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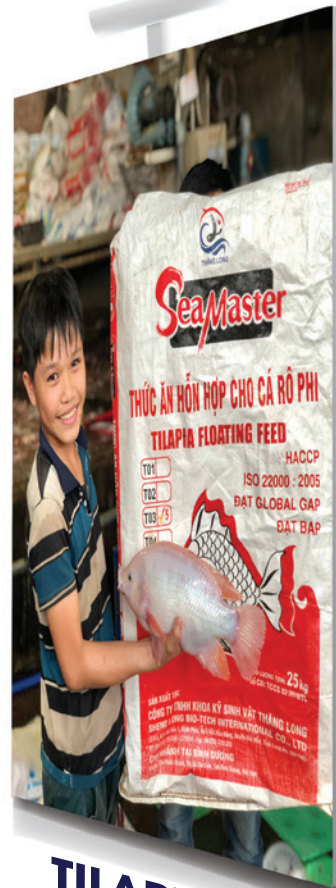
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The global shrimp: Is Asia losing out?

negatively affecting demand. China, with its zero-Covid policy still sees poor food service demand due to restrictions. We may see supply exceeding demand affecting prices in 2H 2022.

At the PMI Talkshow in Bali, millennial farmers of Indonesia see the need to prioritise markets and sustainability over production volumes. Ex-farm prices are dropping after a peak in April and with increasing feed prices leading to higher production costs, margins are being squeezed. Nearly 80% of Indonesia's exports are destined to the US. Whether Indonesia is over reliant on the US market, or its products match this market is irrelevant. It just makes it more difficult for Indonesia to pivot when prices fall.

Due to the large market and high number of genetics suppliers, Indian hatchery operators normally do not rely on any single supplier and willingly try new lines. The AISHA webinar for Indian hatchery operators highlighted their demands from genetics companies. Everyone is looking for high fecundity, good growth performance and robustness. There is an acceptance for robustness with a certain loss of growth performance only. With regard to efficiency, Jim Wyban showed that when production tonnage divided by post larvae produced, then India's numbers have deteriorated.

How do we compare competitiveness amongst the leading shrimp producers? Arguably, the single best method of comparison is by direct cost of production, but average data is rather meaningless due to the high variation between the best and worst producers in Asia. McIntosh highlighted that the coefficient of variation has increased from 13% in 2010 to 30% in 2020. Adding complication to this comparison is the number of crop failures in Asia.

Another method of comparison is ex-farm prices between countries for the same harvest sizes since economic theory assumes that all farmers require the same margins to survive or else, they would forego farming or sit out the next cycle. Kontali Shrimp shows interesting data for farm-gate prices of size 40 shrimp for week 27 this year. Ecuador has the cheapest prices at USD 4.25/kg vs India at USD4.70/kg vs Indonesia at USD5.01/kg. Does this indicate Ecuador having the lowest cost of production and if so, why are the countries in Asia uncompetitive?

Asia's most glaring weakness is its poor survival rates. From an average 80% in 2010, Asia is averaging 'real' survival rates of 60% today and this is discounting crop failures. It is critical to emphasise 'real' as most hatcheries provide a bonus quantity of 20% of post larvae which is never counted during stocking. The Asian industry is shooting itself in the foot with this practice as one could exceed the carrying capacity of the pond, causing stress to the shrimp, hence inviting disease. Ecuador does not face this issue with low stocking densities.

Another weakness is our apathy in promoting traceability, sustainability and branding quality shrimp. Although Ecuador has shown the way forward with its Sustainable Shrimp Partnership programme, not one of the Asian countries has taken advantage of this opportunity. Perhaps the business environment has been comfortable for Asia so far, but AAP hopes that it does not take a catastrophe for the need to change.

If you have any comments,
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The vannamei shrimp could not have been a better saviour for the Asian shrimp industry in the early 2000. It was the perfect combination of the push-pull factor. The monodon shrimp was decimated by disease and domesticated SPF broodstock arrived on the scene just in time. By 2010, Asia was producing close to 80% of global shrimp. Fast forward to today, Robins Mcintosh at the Infofish Shrimp 2022 forecasts that Asia will only contribute 55% to global shrimp production by 2030, from 65% in 2019. Why is Asia losing out?

Many of the symptoms of the plight of the Asian shrimp can be seen from take-away messages from three recent meetings. At Infofish Shrimp 2022, we report on production where Ecuador led the pack by crossing the million tonnes production mark followed by India.

Revenge consumption of shrimp has helped compensatory growth in the US and EU markets post Covid-19 but since the beginning of 2022, higher prices due to supply disruptions as well as inflation are

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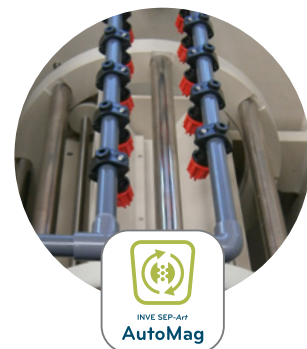
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Bali Rebound for Indonesia's millennials in shrimp farming

Prioritising markets and producing sustainable and traceable shrimp

Indonesia has a large cohort of young under 40s shrimp farmers and together they form the Indonesian Young Farmers Association (Petambak Muda Indonesia or PMI). Today PMI has 200 members. The mission is to improve shrimp culture to meet the next growth phase. In 2019, they were Bali Bound for their annual gathering and in June, staged "Bali Rebound" for a face-to-face meeting.

PMI members, most of whom run highly successful commercial farms in Indonesia, came together with the wish to be more aware of market demand in production planning. PMI members contribute almost 25% to the national production.

Rizky Darmawan, Director of PT Delta Marine Indonesia and Chair of PMI said, "We have waited two years for this in-person meeting. We should not be comfortable with the current situation. Production cost is rising, ex-farm shrimp prices are low and we still have disease challenges. There are outbreaks of acute hepatopancreatic necrosis disease (AHPND), serious in some regions like in Lampung.

"Our concern is how the market is slowing down and our Indonesian shrimp is not competitive in global markets. Most of our exports go to the US and they buy our shrimp only when supply is short from India and Ecuador. Where will we be when these two countries produce more shrimp? How can we differentiate our products?" asked Rizky. "It is not business as usual. At the Talk Show we will discuss market issues. We usually focus on production, which we know we can do well. For the moment all is well as supply is low but as we produce more, what will be the situation?"

TB Haeru Rahayu, Director General of the Aquaculture Directorate, Ministry of Marine Affairs and Fisheries (MMAF) presented on the plan of action to increase shrimp production to 2 million tonnes by 2024. The ambitious plan will require the revitalisation of traditional ponds and increase productivity to 30 tonnes/ha/year.

Although shrimp aquaculture is promising, Haris Muhtadi, Aquafeed Division of the Indonesian Feedmills Association (GPMI) and Associate Director at PT CJ Feed and Livestock, said that PMI members should adopt more of IoT and digitalisation, consider controlled culture systems such as circular tanks and use functional feeds. "Our challenges are sustainability and certification and we need to develop niche markets. Our competitors are Ecuador, India and

Vietnam. We need to focus on branding and marketing." He showed logos of leading market organisations in India (MPEDA), and Vietnam (VASEP) as well as the SSP (Sustainable Shrimp Partnership) logo for Ecuadorian shrimp. His message was for the young farmers to do more in marketing Indonesian shrimp.

Information compiled from the apps of the startup, JALA showed that stocking densities in semi-intensive ponds are less than 100PL/m²; intensive farms stock at 100-200PL/m² and super intensive ponds stock at more than 200PL/m². There is a wide range of productivity, from 11-36 tonnes/ha for super intensive ponds, 5.5 to 25 tonnes/ha in intensive ponds and for semi-intensive ponds, the range is large from 0.82 to 2.74 tonnes/ha. When farms have disease, such as with EHP, productivity drops to 10.4 tonnes/ha for the high performing super intensive farms. Production costs range from a high at IDR78,000/kg (USD5.19/kg) to as low as IDR42,000 (USD2.8 /kg) for super intensive farms.

The wish of PMI is to market sustainable shrimp, using green energy such as PV panels, reforest mangroves and of course traceability is essential. This cohort of shrimp farmers comprises two groups. Some are second generation farmers taking over farms from their parents and others are highly successful young entrepreneurs in shrimp farming. They are well educated and are comfortable with English and look at shrimp farming in a scientific way, analysing data in decision-making.

Robust shrimp and managing stressors

Faced with very low survival rates and loss of some crops, some farmers in Lampung began to use broodstock from American Penaeid Inc (API) with good results. API has developed robust and tolerant broodstock, focusing on survival first. Robin Pearl, CEO said that disease will always be part of the shrimp industry, but we can overcome it with strong shrimp selected to survive and then improve farming practices.

On API's strategy in broodstock development, Pearl said, "Our quality control allows us to produce successful stock year after year. The strategy is to be consistent which the farmer needs." Pearl discussed API's Dragon line developed for the markets in China and which is now available in Indonesia. Average weekly growth is 2g/week in ponds stocked with 250PL/m² and harvest sizes are 35-40/kg.



Abang Murali Simanjuntak



Haris Muhtadi



Robin Pearl



Rizky Darmawan



From left, Cynthia Darmawan, Christopher Tan, Ronnie Tan, Haris Muhtadi, and Denny Leonardo.

Technical Expert Manager - Aquaculture at DSM Indonesia, Abang Murali Simanjuntak gave a very comprehensive description on microbiota changes in shrimp with stressors from the environment and the complex role in animal health. Over the 16-week culture period, diseases can occur with AHPND from stocking to week 4. Throughout the whole cycle, there is the threat of WSSV and EHP. Factors affecting the composition of gut microbiota are development stages, feed composition, environment and health status.

“Environmental stress from ammonia and sulphides reshapes the gut microbial community structure. Pond sediment collected from shrimp culture ponds in China showed how the bacterial communities were becoming increasingly different from the start of the cycle. Therefore, gut microbiota is similar to sediment which means that managing sediment is as important as managing water.”

He also discussed managing *Vibrio* populations which are strongly influenced by salinity and temperature. A holistic approach to the environment, pathogen and host is essential to increase shrimp’s adaptive capacity to reduce risk to diseases. Abang Murali suggested keeping *Vibrio* levels low at CFU of 10³ but preferably at CFU of 10², which is achievable but requires a lot of work and attention.

Wayan Agus Edhi, shrimp consultant, followed with a discussion on water quality management, based on his experiences managing farms at various locations. He has published a book on dynamics of water quality in shrimp ponds in the Indonesian language. Dr Boris Hinz introduced the technical details on how peracetic acid (Stockmeier Chemie) which is stronger than other disinfectants, can be used in shrimp farming.

On new technologies, Ivan Tay presented AquaEasy’s developments with the i-Feeder. JALA has 13,500 users on its apps and monitors 7,700 tonnes of shrimp monthly and 306 small scale farmers under its sustained management program. New startup Delos wants to ‘Tesla-rise’ shrimp farming in Indonesia with interventions and new ideas. Alex Farthing showed the areas in the production chain where new technologies can reduce risks and improve production consistency. One area is to harness the potential of probiotics, prebiotics, synbiotics, paraprobiotics and postbiotics for shrimp farming. Diamond V’s Dr Wee Kok Leong said that feeding a postbiotic can give consistency in production and support survival with high challenges such as with AHPND outbreaks.

Marketing Indonesian shrimp

The talk show had a panel to address a burning question – why are shrimp prices going down and how long will this last? Moderators were Cynthia Darmawan, COO, PT Delta Marine and Denny Leonardo, Business Development Manager, PT Tequisa Indonesia. The panellists were Christopher Tan, Senior Trader at Mida Trade Ventures International, Singapore, Haris Muhtadi and Ronnie Tan, USGC consultant, Malaysia.

“Low prices are because of increased supply. Demand in the US is around 900,000 tonnes and in the EU, around 800,000 tonnes but the issue is China, where imports dropped to only 600,000 tonnes from the high of 800,000 tonnes,” said Ronnie. “In the US shrimp prices are up by 10% as consumers are willing to pay high prices but there is a mismatch; we know that at the farm level, ex-farm prices are low, but freight costs have escalated.”



Figure 1. Trends in ex farm shrimp prices in Indonesia (IDR 14,965.8 =one USD). Courtesy of JALA.



Clockwise from top left: During the Q&A; farmer Stephen discussed controlling *Vibrio* populations; Anwar Hasan, Cargill, Indonesia (centre) with Rizky and friends; Ning Widjaja, Diamond V (centre left), and the aqua team.

Christopher added, "China is not opening and unless this happens, there is no way prices will go up. In 2021, we had demand outpacing supply and markets were bullish. But in 2022, in January, there was a high inventory in the US with delays in shipments of 2021. Then with the Ukraine war, 2022 took a different turn, consumer sentiment was down and inflation crept in. Can this scenario change? The silver bullet will be when China starts buying again."

In 2021, Indonesia exported 179,000 tonnes of shrimp to the US based on NOAA data. "Indonesia exports almost 80% to the US market, which makes it extremely vulnerable. Therefore, prices for Indonesia's shrimp will depend on the US economy," said Christopher.

Ecuador's exports into the US expanded to 183,886 tonnes in 2021 from 125,840 tonnes in 2020. Ecuador's shrimp is now equally distributed into the US, China and EU markets since 2021. "Previously, Indonesia's competitor in the US market was India, but then Ecuador could get its shrimp faster to the US leaving Indonesia out," said Christopher.

Cost of production has increased because of feed prices and Haris explained. "In 2021, feed ingredient prices have increased by 30% and GPMT members did not have any choice except to increase shrimp feed prices to maintain feed quality."

The Ukraine war is a black swan incident which added more pressure to feed ingredient prices. In the region, feed prices were up by 7% in 2021 and again feed millers increased prices by 5% in 2022. Compared with Vietnam, Indonesian shrimp feed prices are relatively low.

The panel exchanged information on cost of production (OPEX) which has gone up to USD3.60/kg for size 60/kg. When offer prices to farmers decrease or when prices are fluctuating, farmers stop cycles. In 2020 to 2021, the proportion for retail went up for home cooking but then in 2021, food service came back while retail remained popular. "What we see in 2022 is all because of inflationary pressures," said Ronnie.

On the position of large shrimp (size 30/kg), Christopher described the changes effected by Ecuador which used to be strong in large size shrimp but offered smaller shrimp (60-80/kg) in 2021. Sales for Christmas and New Year will depend on the summer sales and Indonesian suppliers will compete with Indian shrimp harvest in August and Ecuadorian shrimp harvest in October for the US markets. "Timing of harvests and planning for exports is critical," added Christopher.

Steps producers can do in the future

Haris has a clear message to the young farmers present. "Do not focus on production but on a healthy production cost. When markets are bad, you can still maintain your production by decreasing stocking density and maintaining good survival rates. In the end, it is production efficiency."

Industry needs to diversify to the EU market, but this requires certification and pivot to quality. Unfortunately, no processor in Indonesia has the EU number nor ASC certification because the authorities deemed local certification to be sufficient. To market to the EU, both processor and farmer play equally important roles together with the competent authority. The EU market is a discerning market where processors need to adhere to norms like no soaking and HOSO shrimp with intact heads. Furthermore, EU buyers demand ASC certification.

While Ecuador has many integrators facilitating easy access to EU markets, the industry in Indonesia is fragmented. It is up to the young farmers to bring up Indonesian shrimp to a sustainable product. PMI, by working together and speaking in one voice, can make a difference.

Diversification into shrimp farming

PT Mitrabara Adiperdana Tbk (MBAP), a coal mining company, through its subsidiary, PT Mitra Alam Bahari Sentosa (MABS), has decided to enter the shrimp farming industry. This is part of its business diversification. MABS has signed a joint venture agreement (JV) with PT Delta Marine Indonesia (DMI), a subsidiary of Delta Marine Group. This joint venture company will conduct business activities in the field of shrimp farming and sales, as well as other supporting businesses.

DMI partners with MABS because the former has highly qualified professional experience in the shrimp farming sector. Delta Marine Group is an aquaculture company with more than 40 years of experience. Currently, Delta Marine Group has shrimp areas of 70ha in the Labuan Mapin area, Sumbawa, West Nusa Tenggara. Director of Delta Marine Indonesia, Rizky said MABS and DMI are both committed to building a dynamic, effective, efficient and productive shrimp pond management system. (Source: www.investor.id)

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More black tiger shrimp from Gujarat

At SEG, Mindhola Foods shares its plan to farm large size black tiger shrimp for European markets.

In 2021, India's vertically integrated seafood company, Mindhola Foods LLC in Surat, Gujarat, exported 1,500 tonnes of farmed shrimp to various countries. This volume comprised 1,000 tonnes of white shrimp *Penaeus vannamei* and 500 tonnes of black tiger shrimp *Penaeus monodon*. At the Seafood Expo Global (SEG) held in April in Barcelona, Spain, Hetal Shantila Patel, CEO was at its booth, within the Indian pavilion to tell the story of their Oceanus brand.

The company has two farms and Hetal announced that with the expansion of the farming area by 100ha, it will farm more of the black tiger shrimp. "Although our own farms produce vannamei shrimp, which totalled 127 tonnes in 2021 after remodelling the culture method and introducing a state-of-the-art nursery, I believe that my farm is not actually amenable to vannamei shrimp farming. White faeces disease (WFD) and *Enterocytozoon hepatopenaei* (EHP) are particularly challenging, although I try to keep water as clean as possible to prevent accumulation of spores of the microsporidian."

The farming of the black tiger shrimp will be at low densities such as 10-15PL/m². Mindhola targets dedicated markets in Japan and Europe for large size shrimp (size 17-18/kg). Hetal said, "Why not, as we have good water quality and high salinity, and we can stock 10PL/m² to produce large size products. We have more than 30 years of farming experience, which has led us to produce quality shrimp in a sustainable way."

There are also market challenges. "We produce vannamei shrimp of all sizes, from 20-80/kg shrimp. Nowadays, most of our vannamei shrimp (about 80%) go to Japan and New Zealand. Exports to the US have decreased. In February/March 2022, we also saw higher prices than in 2021. Our challenge here in Europe, as we observed at this seafood show is that offer prices for Indian vannamei shrimp is USD2.00 higher than shrimp from Ecuador."

Although plans are underway to farm more of the black tiger shrimp, Hetal said that he expected a one-month delay for the arrival of post larvae and a delivery of only 10% of his requirement. In July, Hetal updated that stocking took place in May and June, each with 5 million post larvae and stocking was continuing in other farms in Gujarat as and when post larvae become available.

"There is a high demand for black tiger post larvae from domesticated broodstock originating from Madagascar. Only a selected number of hatcheries have permission to import broodstock and produce post larvae. Farmers in Gujarat expect vannamei production to be less in 2022, down by 60%, since many are converting to farming the black tiger shrimp."

With regards to farming challenges, Hetal listed the high cost of feeds, especially with increasing prices of soybean meal. Costs of feeds have increased 5% from the last cycle to INR110/kg (USD1.40/kg). Mindhola's farms use 10,000 tonnes annually of GMO-free feeds from Charoen Pokphand India. It works with 200 associated and contract farmers covering 1,000ha of ponds. It supplies raw materials, feeds, and other farming supplies to the farmers to ensure the delivery of high-quality shrimp.

A recent addition is a freezing facility with an installed capacity of 75 tonnes/day. It targets premium quality head-on and shell-on shrimp. Its USP (unique selling proposition) is to deliver live shrimp from the farms to the processing plant. Mindhola Foods has certifications from Aquaculture Stewardship Council (ASC), Best Aquaculture Practices (BAP) as well as FSSC 22000 and BRCA, ready for the European shrimp markets.



In April, Hetal Shantila Patel, CEO Mindhola Foods LLC (seated) and his team, Zubin Metha, on his right, Jatin Patel on his left, attended the Seafood Expo Global (SEG) held in Barcelona, Spain. The target was new markets in Europe for its black tiger shrimp as well as vannamei shrimp as it expands production.



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Shrimp breeding: Strategies for Success

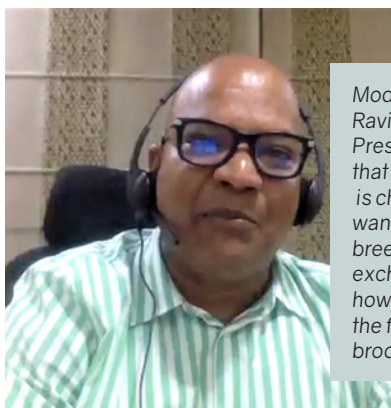
A discussion with broodstock suppliers to help the hatchery and farming sectors in India harness the potential of current lines of vannamei broodstock



Shrimp breeding, per se, plays a critical role in the shrimp aquaculture value chain. India's vannamei shrimp farming industry is a major market for global shrimp breeding companies supplying specific pathogen-free (SPF) *Penaeus vannamei* broodstock. In 2021, it imported almost 300,000 broodstock for an 80 billion post larvae production. In its registry, the Coastal Aquaculture Authority (CAA) has 11 approved suppliers. All imports of broodstock undergo quarantine at the Aquatic Quarantine Facility in Chennai operated by the Rajiv Gandhi Centre for Aquaculture (RGCA).

"We have achieved a total production of 920,000 tonnes of shrimp in 2021, with vannamei shrimp accounting for 90%. This could not have happened without these SPF broodstock. But we are at a crossroads, as the farming sector is facing a zero-sum game with inflationary pressures, production costs going up and diseases reducing efficiencies. Cash flow is down with freight disruptions and broodstock shipments late in reaching their destinations. Today, no segment in the supply chain is happy and is losing confidence upstream and downstream. Recurring crop failures and losses make the hatcheries and farmers cast doubts on shrimp genetics too," said **Ravi Kumar Yellanki**, Managing Director of Vaisakhi Bio-Resources and President of the All India Shrimp Hatcheries Association or AISHA.

AISHA represents close to 600 shrimp hatcheries operating in India, with a total production capacity of 80-100 billion post larvae annually. A webinar "Shrimp breeding: Strategies for Success" was held over two days



Moderator for the webinar, Ravi Kumar Yellanki, President of AISHA said that the farming segment is changing in India, "We want to engage with shrimp breeding companies. In this exchange, we want to know how hatcheries can harness the full potential of their broodstock."

(May 10-11) with the participation of local and regional hatchery operators and farmers. "Together with leading broodstock suppliers, we want to share experiences, address the plight of several of the hatchery operators regarding performance of broodstock, production of quality post larvae and later, performance in terms of size and survival rate."

New shrimp lines

All the broodstock suppliers have several lines supporting growth, survival, balanced traits, etc. These have added to the confusion in the hatchery segment. "We understand that a lot is happening in shrimp breeding, but have we done enough?" asks Ravi Kumar who also moderated the webinar. "The farming segment is changing in India and we want to engage with shrimp breeding companies. We need to come together because we are all integral to the success of farmers. If our farmers do not do well, hatcheries and breeding companies will be affected. In this exchange, we want to know how hatcheries can harness the full potential of their broodstock." He also compared India's competitiveness with Ecuador, the country reached a million tonnes production and in 2022, is exporting more than 90,000 tonnes per month. "The shrimp industry in Ecuador seems to be doing well; they have tweaked genetics for disease tolerance and larger size shrimp."



In his presentation "It's a wake-up time: Shrimp breeding for shrimp culture success in India," Robins McIntosh, said that the difference between India and Ecuador is crop failure rates - very low in Ecuador and moderate and going higher in India.

Some musts for successful shrimp farming

Bringing lessons from Ecuador to Asia, **Robins McIntosh**, Charoen Pokphand Foods, said that Ecuador and India aim to reach one million tonnes. The steep uptrend in production in Ecuador will continue but for India, this trendline is bearing down. "This is always a bad sign. India needs to adjust to be back on track and challenge Ecuador." McIntosh described how Ecuador used Asia's closed systems with autofeeders (1 unit/ha) and aerators (6-10HP/ha) and how it has used the genetics of fast growth, large size and robust lines. Now, many ponds can produce 20 tonnes/ha/year by stocking at 30PL/m².

In the case of India, McIntosh said that farmers became nervous when shrimp prices went down and aquafeed prices rose to INR85,000/tonne (up by INR5,000/tonne). "The difference between India and Ecuador is crop failure rates - very low in Ecuador, while moderate and going higher in India."

The crucial role played by the changing culture environment in addition to genetics was highlighted. With the rapid increase in shrimp production, environmental issues need to be given due attention to maintain sustainability of

commercial shrimp farming. Some musts for successful shrimp farming are:

- SPF broodstock and healthy and larger post larvae. With genetics, PL12 are larger (350/g in 2002 vs 40/g in 2018).
- Enhanced tolerant stocks to withstand diseases.
- Enhanced robustness which is the capacity to maintain high health in adverse environmental conditions.
- Basic pond biosecurity to minimise exposure to pathogens.
- Less reliance on the use of pond chemicals unless there are observed gains.

McIntosh analysed the challenges influencing the production cost and profitability of shrimp aquaculture. Diseases like white spot syndrome virus (WSSV), acute hepatopancreatic necrosis disease (AHPND) and *Enterocytozoon hepatopenaei* (EHP) impact shrimp farming badly and the increased loads of *Vibrio*-like bacteria make the pathogens more virulent. Stresses make shrimp more susceptible to diseases.

He discussed the status of new robust and WSSV tolerant CP Kong broodstock, the black tiger shrimp development program, and recommended the usage of tolerant/hardy lines of shrimp broodstock considering the current culture conditions in India. The future lies in utilising marker assisted selection to obtain robustness, tolerance to WSSV and EHP, and colour.

