as an antimicrobial. And if those promises bear fruit, then there are benefits beyond just the cost per amino acid.

Christopher: Whether the retail sector can bear the cost is a very market-driven question. Today, retailers are king. A year ago, if retailers were asked to pay an additional premium, they would have said "we have no choice" because otherwise, they would not get any product. This comes back to marketing. The retailer will put pressure on the processor, who will put pressure on the farmer and the farmer will put pressure on the feed mill. I do not think that placing the responsibility squarely on any one segment of the supply chain will do any good. It takes, for example, a third party like WWF to step in and really enhance it.

Will consumers pay a premium price for sustainable (final) products?

Josh: In consumer surveys, a sizeable group of people consistently indicate that they want to eat more sustainably and will pay a premium for foods that align with their values. However, this is increasingly becoming a "baseline" expectation and less of something that will generate a premium. Our "Better Fish" brand is built around the idea of a Better fish for a Better World and so we need to find ways to back this up with innovation that supports our goals and aspirations. We certainly see it as an important part of how we drive demand and create value.

Christopher: I think the buyer, the processing plant and the supermarket chain will not want to bear the cost. Novel feed ingredients or what goes into the feed is a highly unsexy subject to talk about. To a consumer, sustainability is about the environmental impact, followed by carbon footprint and global warming. These topics are very sexy now. Third is animal welfare. Consumers are more concerned about the fish being sustainable, but what the fish and shrimp eat is just too far away in terms of the degrees of separation. The consumer does not have the time nor the patience for complex messages or to understand these little nuances in the industry.

Henrik: Joss and Chris highlighted the education of the consumer. We are involved in many projects which are value chain collaborations, where we have the whole chain together from retail all the way down to our suppliers of ingredients. If we get the systems up and get the collaboration through the value chain, then we have a possibility of creating change.

Consumers' acceptance of sustainable products

The oils have done it well (see box), but the protein alternatives have not.

Henrik: The oils have an advantage because EPA and DHA clearly have health benefits. A health claim is associated with them all the way through to the consumer, and at the same time, they can also claim sustainability. There is a nice consumer story here. Sitting at the table together with the whole supply chain to discuss what exactly are the issues. What we tried to do is to go for the holistic story.

It is not just about having insect meal. It is also about the way we are farming - the carbon footprint and the origin of the ingredients. You need to take the whole thing in to have a product that ultimately becomes sexy. There are many different types of consumers. Most consumers could not care less about sustainability – preferring to look at the price. Collaboration and traceability are so important. If possible, reach that segment and come up with a story that holds all the way through.

Christopher: There are some customers who are very interested in sustainability. The US and European markets absorb a grand total of about 35% of the global shrimp supply. The rest of the world, the remaining 65%, do not care about certification or sustainability. China absorbs about 30% or 35% of the global shrimp production and the huge push for certification in 2020 and 2021 was because producers realise they could not rely on the Chinese market. Walmart, Costco and Tesco are the big buyers. Yes, they consume a lot volume-wise, but they are not the be-all and end-all. There has to be a better push in markets like in Asia or Latin America, but the consumers in these regions are still not as sustainability-focused as those in the US and Europe.

Tony: There are some 1,000 processors in Vietnam and almost all the farmers sell to the processors. There is a clear direction and demand in the market for Vietnam's shrimp and the prices are slightly higher than those from India. On a holistic approach to produce and export sustainable shrimp to the US or Europe, our grow-out techniques also veer towards sustainability. We use probiotic products to treat the water and maintain the environment for the shrimp. We have tried to use insect meals top dressed in feeds.

What next with inflationary pressures and looming recession?

The scenario is rising inflation reducing consumers' purchasing power. There is a looming recession and rising costs. Shrimp in the US is a very elastic product when volumes are up and prices come down. How can producers handle the extra costs? A shrimp cycle is only 3 months, increasing the volatility index when farmers leave the pond fallow and jump in again later.

Tony: For farmers, it is a very tough situation because we cannot control the offer prices of processors. Over the past 18 months or so, there have been increases in inputs from feeds and the rest. When we talk about novel ingredients, we are interested in whether shrimp grows faster in a shorter time. If there is a 5% increase over the whole supply chain and it is good for the end consumers' health, we need to educate the market. Then this is the direction we need to put more effort into.

Henrik: Again, there is collaboration within the value chain. Sitting with the shrimp retailers, if you can get a commitment that you have to deliver, six months from now, a more sustainable shrimp and you have the volume commitment backwards, then it can work.

At the moment, there is a big risk that all the good efforts that we could have made a year ago might be very different today. There is a real risk that some good initiatives will fade away, but it does not mean that we should not try. We have an obligation to try. We should make the solutions readily available, and hopefully we will see the markets stabilise again and we definitely need to be ready.

Josh: For seabass, the production cycle is typically about 20 months; so we do not have the luxury of being able to ramp production up or down based on short term economic cycles. Most of the fish well sell in 2024 are already in the water and our crystal ball just isn't that well-polished.

So, we need to have the conviction of a longer view with clear goals. Many of our most important customers have made significant ESG commitments which inspires us to work with this community to improve performance. As Robert (see box) said, if we are sitting together at the table, we can weave these stories in ways that help align peoples actions with their commitments and maybe even get them to accept some higher costs to drive adoption during the early part of the cycle. The combination of product innovation and stronger evidence for functional characteristics can certainly help drive the pace of adoption.

Christopher: When the economy and demand are good, people will put in more effort and take initiative. When the market shifts and crashes, we cannot sell products. We kill all these new projects. Do we abandon all the steps that we have taken for the past two years just because we are in a recession? This is a very short-term view. In my opinion, if you start during the bad times, you are in a prime position to tackle the market with new initiatives, products and solutions when the times are good. Then we will not be having this conversation about the extra 3% or 5% because when the good times come, you can see how prices have skyrocketed. What is 3% on a product that has gone up by 100%?

Conclusion

The takeway from this Hard Talk is that we cannot find an absolute answer to the slow adoption of novel ingredients and additives in aquafeeds and on who should pay for early adoption. However, the thing we can do is follow what has been suggested by Robert of Veramaris, which is to sit down, with all the people along the supply chain, and work together.

Participants were fully engaged during the Roundtable Breakout session.

Success in engaging the consumer

Both Veramaris (which produces omega-3 fatty acids EPA and DHA from microalgae) and Corbion (which produces omega-3 fatty acids DHA from microalgae) have been successful in engaging the supply chain and incorporating their products into aquafeeds. Here Robert Redman, Veramaris and Norman Lim, Corbion described their respective strategies.

"It is the sort of product that is not easy to move into the whole chain. We did it by sitting people at the same table to understand the issues. The retail end needed either category growth or margin growth to make this work for them. There is a cost element, but it is now lower than before, and that has to move through that chain. People have to see the benefit of doing it. The feed mill to use the product and the farmer, the feed and track it through and then the retailer has to be able to market/promote it."

– Robert Redman, Consultant Asia Pacific, Veramaris

"Corbion did partnerships with feed companies and farms in key areas. We started in Norway, working towards the farms, educating them and then driving demand. We also partner with feed companies that can incorporate the product into the formula. Being able to manufacture the product at scale and bring down the cost of our product to the feed companies helped."

– Norman Lim, Regional Sales Manager, Corbion

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Evidence matters - The bottom-line impact

An evidence-based approach with enzymes

By Chiow-Yen Liew and Rutchanee Chotikachinda

The upward trend of soybean meal (SBM) prices is really a testing time for animal feed producers; their flexibility and resiliency in protecting their bottom line are stretched to the fullest. For example, rising costs of soybean meal (SBM) and corn, both key raw materials in poultry feed, can make or break a poultry feed mill.

The price of SBM has increased close to 15% compared to last year. However, the price has softened and aquafeed producers are not seeing as much pressure as poultry feed producers. Nevertheless, the impact is still significant even for industry leaders with comfortable sales margins.

The current high price of SBM, together with unfavourable foreign exchange rates against the US dollar for many Asian currencies, plus the difficulty in sourcing adequate supplies of ingredients, are challenges presently confronting the aquafeed industry.

Substantial feed costs

To stay competitive, a feed mill has no choice but to try to absorb the increasing costs, sometimes compromising sales margins while maximising production to spread out their fixed costs.

To achieve price stability, any reduction in costs of key ingredients will lower overall costs of formulations and will positively impact total production cost and enhance the bottom line.

Aquafeed cost simulation

In a typical non-integrated warm water aquaculture operation, up to 70% of the production cost comes from feeds. Since an average or standard grade aquafeed contains about 20% SBM, a 30% increase in SBM price could potentially lead to a feed price increase which would raise the total cost of production by 2.1%. However, in the highly competitive Asian feed markets, most feed mills would try to absorb the price increase and only consider increasing feed prices as a last resort.

A declining bottom line

In some Asian countries, feed prices are controlled by the state and feed price increases are subject to approval by a government authority. In situations where price increases are not approved, there is little recourse for feed companies but to change formulations when their bottom line becomes critical.

Being able to reduce feed costs while still maintaining consistency of performance and quality, and not significantly impacting production efficiency sounds too good to be true. It is probably true that most departments in a feed milling operation do not have a consolidated overview of cost savings strategies and how much they impact the overall feed mill profitability.

The need to establish a common understanding on the **bigger cost** and how every department, aside from finance - including procurement, quality control, R&D, operations and management can contribute to the common goal, is the key to optimisation.

While the focus is on the bigger cost, better management of overheads, efficiency of production and equipment, energy consumption and asset depreciation value can also support overall total savings.

Optimising the bigger cost

In aquafeed production, the cost of ingredients in the formulation is known to be the major portion of production cost and can be up to 75% of the total cost of sales. This rising cost of formulations and other variable production expenses constantly pushes the industry to look for options that can maximise nutrient efficiency yet optimise formula cost by creating more flexibility in selecting cost-effective ingredients.

One way of achieving this is through the fascinating catalytic capabilities of enzymes. Enzymes provide a valid solution that can help to control raw material costs yet support feed efficiency and performance. It is widely recognised that enzyme usage in aquafeed can increase the resilience of the aquaculture value chain by protecting feed producers from raw material price volatilities and ingredient substitutions caused by irregularity of supply chains while at the same time, minimising environmental impacts.

We have seen the rapid evolution of functional ingredients that can help to:

- Optimise the performance of feed materials and improve animal performance.
- Provide greater flexibility for feed mills in terms of raw material usage and formula cost optimisation.
- Maximise nutrient utilisation; and
- Minimise environmental impacts.

The winning solution lies in taking an unconventional approach which includes moving away from common or traditional practices. Accepting innovation requires willingness to change and following through with modifications to application and production processes. This is where an integrated approach and understanding of the **bigger impacts** by various departments and stakeholders are needed to pull through the change.

Cost of dietary energy

Supplying dietary energy represents one of the most important costs in feed formulation. Fish can produce energy from metabolising protein, carbohydrates and lipid components in their diets, but how much energy is provided by each ingredient depends on its origin. While marine and animal-source proteins provide readily

available energy, the energetic nutrients in plant-based ingredients are usually stored in thick-walled plant cells and a large percentage of the energy is not available to the fish. Most fish can utilise simple sugars, but complex carbohydrates from plant-based ingredients have the potential to be important but overlooked energy sources in aquafeeds.

Cereal plant cell walls are primarily made up of cellulose, hemicellulose, glycoproteins, lignin and pectin (Figure 1). Non-starch polysaccharides (NSP) are abundant in all cereal grains. Cereals share some similarity in their NSP. Arabinoxylan is a major NSP, but cereal cell walls also contain pectin, beta-glucan and xyloglucan. There is a large variation in both types of NSP, their abundance, structure and their water solubility.