Shrimp breeding: Status and outlook

In his review on global shrimp production, Hawaii-based Dr **Jim Wyban**, Marine Genetics LLC attributed the phenomenal growth in production to almost 4.5 million tonnes in 2021 to the adoption of SPF vannamei in Asia. Some 450 billion post larvae (valued at USD1.6 billion)



Jim Wyban suggested that trade associations of India organise Shrimp Breeder's Challenge to compare performance between commercial strains under similar culture conditions.

are required from 1.5 million pairs of broodstock, the latter valued at USD200 million.

He listed the worldwide exports of broodstock from Hawaii and highlighted the increase in the number of broodstock imported by India. Hawaii exported almost 500,000 broodstock, mainly to India, Vietnam, China and Indonesia. The two leaders, Shrimp Improvement Systems and Kona Bay have more than 91% of India's vannamei broodstock market (Figure 1).

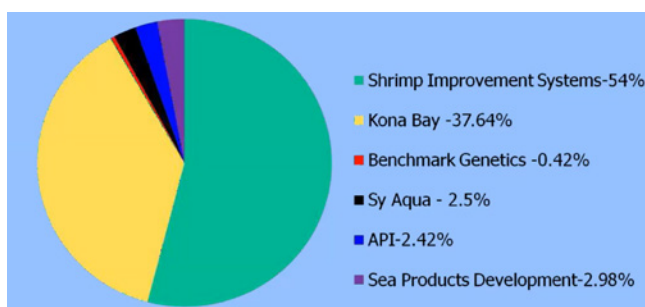


Figure 1. India's vannamei broodstock imports in 2021. Source: Shrimp breeding: Status and outlook by Jim Wyban.

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Wyban discussed India's shrimp production efficiencies and the need for improvement. "Since 2009, efficiency of post larvae per broodstock has improved to 32 million PL/broodstock in 2019 from 12 million PL/broodstock in 2009. However, the production per million PL, independent of the quality of post larvae dropped from 20 to less than 10 in 2021. This reflected the fact that many farmers were harvesting smaller size shrimp."

Breeding companies are increasing the options for farmers to reduce risks. Wyban said that broodstock multiplication centres (BMCs) in India are important recently, especially with the complexity of importing and quarantining broodstock which comes with a high cost. BMCs can improve the industry's efficiency while benefiting from advanced breeding programs. He suggested that the trade associations of India organise Shrimp Breeder's Challenge to compare performance between commercial strains under similar culture conditions. In his appeal to Indian hatcheries to continue growing, he reminded them of the need to intensify biosecurity measures for producing top-quality disease-free post larvae.



Harris B. Wright said, "When you add the changing environmental conditions when developing products for a country like India, you begin to understand the complexity of product enhancement and development."

Product development for changing environments

When comparing farming conditions between the regions in India (east vs west coasts) and with the seasonal variations in each of the farming states, **Harris B. Wright**, Shrimp Improvement Systems, said, "Crop patterns, weather, temperature fluctuations and salinity, more than density, must be visited at every location. Specific diseases tend to be regional and seasonal too."

Wright continued that often overlooked are the interactions between the genotype of the animal and its environment and the need to understand the impact of India's wide-ranging environments and the phenotype expression. It is really getting a grasp of the environmental stressors that shrimp encounter and this is key for product development as well as optimum performance. "When you add the changing environmental conditions when developing products for a country like India, you begin to understand the complexity of product enhancement and development. We focus a lot on our genetic trait correlations, primarily between growth, hardiness and disease."

He stressed, "No matter what product is available, biosecurity is a top-down concept and diseases will evolve too. There is a correlation between genetics and the environment which can be predicted if we work with customers. Analysing the data from our two hatcheries in India, we have developed products to match the management practices and environmental needs to achieve maximum product potential."



Steve Arce, in presenting on "High Performance Breeding: Challenges and opportunities for an evolving global shrimp industry" announced a BMC in India. "In India, local distribution may simplify the import process and AQF to help with certification. The root import risk is removed, and mortality risk from stress is minimal."

Breeding challenges and opportunities

"Breeding is cumulative and better breeding will pay off," said **Steve Arce**, Kona Bay, Hendrix Genetics. In shrimp, the breeding goals are balancing gains for each segment of the production chain (hatcheries, farmers and processors). "Their needs may not be the same but focusing on the right traits will benefit all. Although more vertical integration may help the industry, we recognise the needs of traditional farms in India."

Performance of the shrimp is an interaction between genetics and environment: the interaction between genetics (genotype value) and environment and its impact on the performance (phenotype value) of different lines of broodstock. His message was that environmental influence is significant in the BMC, hatchery, nursery and in grow-out farms. Arce commented on the practice of feeding wild polychaetes to SPF broodstock and added that there is an opportunity to develop SPF polychaetes in India.

He highlighted their recent improvements in their breeding program with reproduction, early growth, robustness and capacity building. This includes natural mating and non-ablation of spawners, and improved disease challenges such as for EMS and appropriate disease challenges for EHP and WFD.

He explained the characteristics of their different broodstock lines for three different production systems (intensive, medium intensive and low input systems). Kona Bay Strength is tailored for challenging environments and selected for disease tolerance specifically for WSSV/EMS. Kona Bay Speed line is recommended for controlled and biosecure environments. Production time may be shorter, and this offers the opportunity for another crop for the farmer. In his presentation, Arce included some charts on feeding protocols in maturation and shrimp larvae rearing.

A local distribution ecosystem with a BMC in India and possibly, future ones in Vietnam and China was discussed. "In India, local distribution may simplify the import process and AQF to help with certification. The root import risk - mortality risk from stress - is removed. The advantage is that broodstock will be available for all hatcheries and not just those able to afford imports."

When the going gets tough, the tough get going

This is the title of the presentation by Robin Pearl, American Penaeid Inc (API). He started with the advice to farmers to go by the actual number of post larvae stocked in the ponds. "Farmers that stock strong shrimp and manage them appropriately can make money, just like in Ecuador."

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Robin Pearl said, "Farmers that stock strong shrimp and manage them appropriately can make money, just like in Ecuador."

The success of Ecuador is attributed to genetics based on survival and there is a continuous improvement in farming practices. API selects for survival first and growth second for its broodstock lines. "We do selection in actual pond environments. Our shrimp do grow slow but for me, it is to give the best for the farmer - hardy shrimp that withstand stress better than the growth lines. We minimise inbreeding and maximise the hybrid vigour of the parent stock," explained Pearl.

Although genetics play a part, Pearl insisted that hatcheries should use quality feeds and Artemia to produce robust post larvae, avoid utilising bonus post larvae and give farmer usage instructions. The farmer should play his part by monitoring for example dissolved oxygen levels. To market to China, he stressed the need for Indian shrimp farmers to create more value for their product? and change the harvest process to maintain the quality at its best.



Thomas Gitterle said, "There is always a debate on what we can select for, resistance vs growth. WSSV remains the main shrimp disease," in his presentation on "Breaking the code: Uncovering and harnessing the genetic potential of shrimp."

Harnessing the genetic potential of shrimp

Geneticist **Thomas Gitterle**, SyAqua Group Inc started his presentation with these words, "This is a tough industry and we are doing our best to bring a product for the industry."

Vannamei shrimp can be cultured in diverse environmental conditions, with salinities of 0-40ppt and stocking densities of 10-500PL/m² and lines for each specific condition are impossible. "There is always a debate on what we can select for, resistance vs growth. WSSV remains the main shrimp disease," said Gitterle. However, there will be no benefit to selecting a resistance line if WSSV is not infective in the pond. "Then we lose the potential of other traits, like growth."

SyAqua has a balanced approach to simultaneously selecting survival, growth and disease resistance in the same breeding population. According to Gitterle, they have improved average daily growth (ADG) by 100% in nine generations, with genetic gain of 15% for harvest weight and 5% for survival. Genomic selection has helped SyAqua to achieve 14% higher selection accuracy against

AHPND/EMS with reasonable growth and survival. Gitterle assured that significant improvement can be expected through fertility traits as they are under genetic control and are heritable. But the capability of the female to deliver depends on the feed and other factors. Finding and selecting phenotypes with low microenvironment sensitivity provides better scope considering the diverse farming conditions.



In "Strategies for dynamic and diverse challenges", Oscar Hennig said that their lines are selected for non-ablation performance. "This is important as market perception is changing and non-ablation is gaining traction."

Diverse challenges

Benchmark Genetics' **Oscar Hennig** described the genomic tools used by Benchmark Genetics and development of SPR from SPF populations for WSSV resistant lines. "Next is to break the negative correlation between WSSV resistance and growth rate," said Hennig who also shared the details on the database software to monitor performance. The maturation module tracks performance through maturation and in hatchery protocols and later there will be the larvae and farm modules. This is for the future, developing a better breed and for full traceability. "The KPI is average nauplii/ female/month. By tracking performances for the same genetics but across countries, we can go deeper on mating rate, etc. We can help the client on nutrition and management."

With regards to non-ablation, Hennig reiterated, "All Benchmark lines are selected for non-ablation performance. This is important as market perception is changing and non-ablation is gaining traction and post larvae performance improved by non-ablation of the female."

Farm performance of the balance line, using data from harvest yields in Indonesia was compared and Hennig showed that this line gave the lowest coefficient of variation for ADG and survival. "The idea is to give predictability at the farm level, and the final client which also works well for the processing plant." Finally, he highlighted the ongoing challenge trials to develop EHP/ WFD resistant broodstock lines. "We are doing both together as we are mimicking what happens in the pond."



Q&A

Can breeding companies produce specific stocks for Indian conditions?

There was a consensus that it will be difficult to select lines specific to India. However, a recommendation is to establish more BMCs where lines can be improved and adapted to local conditions.

Is EHP-resistant broodstock possible?

While no science can understand EHP better, proper management can clear EHP by minimising stress, farmers can handle EHP better in a culture system rather than seek EHP-resistant lines. However, as mentioned, some breeding companies are working on EHP-resistant lines.

Which should Indian shrimp farmers choose -growth or hardy lines?

Considering the current farming conditions in India, many speakers suggested hardy or resistant lines for India. However, if the farmer has a controlled system, high biosecurity and proper management, he should opt for growth lines. In general, genetically selected shrimp perform better than the tolerant (SPT) stock.

Broodstock used to take 8 months to reach 35-40g. Today, it takes only 4-5 months to reach these sizes. In the latter, is there any impact on spawning and subsequent performance?

The expert opinion was that to calculate the reproductive performance, age plays a major role rather than the mere weight of the animal.

Marine protein is decreasing in feed formulations. Will it impact the growth performance?

Marine protein is essential in shrimp nutrition. Few broodstock lines do well with soy-based formulations and some breeding companies have started working on lines for low protein diets as well as with plant protein-based feed formulations.

How do we control Zoea syndrome in shrimp hatcheries?

Experts felt that improved biosecurity, adequate disinfection, usage of quality feeds and good management can help in minimising the outbreak of zoea syndrome in shrimp hatcheries.

How do we assess the performance of different lines and ensure the claims by the breeding companies?

While this is quite difficult and challenging, the advice is to do a challenge study by stocking post larvae from all lines in a similar environment and check the performance of shrimp from each line.

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Supply trends and market directions for farmed shrimp

Production was higher in 2021 and in the first quarter 2022, Ecuador, India, Vietnam and Indonesia exported more shrimp to the US market.



In 2021, Ecuador emerged as the leading producer of farmed shrimp with more than a million tonnes of vannamei shrimp, followed closely by India with 925,000 tonnes and Vietnam at 931,000 tonnes. Indonesia produced around 400,000–450,000 tonnes. Production comprised largely vannamei shrimp: 80% in India, 71% in Vietnam and 80% in Indonesia. China's farmed shrimp production for 2020 in marine environments was 950,000 tonnes with vannamei shrimp accounting for 83% of this volume.

The above data came from presentations in the session on "Production trends and market directions" at the recent INFOFISH Shrimp 2022. This hybrid conference was held over three days in Putrajaya, Malaysia, from June 8-10 (see pages 60-62). Market analyses on US and European markets came from Kontali Shrimp and Shrimp Insights, respectively.

A view on the global shrimp scenario and the current and future position of Asian production in the international shrimp trade was presented by Robins McIntosh, Charoen Pokphand Foods (CPF), Thailand. The grand total of global shrimp production in 2021 was 4.6 million tonnes and McIntosh expects this to rise to 5 million tonnes with larger contributions mainly from Ecuador, which produced more than 14% of the volume in 2020. He gave the following scenario for 2022 (Figure 1).

"The Americas led by Ecuador is poised to overtake Asia, which had contributed 82% of the global supply in 2008. In 2022, Asia will have a 65% market share and the Americas 31%. More supply will come not only from

	2020	2021	Vannamei	Monodon	2022
Ecuador	850	1,010	1,010		1,150
Mexico	170	155	155		170
Central America	85	60	60		85
South America (- Ecuador)	142	170	170		200
USA & Europe	2.2	2.4	2.4		3.5
Total America	1,249.2	1,397.4	1,397.4	0	1,608.5
China	720	860	710	150	950
India	650	700	660	40	700
Asia (-China, India)	1,327	1,468	1,200	268	1,611
Total Asia	2,697	3,028	2,570	468	3,261
Middle East	80	95	95		100
Others	67	67	50	18	80
Grand Total	4,092.8	4,800.4	4,124.4	476	5,049.5

Figure 1. World shrimp production. Source: Robins McIntosh, CPF, Thailand.

Ecuador and Mexico but other South American producers, as well as from the Middle East countries."

Another recent trend is with black tiger (monodon) shrimp production, a 42% growth since 2019. McIntosh expects more black tiger shrimp from China and India as specific pathogen free (SPF) and genetic improvements changed average growth rate (ADG) from a mere 0.3g in 2010 to 0.5g in 2021. In India, high summer temperatures in April, May and June are problematic for vannamei shrimp culture; some farmers are reverting to black tiger shrimp in the summer months, according to Manoj Sharma, Mayank Aquaculture, when presenting the industry status for India. "Using SPF monodon (Moana), average daily growth (ADG) is 0.47g as compared to the conventional wild post larvae at 0.27g. Days of culture are down to 120 days instead of 200 days. But success depends on a stocking density not exceeding 10-12 PL/m²." (Table 1).

	Post larvae source	
	SPF monodon (Moana)	Conventional wild monodon
ADG (g)	0.47g	0.27g
DOC (days of culture)	120	200
Size(g)	50g	50g

Table 1. Data on average daily growth (ADG) with SPF monodon (Moana) vs the conventional wild broodstock in India. Source: Manoj Sharma, Mayank Aquaculture, India.

McIntosh joined other presenters in expounding on the oversupply situation and how prices are not keeping up with production inputs such as rising feed costs with higher prices for fishmeal, soybean and wheat. The way forward for Asian shrimp is accelerating innovation to be competitive globally.

Rise of Ecuador in 2021

"It was only at the end of 2006 that Ecuador recovered from white spot syndrome virus (WSSV) outbreaks which started in 2000. Since then, its producers have sustained growth," said Yahira Piedrahita, National Chamber of Aquaculture, Ecuador. "In the last 21 years, we attribute this continuous growth to using shrimp from local genetic programs, semi-intensive farming, stocking at 15-25PL/m² and smaller 1-5ha ponds. The increase in total area over this period was less than a fifth. Industry became more productive, and we went from 215kg/ha/year to 3.9 tonnes/ha/year."

On how Ecuador managed its challenges, Piedrahita said that unlike Asia which uses SPF genetic programs, the industry used only tolerant/resistant broodstock and stock at low densities because of the larger ponds. Amongst others, farms use automatic feeders and now acoustic sensors to optimise feed use, and artificial intelligence to estimate size and health of shrimp. Marketwise, there is the commitment to environment and sustainable and consumer safety.

Highest production in India

"India's production in 2021 was 15% higher than the 805,000 tonnes produced in 2019. In 2020, there was a large drop to 650,000 tonnes," said Manoj. "The country



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is happy to reach almost one million tonnes, but in 2010, the farm success rate at the national level was 85%; in 2021, this has dropped to 47%. This is due to poorer post larvae survival, slow growth, EHP, Vibrio, running mortality syndrome, white faeces disease and recently IMNV. The biggest threat is still WSSV." Manoj's message is that too little attention is given to carrying capacity in India, which the industry in other countries should also be aware of.

Almost 90% of farms have less than 5ha culture area and the productivity is 5 tonnes/ha over 200,000ha of culture area. In India, producers face rising costs such as energy up by 15%, feed costs by 20%, while post larvae costs remained relatively stable. Post Covid-19 labour cost is challenging Indian farmers to be more competitive.

High productivity in Vietnam

"Over the last 5 years, the increase of 13% in vannamei shrimp production was attributed to improved productivity since total farming area increased marginally at 18% from 94,000 to 115,000ha while for extensive farming of black tiger shrimp, the increase in culture area was much smaller at only 3.5%, from 600,399ha to 622,000ha," said Le Hang, Vietnam Association of Seafood Exporters and Processors (VASEP).

While the challenges are with climate change, especially drought and salination, particularly for vannamei shrimp, producers face competitive pressure on price and supply from India and Ecuador. Input costs are continuously increasing both for shrimp post larvae and feed. Hang attributed these high input costs as the reason why Vietnam's shrimp price is higher than that of some other countries. The opportunity for its producers is to strive for certification such as GlobalGap and ASC which is required by markets in the US and EU.

Initiatives to increase supply in Indonesia

While the government estimated a production of nearly 900,000 tonnes, Sudari Pawiro at UNIDO's Global Quality and Standards Programme Indonesia (GQSP) said that shrimp stakeholders such as Shrimp Club Indonesia (SCI) estimated only 400,000 to 450,000 tonnes. In 2020, the hectareage of shrimp farming and their contribution to total production was 9,055ha of intensive ponds (32%); 43,643ha of semi-intensive ponds (51%) and 247,803ha of traditional ponds (17%). The latter produces 200-300kg/ha. "Together there is a collaborative effort among stakeholders and NGOs to increase production and productivity. The government targets USD4.3 billion by 2025 from shrimp exports. One way is to revitalise and increase productivity of traditional farms."

In terms of challenges at the farm level, Sudari said, "Just like other shrimp producing countries, disease remains the main challenge, affecting production in Sumatra, Jawa, Sulawesi and Nusa Tenggara. AHPND is currently a main concern. The Indonesian government is tackling productivity with initiatives such as shrimp cluster, shrimp estate, millennial shrimp projects and infrastructure improvements. While farmers are challenged by high cost of feeds, energy, availability of disease free broodstock and post larvae quality and price, shrimp prices dropped by 10-20% in 2022.

Additionally, the SMART-Fish 2 of GQSP provides support for; for quality improvement, SOP for semi-intensive shrimp farming, the traditional plus program; certification and standardisation such as with IndoGAP, aquaculture improvements programs and shrimp branding.

In markets, perspectives of buyers on Indonesian farmed shrimp showed a need for improvement. "Swiss Contact's overall score for Indonesian shrimp was 4/5. While scoring above 4 for quality, size continuity and supply, our score was low for shrimp prices and sustainability.

Growth in China

In his overview on what is happening in China, Dr Cui He, China Aquatic Products Processing and Marketing Alliance (CAPPMA), said that in inland areas, vannamei shrimp accounted for 14% of the total of 3.2 million tonnes of freshwater prawn, crayfish etc. Production was more than in 2019 and was attributed to expansion of farming areas in the northern provinces and more industrialised farming in the southern provinces. In many places, there is controlled production in indoor systems where yields are 5-12kg/m² and in 'high-efficiency' engineered ponds, the production is 22.5-37.5 tonnes/ha.

In a comparison of shrimp farming costs, He listed the advantages of the industry in China against those in Ecuador, India, Vietnam, Thailand and Mexico. China's strength is in shrimp breeding, feeds, cost of electricity where the cost ratio is 8%, 60% and 6% only. Weaknesses are with poor disease control and high pond rental and labour costs.

In terms of the shrimp trade, 6 years ago, China became a net importer of shrimp. In 2019, imports exceeded 810,000 tonnes, mainly processed frozen products. However, with the pandemic over the past 2 years and into 2022, imports have dropped significantly to 690,000 tonnes in 2021. Frozen shrimp came mainly from Ecuador and India (Figure 2). Some 56% of imports went to wholesale and 30% to retail.

Up to today, China is facing adjustments on shrimp imports as it returns to normality amidst lockdowns, testing for the coronavirus, freight disruptions and port detentions. He summarised the future pattern in shrimp consumption in China. "Growth will continue but there will be more household consumption, moving from fresh to frozen. We see shrimp as a good option, easy to cook for home cooking during the pandemic. The traditional distribution platform has changed to ecommerce."

Processing and marketing

"Out of the 773 seafood processors in Indonesia, 100 process shrimp. In 2021, only 385,000 tonnes of raw material were processed using only 60-70% of the installed capacity of 500,000 tonnes/year," said Sudari. "Processors have issues with quality, quantity and price of raw material as they depend on middlemen. Often there is the question of profit margins when raw material costs are high such as the ex-farm price of USD3.9-4.0/kg for size 50/kg.

Hang said that in 2021, strict regulations pertaining to Covid-19 affected processors in the Mekong Delta and stagnated exports. Growth in frozen shrimp exports was in the US and EU markets. Strict inspection of imports curtailed exports into China. Exports improved in 3Q 2021 and in 2022 exports have returned to levels before the pandemic.

Exports

In 2021, Ecuador was the leading shrimp exporter. With 843,470 tonnes of shrimp, it increased exports by 24.4% more than in 2020 and most went to the US. In the 2020/2021 financial year (April 2020-March 2021) India exported 492,271 tonnes of the vannamei shrimp (Mpeda, 2022). Hang said that Vietnam's exports in 2021 were vannamei and black tiger shrimp. Exports of frozen shrimp products totalled USD3 billion.

In the first 4 months of 2022, Vietnam's shrimp exports rose by 45% as compared to the same period in 2021. The US, Japan, Korea and China, account for 58% of total shrimp exports while exports to China increased by 114%. Hang said that the average price of Vietnam's shrimp exports in the first quarter of 2022 was up by 6% to USD9.06/kg as compared to the same period in 2021.

One of the biggest challenges for Indian producers is competing in global markets. Manoj said that as producers globally are increasing production and putting pressure on prices, it is time for India to develop a domestic market. He believes that half of its 1.3 billion population who are non-vegetarian can absorb some of its shrimp production. His initiative in 2019 was a “farmed-shrimp to plate” restaurant as well as retail delivery of fresh/frozen shrimp.

Indonesia exported 250,700 tonnes, valued at USD2.23 billion in 2021, mainly to the US (72%) and Japan (14%). There is a high dependence on the US market at 72% and Japan at 14%. Exports have been growing at a CAGR of 8.61% in quantity and in 2024 to 2025, Indonesia expects exports to grow to USD4.3 billion. Sudari commented on how Indonesia's shrimp price is uncompetitive (USD1 higher); exporters are heavily dependent on the US market and are unable to exploit the fast-moving Chinese market. Indonesia's exports to China only grew 7.3% over the past 5 years.

US and EU markets

According to FAO's Dr Audem Lem, Fisheries Division, during 2020-2021, the shrimp trade was less impacted by the pandemic compared to other commodities. While trade volumes were down in 2020, it rebounded in 2021 by 13% as compared to the 2019 levels. Strong demand from the US brought imports up by 26%.

Sophia Balod, Analyst at Kontali presented on some recent trends in the US shrimp market. There was a healthy demand for warm water shrimp in 2021. Up to April 2022, imports were 17% more as compared to the same period in 2021 and prices were highest at USD9.75/kg. On the supplier side, India and Indonesia are the leaders, but Ecuador is fast catching up at a 27% increase year-on-year.

In comparing trends for January to April 2022 against that for the previous year, India's volumes (96,000 tonnes) rose by 12% with relatively good prices; imports from Indonesia and Ecuador were 69,000 and 65,000 tonnes, respectively. She added that Vietnam also increased import volumes. Import prices were the lowest in 2021 but as Ecuadorian suppliers are offering more processed products, prices were USD1.48 higher year-on-year to USD7.87/kg in March.

Led by strong retail demand in the US, peeled frozen products dominated with 125,000 tonnes imported year to date. There was also a 16% growth year-on-year for value-added products. Balod said that in 2022, Indian exporters were met with strong competition in the US by Ecuador and Indonesia. Ecuador has the geographical advantage in terms of less shipping time to the US. The effect is low demand from the processing plants in India, reflected by

lower ex-farm prices in May. Ex-farm prices in Andhra Pradesh dropped for the larger size 30/kg in May. There was also early harvest to manage disease outbreaks.

Ecuador's shrimp exports to the US based on the whole shrimp equivalent (WSE) reflected how Ecuador is now specialising in more processed products (peeled, HLSO and HOSO) and all products showed increases in volumes since 2019. “Ecuador is successfully expanding and diversifying markets amid challenges in the Chinese shrimp markets.”

In her outlook for the US market, Balod said that the positive aspect is that shrimp is the number one species consumed in the US in 2020 at 2.3kg/capita. In the retail sector, online purchasing will remain strong. Total retail sales are up by 11% year-on-year. The food service sector is recovering well and in the short term, an increase in restaurant consumption into the summer holidays can be expected. However, with a surge of raw materials from Ecuador, India and Indonesia, lower prices are already apparent. A caveat is the global inflationary pressures and economic slowdown.

On EU markets, Willem van der Pijl, Shrimp Insights said that with the Covid-19 pandemic, imports of warm water shrimp increased in 2020 and 2021. Out of the total imports of farmed shrimp at 460,000 tonnes in 2021, penaeid shrimp was around 300,000 tonnes. In terms of suppliers in 2021, Ecuador led with almost 48% of imports, followed by India and Vietnam, each at around 10% and Venezuela at 9%. Bangladesh mainly supplied monodon shrimp. Van der Pijl noted the overall position of Venezuela in Europe. Although imports were more in southern Europe, market growth was more in north western Europe with imports of mainly peeled and HLSO, at 23% versus 13% in southern Europe where HOSO products dominate.

He addressed the shift of South American products in north-western Europe which could be temporary or long term. Extremely low-price levels in South America, compared to Asian shrimp were due to the difficulties to enter the Chinese market coupled by the logistical challenges for sourcing shrimp from Asia. However, South American players have much larger production scale with higher efficiency than their Asian counterparts, Understandably, they will need to penetrate markets to support investments.

“Perception is very important,” said van der Pijl. “This is less tangible, but buyers have stated that there is less risk in buying South American shrimp. The quality of the shrimp is better, and even the shrimp is more sustainable.” His message to Asian producers was, “To remain competitive in the EU market, they need to focus on efficiency on one hand and improving perception on the other. The right combination of product specifications can make or break a competitive position in the EU market.”

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Nursery diet for freshwater fish: A concentrate of technology

By Frédéric Baron and Delphine Weissman

Enhanced production of high quality and healthy fry is the key target for a successful and competitive expansion of the aquaculture industry (Valente et al., 2013). During larval and nursery stages, the growth potential of freshwater species like tilapia, African catfish and Pangasius is exponential and needs to be fully supported.

The primary nutrients source for farmed fish is in formulated complete feed. Consequently, technology and know-how are mandatory to provide feeds adapted to each species at each stage. Nursery feeds are crucial for this sensitive period. Therefore, they must be precisely designed with the correct nutritional requirements.

These feeds need to be designed to comply with physical pellet quality, feed intake and nutritional efficiency. Precise technology with specific formulation is necessary for the starting phase feeds.

Precise nutrition and adapted formula

DP/DE ratio

Understanding the raw materials characterisation and nutritional requirements of the fish for development are crucial to formulate feeds using digestible nutrients. Dietary protein digestibility is important to determine how efficiently the ingested proteins can be utilised by fish fry. ADM's R&D facilities in Vietnam conducted trials and compiled them in a meta-analysis that clearly shows the effects of digestible protein intake on young tilapia growth (Figure 1). The right ratio of digestible protein/digestible energy (DP/DE) in the diet formulation optimises growth and avoids massive nitrogenous discharges that may pollute the aquatic environment (Figure 2).

Lipids

Freshwater fish species possess the ability to desaturate and elongate the C18 essential fatty acids chain to a longer unsaturated fatty acid chain (HUFA). Hence,

they do not have the same nutritional dependence on HUFA (omega-3) compared to marine species (Kolkovski et al., 2009). Nevertheless, during nursery phase, cell multiplication is constantly occurring and phospholipids are crucial to complete the lipidic profile of nursery diet. Phospholipids are structural constituents of biomembranes and are in high demand during the nursery phase due to their importance to fish development.

Minerals, vitamins and functional additives

Ensuring an adequate dietary supply of macro- and micro-minerals for farmed fish is essential for proper somatic and skeletal growth, health and final flesh quality. In addition to morphological changes and exponential growth, young fish are exposed to numerous stressors such as handling, grading, vaccination, transferring between different culture systems or farms, mixing of populations, density and water quality variations, multiple pathogenic pressure, etc. At the same time, it is a period when both the immune and digestive systems are still immature. Therefore, young fish need high quality feeds with the correct quantity of specific minerals and vitamins. Key functional additives for strategic objectives should be included in the diet to better support fish during this critical stage and beyond.

Digestive enzyme activity

In farming, feed efficiency for maximal growth in animals depends on nutrition profile, ability to consume, digest, absorb and metabolise nutrients from feed (Umalatha et al., 2016). Nutrient utilisation in aquatic animals depends on digestive enzyme activity, which changes during fish growth (Kolkovski, 2001). Since each age group has different digestive enzyme activity, fish also has different nutritional requirements during growth. Therefore, it is necessary to develop feed formulation that is suitable for different sizes of fish.

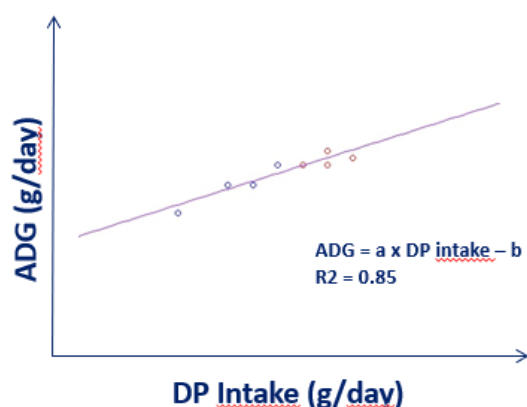


Figure 1. Young tilapia daily growth vs digestible protein (DP) intake

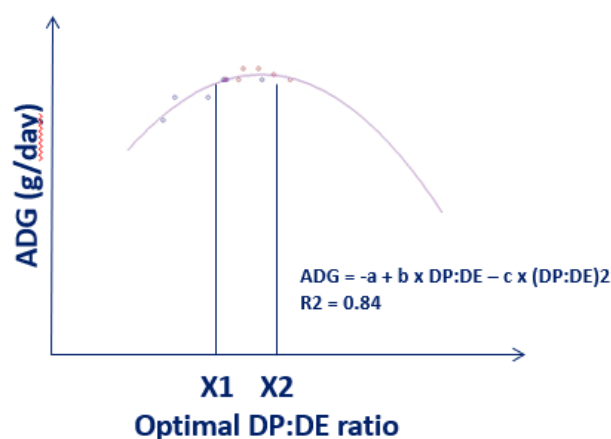


Figure 2. Young tilapia daily growth vs digestible protein/digestible energy (DP/DE) ratio. Source: ADM internal R&D data

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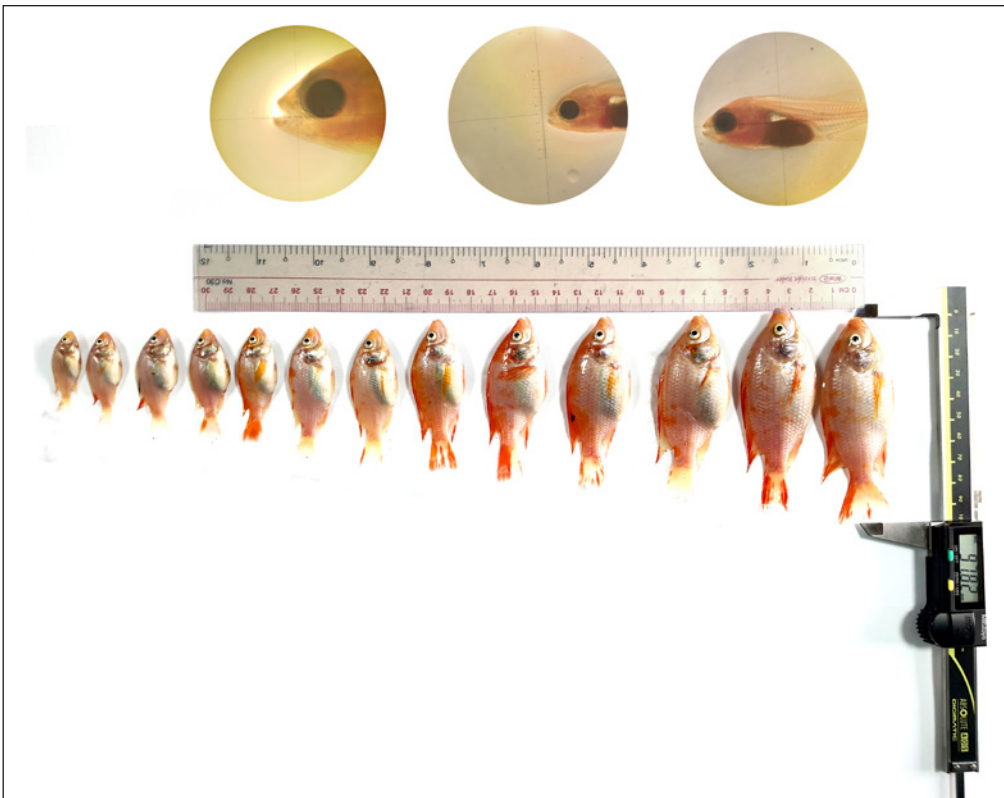


Figure 3. Mouth size of red tilapia fingerlings. Source: Technical team, ADM Asia

Feed intake stimulation

Fish fry grow extremely rapidly and are required to be fed many times a day. Therefore, quality of raw materials is crucial to provide attractability and essential nutrients needed for the fry. Additionally, attractability and feed intake can be increased by potent stimulants, such as free amino acids or small peptides. These attractants can increase feed intake during the search for food, detection and recognition.



Figure 4. Nursery extruded pellets from 0.5 – 1.0 – 1.5 – 2.0 mm size under microscope X20 times. Source: Technical team, ADM Asia



Figure 5. Advanced technologies produce quality nursery feeds.

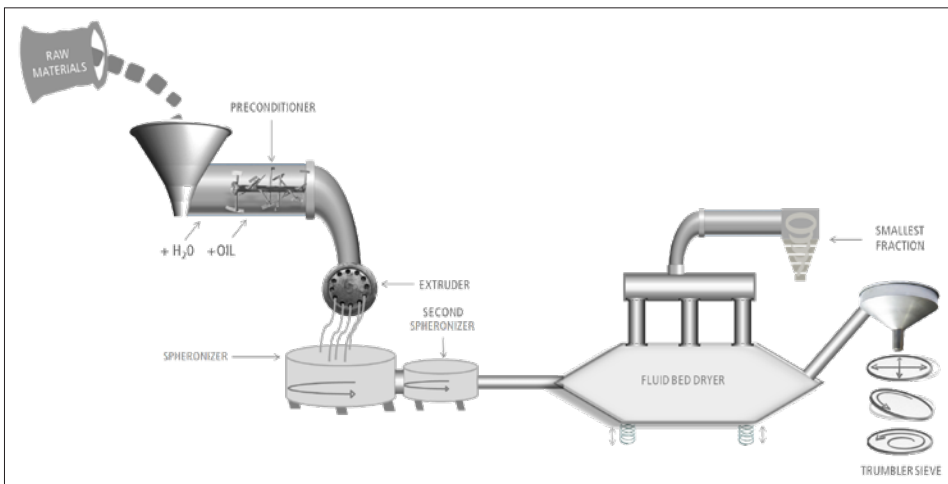


Figure 6. Demonstration of micro-extrusion technology.

A unique nursery feed manufacturing technology

Pellets need to be sufficiently stable to prevent the particles disintegrating in water. A good stability maintains a good retention of water soluble micronutrients and minimises water pollution. Pellets should also be accessible to fingerlings and have an appropriate diameter and shape (Hamre et al., 2013). Micro-pelleted feeds fit completely with these properties, preventing excessive nutrient leaching, achieving good digestibility and particle homogeneity.

ADM uses two technologies to produce the nursery feed range. We apply the marumerisation technology (for 0.2, 0.3 and 0.5mm pellet sizes) and micro-extrusion (for 0.6, 1.0, 1.5, 2mm pellet sizes). Marumerisation technology includes cold extrusion and spheronisation processes. The cold temperature process prevents proteins from being denatured, hence improving digestibility and growth performance. Spheronisation creates evenly rounded feed pellets and improves water stability of the particles (less leaching). The micro-extrusion technology produces floating feeds that are well-adapted to the fingerlings' behaviour and farmer demands.

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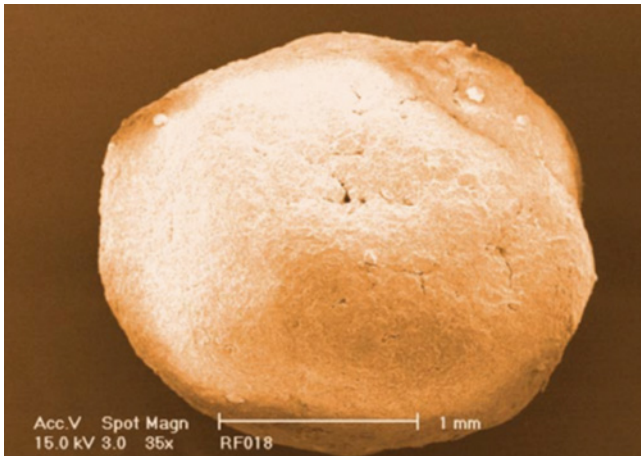
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Microscope view of a premium nursery feed particle (Weal Prime)

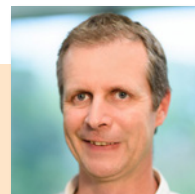
The nursery phase is the critical period to invest in using formulated. Indeed, right feed selection during this stage will support the fish performance throughout its life cycle by coping better with external stress and potential pathogens. Investment in quality feed during this short but critical period should be carefully considered by farmers because it can greatly contribute to the farm's economic success.

ADM's Nanolis nursery feed range for freshwater fish contributes to healthy fingerlings and economic success. ADM's expertise across multiple disciplines, including nutrition, R&D and manufacturing as well as field experiences in all aquaculture production systems, allows us to implement a holistic approach to support all aquaculture stakeholders. By focusing on the fingerlings' health through a nutritional perspective, farmers can positively impact the performance of their fish in subsequent life stages.

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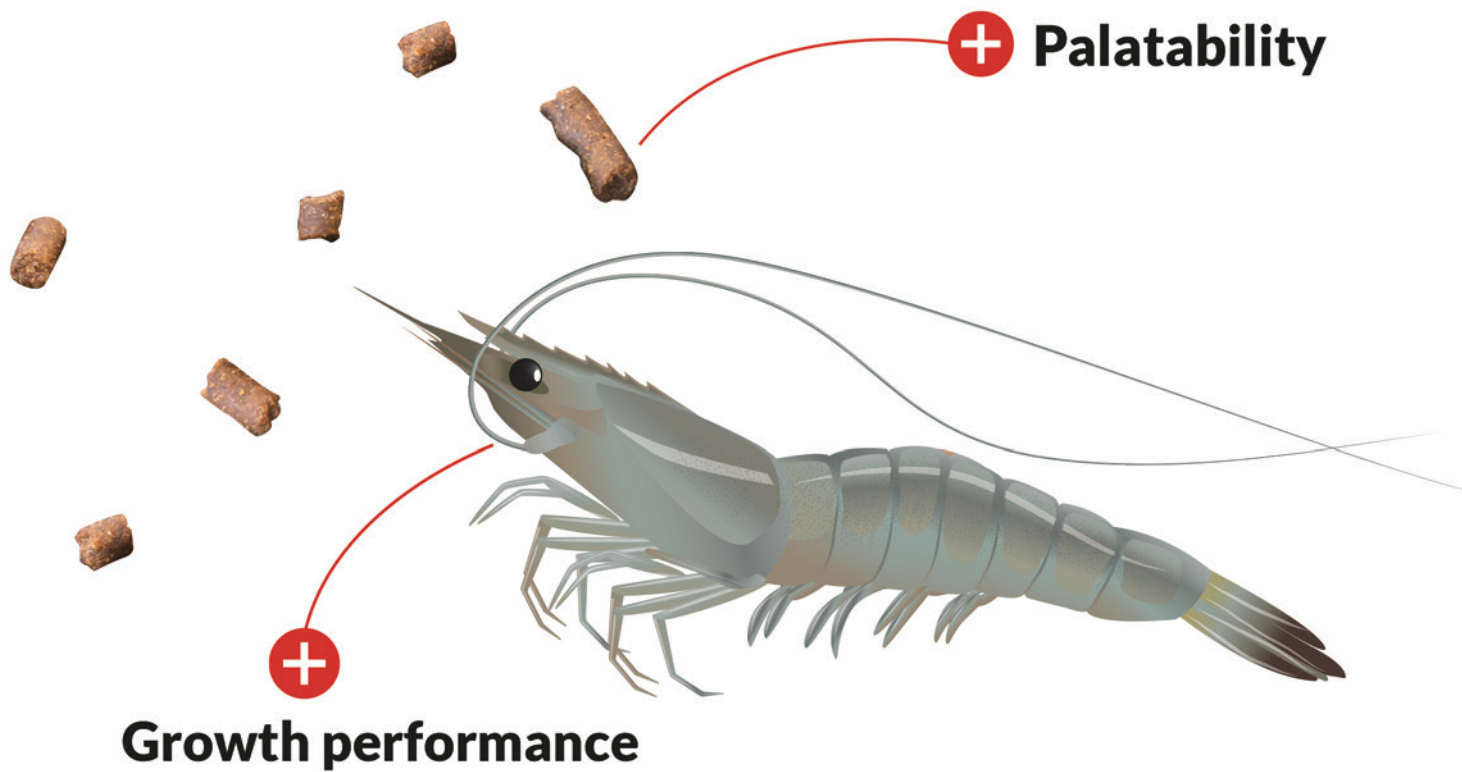
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A mix of free amino acids enhances growth, digestive enzyme activities, fillet composition, antioxidant and immune responses of juvenile Nile tilapia

The dietary supplementation in feeds showed better growth parameters and biomass as well as feed conversion ratio reduction demonstrating how the mix acts as a sustainable and efficient feed ingredient

By Pierrick Kersanté, Eakapol Wangkahart and Guillaume Le Reste

Free amino acids are efficient key nutrients which can improve aquatic species farming performances. More than 60 studies were recently conducted by BCF Life Sciences (France) in partnership with research centres, universities and farms. Most of them underline positive effects of Kera-Stim®50, a natural mix of free amino acids (MFAA) on zootechnical parameters for shrimp (Le Reste et al., 2019).

Complementary works conducted in partnership with Concepto Azul-Incabiotech, Peru, underline positive effects of this MFAA on survival under bacteriological and viral challenges for shrimp (Kersanté et al., 2021). In addition, numerous applications in shrimp farms underline positive effects of this MFAA supplementation on feed not only during normal conditions but also in the case of outbreaks of white faeces, a reduced impact of this syndrome and a faster recovery.

With these positive observations and to better identify MFAA effects on antioxidant and immune responses for fish, we conducted a trial in partnership with Mahasarakham University, Thailand. Here, 450 healthy tilapia juveniles were randomly allocated to cages, at 30 fish per cage and three replicates per treatment. Animals were fed a control and four treatment diets; (control+0.25% (MFAA0.25), control+0.50% (MFAA0.50), control+0.75% (MFAA0.75) and control+1.00% (MFAA1.00) for 8 weeks with application of the MFAA into the pellet mix.

MFAA supplementation of the feed significantly influenced zootechnical performances, with increase of growth parameters, biomass and feed conversion ratio (FCR) reduction. In regard to these parameters, we noted positive

effects on the digestive enzyme activities. Amylase, protease and lipase in fish intestine were significantly increased with the use of MFAA. Antioxidative status of fish was measured by determination of non-specific immune enzymes in fish serum: superoxide dismutase (SOD), glutathione peroxidase (GPx) and glutathione reductase (GRD).

Results show significantly higher activity levels. We also observed significant improvements of innate immune response of fish serum such as lysozyme (LZM), myeloperoxidase (MPO) and catalase (CAT) activities. It is noteworthy that, in correlation with growth performances, MFAA supplementation on feed generates significant higher levels of the digestive, antioxidative and innate immune response enzymatic activities of Nile tilapia. We recently published these research results in the journal *Aquaculture* (Wangkahart et al., 2022).

Animal husbandry and feeding protocol

The 450 healthy tilapia juveniles (*Oreochromis niloticus*), $4.76 \pm 0.05\text{g}$ initial weight (IW) were purchased from Mahasarakham province, Thailand. The fish were acclimatised to laboratory conditions in circular fibreglass tanks for 2 weeks, in the aquarium of the Division of Fisheries, Mahasarakham University. During this period, fish were fed with a commercial diet containing 32% crude protein and 4% fat (Charoen Pokphand Foods, Thailand). After acclimatisation, fish were allocated to 15 floating cages (2x1.5x1.5m) in five triplicate groups at a stocking density of 30 fish per cage, in an open circulatory freshwater system.

In order to meet or exceed the nutritional requirements of tilapia established by the National Research Council (2011), we formulated five isonitrogenous (32% crude protein) and isolipidic (4.2% crude lipid) diets, supplemented with MFAA.

Four different concentrations of Kera-Stim®50 were tested: 2.5g/kg of feed (0.25%), 5g/kg of feed (0.50%), 7.5g/kg of feed (0.75%) and 10g/kg of feed (1.00%). The MFAA was included into the pellet mix, before pelletising.

Fish were fed twice a day (8am and 4pm). A daily feeding rate of 5% of the biomass was applied which was adjusted every 2 weeks, according to fish growth performance. The experiment was conducted over 8 weeks. Fish handling and experimental protocols were approved by the ethics committee of Mahasarakham University (IACUC-MSU-29/2021).

Evaluated parameters

Zotechnical parameters, feed utilisation and body condition indices

We measured the growth parameters including final weight (FW, g), weight gain (WG, g); specific growth rate (SGR, % per day) and feed conversion ratio (FCR). Additionally, we calculated body indices: protein efficiency ratio (PER; %) = $100 \times (\text{total final body weight} - \text{total initial body weight}) / (\text{dry feed intake} \times \text{protein content in the feed})$ and viscerosomatic index (VSI; %) = $100 \times \text{visceral wet weight} / \text{body wet weight}$.

Digestive enzyme activities

Amylase activity was measured according to Nater et al. (2006). Proteinase activity was determined using the azocasein hydrolysis assay according to the method of Iversen and Jørgensen (1995). Lipase activity was determined through the Pencreac'h and Baratti (1996) method.

Antioxidant enzymes activity

The activity of antioxidant enzymes (including SOD, GRD and GPx) was analysed spectrophotometrically at 420nm according to the method of Weydert and Cullen (2010).

Innate immune response parameters

Serum LZM activity was evaluated by measuring the decrease in turbidity after lysis of the gram-positive bacterium *Micrococcus lysodeikticus*, according to Ellis (1990). Serum MPO concentration was measured according to Sahoo et al. (2005). CAT activity, an antioxidant enzyme, was examined spectrophotometrically at 420nm according to the method of Weydert and Cullen (2010).

Analysis of fillet colour

At the end of the experiment, nine fish (3 fish/tank x 3 tanks/group) were collected from each group. These fish were filleted (butterfly cuts). Fillet colour was measured with a CR400 chromameter (Minolta, Japan) to determine the redness index or a^* (red-green intensity), yellowness index or b^* (yellow-blue intensity), and lightness index or L^* (dark to light).

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Analysis of fillet composition

Fish muscle samples were also used for measurement of fatty acid composition (Horwitz, 1977; Chen et al., 2016) using gas chromatography mass spectrometry (GC-MS). Triplicate analyses were performed for each sample.

Data were submitted to ANOVA and in case of significance ($P \leq 0.05$) a Duncan test was performed. Statistical analyses were made with the SPSS software.

Growth improvements with MFAA supplementation

Our data showed interesting improvements of growth parameters with MFAA supplementation. A dose effect could be seen with best performances achieved for animals fed with MFAA1.00 treatment, generating significant gains on biomass evolution with final weight improving by 28.9%, weight gain by 31.5%, specific growth rate by 8.9% and FCR reduction of 24% after 8 weeks ($P < 0.05$) as shown in Figure 1.

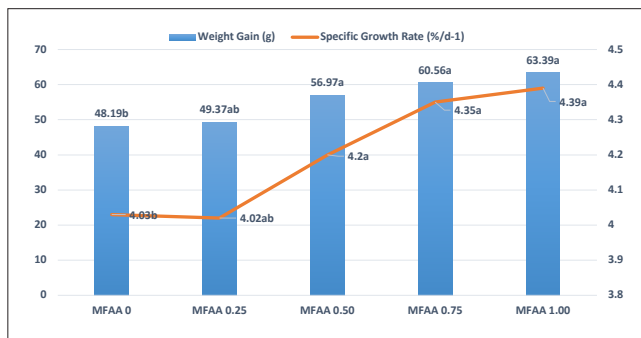


Figure 1. Weight Gain and Specific Growth Rate of Nile tilapia fed the control and MFAA (Kera-Stim®50) treatment diets after 8 weeks. Different letters indicate significant differences among treatments at $P < 0.05$.

Growth performances were also correlated with modifications in body composition indices and feed utilisation. These parameters clearly underlined better performances for all MFAA treatments ($P < 0.05$), with significant gains on PER, carcass yield and a reduction of the VSI. Regarding these parameters, all MFAA treatments induced some significant improvements and we observed a dose effect with PER improved by 29.2%, carcass yield by 9.3% and 19.5% reduction of the VSI for MFAA1.00 ($P < 0.05$).