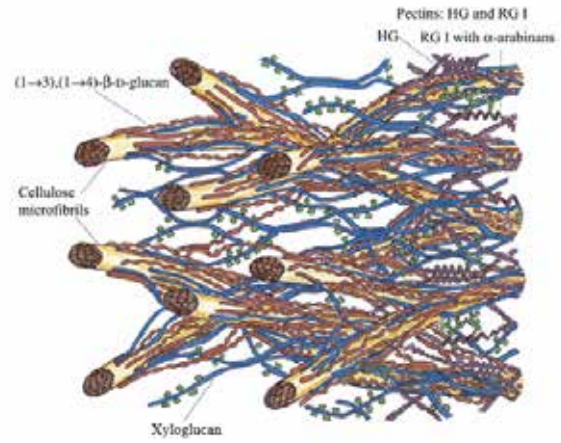
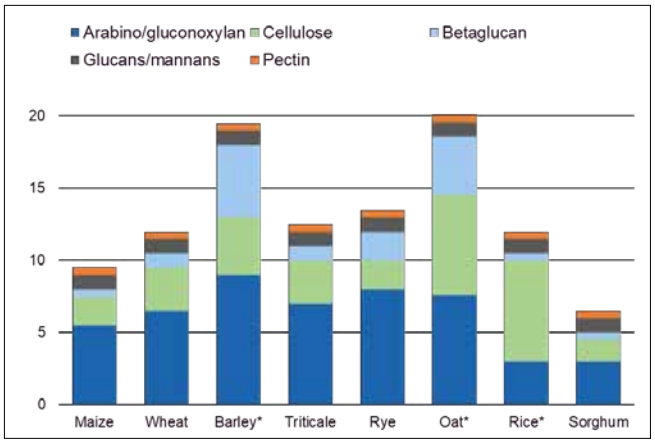


Figure 1. Cereal plant cell walls (modified from Carpita and Gibeaut, 1993). The numerous complex carbohydrates in plant cell walls contribute to two anti-nutritional effects (ANF) in the digestive tract (Table 1). Soluble NSP increases viscosity in fish gut. High viscosity in the intestine reduces the digestion and absorption of nutrients at the gut wall. Fish are not able to digest insoluble NSP, causing the valuable nutrients to be trapped and excreted with the faeces of fish.



** Hulls are included for barley, oat and rice which is why they have higher cellulose*

Figure 2. Cereal grains cell wall, its NSP content and structure.

Viscosity effect	Cage effect
Decrease feed passage time *Increase water binding capacity* *Increase unwanted bacterial population*	Capture nutrients Increase dietary problems Limit nutrient to gut wall Reduces action of endogenous enzymes

Table 1. The effect of soluble and insoluble NSP.

Xylans are the most abundant hemicellulose in cereal grains (Figure 2). Ronozyme®WX (xylanase) in feed breaks down cell wall components, enabling the release of nutrients, making them available to the animal. Xylanase also reduces the viscosity of NSP gels in the gut, allowing proteases and other enzymes to reach and digest the available substrates; the digested nutrients are then able to reach the gut wall for absorption. By releasing energy trapped in complex carbohydrates, energy utilisation from plant-based ingredients is increased, enabling feed cost reduction, because this energy is lower cost compared to obtaining energy from dietary protein or fats.

The choice of enzyme should relate to the substrate in the diet. The use of combination of carbohydrase (Ronozyme® Multigrain) that contains beta-glucanase, xylanase, cellulase, xyloglucanase, and arabinoxylan debranching effects can be a strategic tool for diet containing corn, wheat, barley and rice bran substrate. For diets containing soy, canola, cotton seed or lupin meal, the use of enzymes containing hemicellulase, pectinase, pentosanase and beta- glucanase can help to degrade the fibre content and enhance the digestibility to maximise the benefit of the nutrient in the feed.

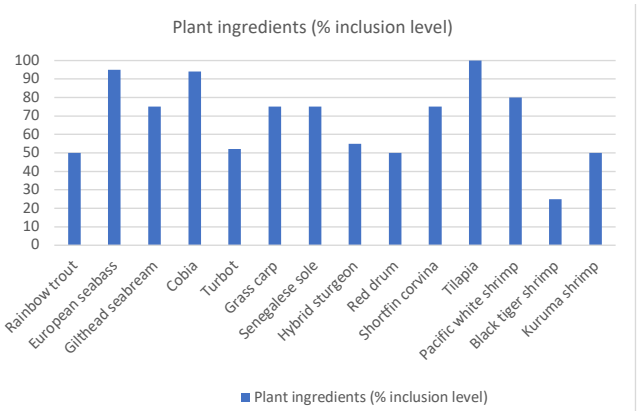


Figure 3. The use of plant ingredients in diet of aquatic animal species (Modified from Daniel, 2018).

Costs of protein

Replacing animal origin proteins with plant-based proteins in aquafeeds (Figure 2) is a more sustainable alternative which minimises feed costs while also reducing the environmental impacts. Using phytase in aquafeed brings significant savings when using plant proteins without affecting feed performance.

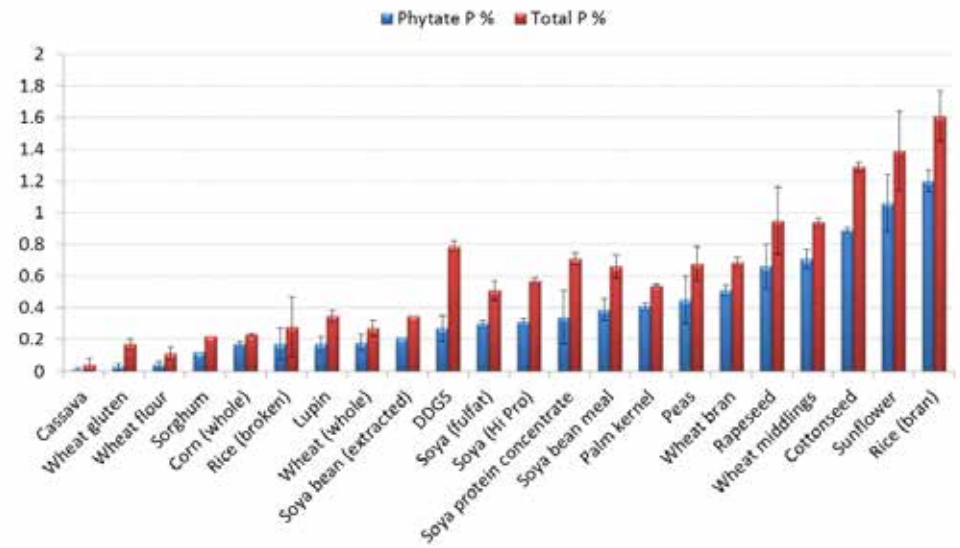


Figure 4. Phytate P and total-P in main aquafeed ingredients

Ronozyme HiPhos (phytase) reduces anti-nutritional effects by breaking down phytate, which causes it to release bound phosphorus, proteins, amino acids, and polar lipids for energy. Besides increasing the flexibility of plant raw material use, the supplementation of phytase can also deliver extra phosphoric effects that lead to better feed conversion ratio (FCR) and growth performance.

One of the significant milestones the industry has achieved is the successful reduction of fish meal usage in aquafeed formulations. Fish meal-free solutions and phytate-free nutrition are now possible by using high performance enzymes such as phytase and protease.

The use of protease increases the bioavailability of amino acids in the feed by improving their digestibility and absorption. Protease enzymes, by increasing amino acid utilisation, reducing nitrogen (N) excretion and loading to the environment, in turn reduce the likelihood that dissolved ammonia in the water will reach toxic levels.

Cost of minerals

With the increasing use of plant-based ingredients, industry needs to reconsider mineral availability in their formulations. Phytate-phosphorus (Phytate-P) in plant protein meals is not available to animals and phytic acid forms complexes with trace minerals such as zinc and copper. The undigested phytate-P that is excreted to the environment increases the risk of eutrophication and algal blooms. To meet growth requirements, inorganic phosphorus is often supplemented in the diet to raise digestible phosphorus (P). However, the supplementation of inorganic phosphates is the biggest mineral cost in the overall feed formula and since most supplements are not totally digested, it also increases excreted phosphorus into the environment.

Using phytase enzymes to improve dietary phosphorus utilisation when protein from fishmeal is replaced by plant proteins like soy protein has become a popular and important strategy in reducing phosphorus and nitrogen wastes entering water bodies.

Ronozyme HiPhos (phytase) supports the release of phosphorus from phytate, improves plant phosphorus digestibility and increases absorption of minerals such as phosphorus, magnesium, potassium, iron, copper and zinc. Furthermore, phytase has been shown to improve the utilisation of proteins and amino acids that would otherwise be excreted after being bound to phytic acid.

Profits, People & Planet – the triple bottom line

Considering the importance of the triple bottom line (TBL) - Profits, People & Planet - is fundamental to the success and future sustainability of the aquafeed industry. The interconnection and the complexities of markets and the pressure to become sustainable is changing the business environment. Feed companies must rethink formulation and production strategies and address consumer issues by adopting innovative versatile solutions that can fit in to the positive TBL impacts.

DSM enzyme solution is a powerful tool and should not be overlooked. There are several evidence-based examples using enzymes successfully with fish feeds for many species and reducing reliance on some raw materials. Aquaculture stakeholders need to understand the solid science that such functional enzymes bring to feeds. It is worthwhile to give in to curiosity and explore the concept of using a single enzyme or a combination of enzymes to yield maximum nutrient recovery and improve the energy potential when plant ingredients are used in feed.

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A new normal in shrimp feed processing

A relook at the inadequacy of pelleted shrimp feed

By Steven Goh

With rising raw material costs affecting aquafeed prices, and farmers struggling with low survival rates from pond water quality and the constant threats of diseases, the future for shrimp farming is dauntingly more challenging. Rising feed additive costs and questionable feed quality add more difficulties and uncertainties to the sustainability of shrimp farming. Besides providing adequate nutritional needs and water stability, pellet integrity and density are areas of great concern in shrimp feed processing. This impacts nutrient leaching into the water and the desired sinking rate of the pellets.

The crucial question is "What more can be done to improve farm productivity and survival rates?" We cannot control rising ingredient costs but we can certainly look for a better understanding of what it takes to produce good quality feed and the economic benefits that can be gained from a good approach to feed processing. This article addresses an area of feed processing which many in the industry are most likely not aware of, due largely to the generally well accepted norm with feed production and assessment of feed quality (Figure 1).

However, contrary to what feed producers and the experts think, feed imaging is showing up that starch and protein are really not well processed. The main objective of a well processed feed is to have well processed starch and protein. It is imperative that we understand the problem and utilise science to seek answers and solutions.

The current shrimp feed pelleting process

Shrimp feed pelleting is a complex, semi-dry thermal processing, rendering it impossible to deal with the objective of processing starch and protein effectively, without the dreaded Maillard reaction problem (Figure 2).

The industry has been working under the notion that the feed has been processed well enough, but feed imaging is now showing up the problems clearly. Feed pelleting is merely a forced feeding of hot-moist conditioned mash through a die and at best, only the pellet surface is anywhere close to being well cooked, with the presence of high surface moisture and searing effect from the hot die surface.

In the shrimp pelletisation process, the production parameters for each of the steps below is very precise.

- Pulverised grinding- to a minimum size of 250µm
- High water added at mixer
- Long mixing time
- Very long conditioning dwell time
- Extra post conditioning
- Small pellet size 1.2mm – 1.8mm
- High die compression – 24-26 (die thickness over pellet size)

Therefore, when these requirements are met, it is normal to assume that the resultant pellet is well processed and meets specifications. However, we still frequently observe under the microscope, how starch has been improperly processed. The whitish spots and rough pellet surface are good indicators that all is not quite correct. Some obvious factors such as high protein ratio over starch, higher ratio of alternative soy protein over native protein, high processing temperature and high die compression worsen the situation.

In a very different context away from current industry norm, the main objective with feed processing should be to:

- Induce positive chemistry changes in starch and protein
- Minimise the negative chemical changes caused by the Maillard reaction.

A proper approach to feed processing involves managing production parameters that enhances proper mash hydration. It is very important to get sufficient moisture into the feed chemistry for the functional purpose of hydrolysis of starch and protein for a well processed feed.

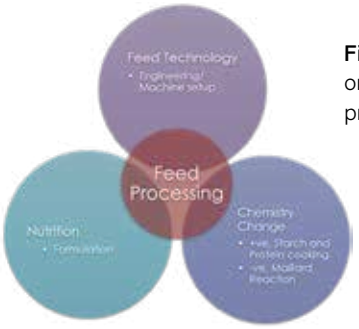

Figure 1. A summary diagram on the pivotal role of feed processing to aquafeed.