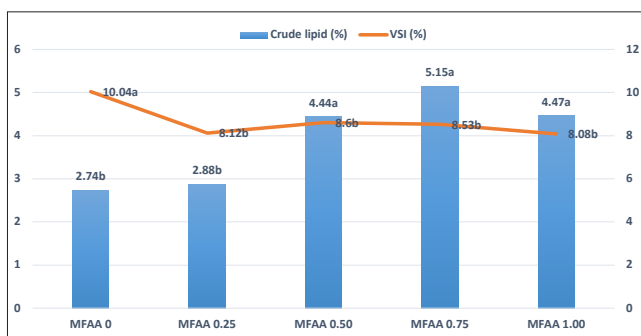


Figure 2. Crude lipid fillet composition and viscerosomatic index (VSI) of Nile tilapia fed the control and MFAA (Kera-Stim®50) treatment diets after 8 weeks. Different letters indicate significant differences among treatments at $P < 0.05$.

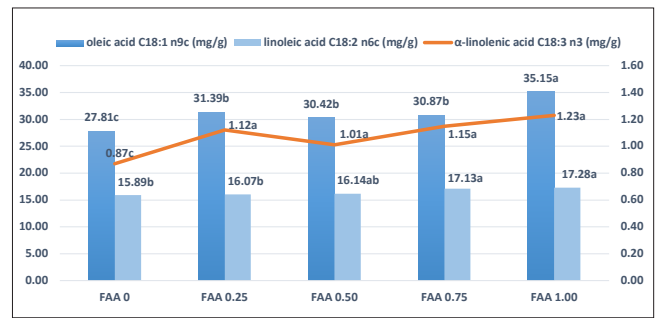


Figure 3. Unsaturated fatty acid composition (mg/g) of Nile tilapia fed the control and MFAA (Kera-Stim®50) treatment diets after 8 weeks. Different letters indicate significant differences among treatments at $P < 0.05$.

Fillet composition analysis underlined significant influence of MFAA on the fillet lipid content (+88% with MFAA0.75) as shown in Figure 3. Thirty-seven different fatty acids were examined in the muscle tissues of fish following the different diet treatments. Most of the analysed individual monounsaturated fatty acids (MUFA) such as palmitoleic acid (C16:1), oleic acid (C18:1n-9c) and erucic acid (C22:1n-9), as well as the total amount of MUFA, were found to be higher in the muscle from fish fed any MFAA diet compared to the control group ($P < 0.05$). Interestingly, linoleic acid (C18:2n-6c) and α-linolenic acid (C18:3n-3) levels were higher in the fish fed MFAA0.75 and MFAA1.00 diets ($P < 0.05$).

The fillet colour measured on the ventral and dorsal regions was also significantly influenced with higher L value, which was related to the lightness and white colour of the fillet. The L values of the fillet from the ventral and dorsal regions, in relation with the whiteness of the fillet meat, were significantly improved by +13.7% and 7.2% respectively, with diet MFAA0.75 ($P < 0.05$), probably in relation with the higher fat content in the fillet composition as seen in Figure 4 and Figure 5. Regarding the fillet colour, there was no difference in the b value (yellowness) probably due to a non-oxidised status of the fat.



Preparing the experimental feed.

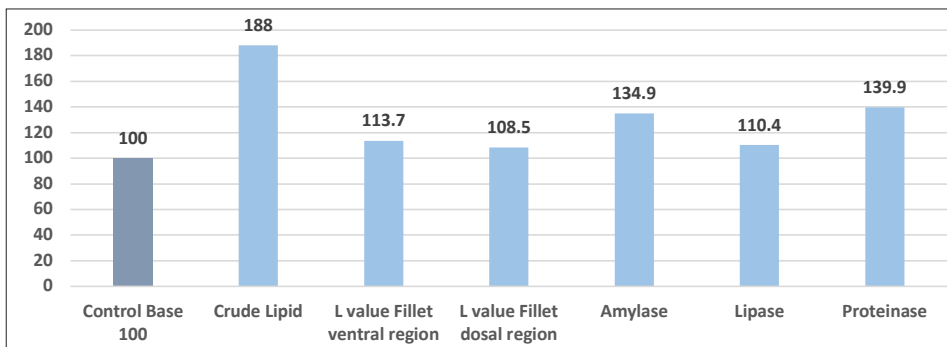


Figure 4. Improvements in lipid composition, lipid fillet composition, fillet colour and digestive enzyme activities with MFAA0.75 (Kera-Stim®50 at 7.5g/kg of feed) addition in comparison with negative control base 100 for Nile tilapia.

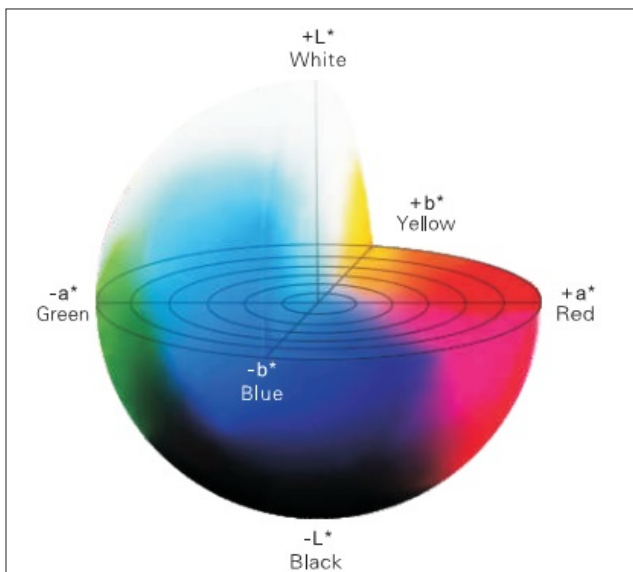


Figure 5. Fillet colour was measured to determine the redness index or a^* (red-green intensity), yellowness index or b^* (yellow-blue intensity), and lightness index or L^* (dark to light).

Digestive enzyme activities (amylase, lipase and proteinase) were significantly increased with MFAA0.75 and MFAA1.00 treatments, respectively from 34.9%, 10.4% and +39.9%, in comparison with the negative control ($P < 0.05$). We can hypothesise that all these parameters are directly in relation with a better utilisation of the feed and assimilation of the energy by animals. Additionally, carcass yield improvement is directly linked to the lower fat deposition around the viscera and the higher fat deposition in the fillet.

Conclusion

This study underlined some particularly interesting effects of MFAA when supplemented in Nile tilapia feed, with regards to growth parameters with positive effects on biomass and feed utilisation. Strong improvements of VSI, fillet composition and fillet colour were seen. We can hypothesise a relation between these observations and a better assimilation of the feed due to optimisation of the energy by the digestive system. In addition, we can hypothesise that the more pronounced white colour of the fillet is probably in relation with a reduction of fat oxidation.

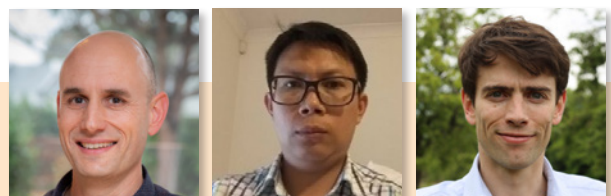
Interestingly, we noted a reduction of the VSI, potentially linked with a higher amylase activity generating a better utilisation of the polysaccharides. This parameter probably induced a lower fat deposition around the viscera and a higher lipid transfer to the fillet. The

results also revealed higher contents of important fatty acids such as oleic acid (C18:1n-9c), linoleic acid (C18:2n-6c) and α -linolenic acid (C18:3n-3) in fish fed with MFAA. The strong effects of Kera-Stim50 on digestive enzymatic parameters with positive impact on body condition indices and fillet quality open new development possibilities to improve fish feed utilisation and farming performances.

Mixes of free amino acids obtained from poultry keratin extensive hydrolysis appear as a sustainable and efficient feed ingredient to improve fish farming performances.

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Shrimp feed management in outdoor ponds for *Litopenaeus vannamei*

Feed is the highest variable cost for shrimp production and feed management have a greater influence on harvest feed conversion ratio than feed quality

By Dean M Akiyama and Dany Yukasano



Uniform size and clean shrimp at harvest, Indonesia.

There is a general understanding that for successful shrimp production, emphasis must be placed on dedicated farm management (at 50-60%), post larvae quality and handling (at 20-25%) and consistent feed quality (at 20-25%). Additionally, key to shrimp farming is the motivation and dedication of farm staff where it is critical that all staff are implementing and completing assignments correctly and without delay when required.

Feed management accounts for 65-75% of the variation in feed conversion ratios (FCRs) at harvests. This is because the amount fed at each feeding, number of feedings per day, distribution of the feed in the pond and feed quantity adjustments have greater influence on the harvest FCR than on feed quality alone.

A standard growth curve for each shrimp production site needs to be developed, adjusted as needed and maintained for proper pond and feed management. Individual pond daily growth rates should be monitored and compared to the standard growth curve. If the growth rates are within $\pm 10\%$ of the standard, the pond conditions and feed management are acceptable. If the growth rate is below the standard curve, the farmer needs to check whether the water quality, pond bottom and/or animal health are at acceptable levels. If these are good, then increase the feeding rate. If the growth curve is above the standard curve, pond conditions are good but maybe survival rate is lower than expected. Consider lowering the feeding rate to maintain acceptable FCR.

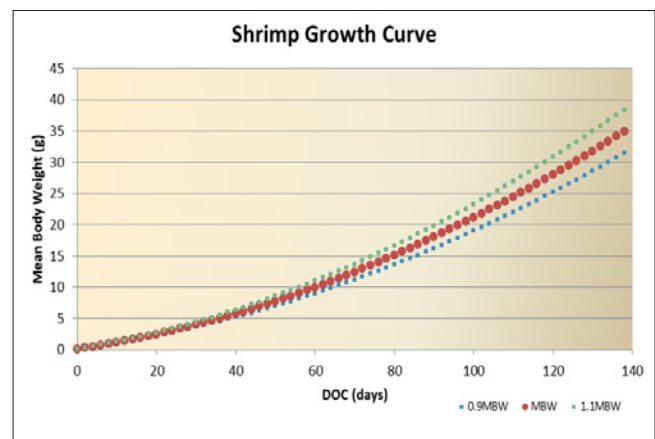


Figure 1. A standard growth curve for each shrimp production site needs to be developed, adjusted as needed and maintained for proper pond and feed management. DOC=days of culture.

Variable costs in production

Feed cost is the highest variable cost for shrimp production. The feed cost will range from 50-60% of the total production cost. The percentage of total cost will vary by country or region because of the pricing variations for manpower, electricity, post larvae and supplies. However, proper shrimp feed management will ensure that total feed cost is acceptable with more consistent production costs which increases the feasibility of shrimp production.

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Proper feed management will also improve the water quality stability and lower pond bottom deterioration. There will be less feed wastes which directly affect water quality and pond bottom cleanliness.

Recommended shrimp feed sizes

Current small diameter shrimp feeds are a function of market or market demand rather than technical shrimp requirement. Shrimp do not swallow feed pellets when feeding. Shrimp will cut and crush feed with their mandibles located before their mouth and these particles are then eaten. Thus, pellet size is of minor importance. However, smaller pellets will have a greater number of pellets/kg feed which is an advantage. Attractants and water-soluble vitamins and minerals will leach faster from the smaller-sized feed. Smaller feed particles are also more easily lost in the pond sediments (Table 1).

ABW (g)	% Biomass	Frequency	Feed type/ pellet diameter (mm)	Length (mm)
PL10-1.0	blind	2-3	crumble	0.4-0.8
1.0-2.5	blind	3	crumble	0.8-1.4
2.5-8	17-20	4	1.5	1.5-2.5
8-18	5-7	4	1.8	2.0-3.0
18-25	4-5	4	2	2.0-3.5
>25	3-4	4	2.2	2.0-4.0

Table 1. Some general recommended pellet type and sizes in shrimp farming in relation to average body weight (ABW)

Feeding time and amount

There should be a minimum quantity of feed allocated for any feeding time by area of pond and not necessarily by feeding rate based on biomass of shrimp less than 4.0g (Table 2). A blind feeding rate table is recommended until shrimp average about 3.5g and when shrimp start to appear on the feeding trays (Refer to appendix I. Blind Feeding Program, 500,000 shrimp in 0.5ha pond (100/m²).

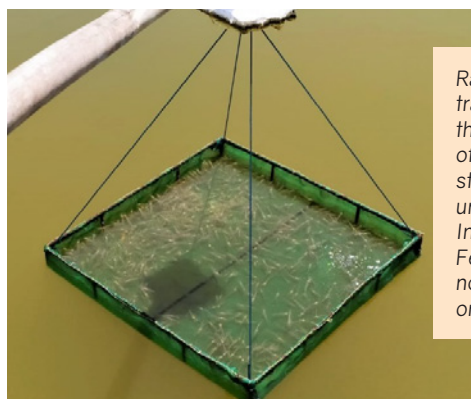
Monitoring daily feed consumption

There have been many systems developed for monitoring daily feed consumption. However, the most common and widely practised system is the use of feeding trays. The proper use of feeding trays is dependent on dedicated and experienced farm technicians. These technicians must interpret the data for feeding tray consumption, shrimp size, estimated biomass/survival rate, weather conditions and water quality at the feeding times.

Feeding trays are normally square or circular. The sides of the feeding tray should be 10cm high. This is important because when trays are raised slowly, the shrimp will remain in the feeding tray. You can observe the health condition of the shrimp as well as size uniformity. The feeding trays are weighted so they will sink evenly without the feed being flushed out from the trays.

Number of feedings per day	Time (hr)	(% of daily feed allocation)	Time (hr)	(% of daily feed allocation)	Time (hr)	(% of daily feed allocation)	Time (hr)	(% of daily feed allocation)
2	0900	50%	1500	50%				
3	0800	25%	1300	30%	1800	35%		
4	0700	10%	1100	25%	1500	30%	1900	35%

Table 2. Example of feed distribution depending on number of feed applications/day.



Raising feeding tray slowly allows the observation of shrimp health status and size uniformity, Indonesia. Feeding trays are normally square or circular.

Feeding trays are attached to the walkways on the side of the pond. The walkway should extend into the pond at a minimum of 2m from the pond dyke. The feeding trays should be placed 30-50cm from the pond bottom. Stable walkways should be built so the technician can easily work the feeding trays and observe the shrimp.

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Sturdy concrete walkway for feeding tray checking, Indonesia.

There should be a minimum of 4 trays/0.5ha pond with trays on each side of the pond. Larger ponds will require more feeding trays; 1ha: 6-8 trays and 2-3ha: 8-10 trays. To accurately calculate the feeding quantity per day, it is necessary to have accurate shrimp size (g, cast net sample) and accurate pond biomass (survival rate x stocking density x size but this is difficult to estimate accurately).

The actual stocking density may vary from 80% of bought numbers with poor transport and acclimation procedures to 120% with free post larvae given as top up to actual number bought. The estimated % survival rate calculated from a table is not reliable. The biomass estimate should be an average of the past 3 days running average of feed consumption to account for normal daily fluctuations. Good farm technicians can estimate biomass within 10% of actual total. This is critical to keep FCR low especially with low survival rates. Good farm technicians do not blindly follow feeding tables.

Feeding tray consumption levels

This is a tool for biomass and survival rate estimations with shrimp weight sampling using a cast net. The biomass estimate is also important at harvest, to determine the number of transport containers and ice required.

The technician will need the last 3 days average feed consumption, initial stocking density, ABW of shrimp and feeding table for the following calculations.

3-day average feed consumption (kg)/% feeding rate for shrimp size = kg biomass

kg biomass/shrimp ABW(g) = number of shrimp population

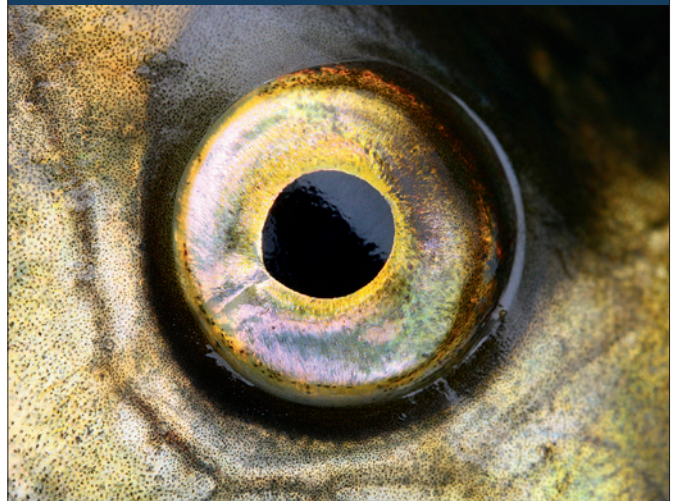
Number of shrimp/stocking density = Survival rate (%)

Example: ABW = 14g, 3-day average feed consumption = 65kg, stocking density = 200,000 shrimp, feeding rate for 14g shrimp = 2.7%; 65kg/0.027 = 2,407kg biomass; 2,407kg/14g = 146,214 shrimp; 146,214 shrimp/200,000 shrimp = 73.1%

Shrimp weight (g)	Feed type	Feed in feed tray (%)	Checking times (minutes)
3 – 5	pellet	0.8	120
5 – 8	pellet	1	120
8 – 10	pellet	1.25	90
10 – 13	pellet	1.5	90
13 – 15	pellet	2	60
> 15	pellet	2.2	60

Table 3. Feeding trays observation programs

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Good feed management requires checking actual feed consumption rates after every feeding or at least daily (Table 3). The amount of feed consumed can be compared to the previous day or days and adjustments can be made. Usually, feeding rate may be adjusted to an amount between +5% increase to -10% decrease. Attention should be given to lowering the feeding rate to maintain good water quality and low harvest FCRs.

However, if the shrimp growth rate is consistently below the established standard growth curve and acceptable water quality, consider increasing the feeding amount. Accurate daily feed consumption levels will also help to determine the standing biomass of shrimp.

Feed left in feeding tray	Score	Feed given
Empty	0	Increase 5%
< 10%	1	Same with previous
10 – 25%	2	Reduce feed 10%
25 – 50%	3	Reduce feed 20%
>50%	4	Reduce feed 40%

Table 4. Allocation of score and feeding adjustment programs based on feed left in feeding trays.

A minimum of 75% of trays (3 of 4 trays) should be scored for feed rate adjustment. For example, a score of 0000 or 0001, feeding rate will be increased by 5%. A score of 0011 or 1111 or 1122, the feeding rate will remain the same. A score of 1222 or 2222, the feeding rate will be reduced by 10% (Table 4).

DOC	Percent of total feed consumption	
30 days	20%	10%
60 days	35%	25%
90 days	45%	30%
120 days	-	35%

Table 5. Quantity of feed consumed per month over a 90-day cycle, 120-day cycle

Most of the feed is consumed during the last 2 months of the shrimp production cycle (Table 5). Proper feed management is more critical during these times. During the first 30 days, the percentage of feed being fed is small, thus the blind feed system is recommended.

Shrimp size (g)	Feeding rate of biomass (%)	Shrimp size (g)	Feeding rate of biomass (%)
4.0	4.4	18.0	2.3
5.0	4.2	19.0	2.3
6.0	4.0	20.0	2.2
7.0	3.8	21.0	2.2
8.0	3.6	22.0	2.1
9.0	3.4	23.0	2.1
10.0	3.2	24.0	2.0
11.0	3.0	25.0	2.0
12.0	2.9	26.0	1.9
13.0	2.8	27.0	1.9
14.0	2.7	28.0	1.8
15.0	2.6	29.0	1.8
16.0	2.5	30.0	1.8
17.0	2.4		

Table 6. Shrimp (*Litopenaeus vannamei*) feeding rate

Feed management concepts

Feeding tables are only “guidelines”. Under normal conditions, actual daily feed consumption will fluctuate between 5-20%. This is primarily due to fluctuating pond conditions, temperature, dissolved oxygen, pond bottom, animal health and other factors. Therefore, the farm can develop a detailed feeding table which may look good, but it is of little value if daily feed consumption is not measured accurately (Table 6).

More feeding times per day of smaller quantities is better for shrimp than less feeding times of larger quantities of feed. Shrimp will eat more feed if fed many times resulting in faster growth and lower FCRs. An additional benefit will be more stable water quality because the leaching and feed waste will be more even during the day. However, there should be a minimum of 5kg feed given at any one time regardless of the stocking density, thus, with 2 feedings per day, there should be a minimum of 10kg feed per day.


The feeding rate for lowest FCR and fastest growth varies by 10-15%. If a higher growth rate is desired, the farm can increase the daily feeding amount by 15%. But an increase in growth rate of 10% (20g to 22g) increases FCR of 0.2-0.3 points (FCR 1.5 to 1.7-1.8). The water quality also needs to be monitored more carefully as there will be 15% more feed added to the pond daily. To achieve the lowest FCR, it is recommended to feed slightly less than satiation. Shrimp may forage the pond bottom for food but if too much sediment is observed in the water column, then the farmer should increase the feeding rate (Table 7).


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Central sludge and waste area accumulation because of water circulation, Indonesia

Water and pond bottom quality critically affect shrimp growth rate, survival and FCR. Over feeding is the major cause of deteriorating pond conditions. If pond conditions are bad, the farm should exchange water and/or reduce feed quantity per day till pond conditions improve.

Low dissolved oxygen and low water temperatures directly reduce shrimp appetite and feed consumption levels. If these two water quality parameters are not optimal, shrimp appetite declines and the feeding rate should be reduced. If the levels are low in the morning, the feeding rate should be reduced too. As dissolved oxygen and temperature increase during the day, shrimp appetite will increase.

Shrimp are poikilotherms; they are cold blooded animals which are different from terrestrial warm-blooded animals. Their appetite and growth are regulated by external water temperatures. Lower water temperatures directly lower shrimp metabolism and growth. For every 1°C difference in temperature there is an 8-10% difference in growth; 30°C will have 15% faster growth than 28°C.

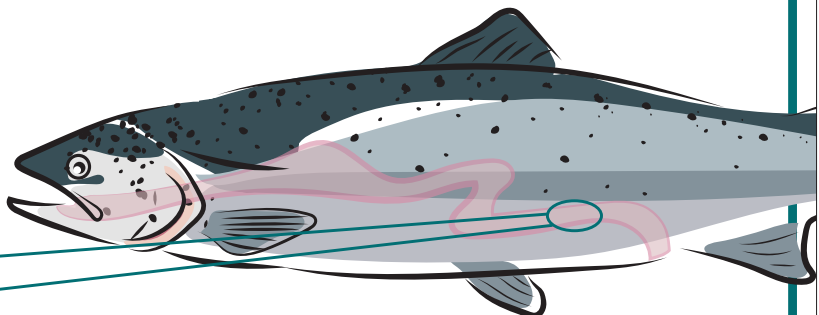
In the morning, shrimp will normally eat less feed than in the afternoon. Daily water temperatures will fluctuate during the day due to regional differences and weather: wind, rain, clouds. The water temperature fluctuation makes it difficult to estimate actual feed consumption at any feeding time.

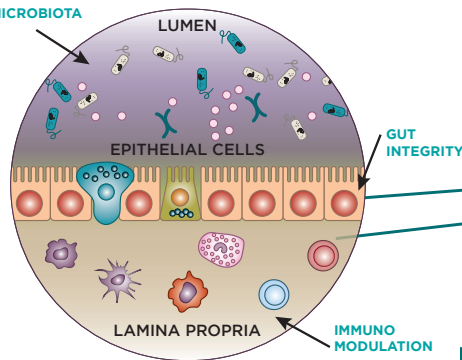


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Clean vannamei shrimp with a full gut an hour after feeding, Indonesia.

Currently, genetically improved shrimp are bred for maximum growth performance. The growth rate of shrimp is the primary physiological stress on the animal. The faster the shrimp growth rate, the greater the stress on the animal. Therefore, water quality parameters should be stable; good water quality results in less energy for animal maintenance. Important water quality parameters include dissolved oxygen, pH, salinity and transparency and among them, dissolved oxygen is most critical. Low dissolved oxygen levels reduce activity and metabolism. Shrimp stocks need a minimum and consistent dissolved oxygen level of 6.0ppm. At lower levels, shrimp may not die but are not growing at optimal levels.

Proper aeration levels should be used not only for maintaining dissolved oxygen levels but also for mixing the colder pond bottom water layer with the warmer top layer. In a deep pond of 1m depth without proper mixing of the water, the temperature difference between the top water and the bottom water layer can be 2°C. Higher dissolved oxygen and warmer water temperature at the pond bottom will improve animal performance.

With unpredictable weather conditions and fluctuating water quality conditions in outdoor production systems, there is no fixed daily nutrient requirement and intake for shrimp. Shrimp will eat more or less feed according to their physiological requirements at any one time. If no feed is available, shrimp will forage in the production environment for food. At times of shrimp stress due to water quality issues, it is recommended to reduce feeding by 50% or completely stop feeding for 2 to 4 days. Shrimp will forage for food and "clean" the pond bottom and reduce excessive algae.

When changing **feed sizes**, there should be 2 to 3 days interval where both feeds are mixed at a 50:50 ratio. This will make the transition from one size to another smoother and without loss of feed consumption. When feed size is abruptly changed, there may be a 2-3 days of lower feed consumption as the shrimp learn to adjust to the new feed. This is primarily because the attractant level and type may change slightly due to the formula and/or feed processing conditions.

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Shrimp are **nocturnal animals** and are more active at night. Shrimp are actively feeding at night and will normally consume 50-60% of feed at night. However, this feeding behaviour is made complicated by the lower water temperatures and lower dissolved oxygen levels which decline at night. dissolved oxygen levels will still be decreasing at sunrise and will start to increase only about 2 hours after sunrise.

Avoid feeding at the centre of the pond where sludge and wastes accumulate because of paddlewheel water circulation. This area will have toxic gasses such as hydrogen sulphide from decaying organic material. A layer of oxidised material will cover the sludge area and if this layer is disturbed, these toxic gasses will be released into the pond water.

Days of culture (DOC)	Survival rate (SR%)	Days of culture (DOC)	Survival rate (SR%)
30	90.0	75	81.0
35	89.0	80	80.0
40	88.0	85	79.0
45	87.0	90	78.0
50	86.0	95	77.0
55	85.0	100	76.0
60	84.0	105	74.5
65	83.0	110	73.0
70	82.0	115	71.5
		120	70.0

Table 7. Days of culture (DOC) with estimated survival rate (%) based on +/- 70% harvest survival.

Appendices to this article are available from this link (<https://bit.ly/3bpgFeA>)
<https://aquaasiapac.com/2022/06/23/appendices-for-shrimp-feed-management-in-outdoor-ponds-for-litopenaeus-vannamei-by-dean-m-akiyama-and-dany-yukasano/>
 Appendix I. Blind Feeding Program, 500,000 shrimp in 0.5ha pond (100/m²).
 Appendix II. Feeding Program for L vannamei, 500,000 shrimp in 0.5ha pond (100/m²). Harvest production of 20.0 tonnes/ha, 70% survival rate, final body weight 28.0 g, FCR of 1.45.



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Gut health is the key to optimising performance in aquaculture production

Ensuring efficient and sustainable aquatic production is not always an easy task. Aquaculture production is a result of farming a high diversity of species with very diverse feeding habits and cycles which hinder the use of a single solution.

By Marta Arredondo and José A. Oroz

Aquaculture production has been growing exponentially for years and the World Bank estimates that by 2030, 62% of fish produced worldwide will come from aquaculture. The intensification of aquaculture in the past forced industry to look for solutions to optimise culture conditions and increase survival. However, constant bacterial and parasitic outbreaks have been difficult to control. At that time, the use of antibiotics and chemical products was the only solution.

In the past and still currently in some countries, there is an excessive use of antibiotics to prevent and/or control infectious diseases caused by bacterial pathogens and also for growth promoting purposes. An enhanced public awareness of the potential harm to human health due to antibiotic residue bioaccumulation and antibiotic resistance has led to a global ban/reduction of antibiotic use in the aquatic/terrestrial animal production. Therefore, a worldwide effort is required to minimise and to finally remove the use of antibiotics completely as growth promoters. This led to the search of non-antibiotic compounds as an alternative to antibiotics.

The use of organic acids and its salts in aquafeeds is a current practice nowadays due to their benefits in the gastrointestinal tract. Most of the improved performance is due to their action on inhibition of pathogenic bacteria as well as supporting digestion and absorption of nutrients. This results in better fish and shrimp performance.

There are more than 20 different organic acids that are frequently used in animal nutrition. We can divide them into short chain fatty acids with less than 6 carbon atoms: medium chain fatty acids with 6 to 12 carbon atoms and long chain fatty acids with 12 to 21 carbon atoms. Short chain fatty acids are very popular due to their bactericidal and fungicidal effects since the small size and chemical structure of the acids allow for a better penetration and metabolic alteration inside the pathogens.

Initially, organic acids were used in aquaculture as bacterial inhibitors, but actually, depending on the organic acid used, it will have a completely different action in the fish cycle, depending on whether they are in their dissociated

or undissociated forms. Undissociated forms diffuse passively through the bacterial cell wall. Several studies using a mixture of organic acids in feed showed significant decrease in mortality rate when exposed to bacterial challenges. The combination of organic acids for aquafeed use is a current trend; however, we need to understand the functions of the different organic acids.

Organic acids in tilapia farming

In tilapia farming, one of the common ways to spread disease is through seedstock which are not pathogen free. Clinical signs are not evident at low level infections. The sex reversal process is the most critical phase during tilapia farming, as fingerlings are separated into different production units and the pathogens spread easily.

Formic acid is the most commonly used organic acid, as it has a strong acidification potential as well as bactericidal and fungicidal properties. Phosphoric acid is also well known in animal nutrition for its strong acidification action. Propionic acid is commonly used in feed preservatives to control and prevent moulds and yeast in feeds. Additionally, organic acids like butyric acid have also been promoted as bactericide.

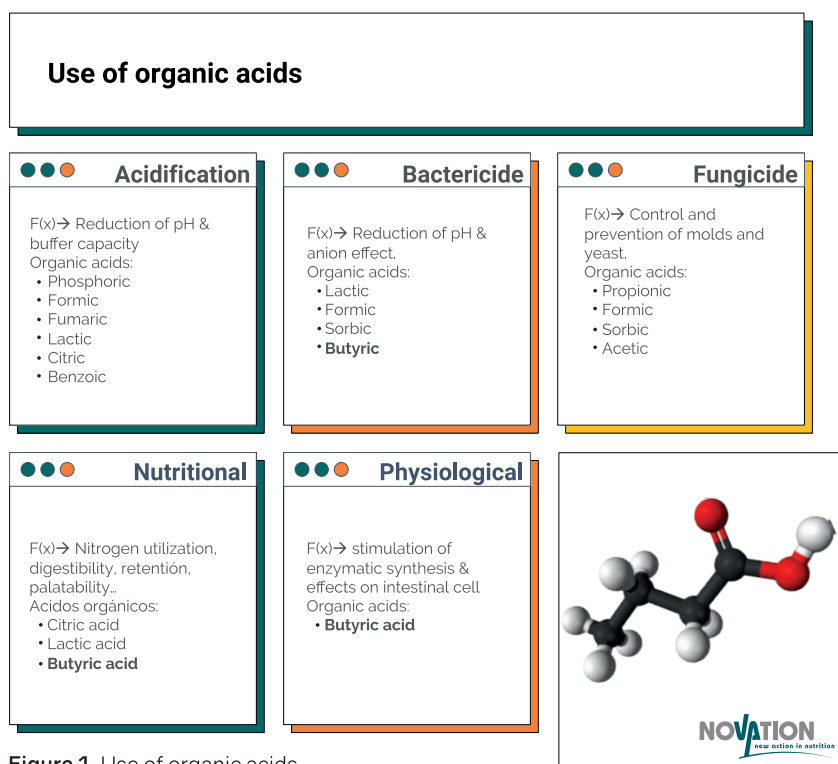


Figure 1. Use of organic acids

An interesting function of organic acid is its nutritional and physiological benefits. Organic acids such as citric and lactic acids, besides being able to reduce pH, they also play a role in nitrogen utilisation and increase digestibility, retention and palatability. All these properties make them a good candidate to be utilised in an organic mixture for its synergistic effects in animal nutrition.

However, only butyric acid combines the reduction of pH action (bactericide and digestive) with the nutritional and physiological benefits. Butyric acid is the main energy source of intestinal epithelial cells and plays a positive role in maintaining intestinal health, promoting growth and development of enterocytes cells for optimal nutrient absorption. This translates to an improved animal growth performance, immunity, and intestinal microbiota balance. This makes butyric acid the unbeatable organic acid, that can be added by itself in the feed or in combination with other organic acids or even plant extracts and essential oils.

There are two key points on the absorption process; one is the place of absorption, and the other is the mechanism of absorption. The place of absorption is more related with protection.

Protection is key

Different forms of butyric acid have been used in terrestrial animal feeds for a long time due to its positive effects on the gastrointestinal tract. Commonly sodium and calcium butyrate salts are used instead of butyric acid due to a higher stability and less intense odour. However additional protection is needed to ensure the molecule

is protected for stability during the extrusion process in aquafeed production and to be able to reach the absorption cells (enterocytes) where the butyric acid has its key functionality.

When using different butyric acid protected forms, it is also important to take into account the digestive system we are working with, for example butyrin (esters of butyric acid) are well known in terrestrial nutrition, but when considering the shrimp digestive tract, they are not as efficient, since shrimp digest feed very quickly and butyric acid molecules will not be as efficient.

Optimal absorption makes a difference

In the intestinal lumen, the butyric acid is in a chemical balance between the dissociated form and the non-dissociated forms (the non-dissociated forms can be the butyrate salts or the butyric acid). This equilibrium is affected by the pKa value of the butyric acid which is around 4.89. At this point the non-dissociated butyric acid (about 10%), can be absorbed by diffusion from the intestine to enterocytes. Simultaneously, the dissociated form, which is a negative ion and represents 90% of the total butyric acid, can be absorbed by three different mechanisms: passive diffusion from lumen to enterocytes, active transport with some specific proteins or by ion exchange like for example bicarbonate exchange. After the butyric acid is absorbed inside the enterocyte, it is incorporated into the energy metabolism of the enterocyte. This is the Krebs cycle, so this is the metabolic way of how butyric acid is responsible for the growth of epithelial cells (Figure 2)

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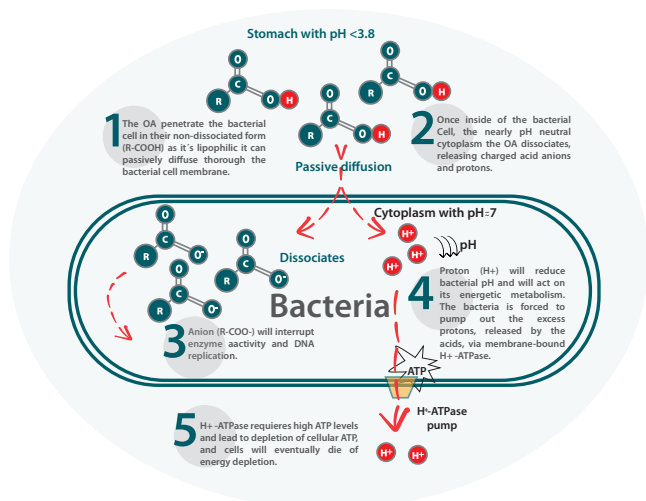


Figure 2. The chemical balance between the dissociated form and the non-dissociated forms of butyric acid in the lumen.

There is also a small fraction of the butyric acid that passes through the epithelial cell and has some other actions, for example, positive effects on the lymphocytes-T at the intestinal barrier as well as positive stimulation for pancreas enzymatic production, especially insulin production. The impact of butyric acid on other parts of the body has a positive effect on the animal health status, like immunity health, pancreas and liver functions and reproductive status.

The importance of butyric acid in aquaculture

Recent trials conducted in Brazil where a protected sodium butyrate Butirex-C4 and a non-protected sodium butyrate were supplemented in tilapia feeds, showed the importance of appropriate protection as well as the multiple benefits obtained in tilapia farming.

Final biomass results showed statistically significant differences between the control diets (not supplemented) and those supplemented with non-protected sodium butyrate diets. However, the highest final biomass was obtained with Butirex-C4 (5kg/tonne) with an average increase of 6.49g compared to the control diet (Figure 3).

The improved final biomass was also accompanied by an increase in survival (Figure 3). We can see an average increase in survival of +2.61% using diets containing the protected sodium butyrate compared to the control diets.

During this trial, we also observed as part of the improved general performance, a significant reduction in the feed conversion ratio (FCR) with supplementation of Butirex-C4 (Figure 4). Additionally, the yield (kg/m³) was evaluated and showed that diets supplemented at 5kg/tonne of the protected sodium butyrate increased yields too.

Following the evaluation of the general performance parameters, the different groups were put through a *Aeromonas hydrophila* challenge (Figure 5). Mortality was recorded until 288 hours post-challenge. Results showed a protection against the bacterial challenge of the tilapia groups fed the supplemented diets with the protected sodium butyrate.

Additional trials were conducted with rainbow trout, to understand the mode of action of the protected sodium butyrate (Butirex-C4) in fish gut health. Following the improved performance when supplementing aquafeeds in the same way as the tilapia trial, we observed the effect on protection of the first physical barrier.

A stronger barrier function has a direct effect on the animal health since it blocks the entry of bacteria, parasites and other pathogenic agents from crossing the intestinal barrier and provoking the so-called "leaky gut". Studies conducted with Butirex C4 in rainbow trout have also shown a higher gene expression of tight junctions (TJ). TJ proteins act as a lock or chain that joins the enterocytes making the gut barrier impenetrable and strong. We can reduce the bacterial translocation or bacteria penetration with butyric acid supplementation in aquafeeds by increasing the expression of TJ proteins.

Trials conducted with rainbow trout showed that supplementing aquafeeds with protected sodium butyrate helps villi growth and development. This translates to more absorption on the surface, resulting in an optimised nutrient uptake and improved digestibility (Figure 6).

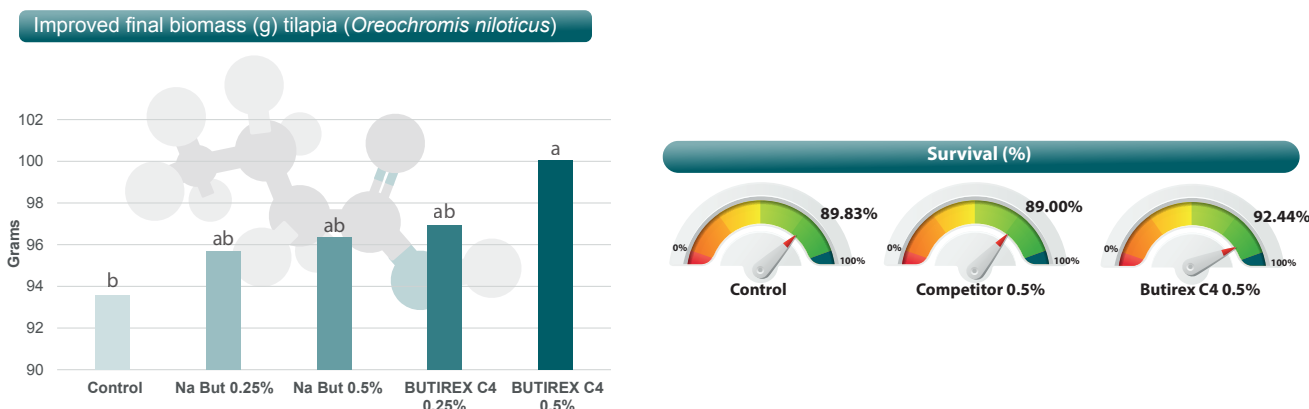


Figure 3. Final biomass and survival (%) between the tilapia fed the control diets (not supplemented), diets supplemented with non-protected sodium butyrate and diets supplemented with Butirex-C4 at 2.5kg and 5kg/tonne of feed.

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Feed conversion ratio (FCR) tilapia (*Oreochromis niloticus*)

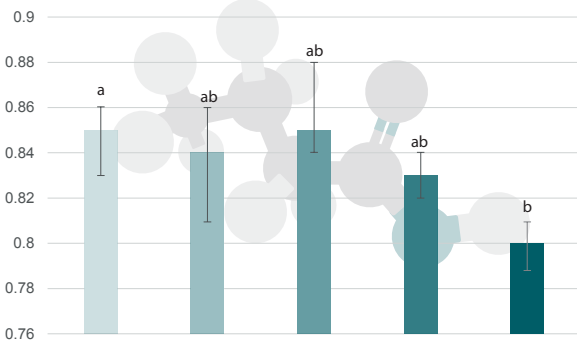


Figure 4. Feed conversion ratio (FCR) of tilapia fed the control diets (not supplemented), diet supplemented with non-protected sodium butyrate and diets supplemented with Butirex-C4 at 2.5kg and 5kg/tonne of feed.

Mortality during *Aeromonas hydrophila* challenge tilapia (*Oreochromis niloticus*)

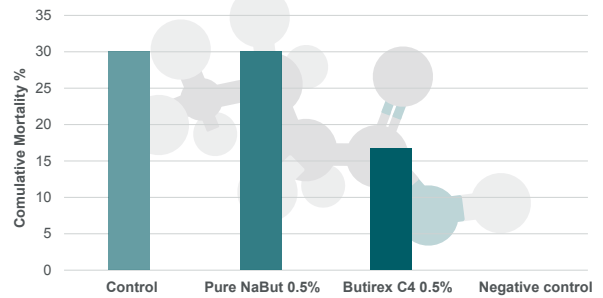


Figure 5. Mortality rate (%) with *Aeromonas hydrophila* challenge of tilapia fed the control diets (not supplemented), diet supplemented with non-protected sodium butyrate diets and diets supplemented with Butirex-C4 at 5kg/tonne of feed.

Villi growth and development

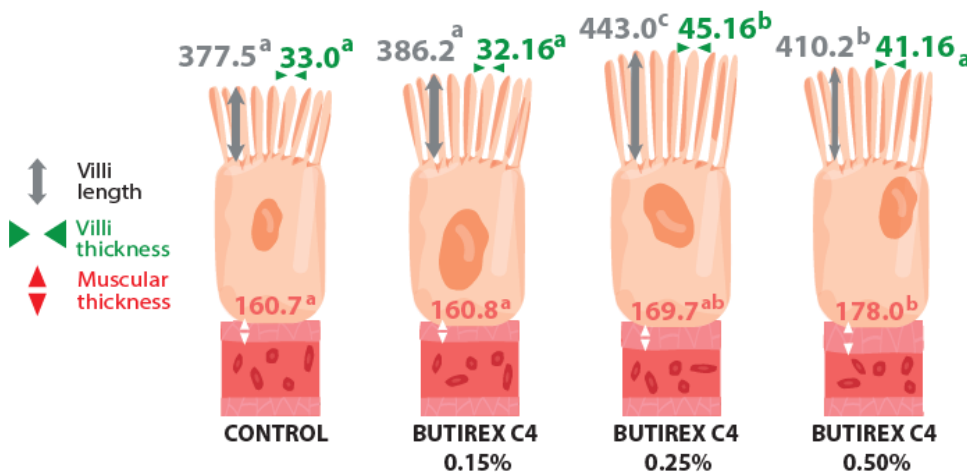


Figure 6. Supplementing aquafeeds with Butirex-C4 helps villi growth in rainbow trout.

The gut health is the start to optimal welfare

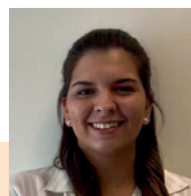
It is also important to consider the effects on the immune system and how butyric acid stimulates the lymphocytes located in the lamina propria. Not only the lymphocytes, but also the stimulation of macrophages and a regulation on the interleukins play important roles to maintain the immune system in the best conditions. Trials in terrestrial animals have shown how butyric acid supplementation post-vaccination resulted in a higher antibody titre. In recent trials in 2021, we measured the effect on the complement system, proinflammatory and anti-inflammatory cytokines with a very positive response with the butyric acid supplementation diets.

Results obtained where rainbow trout diets were supplemented with butyric acid have shown intestinal anti-inflammatory gene expression and reduction in intestinal proinflammatory gene expression.

All these – villi growth, bacteria balance, tight junctions or immune effects, reflect on a better intestinal health and better feed efficiency in the farms. These are parameters most appreciated by nutritionists – how we can improve feed conversion or reduce the feed cost, saving energy or soya from the matrix because of the action of butyric acid on the digestion process.

In aquafeed formulation, the alternative to antibiotic growth promoters is the combination of several items and not just a single one. The use of organic acids can help eliminate bacteria and fungi contaminations in the raw materials and butyric acid can help to support the intestinal barrier and increase efficiency.

To improve aquaculture production and promote sustainable production worldwide, we have proposed how organic acids can be a key player in fish and shrimp nutrition.



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A conversation on functional nutritional solutions for shrimp and fish farming in LATAM and APAC regions

There may be small regional differences on the uptake of functional feeds but, for any farmer, it is return on investment of the farming business, say ADM's François Jégou and Yoav Rosen



In this interview, Yoav Rosen, Global Aquaculture Marketing Director, ADM Animal Nutrition (left) and Dr François Jégou, Aquaculture Health & Performance for ADM Animal Nutrition elaborate on the present and future of functional feeds to counter adverse conditions in shrimp and fish farming, for better health and growth performances.

At the recent World Aquaculture 2022 in Mérida, Mexico, ADM's aquaculture teams presented some recent functional nutritional solutions. They shared *in vivo* trial results and benefits for the shrimp industry when using functional feed additives. **Dr François Jégou**, Aquaculture Health & Performance for ADM Animal Nutrition, concluded that its functional feed offers unique benefits for use in shrimp culture and daily management, improving growth while significantly helping the shrimp to better cope with physiological and disease stress.

ADM is among the ABCDs, the top four global agricultural companies. In 2019, it acquired the animal nutrition business of Neovia, giving it a leading role in aquaculture in both Asia and Latin America. Pancosma, acquired in 2019, provides innovative animal feed additive solutions and concepts including bioactives and organic acids. ADM's R&D network of research centres in Latin America and Asia explore and investigate additives for aquaculture to complete its feed businesses with a full range of components and formulations. Aquafeed marketing for Asia radiates mainly from the feed mill in Vietnam but a recent acquisition in Mindanao will allow local aquafeed production in the Philippines. In Mexico, Brazil and the rest of South America, the company has a strong position in the tilapia and shrimp feed markets.

This online interview is with France-based Jégou who has 30 years of experience in disease prevention and focuses on health and stress management as a synergistic support to farm performance and sustainability. **Yoav Rosen**, Global Aquaculture Marketing Director, ADM Animal Nutrition joined this conversation from Switzerland. The

subject is mainly ADM's functional feeds for shrimp (and for other species such as the tilapia) and crucial stages in farming where the team sees a need for functional feeds. Since both Jégou and Rosen are active in Asia and Latin America (LATAM), we took the opportunity to get them to compare the level of understanding and acceptance with regards to functional feeds among farmers in both regions.

Approaches on health and growth performance

The objective is to help the farmer and culture species. "This is where we promote the health of the shrimp through different feed additives in our functional feeds. Stress can lead to disease; disease causes stress, and the idea is to help the shrimp to reduce stress." In Mexico, the newcomer in ADM's aquaculture portfolio is an immune modulator and Jégou commented, "We know there is a feed, but it is interesting also to enhance the microbiota in a way to improve growth performance and health. Quite generally in Mexico, stocking density is low, at around 15 post larvae/m², versus in Asia where it is not uncommon to see up to 200 post larvae/m² or more."

Jégou added that with the different culture systems, there are totally different approaches, although the commonality is that in both regions, there is a high risk of infections from pathogens, viruses and bacteria, as well as microsporidians. "Environmental challenges are common in both regions, even though water quality management are not addressed in the same way."

Rosen concurred, "While surely there are differences between the culture methods and the stocking densities in Asia and Latin America, there are also similarities. It remains a fact that we are in aquaculture operations trying to bring maximum production to create profits for the farm. So, common to both regions is the attempt to mitigate the stress factors in aquaculture production."

Functional feeds for shrimp and fish

"Feed is almost the only component we can deliver immediately to the shrimp to have an impact, both on growth and health," said Rosen.

Jégou added that there is an opportunity to tailor the feed with different additives to counter an adverse situation as best as possible. "With early mortality syndrome (EMS), or acute hepatopancreatic necrosis disease (AHPND), we need to remember that very often it is not alone, it comes with some other viral pathogens, or the microsporidian EHP (*Enterocytozoon hepatopenaei*), etc. We need to formulate a feed that is best adapted to the global situation."

Rosen reiterated, "However, the question is how we can make sure that those feed additives really address the entire needs of the industry, especially with so many challenges in the farm. So how do we bring a comprehensive solution at ADM."

In Asia, the complete feed is the Ocialis brand with starter to grow-out feeds. There is the Bernaqua brand for hatchery and nursery feeds. The functional feed line is Life Defense, a result of a synergy: additives from Pancosma, knowledge and understanding from many trials at R&D centres, observations on how those ingredients are functioning under different conditions for shrimp or fish and formulating into the complete feed with premix. "Basically, we synergise all of our capabilities in ADM to provide more of a holistic and custom-made solution to the aquaculture industry."

Focus on early stages

"We want to make sure that we are investing in the right phases to see the results throughout the entire production chain. Early life stages at either the hatchery or the nursery level is also our strong focus because we know that early nutrition pays back later with significantly better overall grow-out performance. A farmer or hatchery manager needs to invest clearly on those stages to be able to get higher performance later. The principle is the same in LATAM as well as in Asia," emphasised Jégou. "In Mexico, we are putting a lot of attention into our raceway formulations, for example in the shrimp, to bring improved and better nutrition."

Vaccination and challenges with fish pathogens

Although ADM sees early nutrition as defining success, late culture stages should not be neglected. EMS comes at the later stage also. *Streptococcus* is an enormous problem at grow-out stages in tilapia farming and losses of marketable fish such as at 700g are significant. While tilapia farms in Brazil changed to vaccinating fish a few years ago, in Asia, this is not yet the case. There is also a seasonality factor. "Summer brings hot temperatures and lower water exchange and a high *Streptococcus* challenge, both in LATAM and in Vietnam. We bring a feed with a double component – a specific feed formulation and an additive mix, to better address the challenge. In the case of the marine Asian seabass or barramundi, the challenge is more related to vibriosis risk," said Jégou, adding, "We have some additives showing interesting results against *Streptococcus*. For example, with two of our products, we obtained almost 40% higher survival compared to control with no additive."

"There is a poor vaccination rate of tilapia in Asia. We need to consider this as an evolution. Just like in the salmon industry, nothing was built in one day, for many reasons, regulatory being an important one. In Brazil, 7-8 years ago, the vaccination rate was extremely low

for tilapia. Unfortunately, farmers mostly see losses from *Streptococcus* mortalities although losses from poor growth due to sub-clinical *Streptococcus* are also considerable."