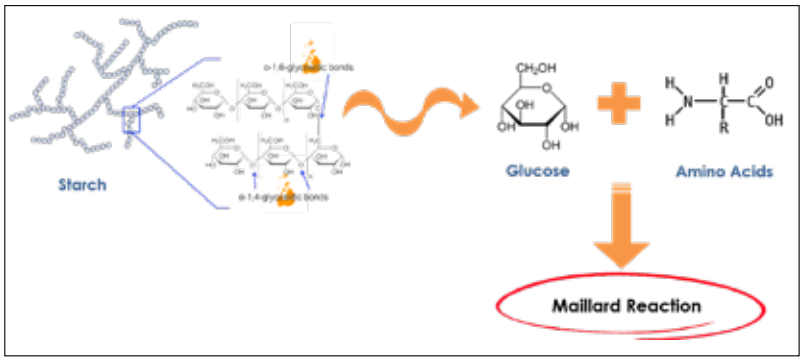

Figure 2. Maillard reaction in feed processing. When food containing starch is cooked, the heat can break glycosidic bonds linking the glucose units together and effectively break-up the polysaccharides to release the glucose monosaccharides, which ultimately leads to the Maillard reaction in feed processing.

We started Forensic Feed Science™ (FFS) to study the macro details for a better understanding of the processed shrimp feed pellet under the microscope. This is very promising as a new reference for evaluating feed quality rather than working blindly. Interestingly, unknown to industry stakeholders, macro details from feed imaging expose problems that could well explain the issues encountered with questionable feed quality, pond water quality, diseases, poor farm productivity and low survival rates. FFS also provides better postmortem insights into the quality of processed shrimp feed over current analyses - wet chemistry analysis for starch gelatinisation, pellet durability index (PDI) and water stability tests. Feed imaging exposes the following problems:

Poor processing of starch/protein

This affects pellet binding, energy value and feeding value. The high die compression ratio for shrimp feed usually produces a pellet with a brittle exterior and very loosely bonded centre.

The feed pellet can be very stable in water, but pellet density will be an issue if intra-particle bonding is poor in the entire pellet. The pellet can disintegrate in water while shrimp is feeding. Leaching of nutrients and uneaten feed particles contaminate the water, and will certainly affect the pond water stability and health of the eco-system.

Maillard reaction

This is a reaction of lysine and some other amino acids with reducing sugars such as glucose. This reaction impacts protein quality, critical for shrimp nutrition. Certainly, we know that the Maillard reaction binds lysine, making it non-reactive, and interferes with the transport of stored nutrients to the muscle for growth.

Whether the Maillard compounds have any negative effects on the general functions of the hepatopancreas (metabolism of lipids and carbohydrates, energy for moulting, regulation of immune response) is yet to be fully understood. However, there are likely effects on absorption and storage of nutrients, as well as synthesis and secretion of digestive enzymes for food digestion.

Feed imaging

This accurately shows how well starch has been processed and the degree of starch gelatinisation. As starch starts to gelatinise with sufficient moisture and heat, we start to observe an increase in granule size, loss of integrity, granular disruption and the eventual loss of birefringence (Figures 3 and 4).

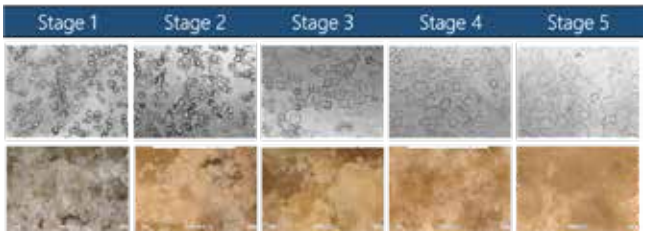

Figure 3. Changes in morphology of maize starch granules throughout the gelatinisation range, under digital light microscopy. Finally, the microscope image will show up the glass transition surface.

When sufficient moisture penetrates the granule, the amorphous regions of the granules absorb the moisture and swell, resulting in the separation of starch chain from the crystallites. Sufficient water also lowers the starch melting point and results in quick melting of the crystallites at high temperature. Poor particle bonding inside the pellet can be clearly observed. A darkened colour clearly indicates browning from Maillard reaction. Sufficient moisture prevents the breakage of glucosidic-bonds holding glucose to carbohydrate structure. The Maillard reaction occurs when breakaway free glucose reacts with lysine

The solution: moisture for proper hydrolysis of starch and protein

This patented bio-chemistry solution assists moisture getting into the feed chemistry in the semi-dry feed pelleting process. In the current low moisture scenario, water molecules do not easily penetrate into the starch granules, even if feed particles are ground to 250µm.

The whole science around feed pelleting is centred around the proper hydrolysis of moisture for effective cooking of starch and protein. For this to happen, moisture needs to get into the feed chemistry. However, the polarity of water molecules alone is insufficient to disrupt the hydrogen bonding of starch and protein structures in the semi-dry feed pelleting process.

DMX, a product developed by DelstAsia, contains divalent cations termed as structure breakers with a high charge density having the ability to disrupt hydrogen bonds of starch and protein. Structure breakers act as “gate-openers” into the native protein structure. It breaks the native structure and forms a new structure. The presence of DMX ions also reduces electrostatic repulsion that prevents gel formation of the negatively charged proteins and helps aggregates of denatured proteins connecting into a desirable network instead. This can be clearly observed under SEM imaging and feed imaging. These cations also possess high polarity, thus strongly attracting water molecules (Figure 5)

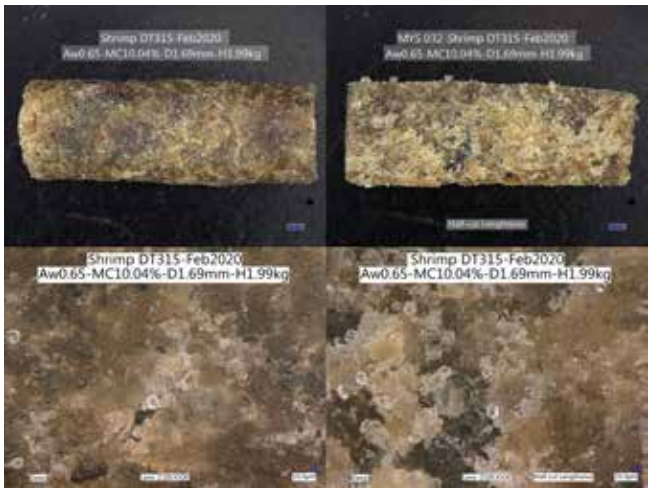

Figure 4. This image of a typical shrimp feed showing lots of birefringence with high amount of crystalline resistant starch particles is a sign that starch is poorly processed. This observation clearly points to the lack of moisture hydrating the starch granules.

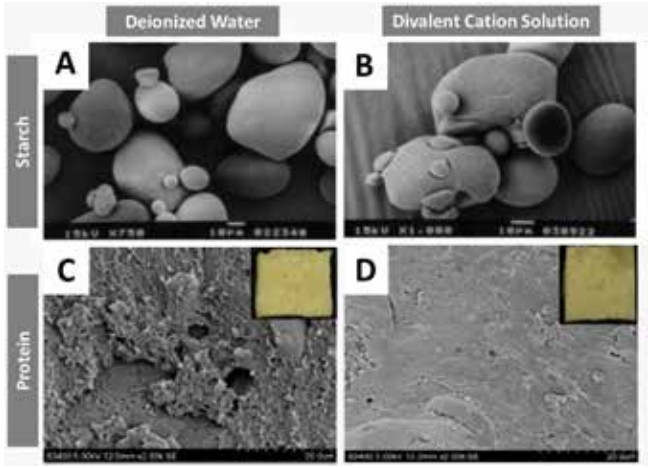

Figure 5. Scanning Electron Microscope (SEM) imaging clearly showing "structure breakers" at work on starch granules and protein. Source: Lai et al, 2002; Zheng et al.,2020.

With the disruption of hydrogen bonds, moisture can penetrate freely into the starch granule, leading to swelling, rupture, and the melting of amorphous and crystalline starch leading to irreversible starch gelatinisation (Figure 6).

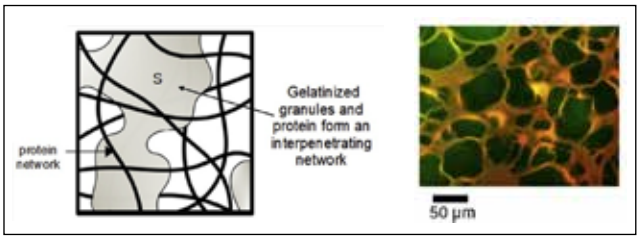

Figure 6. Gelatinised starch reinforces the denatured protein structure forming an interpenetrating network with water holding capacity within the network. This improves the entire pellet quality, production yield, and a safe water activity (AW). Confocal microscope shows fluorescence imaging of starch/protein network.

Moisture plays a very important role in feed processing. It is one of three elements involved in cooking food – heat, moisture and time. An effective moisture management technology determines if moisture will be used functionally by drawing moisture into the feed chemistry for proper hydrolysis of starch and protein. The contribution to positive chemistry changes to starch and protein, greatly determines production efficiency and the processed feed quality.

Figure 7. Results taken from two different approaches. Treatment X (using surface active agent). Treatment Y with DMX (Mash Hydrolyzation™ Concept). Feed imaging confirms if the feed has been well processed over thermal feed processing.

Durability on pellet surface (from high die compression/ shearing/use of pellet binder) does help with water stability. However, we need to be concerned about the content inside the pellet. The feed can crumble and disintegrate as the shrimp are eating.

Mash Hydrolysation™ provides great economics - feed processing efficiency, improved production yield, lowering feed formulation costs, producing good quality performing pellet feed with good chemical stability and extended shelf-life in post-production. What is more important, a well processed feed could well provide important answers to current issues relating to pond water quality, growth performances, diseases and survival rates. With very limited information on Maillard compounds affecting the shrimp hepatopancreas, it would be sensible to produce feed without the dreaded Maillard rection as an extra security (Figure 7).

Industry is at a crossroad where many are seriously studying the need to move towards feed extrusion due to better feeding efficiency, feeding value, pellet density, and pellet integrity that greatly reduces nutrient leaching. It is a known fact that feed extrusion greatly improves starch and protein cooking compared to feed pelleting. The industry has fallen further into a quagmire of confusion that is hard to escape because there is no easy solution to improve pelleted feed quality and capital investment for feed extrusion will be a huge decision.

This concept in Mash Hydrolyzation may well provide feed pelleting the lifeline that will bring the processed feed quality to a level almost matching that of extruded feed, but without the disadvantages of feed extrusion. The onus now lies with shrimp feed producers accepting the shortcomings of the current feed quality status, and making functional changes to bring the processed feed to the next level that farmers desire. Afterall, there is great economics favouring both feed producers and shrimp farmers.

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Inside/Out: The Essential Guide to the Skin, Gills and Guts of Fish

This new educational resource from Alltech® focuses on the commonalities of the skin, gills and guts of fish, offering an insight into their impact on the health and welfare of today's farmed fish. The book is written by **John Sweetman** and **Gijs Rutjes,** who have a combined experience of over 40 years in the field of aquaculture. John decided to undertake this project to provide the industry – fish farmers in particular – with an applied fish health guide that was accessible to everyone, regardless of the level of knowledge or experience of the reader.

"Inside/Out: The Essential Guide to the Skin, Gills and Guts of Fish" is designed to deliver a clear understanding of the function and structure of these three vital tissues, that apply to all aquaculture fish species. Opening with an overview of the skin, gills and guts, the authors then discuss how these tissues relate to key areas such as immune defense, stress management and nutrition. Their role and the effect of nutrition and the environment is discussed in terms of growth, performance and disease prevention. Ultimately this guide presents ways to support and maintain the structural integrity of the skin, gills and guts of fish while optimising their functional capabilities. John explains, "Inside/Out helps the reader understand the commonalities of those tissues and their complex responses."

John was a pioneer in the development of Mediterranean marine species aquaculture. He has 40 years of extensive practical experience in fresh water and marine finfish farm design, construction, production and management. Currently, he is the international project manager of aquaculture for Alltech, charged with implementing its scientific advances in all aspects of industrial aquaculture practices.

His recent areas of interest include innovative advances in the understanding of gut structure and function, mucosal production, mineral nutrition and immune responses that promote robust healthy, well performing fish.

"Every fish farmer is concerned with the health and wellbeing of their stocks, because healthy robust fish perform well and ensure a good financial return," John explains. "The ability to observe, interpret and understand the behaviour of the fish on the farm is an essential prerequisite to good operational management. That is what we want to help readers achieve."

John sought the expertise of his longtime colleague Gijs Rutjes, who helped write this book. Gijs studied aquaculture at Wageningen University, Netherlands, specialising in recirculating aquaculture systems (RAS), fish nutrition and immunity in fish. He joined Alltech Coppens in 2003 and travels extensively to provide technical support on farm. Previously, Gijs worked for a leading African catfish RAS hatchery in Holland and a RAS catfish farm.

Gijs is strongly committed to the Alltech Coppens motto, "Dedicated to your performance," which is the key intention behind the book.

"Inside/Out" is for fish farmers, feed millers and anyone with an interest in aquaculture. Alltech has always been at the forefront of animal nutrition, and it continues that tradition with aquaculture. There have been significant advances in the industry in recent years, and the authors want to showcase a fresh perspective on fish production.

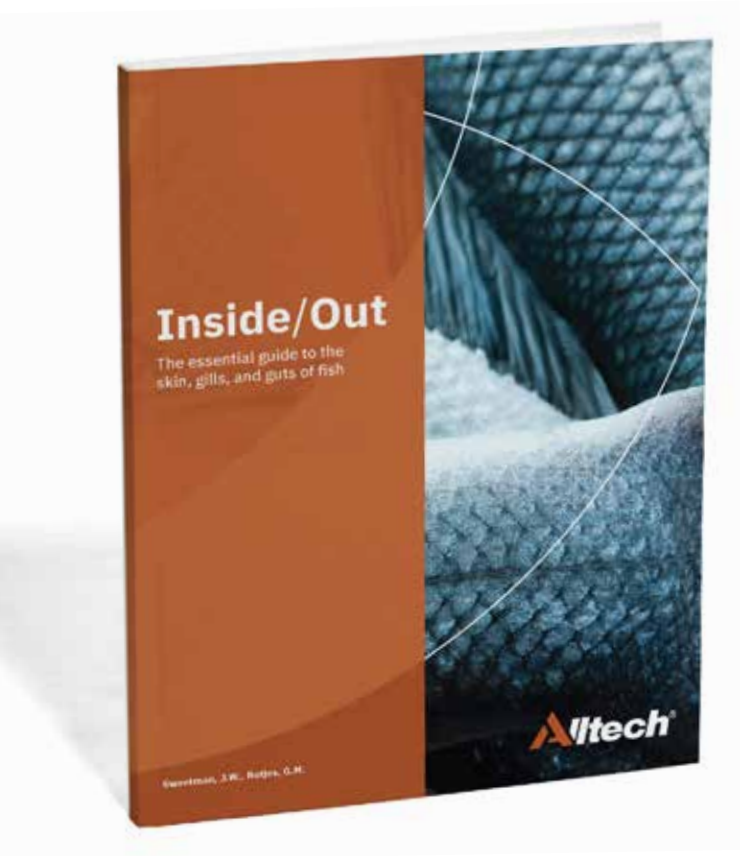
"We feel that being passionately curious is an important component of good management. Innovation comes from every level of operation and leads to the improvement of standard operating procedures, resulting in better efficiency and profitability for the farmer,"said John.

Pre-order a copy at https://go.alltech.com/aqua-inside-out

John Sweetman is the international project manager of aquaculture for Alltech, responsible for the implementing its scientific advances in all aspects of industrial aquaculture practices.

Gijs Rutjes specialises in recirculating aquaculture systems (RAS), fish nutrition and immunity in fish. He joined Alltech Coppens in 2003 and is currently, Technical Sales Support Manager.

Do you know your fish
Inside/Out?



Skin. Gills. Guts.

They all play a vital role in the growth, performance and disease prevention of farmed fish. Understanding their structure and function is essential when addressing the routine management practices that determine the success of your farm.

Written by aquaculture specialists John Sweetman and Gijs Rutjes, “Inside/Out: The Essential Guide to the Skin, Gills and Guts of Fish” is an educational tool for fish farmers, feed millers and anyone interested in aquaculture. **Available now!**

To order your copy please scan

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SPACE 2022: A focus on climate and youth

SPACE took place from September 13-15 in a very warm and positive atmosphere, marking its 35th anniversary. The full scope of the livestock industry was represented, from cattle, pigs, goats and sheep to poultry, rabbits and aquaculture. This 36th edition at the Rennes Exhibition Centre saw more than 90,000 visitors; 8,406 from 120 countries and close to 1,200 exhibitors, of which 300 were international businesses and 250 were taking part in this expo for the first time.

The event recovered its full international dimension after two years. Delegations from around the world came to meet exhibitors and visit farms. Many contacts were established with delegations from West Africa (including Senegal, Côte d'Ivoire, Mali and Benin), Cameroon, the Democratic Republic of the Congo, Morocco, Algeria, Vietnam, the Philippines and numerous European countries. Talks organised for the first time in partnership with Promosalons led to important business exchanges with top buyers from Colombia, Chile, India, Saudi Arabia, Turkey, Morocco and Nigeria.

During these years marked by drought and the soaring price of energy and raw materials, climate change was the annual theme developed by the Espace for the Future. Through the numerous debates, conferences, products and equipment presented by exhibitors, SPACE 2022 provided an opportunity to show that agriculture stakeholders are already taking measures aimed at reducing the impact of livestock farming on the climate.

Innovations in the sector, rewarded with the Innov'Space label (36 winners this year), also highlighted the continuous progress achieved in the world of agriculture. The winners offered visitors new solutions for animal welfare, protecting the environment, health and safety and improving farmers' working conditions.

A new feature of this year's event was the first Youth Forum, a space for young people organised in collaboration with agricultural teaching networks and opened by the Minister of Agriculture and Food Sovereignty, Marc Fesneau, at the start of the expo. This new space enabled young people to voice their visions for their future jobs. They could also express their motivations and questions to Loïg Chesnais-Girard, President of the Brittany Region, who paid very close attention to their points of view.

This event is also unique for its capacity to host around numerous conferences each year, allowing all stakeholders in the agricultural sector to learn about and discuss topical issues such as new technologies, solutions for reducing climate impact, establishing and selling farms, protein self-sufficiency, research into new fodder crops, etc.

The next edition will be from September 12 to 14, 2023, at the Rennes Exhibition Centre.

Aquaculture at SPACE: Advances and trends in aquafeeds

Aquaculture is the fastest growing animal production sector. SPACE highlighted the aquaculture sector by identifying those involved in aquaculture and aquafeeds. There were two half day aquafeed conferences; Zuridah Merican, *Aqua Culture Asia Pacific* and Guillaume Le Reste, Halieutica organised these in English and French, respectively.

The conference on Advances in Aquafeeds started with an overview on **global aquafeed demand, outlook and trends** presented by **Ronnie Tan**, Aquaculture Consultant, US Grains Council. Ronnie said that global aquafeed production in 2021 rose 3% to 49.4 million tonnes, led by Asia and Latin America at 3% and 8% respectively.

Global shrimp feed production was slightly over 7 million tonnes in 2020, mainly from 2 regions, Asia and Latin America. Feed conversion ratios (FCR) ranged from 1.4-1.8 depending on survival rates and disease issues. Major feed ingredients are marine meals and high protein plant meals such as soybean meal and corn gluten meal (CGM).

Speakers at the Aquafeed conference, from left, Pierrick Haffray, Ronnie Tan, Jean Peignon, Guillaume Le Reste, Stephane Ralite and Herve Lucien Brun.

Norway led the global salmon feed production of 3.2 million tonnes in 2020 at 51%. FCR was stable at 1.2 due to good genetics and high fat content for energy and protein sparing.

China, Egypt, Indonesia, Brazil and Bangladesh led the global tilapia feed production amounting to 9 million tonnes in 2020. FCR depends on harvest size and ranged from 1.1 for 350g fish to 1.9 for 1kg fish. Feed ingredients were mainly locally available plant protein meals. DDGS is well suited for this species.

Vietnam had the largest share (51%) of the 4.5 million tonnes of pangasius feeds produced globally. In addition to SBM, low priced ingredients such as rice bran and tapioca meal are used to produce cheap feeds priced at USD550/tonne.

Challenges with high SBM & CGM prices, have led to feed price increases of 10-15%. The opportunity is for new proteins meals, like single cell proteins and insect meals. Regular DDGS with 28% crude protein (CP) and HiPro DDGS 50% CP, both show value and availability. The industry will need to watch for high inflation and the looming recession.

There is a diverse **aquafeed and aquaculture industry in Africa**, said **Guillaume Le Reste**, Halieutica, France. Aquaculture production grew 75% in the last decade, the fastest globally. Farmed fish production is mostly in Egypt and Nigeria, with tilapia and African catfish *Clarias garipenus*, respectively. Africa used 1.5 million tonnes of aquafeeds in 2021, which was 3.0% of global aquafeed production. Aquafeed production ranges from farmed-made to industrial production of extruded feeds. Investments in aquafeed are in small scale 100-500kg/hr/line to industrial lines.

Challenges in aquafeed production include raw material quality and variation. For example, the composition of peanut meal will differ vastly depending on the oil extraction process. Training in feed management is crucial to make better use of the feeds. Today the feed market is shared among pureplay multinational aquafeed producers and multispecies African feed producers. Another challenge for feed expansion in Africa is cost of feeds. Tilapia feed prices range from USD850 to USD1200/tonne whilst imported tilapia fish from China cost only USD1.53 for 800g fish.

In **precision nutrition**, **Jean Peignon**, Aquaculture Nutritionist, Aquaneo, Groupe Techna, France, says that it all starts with the understanding of animals and their requirements. The first step is finding requirements according to species, age, farming conditions, genetics, etc. Next is ingredient selection and matching materials nutritional characteristics with the specific animal's nutritional requirements. AquaNeo has the formulation expertise, to bring the right quantities and qualities of nutrients, at the right price. Functionality aspects with added minerals and vitamins as well as functional additives are the subsequent steps. The process is completed with optimisation in feed processing.

Visitors from Ecuador, Julio Zambrano and Magola Munioz.

Herve Lucien Brun, Consultant, France, said that **feed optimisation** is always a critical need as shrimp feed accounts for 53% of total costs in Ecuador and 67% in Vietnam. The difference is due to the intensification of the culture system. A goal is to improve FCR and so decrease the cost of production. However, farmers pay little attention to digestible protein in aquafeeds. Optimisation of protein retention efficiency ratio (PRE), will reduce feed conversion ratio (FCR). "To do this, we optimise feed formulation, using enzymes," said Herve, adding that in a farm trial in Ecuador where protease was added in extruded shrimp feeds containing marine meals or plant meals, margins were best in 28% shrimp feeds with added protease. Herve correlated this with the reduction in the nitrogen effluent load per tonne of shrimp produced over a 12-month period. "Over these two years, with rises in raw material prices, formulators are looking for some solutions to improve feed costs since prices of fish and shrimp may not change," added Herve.

Pierrick Haffray, Manager of SYSAAF Aquaculture Unit discussed **advances in nutrition and selective breeding** to improve fish farming efficiency and ecological impact. SYSAAF is the French association of poultry, aquaculture and insect breeders. Amongst the 33 breeding companies in the association, 20 are in aquaculture. In terms of interactions between nutrition and genetic improvements, Pierrick listed aspects such as feeding efficiency, feeding practices, growth and resistance to diseases.

At the aquaculture conference in French, Simeon Fagnon, Phytosynthèse, France presented on the role of botanicals on gut health.

He discussed findings from a selection of research conducted by various groups in Europe. One example is the work by Vandeputte et al. 2022 which compared a rainbow trout line selected in freshwater for fillet production for ten generations with an unselected control line from the same base population. Growth, FCR, carcass yield and lipid content strongly improved with selection. Based on this and other research, Pierrick observed that tailoring feed composition to the new and future genotypes is a real perspective. However, collaboration between nutritionists, geneticists and the feed and the farmer is needed.

While most farmers and feed producers work at optimising feeds *per se*, **Stephane Ralite,** Aquaculture Expert, Lallemand Animal Nutrition, France, said that a good feed is of no use in a bad pond environment. In shrimp farming, **optimising the environment** is not easy as the pond environment is a very complex ecosystem. While the aim in shrimp farming is to reduce water exchange to avoid the risk of introducing diseases into the system, by adding a lot of feed and avoiding water exchange, the water must be treated. Stephane discussed the critical role of nitrogen which comes from feed and where a large portion ends in the sediment and water column. Ammonia can be toxic and impairs feed conversion and growth. Lallemand, which produces bacteria and yeast, has a bank of microorganisms. He described the applications of bioremediation bacteria in Indian shrimp ponds to improve water quality, control *Vibrio* loads and increase productivity.