He pointed out that vaccination is also a stressor – i.e., the whole process, including anaesthetising the fish, then holding them out of the water, then needle injecting on small fish. "So, we have been working on how to deal with this by developing vaccination via feed. We obtained exceptionally good results; within 6 weeks, growth was 25% higher with this feed compared to vaccinated control group, which clearly means there is something happening at the fish level, and which also meets farmers' requirements. We will launch this feed first in Brazil, followed by Mexico, and then we will move to Asia."

Extruded versus pelleted shrimp feeds

The industry is slowly moving to extruded shrimp pellets, more so in LATAM as compared to Asia. Jégou commented, "Wherever we create a formulation with feed additives or otherwise, we are carefully measuring and taking care of the integrity of the particles, pelleted or extruded, to make sure we are keeping the nutritional values in the pellet or in the feed with minimum leaching. The adoption of shrimp extruded feeds is quite high in Ecuador while in Mexico it is rising. In parallel with this, with automatic feeders, extruded feed will have less breakages."

"However, we need to carefully consider whether feed functionality be paired exclusively with extruded feed. We try to bring these functional feeds to everyone and since extruded feed is at a higher cost, we adapt to the situation. Therefore, we are following this trend closely and to what is the market today. We now have functional feeds – both extruded and pelleted."

Gaining farmers' trust on functional feeds

Both agreed that this is quite a challenge, especially when dealing with additives and functional feeds. The first step is to make sure that any investment the farmer makes is converted into profit or as added value.

Working with other species, Jégou said that in aquaculture there is a problem of performance assessment that other species have less. "Take for example a cage or a pond, it is definitely not easy to tell the number of fish or shrimp inside it. Farmers can say, 'I tried this; it doesn't work,' or the absolute contrary. So, we should try to look more at facts and figures together and discuss what are the technical benefits and return on investment."



ADM Aquaculture Research, Nhà Bè, Vietnam



ADM Aquaculture Research Center, Decatur, USA

Jégou believes it is an (relatively) easier task to convince farmers on the importance and interest of using functional feeds, whether in LATAM or in Asia, because of the increasing maturity of the industry and because of the overall growing concern on antimicrobial resistance and sustainability. “On the other hand, we are facing vast competition, with many promises. We need to assess what is the situation and understand what the main concerns are; in what way these concerns impact the economic results; and in what way we can help the farmer. We then need to also formulate a plan. We need to see the farmer again as a business partner,” adding that there should be a follow-up. “We need to have this trustworthy relationship.”

Rosen said that for nutrition companies, it is to be better in providing the precise nutrition or functional nutrition. “It is also about bringing more science into aquaculture, more evaluations and making sure that the feed utilised are creating optimal results, technically and economically, and best adapted to their situation. In animal production, the poultry guys have advanced far ahead of us and so we need to catch up!”

Future product development

In Mérida, the ADM team also shared the AquaTrax functional feed additive and its Api Camarón line of shrimp feed. AquaTrax leverages *Pichia guilliermondii* inactivated yeast to alleviate disease stress through a modulating

effect on gut microbiota and immune functions. After two separate disease challenges, *Vibrio parahaemolyticus* and white spot syndrome virus, survival of *Litopenaeus vannamei* after 5 weeks increased by 76% and 84% respectively compared to control without *P. guilliermondii* inclusion. In the field without any specific pathogenic challenge, vannamei shrimp fed supplemented diets showed a significant 10% increase in growth performance compared to control at the end of a 7-week trial.

ADM’s research department is divided into two parts: product development and innovation. “The first develops the actual existing products and bringing them to the market and exploring different functionalities. The second looks at what is possible in nature that we could possibly use to tackle specific problems,” explained Rosen.

There are other ongoing investigations, such as adaptations to automatic feeders; direct measurements of oxygen using IoT and managing ammonia stress with feed formulations, by lowering nitrogen discharge or improved physiology of the animal.

Jégou summarised, “We want and need the industry to progress. We need to be open minded and work together. We do not advocate that our additives are silver bullets, but we can propose targeted holistic solutions from feed design to water bioremediation.”



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Current issues in developing tilapia farming in Indonesia

A strong domestic market absorbs most of its production but for export markets, industry needs to be cost efficient and competitive

By Guruh Arifianto



The tilapia is very special to Indonesia, both as a commodity and a popular food fish domestically. Tilapia is farmed in various water bodies, such as lakes at the edge of volcanic mountains, raceways, freshwater and brackishwater earthen ponds, floating net cages, irrigation canals and rice fields.

From 2011 to 2019, tilapia production in Indonesia was on the rise at a CAGR of 11.9% (GOAL, 2021). In 2017, production was 1.3 million tonnes but this dropped to 1.2 million tonnes in 2018. In 2020, affected by the Covid-19 pandemic, production went down to 1.2 million tonnes from 1.3 million tonnes in 2019 (Figure 1). Farmers suffered as demand dropped by 11%. Some 30-35% of this volume came from farming activities. Based on feed usage, nearly 400,000 tonnes were from intensive culture systems.

In 2021, production remained relatively stagnant due to lower cage culture activities, declining supply of fry and fingerlings, disease outbreaks and environmental issues. Climatic factors included floods and upwellings in lakes. Since demand has been slow to increase, there was a high supply situation. However, there were regional differences with regards to recovery in demand.

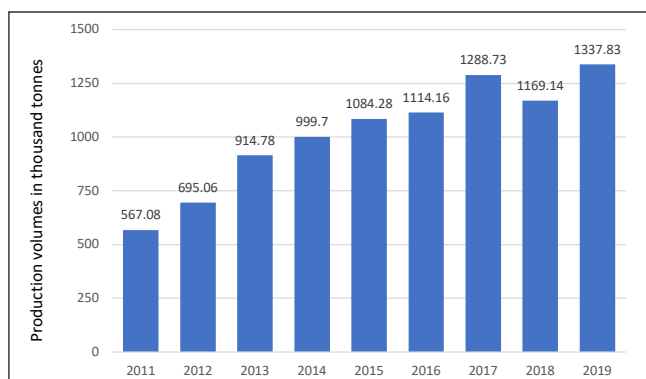


Figure 1. Production volumes of Nile tilapia in Indonesia from 2011 to 2019 (Source: www.statista.com)

In 2022, tilapia production is expected to improve. However, new problems have emerged, due to the extraordinary increase in feed prices: the global rise in costs of some major feed ingredients. Thus, farmers encounter the problem of reaching production cost efficiency. In the first half of 2022, we expect that there will be a slight decline in production, as evidenced by the increase in fish prices in the domestic market. It has been reported that in several areas, small farmers have ceased farming due to rising production costs, mainly due to high feed prices.



Red tilapia cage culture at the edge of Kapuas River with acidic pH. With 10,000 fish/cage (3m x 7m x 1.5m) yield can reach 2 tonnes/cage in a 5-month cycle.



Black tilapia farming at the edge of Tondano Lake, North Sulawesi. This farm is integrated with the hatchery and nursery stage on the lakeshore.

Less production in 2021

In general, farming activity was on the decline. Several reservoirs and lakes are part of the government's ban/restrict floating net cage (Kebijakan Jaring Apung or KJA) policy. Initiated in 2018, the plan is to reduce cage culture in lakes, in favour of tourism-linked activities. Farming activities were disrupted in several major man-made and natural lakes, where tilapia culture predominates, such as Lake Toba and Lake Batur and reservoirs such as Jatigede, Cirata and Jatiluhur. If for each cage of 3m x 3m x 2m, the production capacity is one tonne of fish, then with 1,000 cages, the potential drop in production can be 250-300 tonnes/month.

Another factor influencing production was the allocation of land for rice versus earthen ponds for tilapia culture. Added to the above was the decrease in environmental carrying capacity, diseases and environmental disasters. Separately or together, disease and environmental factors have led to decreases in growth performance and survival rates from 70% to less than 40%. Over the last 15 years, declines in productivity were most evident in traditional earthen ponds, with drops of 50-100%, where the biomass has decreased from 2kg/m³ to 1.0-0.5kg/m³. Some other culture ponds also had the same challenging conditions.

The total demand for tilapia fry is 250 million fry/month from one million broodstock. However seasonal supply fluctuations mean that supply often does not match demand. Furthermore, fry quality is very diverse, affecting grow-out production due to environmental challenges and limited availability of quality broodstock. An adequate fry supply in terms of quality and quantity is necessary to ensure production continuity. There are indications of a decline in production linked to the environment and diseases because the current fry available are generally not adapted to environmental changes and are susceptible to diseases. There has been a decline in growth performance, feed conversion ratio (FCR) and survival resulting in rising production costs (Arifianto, 2022).

Large domestic market

Most of the tilapia (almost 99%) are sold in domestic markets and only 0.5-1.5% of national production are

exported. Prices in domestic markets are much higher than in export markets. Locally prices fluctuate and show regional disparities. Harvest sizes for local markets are much smaller than for export (200g to 500g) and therefore farmers have more crops per year. The local market demands fresh fish, but the pandemic years have spawned more creative value-added tilapia products for local retail markets.

Disease challenges

Over the last 10 years, tilapia has been extremely susceptible to diseases (Figure 2), with infectious *Aeromonas* bacteria occurring at the hatchery and nursery phases and later at grow-out with *Streptococcus* when fish are 10g to 1kg in size. Bacterial diseases cause mass mortality or lower survival rate to only 30%. Susceptibility to parasites and fungi is encountered at the hatchery and nursery stages at 2-3cm fry stages. Environmental challenges include low dissolved oxygen, temperature and pH throughout the culture cycle leading to less than 40% survival rates from an average of 70%. High salinity can pose a problem at the nursery and grow-out stages.

Cost of production

Several factors contribute to rising production costs. Diseases and environmental conditions lowered survival rates. Poor fry and juvenile quality lowered growth performance. Feed and energy costs have been increasing. In Indonesia, the cost of production in 2022 based on an assumption of FCR of 1.5 for 500-800g fish and survival of 50% was IDR16,000-18,000/kg (USD1.11-1.23/kg).

There is a wide range of specifications for tilapia feeds in Indonesia and prices vary with % crude protein and brands. In 2022, prices for feeds rose 15 - 20%.

Prices in local markets in 2022 ranged from IDR23,500/kg to 26,000/kg (USD1.56-1.73/kg). As a comparison, in 2020, wholesale prices for live tilapia in China were between CNY7.5-8 (USD1.09-1.16/kg) for 500-800g (DAP, Hainan). According to Globefish, in 2021, prices remained steady throughout the year. This higher cost of production for tilapia in Indonesia makes it uncompetitive for export markets which will also require some processing. Catering to the domestic market is more attractive for farmers.



Earthen pond in Makassar, South Sulawesi, stocking 5pcs/m³ black tilapia. The productivity is 5-10 tonnes/ha. Several other islands (Java, Sumatra, Lombok) have also developed black tilapia culture with productivity of up to 20 tonnes/ha.

Strategies to increase volumes and production efficiency

There are various ways for farmers to increase efficiency to secure higher incomes from tilapia farming. This is by reduction in costs of production and improvement in productivity.

Polyculture systems

Tilapia can survive well at 20ppt salinity and in symbiosis with other fish or shrimp. Polyculture is possible in various ways: vannamei shrimp with tilapia in ponds; tilapia and carps in raceways and tilapia and pompano in cages. The other fish or shrimp in the polyculture system is a buffer when tilapia prices drop. In Figure 3 and Table 1, we explain the different methods of polyculture of tilapia with vannamei shrimp. There are three methods to design polyculture of tilapia with vannamei.

In a mixed model, there is stocking of both the tilapia and vannamei shrimp at an equal density of 5-15 pcs/m² or unequal with 15:45 (vannamei: tilapia) pcs/m². In a mixed model, one tonne of vannamei can be produced. In the couple model, water from the tilapia ponds flows into the vannamei shrimp ponds and helps to control *Vibrio* spp. populations.

Biofloc systems

These can reduce the use of feeds and increase productivity. Reductions in FCR by 0.1-0.2 points will save feed costs by IDR800-2,000/kg (USD0.5-0.13/kg) while productivity increases to 20-30kg/m². However, few farmers have adopted biofloc systems which require more energy and technical inputs.

Intensive culture

In Jogjakarta and East Java, intensive culture of tilapia is common. Small ponds use paddlewheels and stock 10-15g juveniles (50-55/m³). Survival is around 70-80%. The productivity is 8kg/m³ of 200g fish after 120-140 days which is a problem if the target is the export market. FCR is 1.3-1.4 and cost of production ranges from IDR16,000 to 17,000/kg (USD1.06-1.13/kg). Cost of energy ranges from IDR500-1,000/kg (USD0.03-0.06/kg).

IPRS

A more recent technology is the In-Pond Raceway System (IPRS) introduced by USSEC and GPMT. The aim here is to increase productivity (30 tonnes/cell or more than 125kg/m³) and act as an alternative to cage culture and traditional raceways.

Export potential

The global market for the tilapia comprises 154 importing countries but Indonesia exports to only 16 countries. In an article "Marine Economic Literacy", Suhana (2021) discussed the export performance of tilapia. Tilapia is a target export commodity from Indonesia and is included in the top 10 Indonesian fisheries exports. Data from the Central Bureau of Statistics (Badan Pusat Statistik or BPS, 2021) showed that the export of tilapia in the last three years has increased and even during the Covid-19 pandemic, the export value of tilapia increased by 17.13%. The export volume of tilapia in 2020 reached 12,290 tonnes with an export value of USD78.4 million. This was still only 1% of the production potential. BPS (2021) documented those exports came from production in five provinces led by North Sumatra with 91.7% and Central Java at 8.3%. Exports were mainly to markets in the US, Canada, Taiwan, Netherlands, South Korea and Japan. Lake Toba in North Sumatra contributed 91.6% of total exports of tilapia, valued at USD 71.9 million in 2020.

Increasing competitiveness

The current situation with rising production costs affects its competitiveness in global markets. The Directorate of Aquaculture, Ministry of Fisheries and Marine Affairs has developed more than 20 strains of tilapia in Indonesia for fast growth, low FCR and high fecundity and the first step is to identify and characterise these strains to match changing environmental conditions and develop disease resistance.

Indonesia needs to produce premium quality tilapia. However, the constraints are not only high mineral content of volcanic water bodies but as in the case of Lake Toba, the rivalry between aquaculture and tourism. Export markets demand large sized tilapia of 800-1,000g fish. Therefore, the challenge will be for farmers to move away from producing small sized tilapia, despite high costs of energy. To maintain production of small sized tilapia (<500g) requires creativity in value adding.



Current ex-farm prices for fresh red and black tilapia are IDR20,000-30,000/kg (USD1.3 – 2.0/kg).

Disease	Hatchery	Nursery 1 Larva-2-3 cm	Nursery 2 2-3cm-7-9cm	Nursery 2 7-9cm-10g	Grow-out 10g->1kg
Infectious					
Bacteria					
<i>Aeromonas</i>	Orange	Orange	Orange	Orange	Yellow
<i>Streptococcus</i>				Yellow	Orange
Parasites and mould	Orange	Orange	Yellow	Yellow	
	Orange	Orange	Yellow	Yellow	
Non- Infectious					
Low oxygen	Orange	Orange	Orange	Orange	Orange
Low temperatures	Orange	Orange	Orange	Orange	Orange
Low pH	Yellow	Yellow	Yellow	Orange	Orange
High salinity					

Figure 2. Chart on the susceptibility of tilapia to various pathogens at hatchery, nursery and grow-out stages. Orange bars indicate most frequent occurrences, yellow bars indicate rare incidences.

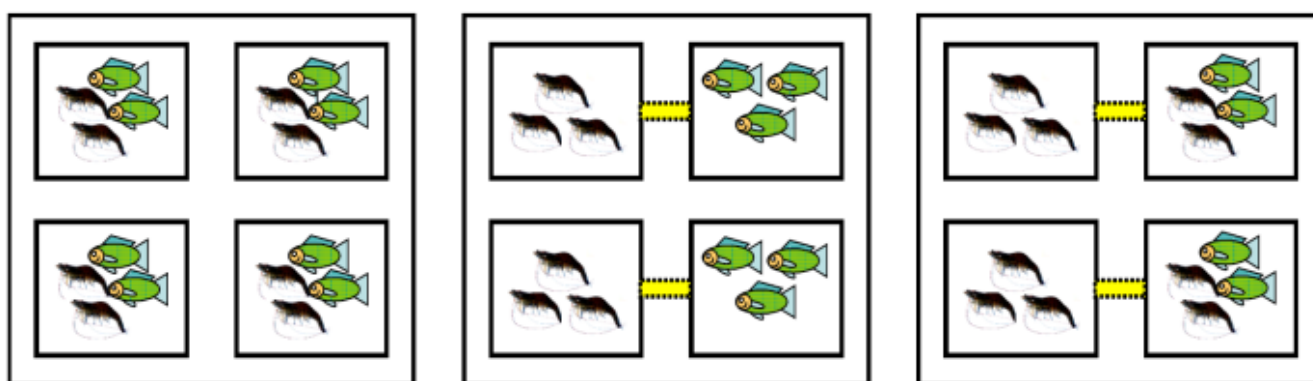


Figure 3. Polyculture models for tilapia and vannamei shrimp.

Polyculture model	Density (pcs/m ²)		Target species	Objective
	tilapia	vannamei shrimp		
Mix	5	5	tilapia	Increase productivity
	15	15	tilapia	Increase productivity
	15	45	tilapia	Increase productivity
	2	100	vannamei shrimp	Water Quality improvement
Couple	15	>100	vannamei shrimp & tilapia	Water Quality improvement
Semi-couple	15	15-100	vannamei shrimp & tilapia	Water Quality improvement & Increase productivity

Table 1. Tilapia/vannamei shrimp polyculture models for increasing productivity and water quality improvements.

Note: This article was adapted and updated from a presentation on Status & Current Issues: Development of tilapia culture in Indonesia, presented at the International Conference of Aquaculture Indonesia 2021 (ICAI), October 28-30, 2021, Semarang, Indonesia.

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Some updates on global tilapia production

In its July report on the tilapia, Globefish (2021) said that the global tilapia industry was able to adapt to the new market landscape by leveraging retail experience and price advantage. It was expected to resume a steady expansion in 2021 although challenged by rising costs.

At GOAL 2021 held in November, Gorjan Nikolik, Rabobank summarised that global production is expected to increase 1.5% in 2021 and in 2022 by 3.75%. China, Indonesia, and Egypt completely dominant global tilapia production at 75% of global volumes (Figure 1)

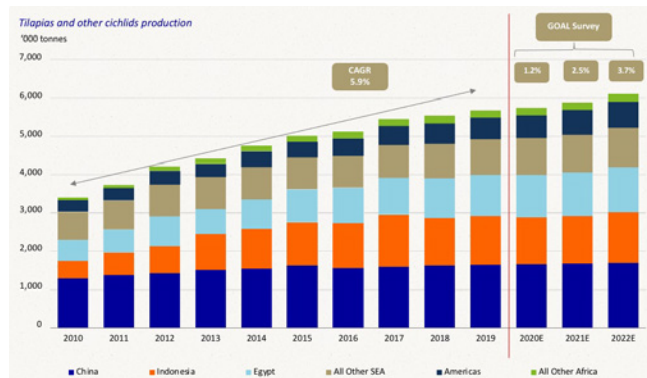


Figure 1. Growth in supply of global tilapia (tilapia and other cichlids). Source: Rabobank, FAO, GSA 2021.

In reporting results of the GOAL survey on finfish production, Nikolik gave some trends (% changes) which have been normalised to FAO 2019 data for consistency of reporting from the survey respondents. China and Indonesia, the big producing countries showed growth at CAGR of 2.8% and 11.9%, respectively, over the years, 2010-2019. The GOAL annual survey showed that production started to improve in 2021 and into 2022 (Figure 2).

More growth is evident in the other producing countries in Asia such as in Bangladesh, Philippines and Thailand. Bangladesh’s tilapia production grew at 34% up to 2019, crossed the 250,000 tonnes and is still growing.

Nikolik said that the giant of African aquaculture is Egypt with its tilapia production. The historical growth was around 7.6% and according to survey respondents, growth will drop at around 3.7% because of some constraints

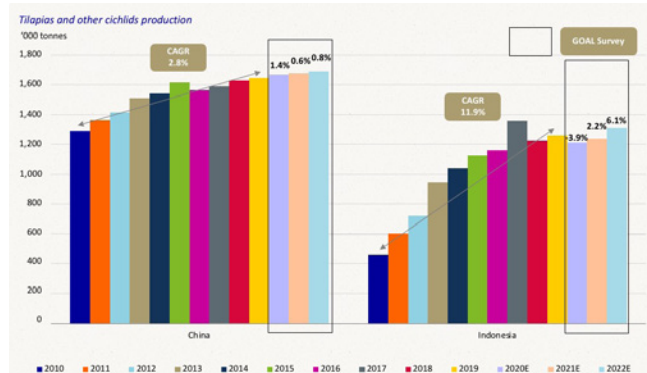


Figure 2. Production trends of tilapia production in China and Indonesia & growth projections for 2020-2022 according to GOAL Survey 2021. Source: Rabobank, FAO, GSA 2021.

particularly of land and water. All other African producers have sizeable production with a combined annual volume of 200,000 tonnes. Although still small in terms of current production volumes, Sub Saharan Africa’s tilapia production is expected to grow fast. In 2021, growth was 10.5% from 8.5% in 2020.

Brazil challenging China’s tilapia dominance

Bullish and almost double-digit growth numbers indicating “an incredible rise” in Latin America’s tilapia industry, which is currently the fastest-growing tilapia region, driven by Brazil (globalseafood.org). Colombia and Mexico are expected to continue to grow in 2021-2022 after growing at 7.5% and 24.0%, respectively, over the 2010-2019 period.

In recent years, the Brazilian tilapia industry has been identified as one of the most notable success stories of Latin American aquaculture rising to the 4th largest tilapia producer. This impressive growth is steadily turning into export revenue (Globefish 2021). In 2021, tilapia production was 534,005 tonnes, 9.8% over that in 2020, said Dr Gustavo L. N. Bozano, Aqua Lagus during a Phileo Lesaffre tilapia webinar in May 2021. This volume was 63.5% of Brazil’s total aquaculture production according to the Brazilian Aquaculture Association (PeixeBr, 2022).

According to a recent report from the Peixe BR, Brazil exported tilapia worth USD6.1 million in the first six months of 2021, an increase of 28% compared with the same period in 2020. Fresh fillet is the most exported tilapia product and the US remains the number one market. Brazil is benefiting from the 25% import tariff on Chinese tilapia in the US. This combined with high freight rates and other logistical issues has created opportunities for Latin American producers who can fly fresh tilapia into the US market within hours of harvest. In turn, China imports significantly large volumes of Brazilian exports in 2021 as compared to 2020.

Bozano said that the cost of tilapia production in Brazil has risen by 80% but selling price has only risen 40-50%. Therefore, margins are tight and producers adopt measures to improve performance. Exports have doubled in the last three years supported but the favourable exchange rate. (References available on request)

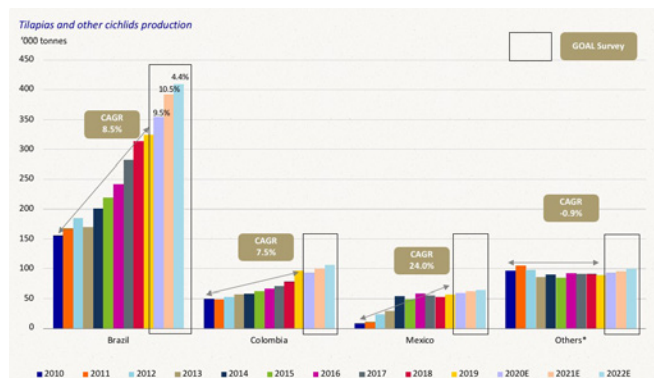


Figure 3. Production trends of tilapia production in Latin America led by Brazil and growth projections for 2020-2022 according to GOAL Survey 2021. Source: Rabobank, FAO, GSA 2021. Others* Belize, Costa Rica, Cuba, Ecuador, El Salvador, Guatemala, Honduras, Panama, Peru, Venezuela

Improved fish health and profits by using Streptococcosis resistant tilapia

A scientific study, analysing the cost-benefit of using genetically selected Streptococcosis resistant fingerlings in farming of Nile tilapia has recently been published in Nature - Scientific Reports. The results demonstrate that tilapia farmers made significantly additional profits in both ponds and cages even at low levels of Streptococcosis related mortality.

Streptococcosis is one of the most important infectious diseases affecting tilapia aquaculture worldwide. The disease reduces survival, downgrades product quality and seriously impacts profitability in tilapia enterprises.

In most parts of the world and particularly among small and medium-size tilapia farms, the only control measures farmers have at hand is to change husbandry practices such as reduce feeding or increased aeration and water exchange.

Antibiotics are also commonly used but the number of approved aquatic antimicrobials is however extremely limited. The vaccination uptake in Asian tilapia aquaculture, where small and medium scale farmers are the norm is limited due to requirements for a minimum size at vaccination of 10-15g and complex administration.