DAA11: Exploring aquatic animal health for sustainable aquaculture

Networking and sharing research on fish and shrimp health management

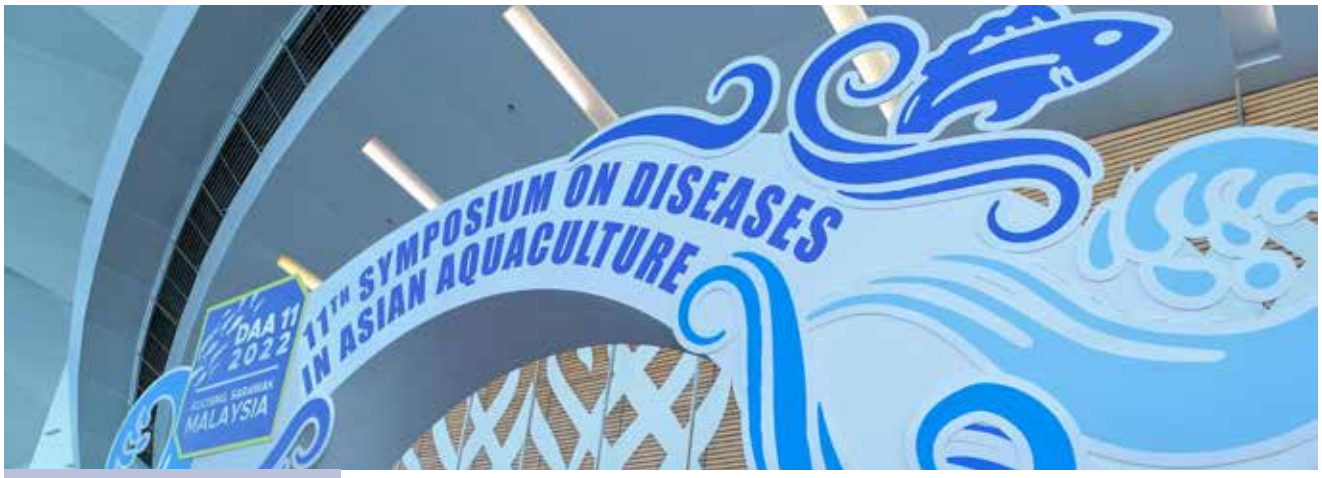


Photo by DOA & JPLS Sarawak.

The 11th symposium on Diseases in Asian Aquaculture (DAA11) was originally planned as an in-person event for 2020. In 2022, it migrated into a virtual event from August 23-26, amidst the global disruption to travel by the Covid-19 pandemic. Part of the triennial symposium series of the Fish Health Section of the Asian Fisheries Society (FHS-AFS), DAA11 was jointly organised by various agencies of the Malaysian government, including the Sarawak government, the Ministry of Agriculture and Food Industries and the Department of Fisheries. The event had 629 online participants from 22 countries and 10 strategic virtual exhibitors and trade displays.

Dr Agus Sunanto, Chairperson of FHS-AFS in his welcome address urged, all participants to share knowledge and stimulate discussion on how aquaculture development and animal health in the Asia-Pacific region and beyond can be better managed on a sustainable basis.

The opening and farmer's day was held in person at the Borneo Convention Centre, Kuching, Sarawak, where the premier of Sarawak, Datuk Patinggi Tan Sri (Dr) Abang Haji Abdul Rahman Zohari bin Tun Datuk Abang Haji Openg highlighted the need to foster collaboration among various aquaculture stakeholders at the national, regional and global levels to address disease transmission and antimicrobial resistance in aquaculture, fish and shrimp welfare and the promotion of the "One Health" concept adopting an integrated and system-based approach.

At the farmer's day session, the Department of Fisheries focused on fish health management and on the use of antibiotics in aquaculture. Dr Loc Tran, Vietnam presented on trends in shrimp health management while Dr Thai Mai, Asian Institute of Technology, Thailand, discussed updates in control strategies for the tilapia lake virus (TiLV).

The symposium featured two plenary sessions – drivers and pathways of disease emergence in aquaculture and the state of aquaculture. There were six sessions dealing with specific topics: biosecurity in aquaculture; epidemiology; detection methods; prevention and control measures; trends in fish and shrimp health management. A total of 143 abstracts were received, comprising 116 presentations and 27 ePosters. DAA11 also featured 3 minutes presentations. It was an exciting four days of scientific presentations, excerpts from some of them are featured in this report.

Emergence of diseases in aquaculture

Drivers and pathways to disease emergence include trade in live animals and products: insufficient knowledge of pathogens and hosts; inadequate health management protocols and control and ecosystem change, said Dr Melba B. Reantaso, Fisheries and Aquaculture Division, FAO. National strategic planning on aquatic health management and biosecurity is vital to reduce the vulnerability of the aquaculture sector to new and emerging diseases, as well as to disease outbreaks and mass mortality in aquatic animals.

She urged countries to adopt the Progressive Management Pathway for improving Aquaculture Biosecurity (PMP-AB) developed by FAO and partners which emphasises on emergency preparedness and risk analysis at all stages and requires strong cooperation under a public-private sector partnership. This pathway is risk-based, progressive, collaborative and focuses on aquaculture diseases at the commodity and enterprise levels.

While describing causative agents and newly found viruses in several aquaculture species, Dr Jie Huang, Network of Aquaculture Centres in Asia-Pacific (NACA), proposed a technology road map and strategies for the confirmation of causative agents of emerging or multiple infections. He said that regulatory authorities should encourage the private sector to be transparent and to report on the occurrences of diseases while governments should develop a communication platform for remote diagnosis as well as establish an insurance policy for losses from adverse events.

At the farmer's day session. Photo by DOA & JPLS Sarawak.

Aquatic health research should be supported; passive surveillance or rapid response to emerging diseases need to be implemented as well as the use of meta-transcriptomic and meta-genomic based technologies. Relevant authorities and industry should establish a contingency plan at all levels and regulators should implement quarantine measures and establish national zoning if necessary.

Novel ideas on pathogen identification and disease monitoring

Dr Yuko Hood from the Department of Agriculture, Water and the Environment, Australia, described a new national aquatic animal disease reporting system known as AUSPestCheck. Benefits of this new system include faster, improved uploading and data management process, more streamlined and real-time reporting, improved visualised outputs and improved access to national disease intelligence that supports decision-making.

There is a web-based system using spatially distributed information which does not require profound knowledge in the field of GIS and its programming, as described by Eleanor Daniella Lokman, Department of Fisheries, Malaysia.

Jerome Delamare-Debouteville, Worldfish, Malaysia, highlighted the Lab-in-a-backpack which uses a nanopore sequencing technology and low-cost low waste sample preparation to generate whole pathogen genome sequence data from diagnostic samples at the farm without laboratory support. The simplified safe workflow includes a cloud-based identification tool that returns near real-time information on the pathogen using a laptop or smartphone.

Tang Kok Mun, Biogenes Technology, Malaysia, discussed the potential of aptamer-based biosensor or Aptasensor for real-time surveillance of animal diseases. He envisioned an eco-system where aptamers can be digitally designed, synthesised *in situ* using a molecular printer, validated in the wet lab and incorporated into portable aptasensor devices for field use.

Biosecurity

The World Organisation of Animal Health (OIE) and FAO have adopted biosecurity as a strategic approach to reduce risk and sustain the aquaculture industry. Biosecurity measures can be put in place to cut economic losses from diseases, reduce environmental impact from aquaculture activities and to create a more sustainable production. According to Dr Edgar Brun, Norwegian Veterinary Institute, biosecurity should be seen as a partnership among neighbours, industry as a whole and regulatory authorities. Components of a biosecurity plan will need to include surveillance, vaccination and regulation of the aquaculture industry from competent authorities.

Epidemiology

In a keynote presentation on a paradigm for aquatic epidemiology (parasitic, bacterial and viral diseases), Dr Kenton L.J. Morgan, Institute of Veterinary Science, University of Liverpool, UK, commented that in general, too much investment has been made to identify the cause, too little investments on its control and that very often the collection of data to help identify routes of transmission is rudimentary. For effective control, people, structures, equipment and networks need to be in place.

He added that when a disease is first reported, speed is of the essence when considering control and there must be communication among all stakeholders. Studies to understand the pattern of the disease and the risk factor, plotting the epidemic curve and establishing the case definition and drawing up a study design are crucial. His message was "You do not need to know what causes a disease to prevent it; you do not learn much about an infection or disease by studying infected animals – they have to be compared with controls; and plotting an epidemic curve can tell you whether a disease is infectious and if it is, what the incubation period is."

Laura Khor, WorldFish Centre, Malaysia, described the Fish Epidemiology and Health Economics (FEHE) survey tool which was created to collect baseline data on existing farm practices, production, inputs, epidemiology, losses and economic impacts of disease and mortality. Survey results were then analysed to identify risk factors and to understand the performance of local aquatic food systems including the economic impacts of infectious diseases.

Trends in fish health management

Dr Kua Beng Chu, Fisheries Research Institute, Penang, Malaysia, discussed environment-friendly alternatives to chemicals in aquatic and health management in her keynote presentation. In Malaysia, research on plant extracts and essential oils as therapeutics, have been carried out since 2010. Several products have been developed, including those for the prevention and treatment of bacterial diseases in fish. Break and Protect (BP) is a device for trapping and removing marine leeches from infested farms by disrupting the life cycle of the leech. An improvised version (BP2) was later introduced for an additional 14 species of farmed fish. KRIPek, a portable kit developed in 2017 is for treating swim bladder disorders on site. Plant-based antimicrobial products include SirehMAX, GARLEX and SitroPro. Essential oils such as cinnamon oil have been shown to be beneficial in preventing marine ectoparasites.

In Sarawak, there was a booth displaying the Break and Protect (BP) device. Photo by DOA & JPLS Sarawak.

Dr Christopher Payne from the University of Stirling, Scotland has characterised *Edwardsiella ictaluri* strains associated with bacillary necrosis of Pangasius (BNP) in farmed striped catfish *Pangasianodon hypopthalmus* in Vietnam over 20 years from 2001-2021. In general, *E. ictalurid* strains were found to be homogeneous in their biochemical profiles irrespective of geographical location or year of recovery. Antibiotic resistance was found to increase over time, with high level, multidrug resistance associated with strains recovered between 2018 and 2021. Continued surveillance of this bacteria in Vietnam will be important to establish biosecurity strategies and aid in the development of effective vaccines against BNP in striped catfish.

Mohammad Shamsur Rahman, University of Dhaka, Bangladesh studied the composition of intestinal microbiota in healthy and diseased Nile tilapia *Oreochromis niloticus* using NGS based 16S rRNA sequencing. His results showed a total of 41 phyla with 548 genera of bacteria were found in healthy tilapia and 46 bacterial phyla with 600 genera were identified in diseased tilapia. Overall, the relative abundance of Proteobacteria, Chloroflexi, Actinobacteria and Firmicutes increased in diseased tilapia than in healthy tilapia.

Mucosal immune system

In fish, the slimy layers (comprising the mucosa of the skin, gills and intestines) contain antiviral, antifungal, antiparasitic and antibacterial substances which stay in constant dialogue with the environment. Professor Karin Pittman, University of Bergen, Norway, said as fish wear their immune system on the outside, what does this means for aquaculture and ecology.

The mucus cells exhibit an organ-wide repeatable response to stimuli such as therapeutics, stress, diet and the environment. Gills, which comprise about 50% of the surface area of fish, have proven to be the most sensitive early warning of systemic dysregulation. "How can we make use of this knowledge to define fish health based on the status of the mucus cells in the fish. In the presence of high levels of toxin there will be a lower abundance of skin mucus cells but higher density of mucus cells in the gills. Making use of this fact (little mucus= healthy gills and too much mucus= poor gill health; too little mucus = poor skin health and lots of mucus= healthy skin) we can then establish the number of mucus cells in a healthy fish, and this number can be used to monitor the status of fish health," said Pitman.

The symposium was opened by the premier of Sarawak which was followed by a visit to booths at the Borneo Convention Centre, Kuching, Sarawak. Photo by DOA & JPLS Sarawak.

Muhamad Faizal bin Mohd, International Islamic University Malaysia, presented some findings on protein profiling of fish body mucus isolated from 150g *Oreochromis* sp infected with either *Streptococcus agalactiae*, *Staphylococcus aureus* or *Aeromonas hydrophila*. The common protein, 14 kDa was found in all mucus isolated from challenged fish and protein of 49 kDa, 81 kDa and 101 kDa were prominent protein of *Streptococcus agalactiae*. While the most prominent protein after challenge with *Aeromonas hydrophila* were 35 kDa, 40 kDa, 60 kDa. These findings are important for better treatment and prevention of disease occurrences in tilapia aquaculture.

Dr Thanwatchai Chaijarasphong, Mahidol University, Thailand has successfully developed CRISPR-based assays for the detection of major diseases in shrimp and fish, including white spot disease virus (WSSV), *Enterocytozoon hepatopenaei* (EHP), scale-drop disease virus (SDDV) and tilapia lake virus (TiLV). This method took only an hour to generate results and provides visual readouts via lateral flow detection and portable fluorescence device. It therefore has many advantages over the conventional molecular diagnostic techniques.

Tilapia lake virus

Several researchers in Malaysia and Thailand presented case studies and work on TiLV. Azila Abdullah, National Fish Health Research Division (NaFisH), Department of Fisheries reported on the prevalence of TiLV in tilapia and in tinfoil barbs. Previously, studies showed that TiLV spread in fish vertically and horizontally by infecting fish, eggs and broodstock. However, Jidapa Yamkasema, Kasetsart University, Thailand evaluated the persistence and infectivity of TiLV in three different types of water: sterile distilled water, freshwater collected from rearing fish tanks, and natural pond water. The findings provide the first evidence to support that TiLV may persist and cause infection in fish rearing water. Appropriate control strategies include disinfecting or resting reservoir water for at least three to five days prior to stocking tilapia in the farm as a biosecurity practice to limit the spread of TiLV.

Researchers at Chulalongkorn University, Thailand have developed two simple cell-culture heat-killed (HKV) and formalin-killed (FKV) vaccines to immunise against TiLV, reported Thao Thu Ma. Both vaccines conferred significant protection for juvenile tilapia with relative percent survival of 71.3% for HKV and 79.6% for FKV. In tilapia broodstock, TiLV-specific antibodies were generated in the majority of both male and female broodstock vaccinated with either HKV or FKV and these antibodies can be transferred into fertilised eggs and 1–3-day-old larvae from vaccinated broodstock, suggesting a potential strategy to prevent TiLV infection in the early stage of culture.

Trends in shrimp health management

The keynote presentation by Emeritus Chair Professor Chu-Feng Lo, National Cheng Kung University, Taiwan, described the work on two of the quorum sensing (QS) master regulators luxO and opaR in the AHPND-causing *Vibrio haemolyticus* strain. Their findings showed that expression of the pirA^{VP} and pirB^{VP} was related to the QS system, with luxO acting as a negative regulator of pirA^{VP} and pirB^{VP}, without any mediation by opaR. They also identified a putative binding site for the transcriptional regulator aphB in the promoter region of pirAB and showed that AphB but not AphA could bind

to this predicted region. AphB was shown to be negatively controlled by luxO and that its expression was parallel to the expression pattern of pirA^{VP} and pirBVP. Taken together, these findings suggest that the QS system may regulate pirA^{VP}/pirB^{VP} expression through AphB^{VP}. This points toward the QS system as a possible target for therapeutics that might one day be able to control the virulence of AHPND-causing bacteria and prevent AHPND.

Right, Sim Ing Jyz of Sea Horse Corporation Sdn Bhd, a Sarawak based shrimp producer and exporter since 1978. Left, Borneo EcoFish, which farms tilapia in Batang Ai, Sarawak. Photo by DOA & JPLS Sarawak.

Dr Anuphap Prachumwat, National Science and Technology Development Agency, Thailand shared results from weekly collection of 10 shrimp intestine samples and four pond water samples from a shrimp culture pond for 8 weeks. The samples were collected from a *Litopenaeus vannamei* farm which was experiencing yellow head virus (YHV) outbreaks and shrimp mortality. Increasing heterogeneous bacterial profiles in the shrimp intestines were observed from weeks 6 to 8, and intestinal and water samples bacterial profile moved closer to one another in week 8. The increased heterogeneity and altered alpha diversities of the intestinal and water bacterial profiles might be associated with the increased YHV loads detected in week 7 water samples with the detection of the virus in both water and shrimp intestines from week 8.

Siti Naquiah Md Pauzi, Universiti Utara Malaysia and co-researchers have established a new procedure for white spot disease (WSD) detection using underwater images with the use of integration between contrast-limited adaptive histogram, equalization (CLAHE) with convolutional neural network (CNN). The study was done under laboratory conditions and showed that this technique could achieve an average accuracy of 94.7% in the detection of WSD. However, it needs to be tested in the field where turbidity conditions of pond water might require some refinement of the technique.

Molecular mechanisms of WSSV at NCKU

Several presentations by researchers at the National Cheng Kung University (NCKU), Taiwan were on the molecular mechanisms of white spot syndrome virus (WSSV). Yen Siong Ng described the work to understand the molecular mechanism underlying the pathogenesis of WSSV. WSSV triggers the glycolytic pathway to benefit viral replication; Ng explained that the activity of glycolytic enzymes, namely phosphofructokinase (PFK), lactate dehydrogenase (LDH) and pyruvate kinase (PK) were increased at the viral genome replication stage (12 hpi). LDH was found to interact with two WSSV viral proteins: WSSV ORFA and WSSV ORFB. The interaction with WSSV ORFA did not increase LDH activity and impaired virus replication. Taken together, this study demonstrated that viral protein from WSSV can interact with LDH and that WSSV ORFA may have an inhibitory role in regulating LDH activity and impede viral spread.

The objective of the research by Tan Yu Kent and Dr Han Ching Wang was to determine the involvement of LvSIRT4 (*Litopenaeus vannamei* SIRT4) in WSSV-induced glutamine metabolism in *L. vannamei*. SIRT4 is a NAD-dependent ADP-ribosyltransferase and member of sirtuins (SIRT) family. They found that glutamate dehydrogenase (GDH) enzyme activity increased in LvSIRT4 silencing or overexpressed in shrimp during WSSV infection. LvSIRT4 was found to regulate GDH activity, and mRNA expression of LvSIRT4 was increased during WSSV infection. Silencing of SIRT4 with dsRNAs decreased WSSV gene expression and genome copy numbers. Based on current data the authors inferred that LvSIRT4 promoted GDH enzyme activity and WSSV replication in shrimp.

The molecular pathogenesis of WSD is not well understood and in the last few years, advances in omics technology have led to the understanding of the WSSV-induced metabolic reprogramming in shrimp, including aerobic glycolysis and glutamine metabolism. Professor Han-Ching Wang said that using multi-omics approach, several shrimp and WSSV databases were established which serves as a fundamental base for her ongoing research. The combined omics technology data with stable isotope tracking resulted in identifying key shrimp metabolic and signalling pathways which have been hijacked by WSSV. The current findings will provide a framework for the understanding of the complex WSSV-WSSV and shrimp-WSSV protein-protein interactions, and hence will increase understanding of the dynamic host-pathogen interactions and facilitate the practical development of effective strategies to mitigate viral replication of WSSV.

Previous reports indicated that WSSV facilitates aerobic glycolysis (Warburg effect), with a high rate of glucose oxidation. Cong-Yan Chen and team used LC-ESI-MS and isotopically labelled glucose and glutamine as metabolic tracers in their study. The results inferred that de novo nucleotide synthesis was involved in WSSV pathogenesis. The researchers still need to investigate how viral proteins are modulated and how they interact with host proteins. The findings clarified that host nucleotide synthesis has a crucial role in WSSV pathogenesis and provided new knowledge for evidence-based approaches to control WSSV outbreaks.

Reference

Kua, B.C., Rimatulhana, R., Wan Norhana, Padilah, B., Rohaiza Asmini, Y., A., Noor Hanis, A. H., Liyana, R., 2022. Handbook of the 11th Symposium on Diseases in Asian Aquaculture (DAA11), Sarawak, Malaysia. The Fish Health Section of the Asian Fisheries Society. http://www.fhs-afs.net/pdf/pub/2.DAA11-HANDBOOK.pdf

Fast on-the-spot nutritional analysis of aquafeed and ingredients

The aquafeed applications are the latest addition to trinamiX's solution for the agriculture industry.

trinamiX GmbH, a leading provider of mobile spectroscopy and wholly owned subsidiary of BASF SE, now enables customers to receive on-the-spot nutritional insights into aquafeed and feed ingredients. Combining a robust handheld device with an intuitive app and advanced material analysis, trinamiX offers customers an easy-to-use tool to ensure that farmed aqua species are fed optimally and efficiently. Applications range from efficient quality checks of ingredients and raw materials processed at feed mills and integrators to the precise formulation of diets on the farm.

trinamiX's Mobile NIR Spectroscopy Solution supports a broad range of sample types and parameters. At the push of a button, it delivers nutritional information on finished aquafeed as well as a wide selection of feed ingredients – for example cereals, oilseed, expeller and animal protein meals. For these types of samples, users receive key nutritional parameters including moisture, crude protein, fat, starch and ash among others.

Users are guided step-by-step through the setup and measurements on the trinamiX app, where nutrient insights are displayed in near real-time. Additional data becomes available in trinamiX's web-based customer portal which can be accessed by a common internet browser. This way, information related to measurements can be centrally accessed, managed or exported to other programs. The end-to-end encrypted environment ensures highest data security in the app and in the customer portal.

"By taking the lab to the sample with our mobile solution, customers can now complement their lab analysis with fast spot checks to enhance quality control at production facilities and needs-based feeding on the farm," explains Nils Mohmeyer, Head of Sales IR Sensing. "The flexibility of a handheld solution makes processes not only more time-efficient, but it also improves result accuracy with the ability to perform multiple checks wherever feed ingredients and raw materials are moved, processed, or fed."

trinamiX works with AB Vista/AUNIR, the leading developer and supplier of NIR calibrations, to offer reliable results based on the widely established INGOTLab database. Besides choosing from ready-to-use packages, customers can enquire whether their existing calibrations or application ideas are suited to be transferred to trinamiX's Mobile NIR Spectroscopy Solution.

The aquafeed applications are the latest addition to trinamiX's solution for the agricultural industry which already supports a broad range of terrestrial feed and ingredients.

Mobile NIR spectroscopy solution

trinamiX's solution combines robust hardware with intelligent data analysis and a mobile app. NIR spectroscopy is a proven technology that trinamiX has integrated into a portable format for on-site analysis. In doing so, trinamiX relies on cloud-based data processing, which ensures continuous development of the solution – there is no need to replace hardware. This allows trinamiX to continuously develop new applications and react flexibly to the industry's changing demands.

trinamiX GmbH develops cutting-edge biometric and mobile NIR spectroscopy solutions, which are used in both consumer electronics and industrial designs. The company's products enable humans and machines to better capture data with the goal of understanding the world around us. This results in improved decision making as well as stronger biometric security. trinamiX, based in Ludwigshafen (Germany), was founded in 2015 as a wholly owned subsidiary of BASF SE. www.trinamiXsensing.com/feedanalysis

Nils Mohmeyer

Aquaculture Solutions

ADM has announced that it will showcase its aquaculture solutions at World Aquaculture 2022 in Singapore. It will feature three aquaculture brands BernAqua, Epicore and Ocialis. Experts will be presenting their state-of-the-art findings at the seminars on feeding strategy and growth performance solutions for fish and shrimp nursery:

- High Quality Early Nutrition as a Strategy for a Productive Aquaculture by Delphine Weissman, Manager Research & Application Aquaculture
- Early Caring of Fish drives Growth Performance by Francois Jegou, Veterinary Aquaculture Health and Performance
- Are You Feeding the Right Pellet Size to Your Fingerlings? by Henry Cuong Tran, Aquaculture Technical Manager Asia
- A New Paradigm of Nursery Feeding: Case of Tilapia by Gaetan Gutter, Regional Sales Manager
- Intensive Nursery System for Whiteleg Shrimp *L. vannamei* in Low Salinity Water and High Disease Pressure Areas by Minh Anh Pham, Asia R&D Director

Save the dates and meet team ADM at Booth #s. 607, 609, 510 & 508 at the trade show and explore ADM's practices on both products and services, as well as a virtual tour on its shrimp farming model. More about WAS: https://www.was.org/meeting/code/WA2020

Singapore's innovators in aquaculture at World Aquaculture 2022

WA Singapore 2022 will be taking place after a two-year gap with the relevant COVID-19 safety measures in place from November 29-December 2. An exciting program will be offered at this long awaited large-scale in-person global conference and exhibition to be hosted in Asia Pacific. Key highlights include the Singapore Pavilion showcasing its aquaculture industry's innovation and advancement which encompasses major local aquaculture farms, Institutes of Higher Learning, startups, and the Marine Aquaculture Centre (Singapore Food Agency's aquaculture R&D facility). In pages 59-63, *AQUA CULTURE Asia Pacific* features some of them.