Preventive genetic strategy to control diseases

Breeding animals for higher genetic tolerance/resistance to diseases is a promising innovation that has demonstrated its value in other livestock and aquatic species. In the case of breeding for Streptococcosis resistance in tilapia, we see the following advantages of the technology for the tilapia industry:

- Accessible to farmers of all sizes and has no barriers to adoption
- Lasts the entire life of the fish and genetic gain in resistance is accumulative over generations of breeding
- No cost of administration since the innovation is already inside the genetic makeup of the fish

“Genetically resistant fingerlings will contribute to increased survival, increased feed efficiency and better growth leading to higher net return,” said Marina Delphino, Fish Health and Welfare Manager in GenoMar Genetics Group.

Beneficial to rear Streptococcosis resistant tilapia

After five years of R&D work and field testing, GenoMar launched Streptococcosis resistant tilapia in the Asian market in early 2021, under the name GenoMar Strong. The



documented protection against Streptococcosis of 30-35% RPS (Relative Percent Survival) was used in an economic break-even analysis. The results showed that genetically selected Streptococcosis resistant tilapia fingerlings were profitable for farmers in both pond and cage culture systems where Streptococcosis is the production constraint.

“This study to perform the economic evaluation will help the farmers to understand the economic value of using genetically selected tilapia fingerlings for their production,” said Rajesh Joshi, Senior Researcher in GenoMar Genetics Group.

The cost of buying Streptococcosis resistant tilapia fingerlings is higher compared to standard fingerling prices because R&D and phenotyping (measurement of observed physical traits) cost are higher. The study showed a significant higher return of investments in both ponds and cages with Streptococcosis outbreaks, even if the amount paid for genetically selected Streptococcosis resistant tilapia fingerlings was double the amount paid for standard fingerlings. Even with low *Streptococcus* related mortality (1-5%), the net profit is in favour of *Streptococcus* resistance fingerlings if the extra amount paid for resistant fingerlings over the standard fingerlings is up to 30% (Figure 1).

“The direct economic benefits and costs of rearing disease resistant tilapia are important for the farmers to consider. However, there are also social and environmental benefits of using the technology such as improved overall fish resilience, reduced use of antibiotics, lower generation of mortality waste and higher resource efficiency. All these contributions will support the development of a more sustainable aquaculture value chain,” said Alejandro Tola Alvarez, CEO in GenoMar Genetics Group. www.genomar.com

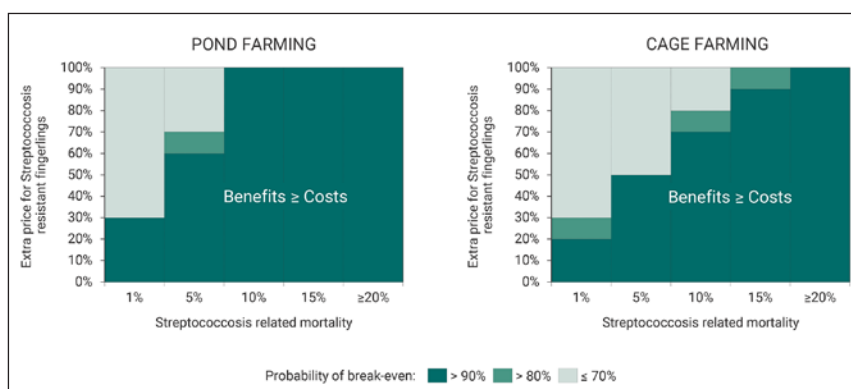


Figure 1. Break-even calculations (benefits \geq costs) when Streptococcosis resistant fingerlings prices and mortalities caused by Streptococcosis increases under pond and cage farming of tilapia in Malaysia. The green colours show the probabilities of break-even when the benefits (protection against Streptococcosis) are higher than or equal to the costs (extra price of buying genetically selected tilapia fingerlings resistant to Streptococcosis over the standard fingerlings).

The impact of extreme rainfall on aquaculture and its prevention

There is an extensive list of events which can be managed with a good understanding of impact and prompt action by farmers

By Li Bing, Dong Qiufen and Zhang Song



Heavy rains and dead fish after rains. Left: Rohu (*Labeo rohita*) pond in the rain in Myanmar. Right: Tonnes of dead fish were found floating on water surface near Jakarta after torrential rains (Daily Mail 2015).

Aquaculture plays a significant role in supplying aquatic products which are important food sources for the global population. According to FAO's State of World Fisheries and Aquaculture 2020 (SOFIA), aquaculture's contribution to global fish production continues, reaching 82.1 million tonnes in 2018, accounting for 46% of the estimated 179 million tonnes of global fish production.

Climate is always crucial to aquaculture; adequate rain can supplement water and improve culture water quality, while extreme rainfall can cause problems and huge losses.

In this article, we explore events in fish and shrimp farming, with the occurrence of rains and what we can do to reduce the negative impacts.

The dynamic processes

During rainy periods, rainwater and run-off will mix with the original pond water. While sunlight will be blocked by rain clouds, at the same time, the air temperature will be lower. The atmospheric pressure is usually quite low during the early part of the rains and sometimes occurs with strong winds. Besides these direct effects on the water environment, rains will also lead to water movements on the pond surface and at the pond bottom, further affecting the state of the pond environment (Figure 1).

Water temperature

Pond water temperatures often drop with heavy rain. According to Rooney et al. (2018), rain may have effects on the pond water surface in four ways: evaporation and cooling of the near water surface-air during precipitation; direct rain heat fluxing into the pond; mixing of the pond surface layer through the flux of kinetic energy; and finally, convection mixing of the pond surface layer. Research indicated that during the days with heavy rainfall, there may be a reduction in lake surface temperatures of approximately 0.3°C by the end of the day compared to the days with light and moderate rainfall.

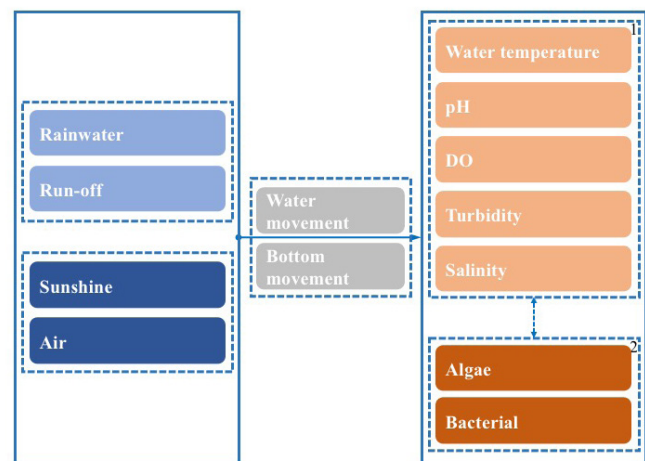


Figure 1. Effects of rain on the water environment and pond ecosystem

pH

The suitable pH in pond culture water is around 7.0-8.5, while the pH of most rainwater is below 6.6 and can be much lower with acid rain (Vet, 2014). Moreover, photosynthesis will be affected due to poor conditions for algae development and diminished sunlight during rains. The pH will then be more than 1.0 after the rains.

Salinity

The mineral content in rainwater is low, although the run-off may carry some minerals. After extreme rain, the salinity declines in full seawater and brackish water bodies, as shown in Table 1.

Location	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	NH ₄ ⁺	Reference
Jordan	165.3	93.12	130.6	85.21	75.36	O.A. Al-Khashman, 2005
Italy	5.18	70	77	17	25	Le Bolloch, 1995
Tirupati, India	150.7	55.51	33.08	33.89	20.37	P. Mouli, S. Mohan, 2005
Newark, USA	6.0	3.3	10.9	1.3	24.4	F. Song, 2009
Shanghai, China	204.0	29.6	50.1	14.9	80.7	X. F. Huang, 2010

Table 1. Chemical analyses of rainwater in various locations (in µeq/L).

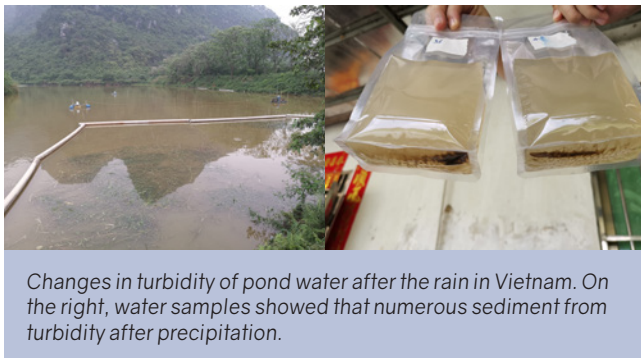
Dissolved oxygen

Table 2 and Figure 2 list the main sources of dissolved oxygen and consumers of dissolved oxygen in a pond. As the various fish farming models and ponds have different dissolved oxygen conditions, there can be a huge risk with the decline in dissolved oxygen during rainy days. Aerators can supply more oxygen during the rains and lower water temperatures can lead to less biological respiration consumption, but the photosynthesis of algae will be limited due to less sunlight and environmental stress. Low air depression will reduce the oxygen dissolution from the air into the water, while potential algae crash and bottom movements may worsen dissolved oxygen conditions.

Turbidity

Turbidity is the measure of water clarity. Suspended particles are the main source of turbidity (Swift, 2006). Run-offs from rains can carry a large volume of insoluble solids into the water. Simultaneously, the soil and water movements at the pond bottom can release insoluble solids into the water body. Dead microorganisms can continuously contribute to the suspension of solids and increase water turbidity.

The effects of suspended solids on fish can be divided into three categories: the lethal effect means a high concentration of suspended solids can directly kill the individual fish; sublethal effects, such as reducing growth rate and resistance to diseases, interference with embryo hatching, and finally, behavioural influence, such as the avoidance response of hardhead trout to turbid waters (Biosson, 1982).



Changes in turbidity of pond water after the rain in Vietnam. On the right, water samples showed that numerous sediment from turbidity after precipitation.

Algae

Low light and lower water temperature will affect the reproduction and activities of algae. The sudden environmental change leads to extreme stress on algae populations, causing a crash.



An algae crash in a shrimp pond after a rain in China

Bacteria

The abundance of bacteria tends to decrease with lower temperatures and environmental stress. The bacterial community will also change. In a study, Hu (2010) showed that without microecological preparations, the number of heterotrophic bacteria in the water body and at the bottom of the shrimp ponds decreased after heavy rainfall. However, the number of *Vibrio* bacteria increased. The Simpson and McIntosh indices decreased significantly ($P < 0.05$).

Pond bottom

Disturbances at the pond bottom are due to the disruption in water flow, depression and the potential temperature difference between upper and lower water layers. The movements at the pond bottom will release harmful compounds such as hydrogen sulphide (H_2S), methane (CH_4), ammonia (NH_3) and nitrite (NO_2^-) into the water in a short time. In turn, this will consume large volumes of dissolved oxygen, and the algae, parasites, pathogens and other harmful living organisms such as pathogenic bacteria will have the chance to bloom.

Hazards



Shrimp (*Penaeus vannamei*) in Vietnam and largemouth bass (*Micropterus salmoides*) in China suffered heavy mortality after extreme rains

Item	Contribution and consumption
Aeration	Contributed 50% of the total DO (Zhou Jinfeng, 2004)
Algae	Contributed 60–95% of the total DO before the use of Aeration (Lei Yanzhi, 1983)
Air dissolution	4.7–40% before use of aeration (Lei Yanzhi, 1983)
Water respiration	59.6–63.9% in marine water culture (Xu Ning, 1999)
Bottom respiration	16–30% (Pan Tengfei, 2010; Lin Bin, 1995)
Animal respiration	Red tilapia 16%, <i>Penaeus chinensis</i> 14% (Xu Ning, 1999)

Table 2. Contribution and consumption of dissolved oxygen (DO) by various sources.



Figure 2. The main sources and consumptions of dissolved oxygen (DO) in a pond.

Stress

Stress refers to the non-specific systemic response of fish when stimulated by various internal and external environmental factors. If any stimulus reaches a certain intensity, in addition to specific changes related to the stimulus, it will also cause a series of systemic non-specific reactions that are not related to the nature of the stimulus. Pickering (1981) divided the adaptive response of fish to stress into three levels. The first-level response refers to the changes in the body's neuroendocrine activity, the second-level response is a series of physiological, biochemical and immune changes caused by the first-level response, and the third-level response is based on the physiological basis of the second-level response, such as slower growth rate, changes in fish behaviour and reduced disease resistance.

Item	Harmful effects
pH	<ul style="list-style-type: none"> In shrimp held at different pH levels (5.6 or 7.8), haemolymph osmoregulation was worse at low pH ($P < 0.01$) (Allan, 1992). As the pH mutation value increased, the antibacterial and lysogenic activities of shrimp decreased and the phenoloxidase activity increased (Pan, 2002).
DO	<ul style="list-style-type: none"> Tilapia under low dissolved oxygen condition (1.5mg/L) increased respiration rate (Xu, 2005). Low dissolved oxygen caused catfish growth and feed utilisation to decline (Andrews, 1973). Enzyme activity of catalase and GST increased in the animal gills submitted to anoxia, and SOD activity decreased. (De Oliveira, 2005).
Salinity	<ul style="list-style-type: none"> When the gap between internal and external osmolarity pressure was too large, the shrimp consumed too much energy to regulate the osmotic pressure. Thus, affecting shrimp growth, survival, development, respiration, metabolism, osmotic pressure regulation capacity, the composition of free amino acids and many other physiological characteristics (Brito, 2002).
Temperature	<ul style="list-style-type: none"> Sudden temperature change caused a reduction in the blood cell content in crustaceans and this led to the body's immune defence and weakened disease resistance (Moullac and Haffner, 2000).

Table 3. Different stress factors and the potential harmful effects on aquatic animals

Harmful and poisonous compounds and organisms

Due to the impact of rainfall on the pond environment and ecology, harmful poisonous compounds, such as NH_3 , NO_2^- , H_2S , and harmful algae will increase. Blue-green algae can produce microcystins in large quantities during algal blooms (Joanna, 2013), which can be a big threat to both aquatic animals and human communities. Harmful algae such as blue-green algae and dinoflagellates have a stronger ability to use light when compared to normal algae like green algae and diatom. The pond bottom movements will release more organics into the water and cause the harmful algae to become a predominant population during rains and bloom on sunny days after rain.



Euglena bloom (left) and blue-green algae bloom (right) after rains in pond in India.

Pathogen blooms

The dramatic environmental change breaks the original balance of the ecosystem, pathogens may dominate while bottom soil and water movements will accelerate this process. Bacterial pathogens and parasites become widespread after the rains, as the eggs of parasites may be released into the water from the pond bottom during the rains.

Prevention and solutions

Best practices range from improving the pond bottom to using health care products, probiotics, disinfectants and fertilisers. The pond bottom can be improved through regular use of conditioners to reduce the harmful effects when the soil-water interface is disturbed. Treatment can be done before the rains. There are several different bottom conditioners ranging from probiotics, oxidants and surfactants, which should be used at the right time and in a proper way.

Quicklime is a versatile product for aquaculture. It can increase pH, supplement calcium, kill pathogens and absorb floating matters. It can be applied evenly around the pond wall to prevent the soil from washing into the water and also added directly into the water to improve water quality.

In terms of health care products, there are, for example, Vitamin C, Vitamin E and β -gluten, which can be used to increase fish immunity or relieve fish stress. They can be used occasionally in water or continuously in the feed. They prevent stress in aquatic animals and reduce the risk of infections by improving vitality and immunity.

The essential minerals in water are crucial for fish osmotic pressure adjustment and are also important nutritional resources for aquatic animals. Since rainfall will reduce the concentration of minerals in the water body and increase the animal's demand for minerals (shrimp are prone to moulting during rains), it is helpful to supplement minerals after the rains for fish and shrimp.

Bacteria and algae are essential in the aquaculture water ecosystem. Probiotics and fertilisers can help growth of beneficial bacteria and algae and rebuild the broken ecosystem after the rains. Sometimes, we may face sudden outbreaks of pathogens after the rains. Disinfection can control some common pathogens, such as harmful bacteria and viruses and pesticides can kill some harmful parasites to restore the water ecosystem.

However, besides taking good care of pond water and aquatic animals, fish farmers should safeguard the pond structure, power supply and human safety to carry out sustainable farming practices.

Although heavy rainfalls can be detrimental to fish farming, we can protect aquatic animals from diseases and mortality with the proper preventive measures and treatments combined with a good understanding of the effects of rains in aquaculture. The China-ASEAN Fisheries Resources Conservation and Exploitation Fund is supporting more research on the impact of extreme rainfall on aquaculture and its prevention to achieve sustainable aquaculture.



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Seafood Expo Global 2022

The 28th edition of Seafood Expo Global (SEG) and Seafood Processing Global had a successful debut at its new home, Fira de Barcelona, Barcelona, Spain. It marked a return to face-to-face events for the global seafood industry. Organisers, Diversified Communications group announced the participation of 1,550 exhibiting companies from 76 different countries and estimated that more than 26,630 seafood buyers and suppliers from all around the globe attended the event. There was an absence of participants from China because of the country's strict quarantine rules, but buyers and other industry professionals visiting from all around the world surpassed 2019 figures.

SEG was held over three days (April 26-28) and aside from meeting and networking on the ground floor, the upper levels of the new venue hosted an extensive -more than 20 conference programs- featuring 65 leading international experts. Topics included sustainable seafood and specific

for aquaculture, sustainable feeds, climate change and Environmental, Social and Governance (ESG) which was reported in issue May/June 2022, pages 4-6.

"In a year challenged by geopolitical issues and COVID-19 restrictions, being able to host an event which is 98% of the largest edition ever held is a testimony that the industry was ready to get back together in person," stated Liz Plizga, Group Vice President. "Exhibitors and visitors have expressed their satisfaction with the exhibition space, its services and the city of Barcelona. They also demonstrated the importance of participating in the event to present and source new products and generate new business opportunities."

Next year's edition of Seafood Expo Global/Seafood Processing Global will take place in Barcelona, Spain, April 25 – 27, 2023 at Fira Barcelona Gran Via (www.seafoodexpo.com/global)



The team from PT Delta Marine Indonesia at SEG. The company which started with buying and processing seafood has been expanding its vannamei shrimp farming business in Sumbawa. The latest venture of the farm is using raceways stocking 150PL/m².



Consultant based in France, Herve Lucien-Brun (middle) and the team at Cap La Pérouse and Sopac SA booth. Sopac was founded in 1984 by hatcheries and distributors to guarantee the quality of the New Caledonian shrimp. The Cristal Blue brand is blue shrimp *Litopenaeus stylirostris*, farmed extensively. The company compares its production to that of grand cru wine. Aquaculture is the largest food export for New Caledonia.

Certifying safe and responsible aquaculture

GLOBALG.A.P. held its annual conference on April 27 during Seafood Expo Global (SEG) in Barcelona on April 27. The team, led by Managing Director Dr Kristian Moeller, provided updates on the new and revised aquaculture certification as well as the expansion of the consumer facing GGN label at international level. Also present was Chair of the Aquaculture Technical Committee Teresa Fernández, Advisory Board member and CLAMA GmbH & Co. KG CEO Martin Hofstede and representatives from retailers across the sector.

IFA revision

The Seafood Expo Global event coincided with the much-anticipated launch of Integrated Farm Assurance (IFA) version 6, the updated standard. The certification solutions for the aquaculture sector support optimal operations throughout the entire production chain for maximum transparency and product integrity. From compound feed, broodstock, and hatchery through to grow out, harvesting and transportation, producers



The panel at the news conference. Standing is Remko Oosterveld, GGN Label Aquaculture Commercial Manager.

gain a complete primary production tool under one standard that considers environmental sustainability, animal health and welfare and workers' well-being while simultaneously increasing market recognition.

Moeller said that from producers to suppliers and retailers, this revision and overall upgrade of IFA v6 is a collaborative project of all stakeholders and partners concerned with responsible farming practices. The result of this collaboration is a smarter standard that takes a holistic approach through the key topics of food safety, animal welfare, environmental sustainability and biodiversity, workers' well-being, production processes, and traceability.

IFA v6 for aquaculture builds on previous success, with IFA v5 being the only aquaculture certification standard recognised by GFSI (Global Food Safety Initiative) at the primary production level, and the only aquaculture certification standard recognised by GSSI (Global Sustainability Seafood Initiative) for all species of finfish, crustaceans, molluscs, and seaweed. GLOBALG.A.P. certified production processes produced over 2.5 million tonnes of farmed seafood for the world market in 2021 – a 23% increase since 2019.

Fernández said that there has been a series of webinars to communicate on IFA v6. There are some hotspots including environmental sustainability, water quality, animal welfare such as ablation in shrimp breeding. The latter is not often discussed publicly but work is in progress to communicate to industry, particularly in Asia. In Latin America, some hatcheries already practice non-ablation.

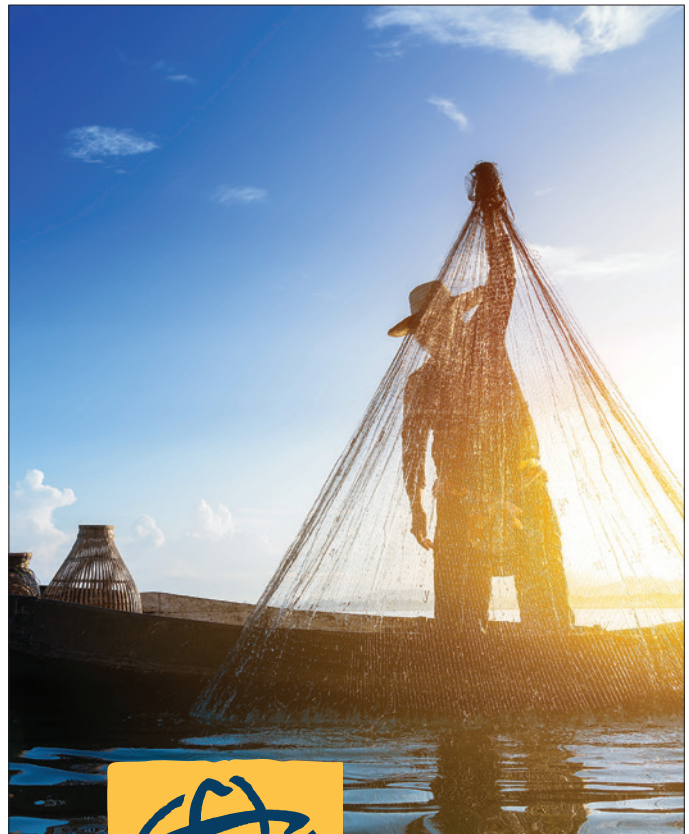
Spotlight on sustainable sourcing

SEG is the first trade fair since the launch of the revised Compound Feed Manufacturing (CFM) standard version 3 in December 2021. This aquaculture certification system covers the full production chain. Aquaculture farms shall only use feed originating from certified production processes. The new version covers the increased demand for sourcing raw materials responsibly, with a focus on fish meal, fish oil, soy, and palm oil sourcing. According to GSSI, 60% of marine ingredients should be certified by Marin Trust.

Addressing rising consumer concerns regarding animal health and welfare as well as the origins and suitability of raw materials used in compound feed, the CFM v3 standard introduces additional criteria in the areas of environmental protection and the responsible sourcing of feed ingredients. With feed mills producing over 23 million tonnes of compound feed annually using GLOBALG.A.P. CFM certified production processes, version 3 of the standard represents an important benchmark in feed and food safety throughout the aquaculture supply chain.

New GGN label sees international acceptance

This event provided an opportunity to highlight the success of the cross-category GGN label since its launch in April 2021 (Aquaculture label launched in 2016). The GGN label confirms that the products were farmed in line with responsible farming practices that cover food safety, environmental protection, animal welfare, social responsibility and supply chain transparency. Since the initial roll out, the GGN label has been experiencing increasing acceptance in the sector for its mission to "make responsible farming visible to consumers" and has been adopted across multiple product categories in both Europe and North America.



**Our new consumer label
is here to make
responsible farming
visible.**

Find out more at
www.globalgap.org/ggnlabel



INFOFISH Shrimp 2022: Recovery through resilience and innovation

Shrimp 2022 was the 6th INFOFISH world trade conference and exhibition, a hybrid conference held in Putrajaya, Malaysia, from June 8-10. The event organised by the Malaysian-based Infofish (www.infofish.org), had 249 participants, both virtual and in-person, with 35 speakers and 33 exhibitors (14 physical and 19 virtual) from 33 countries. It was jointly hosted by Malaysia's Fisheries Development Authority, the Network of Aquaculture Centres in the Asia Pacific (NACA) and China's Aquatic Products Processing and Marketing Alliance (CAPPMA). The conference chair was Jose Antonio Camposano, Executive President, National Chamber of Aquaculture, Ecuador. Shrimp 2022 focused on "Recovery through resilience and innovation", reflecting the difficult challenges for the global shrimp industry over the pandemic years (2020-2021).

The keynote address by FAO's **Dr Audun Lem**, Deputy Director, Fisheries Division was on "Resilience, Innovation and resurgence in the global shrimp industry: What is next." The major challenges are rising production costs – soy prices have risen by 20% and energy costs are soaring. High freight costs continue to be a reality for exporters. Although much lower than before, they remained high due to the low availability of cargo space. The reopening of the Chinese economy and surging oil prices could raise costs again.

In 2022, Lem expected demand for shrimp products to go up with easing of restrictions in the food service segments, although major markets predict lower growth rates. Inflation is reducing consumers' income. However, the long perspective is positive, with strong underlying demand, new product forms and a dynamic service sector boosting demand.