Innovation and technology adoption in Singapore's aquaculture space

aquaculture innovation centre

Growing Together, Innovating for Tomorrow

Singapore is rapidly ramping up local agriculture and aquaculture production capacity for food supply resilience and food security by 2030. Financial assistance schemes for farms, optimisation of land and sea space for intensive farming, providing infrastructure for urban farming and promotion of innovation and technology adoption in farms are some of the country's plans towards achieving the '30 by 30' goal - providing 30% of the total nutritional needs for local consumption. This is the reason Enterprise Singapore set up the **Aquaculture Innovation Centre (AIC)** in 2019.

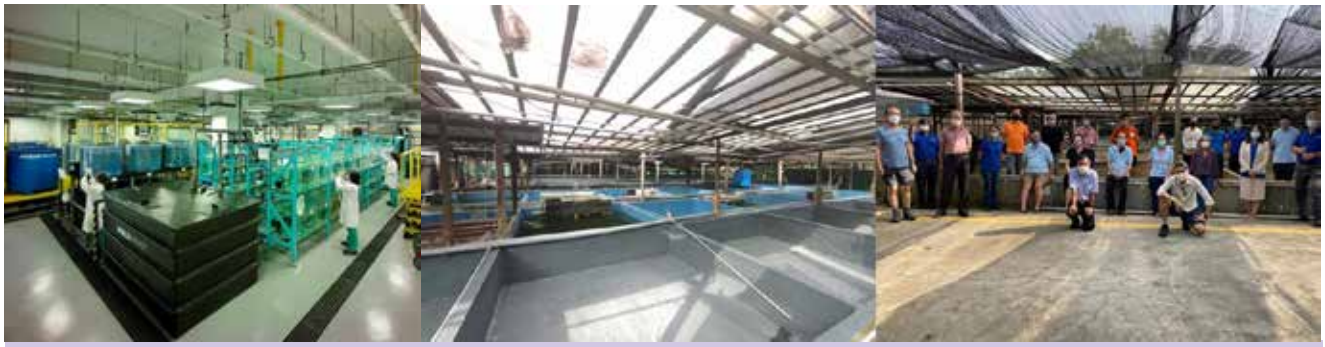
AIC 's key objective is to serve local aquaculture farms with their production needs through project consultancies, research in innovation and technology development, testing services for farm biosecurity management and manpower development. AIC is hosted by Temasek Polytechnic. Well-equipped with aquaculture facilities, AIC has since worked with local and overseas enterprises as well as farms in more than 65 projects since its inception. These also include training in responsible aquaculture practices, research in technology development and translation with institutes of higher learning and research agencies.

With the growing interest in getting into the aquaculture space pushed by the strong government support for developing an active industry, AIC has helped train aspiring aquaculture business minded individuals wanting to establish startups through a 6-month skill based "Entrepreneurship in Aquaculture" programme offered in 2020. A few startup companies were formed in areas of farming and support technology for aquaculture production. Being industry-centric, AIC has been actively supporting both Standard Development Organisation and Singapore Food Agency (SFA) as co-convenors in working with the aquaculture industry to develop a standard on responsible aquaculture practices, such as Singapore Standards 670:2021 and 689:2022. Since Aug 2021, a few local aquaculture farms have completed the training course in SS 670:2021 offered by AIC. Some have gone on to achieve successful farm auditing and GAqP certification by SFA.

As Singapore only has less than 1% arable land for agriculture and aquaculture and only 110 coastal and a few land-based aquaculture farms, intensification of aquaculture production on a small footprint based on the "Grow more with less" concept is a necessity to meet this '30 by 30' goal. For aquaculture production to be sustainable under such high stocking densities, AIC has been offering testing services to farms for their farm biosecurity management; pathogen detection and identification, water and feed quality analyses, microbiological and blood profiling as well as histopathology and microbiome analysis for farms. A collaboration with the Nanyang Technological University in setting up an ISO/IEC 17025 - SAC-SINGLAS certified investigation laboratory is underway to further support farm aquaculture health and disease management. Apart from testing services, AIC has also developed a rapid on-site disease pathogen detection kit and an oral vaccine against iridovirus in grouper and seabass.

AIC's commitment and dedication to the aquaculture industry goes beyond Singapore, especially for local companies with interest to go global. It provides technical assistance and technology transfer to farms setting up their production base overseas. With versatility and commitment demonstrated in striving to serve the aquaculture industry, AIC's effort is revered with much recognition locally and regionally.

Singapore Pavilion, Booths #328 & #427
Email: aic@tp.edu.sg; ww.tp.edu.sg/aic



AIC's indoor RAS, R&D farm and SGUS students with the AIC Team (SGUS is Singapore United Skills programme-a skill based training course for adult learners who were displaced due to the pandemic or are making mid career changes).

Eko-Ark: World's first purpose built closed-containment floating fish farm

Aquaculture Centre of Excellence Pte Ltd (ACE®) aims to reshape the future of fish farming with eco-friendly, cost-effective and sustainable technology. ACE is the first farm to receive Singapore Food Agency's permit for an onboard processing unit, reducing food production miles and enables the shortest unbroken cold-chain management for its final products. With the shortest production mile, fresh and healthy fish are readily available to consumers daily.

ACE founder and CEO Leow Ban Tat, wants to change the way the world farms fish. "To be able to feed the world, we need technology that can revolutionise the way we farm. With the Eco-Ark®, we produce sustainable and healthy fish in abundance and yet do not pollute the environment," says Leow.

ACE Abundance (I) Eco-Ark® is just a kilometre off the coast of Changi Village. The Eco-Ark, patented in 9 countries, including Indonesia, China, Australia and the USA, can produce 20 times more than a traditional farm with the same footprint. In March 2022, two more units of Eco-Ark model EA-600, Abundance (II) and Abundance (III) have been installed together with the new Eco-Spark®, just off the shoreline of Pasir Ris. The Eco-Spark is a hatchery and processing plant and is the latest hybridised intensive "offshore floating integrated agro-culture" farm (OFIA).

Eco-Ark model EA-600 can produce 20 times more than a traditional farm with the same footprint.

This "egg to table" concept has shortened the food mile as it integrates the eco-farming establishment, with the hatchery, pre-nursery and post-nursery all on the Eco-Spark with fish growing out in the Eco-Ark. ACE is able to breed, rear and harvest Asian seabass, four finger threadfin, red snapper, grouper and golden pompano. Full control of the process allows ACE to guarantee no antibiotics or hormones in the fish.

Sustainability is key to this technology. The Eco-Ark creates an optimal environment for healthy fish to be farmed, harvested and processed onboard. Water is pumped in with minimal energy, filtered and sterilised for optimal fish growth. In times of adverse external seawater conditions, the technology allows the use of ballast-tank water for recirculation without taking in the polluted water. The discharge water from culture tanks is siphoned off by gravity from the bottom and undergoes a second filtration and sterilisation, removing solid waste and treating the water before discharging it back to the sea. This ensures the discharge water from culture tanks is almost as clean as when it is pumped into the farm.

In terms of infrastructure, there is a built-in photovoltaic (BiPV) solar roof for the whole farm to harness solar energy. There are oxygen and ozone generators onboard too. It uses proven offshore and marine technology, for stability and the efficient running of equipment, harvests rainwater to the maximum capacity to ensure freshwater is available for ballasting and farming operations.

The Eco-Ark revolutionises marine fish farming - there is a higher production yield by maintaining a higher stock density and uses less sea space. Utilising aquaculture technology for aquatic health and pathogen free seawater to increase the survival rate of fish without needing vaccines, antibiotics and other chemicals to enhance growth, the Eco-Ark is necessary for a sustainable and healthy future.

Singapore Pavilion, Booth # 319. www. ace-sg.com

Cutting-edge solutions in precision feeding and environmental monitoring

UMITRON

The ocean is one of the most valuable resources, covering over 70% of our planet, providing millions of jobs, revenue and services and serving as a major food source. However, with a huge population boom expected by 2050, the way that we produce food to meet global demand needs to be sustainable to ensure that we can preserve our marine resources for future generations. With this in mind, **UMITRON** was established by Ken Fujiwara, Takuma Okamoto and Masahiko Yamada, with its headquarters in Singapore and a secondary office in Japan.

Since 2016, Umitron has been using a combination of IoT, artificial intelligence and satellite remote sensing technologies to create cutting-edge solutions catered to the aquaculture industry to address crucial areas of concern, such as precision feeding for multiple commercial species and environmental monitoring.

Regardless of species, feeding has always been one of the essential elements in aquaculture production, often comprising up to 70% of a farm's operational costs and taking up a significant portion of the daily workload. Therefore, farmers need to have good feed management practices to avoid overfeeding and underfeeding, which usually result in unnecessary feed wastage and pollution of the surrounding waters. The company has achieved an excellent track record with various regional and international producers with Umitron Remora for fish feeding. For shrimp producers, it is currently collaborating with Charoen Pokphand Foods (CPF) in Thailand to use Umitron Eagle, a solution that provides real-time analyses and advanced AI detection to track appetite, health and other factors in intensive production environments.

Access to multi-parameter industry-centric data via Umitron Pulse also assists farmers in planning for adverse weather events and creating suitable operational protocols for varying conditions throughout the year. Used in tandem with precision feeding, they allow producers to achieve maximum farm output whilst keeping a close eye on their production environment to prevent unnecessary harm and maintain a healthy surrounding ecosystem.

To date, Umitron's team has succeeded in helping farms worldwide involved in multiple commercial species, ranging from Atlantic salmon to red sea bream, to improve their feeding operations. Pulse has also received positive feedback from its over 600 global users, many of whom use the service for daily monitoring and planning for upcoming adverse farming conditions.

"We are excited to expand our global footprint to help more producers achieve better production performance. In particular, Umitron Eagle would be an ideal solution for shrimp producers in Southeast Asia, especially for farms in Thailand, Vietnam and Indonesia. Looking further along the value chain, we're also keen to take on the challenge of connecting farms using Umitron technologies to the retail market and importing or exporting their products to consumers and restaurants," said Masahiko Yamada.
Booth #120; www.umitron.com

UMITRON Eagle and farmer

Research, entrepreneurship and community development

BLUE AQUA
Sustain Our Future

Blue Aqua owns and integrates every step of the aquaculture ecosystem and implement environment-conscious practices across its businesses. The foremost priority is to feed the future safely and sustainably. Blue Aqua believes in the power of food to change the world and takes on this challenge by providing real, tangible solutions to combat global food insecurity.

This mission is supported and scaled by five Blue Aqua business units and a Centre of Excellence for the shrimp industry. This includes innovations in farm care, feed and nutrition, farming, fishmeal replacement and food supply. With Singapore's '30 by 30' food security goal in mind, Blue Aqua is committed to home in on super-intensive and sustainable technologies to produce more with less.

The group currently runs a multi-species shrimp farm and hatchery in Singapore, supplying fresh shrimp daily to major grocery chains across the country. Since 2009, Blue Aqua has built a strong track record in sustainable urban farming, with a presence in 14 countries. To further contribute to Singapore's vision for food security, it has developed an integrated business model across the aquaculture supply chain.

Blue Aqua's super-intensive shrimp farm in Neo Tiew, Singapore.

Blue Aqua's approach is rooted in research, entrepreneurship and community development. It works closely with farmers, scientists, and customers to build better solutions that shape the future of food.