The conference had an extensive program which began with a session on production and markets trends (pages 16-19), followed by sessions covering technology for intensification of culture, innovations for high productivity, aquafeed and nutrition, sustainability



Steven Goh (left) and Mathew Clark, Delst Asia. Goh discussed forensic feed science to address issues with gelatinisation in feed pellets.

and social accountability, partnerships and investments and challenges over these pandemic years.

Technologies for higher productivity

In improving cost efficiency, **Manoj M Sharma**, Mayank Aquaculture, India, described the complex that he has built up with indoor facilities for a hatchery and nursery in Gujarat. With this multiphase farming, the cost of production for sizes 30-40/kg over 70-80 days was USD3.55/kg versus USD4.25/kg in a regular culture model. The cost difference was due to lower costs of feed, energy and less use of health products.

Daniel Gruenberg, Aquavative Technologies, Thailand and his team strongly believe in the sustainability of shrimp farming using recirculation aquaculture systems (RAS). He focussed on two lines of development, Super RAS and Phyto RAS. The latter is recommended for producer countries with low market prices, such as Thailand. Phyto RAS has low capital costs due to inexpensive construction. Usually, these are 5-10m wide and 100m long HDPE raceways under greenhouse sheeting. Compared to traditional pond systems, there is superior biosecurity and good water quality. Shrimp get nutrients from bioflocs and pelleted diets, giving better feed conversion ratios (FCRs). Shrimp have dark pigmentation. "Current densities are 3.75kg/m³ and the growth rate is more than 0.5g/day but with current genetics, we may reach 1g/day. We get 25g shrimp in less than 50 days and can do 12 crops/year in two-stage systems. So far, survival rates have been good at >95%."

Benchmark Genetics' **Morten Rye** gave some key trends in shrimp genetics. Selection for disease resistance is becoming important since viral and bacterial diseases have caused extensive losses. But geneticists need to be mindful of new pathogens. He explained how genomics selection is used for developing WSSV-resistant shrimp with a realised response of 14% for WSSV. The next target trait is for AHPND survival. Over the last year, Benchmark is paying attention to animal welfare and that all maturation lines do not use ablation.

Innovations in shrimp farming

Dr Krishna R Salin, Asian Institute of Technology introduced some recent trends. The future for shrimp aquaculture is pathbreaking technologies (IoT, AI and blockchain) to move aquaculture from a traditional system to automation. Innovations already applied are smart sensors and real-time water quality monitoring in fish and shrimp farms.



Malaysian stakeholders attending Shrimp 2022. Tuan Syed Omar (seated left) with Yip Kam Toh (seated right) and the team at Charoen Pokphand Malaysia (From the left, Sean Lai Yoke Wai, Benedict Tan and Weerawut Hiranmateekul).



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Dr Kabir Chowdhury, Jejo Nutrition (right) with Fatima Ferdous and Sujit Krishna Das, Infofish (left).

Making waves in Vietnam is Rynan Technologies with totally digital HDPE shrimp ponds with floating roofs and unique tracking barcodes. **Dr My T Nguyen** showed the integration with AI technology to monitor water quality parameters, shrimp growth, size and health and identify diseases, as well as evaluate the level of *Vibrio* bacteria in the pond. All data is uploaded onto the application, TraceMe. Hardware devices which are monitored via several IoT systems cover a large range, including a smart feeder, water quality sensors (salinity, pH, dissolved oxygen, water levels and alkalinity) and a water circulator. Additional features are a smart ultrasound algae controller and smart LED lighting systems since shrimp grow 15% faster under blue and green LEDs. Rynan also extends its technology to post-harvest processing and value-adding to sales via vending machines and ecommerce.

Singapore-based AquaEasy now supports 3,200 ponds in Vietnam, Singapore and Indonesia said **François Vervial**. It has AI-based biomass prediction using feed company historical data. It also predicts growth trends to identify future problems when the growth deviates from a standard growth curve.

In 2019, Spanish company Marine Instruments entered the aquaculture sector with a smart feeding system with passive acoustics. Successfully installed in several shrimp farms in Ecuador, the sensors are an adaptation of their tuna sonar technology. For shrimp farming, it has been able to remove other noises in the pond. **Jorge Pérez Bouzada** said that output from farms in Ecuador and Mexico showed weekly average growth at +25%, FCR at -20%, survival 65-85% and there was an increased number of harvests. Intangible outputs are from shrimp behaviour and health status.

Blockchain technology in seafood

Blockchain technology is data bundled from farm, harvest, processing, exporting, importing, and distribution to retail. It builds trust, and transfers value and ownership over the production chain. There is a lot of AI in aquaculture and blockchain is used a lot in seafood traceability. **Eric Enno Tamm**, Thisfish, Canada, says to ensure traceability in the shrimp value chain using AI and blockchain is important but there has been little application of AI in seafood processing and supply chain due to limited data.

Alistair Smart, SmartAqua, Australia, discussed the future of seafood logistics and how it needs to go digital. He said, "We cannot achieve whole chain traceability if we cannot identify and verify the legality of goods. Without this, we cannot reward sustainable and responsible production." This requires tracing the shrimp at each segment in the production chain and Smart discussed a case study with Indonesian black tiger shrimp, farmed and from wild fisheries.

Chuck Anderson from Certified Quality introduced an interesting innovation using Bioelectrical Impedance Analysis (BIA) Electrical currents that are passed through the product providing a cellular quality view. This measures seafood quality with non-invasive body composition. It identifies water soaking and quality. He said that the benefits of soaking fresh shrimp prior to peeling are minimal after 4 to 8 hours, whereas water pickup and yield continue to increase for 20 to 24 hours. This innovation is an effective method for identifying soaked shrimp and the approximate water pickup.

Advancing feeds and nutrition

Since February 2022, with the Russia-Ukraine war, feed ingredient prices have escalated; wheat prices have increased by 39% and corn prices by 16%. However, energy costs have increased by 25%. These put pressure on aquafeed producers, said **Dr Kabir Chowdhury**, Jejo Nutrition. For a typical shrimp feed formulation, the cost increase is 53%. As he explored the use of several local and new raw materials, Chowdhury stressed how critical it is to move to precision nutrition with digestible nutrients. To increase feed efficacy, enzymes are highly effective biological catalysts, capable of accelerating chemical reactions.



William Kramer, Philippines (third left) with the team at the Star Feedmills booth.

Feed processing plays a pivotal role in feed quality and **Steven Goh**, Delst Asia wants to bring feed processing to a new level. However well a feed is formulated, it can easily be destroyed by poor feed processing. "Managing processing and solving problems can be through feed imaging where we observe chemistry changes to starch and protein during cooking. In shrimp feed, imaging has shown areas of concern and linking the many problems on growth performance and diseases observed at the farm level. This begs the question, is the root cause a poorly processed feed?" According to Goh, in the pelleting process, there is the chemical transformation of starch and protein. When starch is uncooked, it affects pellet quality, nutritional value and water stability. Goh showed some feed samples with poor starch gelatinisation and in contrast, examples of improved pellet quality with the inclusion of the DMX-7 compound.

Blue Food Innovation Summit

The inaugural Blue Food Innovation Summit went live in London on June 14-15. This is a new chapter from the hosts of World Agri-Tech, Future Food-Tech and Animal Ag-Tech, to catalyse innovation and investment in aquaculture. It was also live streamed to a global audience.

The keynote speech by Professor Manuel Barange, Director of Fisheries and Aquaculture Division, FAO on "Realising the full potential of the blue food economy" set the scene for two days of collaborative discussion and networking to accelerate technologies in sustainable aquaculture and ocean health. Barange shared, "As we move towards a world of 10 billion people, aquatic foods are progressively under the spotlight. Transforming the aquatic food sector, from expanding aquaculture, improving capture fisheries and developing fish value chains is increasingly crucial to reduce growing poverty and hunger around the world."

Through plenary discussions, start-up showcases, fireside chats and 1-1 networking, the summit's conversations looked across species and areas on how to create more circular systems and reduce the carbon footprint of aquatic foods, whilst increasing health, welfare and yield.

Future production systems

Recirculating Aquaculture System (RAS) technology is making waves worldwide. **AquaMaof** systems can be set up close to markets and reduce carbon footprint emissions and during these times when freight costs have skyrocketed, they answer transportation woes. Yoav Dagan, Partner and VP of Business Development said its land-based RAS technology has created a unique ecosystem for some species. Its technology facilitates sustainable RAS production free from extreme climatic fluctuations, and enables the production of a healthy, fresh, and nutritious product all year round, ensuring food safety. The module is flexible and efficient with regards to design etc. Dagan said that it is not enough to have a good technology; what is important is its execution. He provided some project IRR of 15-25% in his presentation as well as minimum tonnages of salmon and kingfish.

Singapore's **Vertical Oceans** CEO, John Diener described his multitrophic recirculating system for shrimp in a tall building. Able to be in any city, Vertical Oceans grows sustainable shrimp in large "aqua towers", which can be located inside cities, potentially in facilities that even look like buildings. The towers can culture shrimp all year round without chemicals or antibiotics. "We use a multitrophic recirculating aquaculture system for shrimp and we are developing our own feed. Fundamental is the management of the microbial communities. Sensors feed information into adaptive algorithms for various devices like pulse feeding. We generate a lot of data."

"The shrimp grow in half the time as compared to pond culture, with improved feed conversion ratios and production of a great tasting shrimp," said Diener. In its downtown facility, within 4-6 hours, shrimp can be delivered to customers. Vertical Oceans markets fresh premium products. With vertical systems, Diener said there is a gain in manpower and energy. A 1,000



John Diener says that Vertical Oceans' multitrophic recirculating system produces shrimp in half the time as compared to pond culture.

tonnes/year production unit can have a small footprint of 3000m² of land.

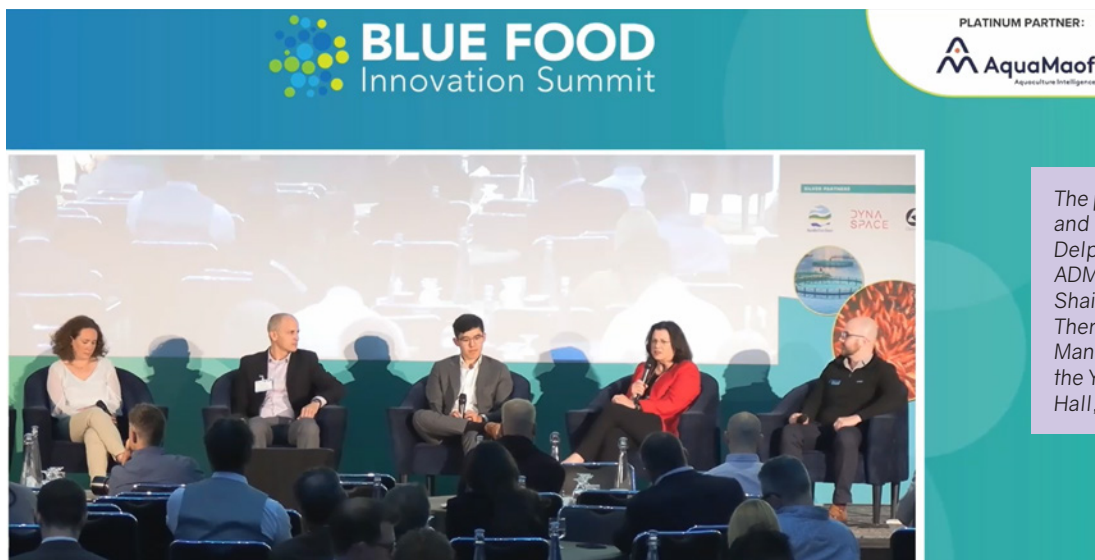
Innovators in aquaculture

The summit presented 23 innovators from across the globe, pioneering breakthrough technologies in aquaculture and blue food, and seeking opportunities to scale through partnerships and investments. Over two days of panel discussions and innovation showcases, these entrepreneurs at the cutting edge of innovation showcased their ground-breaking solutions. Some innovators in aquaculture are featured below.

Founded in 2020, **Sea Green** is a Singapore based start-up seeking to solve the connectivity gaps in the blue economy. It uses blockchain technology to deliver connectivity and services to the seaweed industry, maximising financial service integration for smallholders and harnessing data to drive research into the potential of macroalgae. "We have developed an app for the seaweed farming industry in Indonesia where there are 265,000 small farmers," said Fred Puckle Hobbs, COO. The target is to reach 20,000 of them in the next five years.

Through biotechnology, **TeOra** designs proprietary peptides for immunostimulation and disease prevention. The startup is initially targeting white spot syndrome virus (WSSV) prevention in shrimp with its Shrimpguard. It has designed the delivery of oral vaccines via encapsulation. In trials, survival rate of shrimp fed the oral vaccine was 83% as compared to 2% in the control treatment. Rishita Changede, CEO said that TeOra is making progress with signed MOUs with customers and feed distributors in India and Indonesia for commercial scale trials. Next it will target the fish aquaculture market with Fishguard.

Singapore based **Luminis** Water Technologies provides proprietary water sampling and analysis equipment, molecular diagnostics, rapid in-the-field pathogen ID, and advanced AI microbiome analytics. In her presentation, Rachelle Jensen, Business Development said that the aquaculture industry is a target for its microbiome analytics. Marine microbiome is highly complex and can easily fall out of balance leading to disease and water quality issues. She showed the microbiome biodiversity of probiotics, algae and pathogens. The company has the support of Oxford Nanopore and is fully operational with a DNA sequencing laboratory.



The panel on Fish Health and Welfare, from left: Delphine Weissman, ADM Animal Nutrition; Shai Ufaz, ViAqua Therapeutics; Tony Chen, Manolin; Claire Pribula, the Yield Lab; and Evan Hall, Wittaya Aqua.

Founded and headquartered in Norway, **Dynaspace** is an award-winning startup advancing the transparency of farmed seafood through satellite observations and a cloud-based dashboard. It gives updated information to enable data-driven decision making and transparency in aquaculture. CEO and Co-Founder, Hogne Anderson, shared details on application of the technology. In Ecuador it works with feed company Cargill and tracks the activities of Ecuadorian shrimp farms covering 200,000ha on a weekly basis. It gives insights into the pond cycle and other activities, allowing Cargill to innovate products for the industry.

Sustainable aquafeeds

In the panel on Sustainable aquafeed: Scaling alternatives and novel feed ingredients, discussion was on the roles of novel feed ingredients as sustainable and viable feed alternatives. Fernando Norambuena, Biomar said that today with modern aquaculture, it is not replacing raw materials but looking at the economic and biological value of the nutrients before adding into the feed formulation. A novel ingredient is single cell protein. The target by Biomar by 2030, is to reduce 30% of the carbon footprint and have 50% of circular ingredients into feeds. For retailer The Co-Op, Aisla Jones said that sustainability is becoming important, and it would like all feed ingredients to demonstrate that they can be sustainable.

Chloé Phan Van Phi from insect meal producer, Innovafeed said that it is not just sustainability, but to demonstrate zootechnical performance of feeds containing the insect meal, health and organoleptic benefits. Scalability is often discussed, and Phan said that scale is coming up, such as at Innovafeed with two facilities meeting the target of 15,000 tonnes/year. "Scale is also coming up at Unibio but large feedmillers require large volumes," said David Henstrom. The ingredient also needs to be fit for purpose. Norambuena said cost effectiveness of the novel ingredient is a big issue. There is a need to be competitive and the feed miller will collaborate with producers, to ensure feed performance and find common targets. There may be increases in costs with using novel ingredients, but will consumers be willing to pay more for sustainability? There are some good examples in France where consumers

were willing to pay more but Jones, said that broadly the ingredients need to be competitive.

Fish Health and Welfare

The panel on Fish Health and Welfare: Tackling disease through vaccines, feed additives and fortification had Claire Pribula, the Yield Lab leading discussions on how to innovate for prevention rather than curative health solutions. There are two innovative companies involved in aquaculture health. ViAqua Therapeutics, represented by Shai Ufaz, offers effective, specific, and affordable health management through its orally administered particle-based platform for the delivery of RNA to improve resistance against diseases of shrimp and other aquaculture species. It uses encapsulation technology to protect the RNA during the extrusion process. The first product is against WSSV, and it is collaborating with feed companies, Thai Union and Skretting.

Tony Chen is founder of Manolin which has a prediction platform that scans hundreds of millions of industry data points every 15 minutes, predicting early onsite of disease with 93% accuracy and alerting farmers when there is any abnormality. He said that their predictive model is across species, and they are also looking at shrimp farms by collecting lots of data. Evan Hall is from Wittaya Aqua, which helps aquaculture professionals manage their feed ingredient data in a single location to gain insights into ingredient sourcing, raw material management, feed formulation, and market entry. Evan said that feed millers can produce feeds, but they need the farmers to give them information on feed performance. Merck's Kasha Cox said that they have holistic solutions for producers. In the hatchery space, it has acquired VAKI which has the sealice camera, a real-time video monitoring technology to advance fish health and welfare.

On where the industry is at present, the panel had diverse opinions. Delphine Weissman, ADM Animal Nutrition, said that the technology is here and available, but it is important to be able to anticipate and adapt. Chen said that in animal health we have not made progress as large companies do not buy functional feed. It is also complicated with many species and culture systems, but nevertheless there has been progress with many solutions.

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SPACE 2022 will be held from 13-15 September at the Rennes Exhibition Centre, France



Annually, SPACE, the international livestock trade exhibition is held in the Rennes Exhibition Centre. However, hit by the Covid 19 pandemic for the past two years, in-person visits to the Expo were cancelled in 2020, only to return in 2021 under conditions adapted to health safety measures. There is Innov'Space which rewards the latest innovations in the livestock sector.

Year 2022 will be its 35th anniversary and SPACE has ambitions to make its 2022 edition stronger than ever. It looks to engage in the challenges of livestock farmers, bring together all the different animal production sectors in a forward-looking approach, and, thanks to state-of-the-art developments and innovations presented by the exhibitors, show visitors what the livestock industry is really about today. This is an industry undergoing continuous shifts as it pays close attention to consumers, adapt to meet societal demands both in terms of rearing practices and their impact on global climate.

In 2022, these challenges are rendered even more complex by the conflict in Ukraine, alarming climate conditions due to drought, the avian influenza crisis, the soaring costs of raw materials and the rising costs of energy, fertilisers and feed. Within this unstable overall climate, food sovereignty has become a major concern. During the Covid pandemic, players in the agricultural sector demonstrated their strength by making sure the food supply chain continued to function for the country's population.

Currently, farmers are again faced with numerous challenges as certain areas of the world are confronted with the risk of famine and shortages. The FARM initiative supported by the European Union and France is a response to the food security challenge at hand. Its goal is to encourage the agricultural sector to produce enough to sustain trade relations and emergency food assistance in the coming weeks, without losing sight as local food production is a priority.

As of May 18, organisers announced that there will be 1060 exhibitors, comprising 318 exhibitors from 37 countries. Some 185 are new exhibitors.

Aquaculture at SPACE

SPACE has been hosting conferences on aquaculture for several years. On the strength of this initial success, SPACE now plans aquaculture to be key for French and international businesses in this fast-growing sector. Each year, more than 80 businesses from the aquaculture sector come to exhibit at SPACE, including those working in animal feed and nutrition, farming equipment, consulting, research, genetics, etc. This booming sector attracts the attention of SPACE visitors: 26% of French visitors and 50% of international visitors have an interest in aquaculture (source: ADQuation 2019). Some 10% of the international visitors in 2021 had jobs in this sector.

Aquaculture is the fastest growing animal production sector in recent years. While the bulk of shrimp and fish farming is based in Asia, it is also developing in all other global regions. Global aquaculture produces about 80 million tonnes of animals and 30 million tonnes of plants each year. There are also areas where the sector posts over 10% growth, particularly in Africa, where the potential remains largely under-exploited.

The volumes produced by aquaculture are expected to continue to grow in the coming years, and it is estimated that farmed fish will represent a higher volume than capture fisheries. With this in mind, SPACE has developed some activities to showcase the aquaculture sector:

- itinerary guide for visitors.
- visual identification of those stands offering relevant solutions.
- two conferences (each lasting a half day) scheduled on September 13. To reach a wide audience, one will be in French and the other in English. www.space.fr



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Benchmark Genetics strengthens its commercial and technical team in India

Balachandar Jayaraman has been appointed as Sales Technical Manager responsible for sales and technical support in India and neighbouring countries. Coming from The Waterbase Limited before joining Benchmark, Balachandar or Bala has held several positions of responsibility in commercial coordination and technical functions.



Balachandar has a vast commercial and technical network, built through his over 28 years of experience in the shrimp culture business in India, Bangladesh, Vietnam and Malaysia. His experience, along with his expertise in shrimp larviculture, maturation, nursery, grow out and broodstock multiplication operations will be used to best serve the interests and needs of Benchmark's current and future customers.

Balachandar holds a Bachelor of Biology degree, Master of Business Administration specialising in Project Management, a Diploma in Aquaculture and Post Graduate Diploma in Marine Microbial Technology (India). Balachandar will report to Bruno Decock, Operations Manager of Benchmark's Shrimp breeding program in Asia in his new position.

"With the emergence of new challenges in Aquaculture, the solution must come from genetics, nutrition and environment. Breeding with genomic precision, providing advanced nutrition and environmentally friendly health products, sets us apart and I am proud

to be part of this team that sets new benchmarks for the industry", said Balachandar

"We are very happy to welcome Balachandar to the team" said Oscar Hennig, Operations Director of Benchmark Genetics Shrimp. "We are convinced that Bala's knowledge, expertise and skills, both in the commercial and technical field, will contribute to the success of Benchmark and its customers in the region." www.bmkgenetics.com

NEXT ISSUES

September/October 2022

Issue focus: Aquaculture Innovations

Industry Review: Marine Shrimp

Feed/Production Technology: Novel Ingredients/
Feed Management

November/December 2022

Issue focus: Health & Disease Management

Industry Review: Catfish & Freshwater Fish

Feed/Production Technology: Feed Enzymes/
Post Pellet Applications/Post Harvest

Deadlines: Articles - September 13/Adverts - September 23

Show preview: *World Aquaculture 2022 Singapore,
November 29 - December 2

More information:

zuridah@aquaaasiapac.com

enquiries@aquaaasiapac.com



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					
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For more info on the TRADESHOW: mario@marevent.com





The **World Aquaculture Society (WAS)** has announced the following.

Singapore has fully reopened to travellers and events operate at full scale. As a result, WAS and the Steering Committee of World Aquaculture Singapore 2022 are happy to announce that the preparations for the upcoming WAS event in Singapore which will be held during **November 29 to December 2, 2022** at **Singapore EXPO Convention and Exhibition Centre & Max Atria** are going extremely well.

WAS is honoured to welcome Ms Grace Fu, Minister for Sustainability, and the Environment, to open the conference and trade show on November 30, 2022. The grand opening will also feature Dr Matthias Halwart from the Food and Agriculture Organisation of the United Nations (FAO) who will present an overview of aquaculture roles in food security.

To date, more than 200 booths slots for the tradeshow have been booked and hundreds of papers have already been submitted. The conference will feature many world-class speakers and delegates from around the globe sharing their knowledge on the science, technology, business, and social aspects of aquaculture. Considering the range of facilities, there are no limits to the size of the event and we expect therefore that #WASingapore event at the crossroads of Asia to be the biggest opportunity for all to reconvene.

New delegates register every day, benefitting from the early bird discounts. It is advised to start planning early your trip to Singapore to benefit from the best travel and accommodation rates, but registrations will be possible up to the end of the event. The steering committee is now coordinating side events for visitors, industry visits and activities for students, supporting the consolidation of knowledge and the development of the industry during this 4-day event.

More information: www.was.org

Email: worldaqua@was.org;

Booths and Sponsors, email: mario@marevent.com (Mario Stael); WAS-APC Chapter secretariat executive officer, email: apcsec@was.org.



Ms Grace Fu,
Minister for Sustainability,
and the Environment will
open WA2022 Singapore



FAO's Dr Matthias Halwart
will present an overview of
aquaculture roles in food
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August 22-26

9th International Conference on Fisheries and Aquaculture 2022 (ICFA 2022) & 2nd International conference of Politeknik Ahli Usaha Perikanan (AUP)

Jakarta, Indonesia

www.aquaconference.com

August 23-26

11th Symposium on Diseases in Asian Aquaculture (DAA11) Kuching, Malaysia (Virtual)

www.daa11.org

August 24-26

Vietnam Fisheries International Exhibition (Vietfish 2022)

Ho Chi Minh City

www.vietfish.com.vn/en

September 6-8

Global Shrimp Forum
Utrecht, The Netherlands

www.shrimp-forum.com

September 7-9

Nutrition and Health Asia/Victam 2022
Bangkok, Thailand

<https://victamasiam.com/>

September 13-15

SPACE
Rennes, France

www.space.fr

September 27-30

Aquaculture Europe 2022
Rimini, Italy

www.aquaeas.eu

October 6-7

TARS 2022: Aquafeeds
Ho Chi Minh City, Vietnam

www.tarsaquaculture.com

November 9-11

Aquatica Asia
Jakarta- Indonesia

<https://aquaticaasia.com/>

November 29-December 2

World Aquaculture Singapore 2022

www.was.org



2023

February 23 - 26

Aquaculture America
2023

New Orleans, USA

www.was.org

March 8-10

VIV Asia 2023

Bangkok, Thailand

www.vivasia.nl

April 18 - 21

Latin American & Caribbean
Aquaculture 2023

Panama City, Panama

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May 29 - June 1

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