Innovation is driven through the group's foundation of a patented culture method and three levers of technology.

- Mixotrophic™ System - a patented methodology for sustainable intensification of aquaculture
- Super-intensive urban farming techniques
- Utilisation of AI and blockchain technology
- Sustainable protein for fishmeal replacement

These levers enable the group to achieve high yields and quality produce, reduce the environmental footprint and in addition, create a circular economy by completing a closed-loop aquaculture ecosystem. Blue Aqua recognises the need to collaborate to positively to change the future. Through Doctor Shrimp™ it shares knowledge and practical learning opportunities and builds a team of futurists to grow the industry, whether they choose a career with Blue Aqua or beyond. "Only by joining hands can we create significant change and effectively protect our future," said Dr Farshad Shishehchian, President and CEO. "We strongly believe that how we grow our food is how we grow our future. Given our global influence, we have an important role to play and made it our goal to champion sustainability efforts across the global food supply chain."

Blue Aqua's sustainability efforts include:

- Partnership with VeChain to improve supply chain traceability with the integration of blockchain technology for food security, safety and quality
- A patented multi-species zero water waste RAS
- R&D in alternative protein for fishmeal replacement for aquafeed
- Green energy utilisation with solar across our inland farming operations
- Doctor Shrimp Academy – for skills transfer of sustainable and effective farming methods in support of the aquaculture industry globally

The group's farming arm is also developing a smart farm capable of producing 3,000 tonnes of rainbow trout annually in Singapore. A key workaround for Singapore's land limitation is its access to water as an island nation. Given its geographic advantage, Singapore should integrate seafood farming as a major component of its food supply. The country produces only 5% of its seafood consumption today. The project looks to develop Singapore's first high-tech fish farm to cater to local demand for fresh, sustainable, premium fish daily. Local, sustainable, aquaculture is imperative to decrease reliance on imports and increase Singapore's food security.

Booth #502; Email: nathalie@ blueaquaint.com (Nathalie Lim, VP Marketing); www.blueaquaint.com

Indoor urban farms closer to communities

Universal Aquaculture (UA) is a deep tech aquaculture company that leverages its proprietary Hybrid Biological Recirculation System and AquaOS to farm high quality seafood in indoor urban farms closer to its communities and gentler to the environment. This tech stack enables UA to farm sashimi grade seafood, everywhere every day. Headquartered in Singapore, the company has been researching and refining its technology and practices since 2015. Its customers include bars, restaurants and various group buy communities across Singapore. "We will have to wait for our next farm to give us the scale to fulfil the demand from the retail segment via larger distribution partners," says CEO Jeremy Ong.

Booth #324; www. uniaqua.net

At Universal Aquaculture's inaugural farm, tanks are stacked 12m high in a warehouse.

Fast and easy to use tests for shrimp diseases

Forte Biotech is producing an easy-to-use on-site PCR test kit that allows farmers to perform PCR to identify diseases. Forte's RAPID test kit gives farmers results within 2 hours from as low as USD6 per test, as opposed to 24 hours and USD20 per test for lab-based PCR tests. RAPID is now being used in shrimp farms in the Mekong Delta, Vietnam and has successfully detected *Enterocytozoon hepatopenaei* (EHP), early mortality syndrome (EMS) and white spot syndrome virus (WSSV) in farms through tests performed by the farmers themselves. RAPID can use water/tissue samples to detect viruses and bacteria in the water.

Kit Yong and Michael Nguyen started Forte Biotech as a National University of Singapore (NUS) startup spinoff in 2021. Since then, Forte has developed a farm ready machine that has been field tested, producing good results. Kit and Michael have seen how disease can turn previously successful farmers bankrupt and homeless and they both believe that shrimp farmers lack crucial data to make decisions in a timely manner now to protect their livestock and livelihoods.

RAPID is now being used in shrimp farms in the Mekong Delta and has successfully detected EHP, EMS and WSSV in farms through tests performed by the farmers themselves.

Forte Biotech has raised pre-seed funding for a limited launch in the Mekong Delta region and is currently preparing to raise a seed round to launch in Vietnam, Indonesia and further afield, as well as to build a factory to bring the manufacturing in-house.

Booth #424, Email: kit@fortebio.tech (Kit Yong); www.fortebio.tech

Great atmosphere at the heart of Victam Asia, Health & Nutrition Asia and GRAPAS Asia 2022

VICTAM Corporation and VIV worldwide welcomed exhibitors and visitors from September 7 – 9, 2022 at the IMPACT Bangkok, Thailand for three events Victam Asia, Health & Nutrition Asia and GRAPAS Asia. The three co-located trade fairs focused on animal feed, animal health and nutrition, and the grain and rice processing industries.

"It was exciting to be back in Asia again after the Covid pandemic. The atmosphere at the event was excellent as exhibitors and visitors were glad to be participating at a live event again," says General Manager of the Victam Corporation, Sebas van den Ende. "We were happy to finally welcome all these companies and professionals. A few exhibitors were not able to participate due to the strict Covid rules in their countries, but we provided them with a hybrid platform, so they were able to participate online. The participating exhibitors attended with exciting stands, machinery, and innovations."

"This was a great opportunity for the feed and animal health industry to meet in 2022. The exhibition halls were busy over the three event days, with the top 10 visiting countries being Thailand, India, Philippines, Vietnam, Bangladesh, Malaysia, Indonesia, Korea, Myanmar, and Singapore," said Birgit Horn, Managing Director VIV worldwide.

Visitors and press were pleased with the extensive range of products on display, especially newly launched products, the high quality of the exhibition stands and the great networking opportunities onsite. There were 231 exhibitors from 33 countries present.
Likewise, the exhibitors were very satisfied with the visitors. The companies stated that it was great to meet their clients and prospects face-to-face again. The exhibitors also commented on the very high quality of the visitors and the wide range of countries from which they came.

Spread over the three show days, there were 6,121 visitors from 64 countries. 90.4% of the visitors were from Asia and 9.6% of the visitors were international visitors (EMEA, America's, Oceania).

Left, Birgit Horn, Managing Director VIV worldwide and right, Sebas van den Ende, General Manager of the Victam Corporation.

Dr Manoj Sharma, Mayank Aquaculture, Gujarat India (right).

A VIP tour and luncheon were organised at the opening day with key Asian buyers, institutions representatives and local authorities, while a delegation of Korean professionals joined on the second day. On the last day, the show organisers welcomed the management teams of Charoen Pokphand, Betagro, Centaco, Thai Food Group, Thai Vegetable Oil and more.

The organisers of VICTAM Asia and Health & Nutrition Asia were proud to host several conferences and meetings with the cooperation of key industry partners, among them; The Asian Food and Feed Insect Association (AFFIA), Aquafeed.com, GMP+, GRAPAS Innovation Seminars, the Thai Feed Mill Association, WPSA. The different conference organisers stated that the delegate attendance was good and that the delegates have appreciated the quality of both the speakers and their papers.

Additionally, several exhibitors like Amandus Kahl, Bioproton, Bühler Group, Clextral, DSM, Evonik, Grain Technik, J E S Innovative, Kanters, Premiertech, and Proteon presented technical seminars during the three show days.

During the event both the Victam Corporation and VIV worldwide announced their upcoming events respectively.

The Victam Corporation announced that it will expand its business to Latin America.

- VICTAM LatAm will be organised from October 3 – 5, 2023 at Expo Center Norte in São Paulo, Brazil. VICTAM LatAm is co-located with GRAPAS LatAm, the event for the grain milling and processing industries and with GEAPS, the biggest and best show in the grain industry!
- VICTAM Asia and Health & Nutrition Asia and GRAPAS Asia will be back in 2024, March 12 – 14 at the BITEC venue.

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VIV ASIA 2023
BANGKOK, THAILAND
8-10 MARCH

The organisers **VNU Asia Pacific** and **VNU Europe** have announced that **VIV Asia** will take place on **March 8-10, 2023.** The show will move to IMPACT, a bigger venue to host a steadily expanding show. The co-location of VIV Asia with the first edition of Meat Pro Asia is also confirmed on **March 8-10, 2023** by Meat Pro Asia organisers Messe Frankfurt (HK) Ltd. and VNU Asia Pacific.

VIV Asia is officially returning to the traditional March cycle in the odd years, after Covid pandemic disruption. The organisers trust that this decision will bring a clear and final direction for all stakeholders' future business planning.

VIV Asia is coming back as the number 1 leading international event for the livestock, animal proteins, feed to food industry with global and regional players and industry professionals finally gathering in 2023 in the exciting city of Bangkok from the entire Asian continent. Exhibitors and visitors will also enjoy by then the complete BTS Skytrain extension from city centre directly to the venue. www.vivasia.nl

AQUA CULTURE Asia Pacific

EDITORIAL CALENDAR 2023

Look out for AAP's annual report on trends in Asia's production of marine shrimp and aquafeeds

Volume 19	January/February	March/April	May/June	July/August	September/ October	November/ December
Deadlines -*Technical articles*	*November 15, 2022*	*January 17*	*March 14*	*May 16*	*July 18*	*September 19*
Deadlines - *Advert Bookings*	*November 22, 2022*	*January 24*	*March 21*	*May 23*	*July 25*	*September 26*
Innovations/ Startups	Experiences and opinions covering role models; clear and present needs of industry; innovations and digitalisation in aquaculture					
Interviews with industry leaders	Focus in 2023 will be leaders pushing for sustainable aquaculture					
Issue focus Emerging trends and challenges	Nursery & Hatchery	Health & Disease Management	Sustainable & Responsible Aquaculture	Demand & Supply Equilibrium	Aquaculture Innovations	Health & Disease Management
Industry Review	Production Innovations	Marine Shrimp	Aquafeed Production	Tilapia	Marine Fish	Catfish & Freshwater Fish
Feeds & Processing Technology	Functional Feeds/ Additives	Fish meal/oil Replacements	Sustainable Feeds	Novel Ingredients	Larval & Nursery Feeds	Feed Enzymes
Production Technology	Controlled Systems (hybrid/RAS)	Offshore and Industrialisation	Hatchery Technology	Real Time Monitoring/Big Data	Feed management	Post-Harvest Processing
Marketing activities	Market and product developments, generic marketing, certifications, branding, food safety etc					
Company/Product News	News on activities at international, regional and local conferences and trade shows					
For advertising/article contributions and guidelines contact: zuridah@aquaasiapac.com						

VIV ASIA 2023

BANGKOK, THAILAND
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32nd Annual Practical Short Course on Feeds & Pet Food Extrusion January 30- February 3, 2023

A one-week Practical Short Course on Feeds & Pet Food Extrusion will be held at Texas A&M University in hybrid format by staff, industry representatives, and consultants. The program will cover information on different extrusion systems such as dry extruder, expander, single and twin-screw extruder, designing new feed mills and selecting conveying, drying, grinding, conditioning and feed mixing equipment. Current practices for production of pet foods, preparing full-fat soy meal; recycling by-products and secondary resources; spraying and coating fats, digests and preservatives; use of encapsulated ingredients and preparation of premixes are reviewed. Participants can register online.

Reservations are accepted on a first-come basis. For more information, programs and application forms, contact: Mian N. Riaz, Ph.D, CFS, Director, Extrusion Technology Program, Professional & Continuing Education- TEES Edge. Texas A&M University

College Station, E-mail: mnriaz@tamu.edu
https://foodscience.tamu.edu
https://teesedge.tamu.edu/online/extrusion

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World Aquaculture Singapore 2022
www.was.org

2023

January 30-February 3
32 Annual Practical Short Course on Feeds & Pet Food Extrusion
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www.teesedge.tamu.edu/online/extrusion

February 23 - 26
Aquaculture America 2023
New Orleans, USA
www.was.org

March 8-10
VIV Asia 2023
Bangkok, Thailand
www. vivasia.nl

April 12-14
Vietshrimp Aquaculture International Fair
Can Tho, Vietnam
https://vietshrimp.net

April 18 - 21
Latin American & Caribbean Aquaculture 2023
Panama City, Panama
www.was.org

April 21-22
RASTECH 2023
Florida, USA
www.ras-tec.com

April 25-27
Seafood Expo Global/Seafood Processing Global
Barcelona, Spain
www.seafoodexpo.com/global

May 29 – June 1
World Aquaculture 2023 Darwin, Northern Territories, Australia
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