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Aquafeeds in 2020: Prelude to a crisis

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Zuridah Merican

A looming aquafeed crisis?

A quick review of the aquaculture feed industry shows the key drivers in 2019 were farm to fork traceability, non-GMO ingredients and antibiotic free feeds. While 2020 was a bad year due to supply chain disruptions, low prices for aquaculture products and food security, 2021 is looking like a painful year for aquafeed producers. The industry has seen a sharp increase in plant protein meals compounded by high freight costs. With this impending commodities super cycle, how will this affect the feed segment and the industry in general?

At the start of the Asian shrimp feed industry in the early 1980s, fish meal was a major ingredient included at 35% in shrimp feeds. Due to increasing fish meal prices combined with efforts from the American Soybean Association (today USSEC), high protein soybean meal and corn gluten meal managed to partially substitute fish meal while keeping the price of shrimp feeds at an average of USD1.00/kg over the past 40 years. However, soybean meal prices have increased over 50% and corn over 130% since September 2020 knocking over the price stability of all feeds, including those for aquaculture. Taking an example, if an Indonesian shrimp feed formulation done in Aug 2020 is unchanged, the cost of the same formula would have increased by 16% in April 2021.

Should the feed industry revert to fish meal? Peru, a major fish meal producer has announced that the quota for the next fishing season will be maintained and hence fish meal prices is forecasted to remain at USD1,500/tonne in the short term and this price differential makes fish meal attractive for least cost formulation programmes. There is always the question of a "rising tide will lift all boats" so will rising protein meal prices move fish meal in the same direction? Sustainability has become another push for fish meal reduction in feeds driven by the debate that wild fish should be directed for human consumption instead of feeding fish with fish. Fish in-Fish out (FIFO) ratio is the sustainability measure for wild fish used in aquafeeds. FIFO ratios for crustacean feed have been reduced from 0.93 in 2000 to 0.46 in 2015 and ratios for tilapia, from 0.23 in 2000 to 0.15 in 2015 (iffo.com). Therefore, although fish meal utilisation may be driven by attractive prices, it will be challenged by FIFO and sustainability issues.

This situation has opened up opportunities for novel protein ingredients. The examples below are just a flavour of what is available. Single cell proteins produced with methanotroph bacteria may contain 72% crude protein (CP) and offers itself as a credible alternative as a specialty protein component. It can also be manufactured at a large economy of scale using a very small footprint. Black soldier fly larvae meal containing 50% CP using industrial food waste promoting the circular economy can also be produced at scale. Many companies have grown from startups to hundred-million USD investments in just a period of 3 years. With new manufacturing technology, dried distiller's grains (DDG) can now offer up to 50% CP carving out a distinct segment for itself while developing a credible co-product of the ethanol industry.

Marine fish feeds in Asia have a CP level of 42% and with a price around USD1.20/kg will face similar opportunities and threats as the 35% CP shrimp feed. Here, as marine fish feeds are still in the development stage, it is unlikely to be under similar pressure of conforming with FIFO ratio requirements in the short term compared to shrimp feeds. Our first step is to replace trash fish with compound feeds.

The greatest pressure of the increasing cost of protein meals will be seen in freshwater fish feeds. Pangasius feeds have around 26% CP. Feed costs an average USD450/tonne; in Vietnam pangasius feeds comprise four major feed ingredients: cassava meal, rice bran, wheat bran and soybean meal. With no alternatives and margins turning negative, it only leaves the option for a price increase but pangasius ex-farm prices are at an all-time low in Vietnam. Pangasius exports to China have been curtailed in 2020, leading to higher supply and the poor prices will not allow for any increase in feed prices. Farmers are likely to skip cycles in order not to lose money.

There is no doubt that the outlook is challenging but with this change comes opportunity. The COVID-19 pandemic has taught us to think global but act local. This has put not only food security but feed security at the forefront for every nation.

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

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Repositioning Indonesian aquaculture up to 2024

There is a strong drive for seafood products to be one of the top ten exports in Indonesia and to contribute to the national economy. At a growth rate of 2.5% annually, market research indicated that the global seafood market is now at USD159 billion and is poised to rise to USD193 billion by 2027.

In 2019, Indonesia's seafood exports rose to USD4.91 billion and the major markets were the US, China, Japan, ASEAN and EU. To be among the top five global seafood exporters, Indonesia needs to strategize to export more than USD8 billion in value. With aquaculture's growth at 12% annually and fisheries growing at only 4%, the aquaculture sector will have to take the lead to achieve this mandate. In 2020, aquaculture production was 5.53 million tonnes valued at IDR143.9 trillion (USD10 billion). In terms of volume, tilapia was leading at 22%, followed by the *Clarias* catfish, 18%, milkfish, 13% and common carp, 9%. In terms of value, marine shrimp led at 32% of total value, followed by tilapia at 17%.

In March, at the event Fisheries Outlook 2021: Repositioning of Indonesian Aquaculture Products on the World Stage, aquaculture stakeholders discussed the way forward for a successful aquaculture industry in Indonesia. Director General of Aquaculture, Ministry of Marine Affairs and Fisheries (MMAF), Dr Slamet Soebjakto highlighted the strategies to increase aquaculture production and to reposition Indonesia in the global seafood map. MMAF has identified three commodities: shrimp, seaweed and lobster. There are also village level community economic development programs focusing on freshwater and brackish water aquaculture.

Exports led by marine shrimp

Shrimp export in 2019 was 207,703 tonnes valued at USD1.7 billion, rising to 239,230 tonnes valued at USD2.04 billion in 2020. Shrimp takes top position as the commodity with the highest value at 38% of the total seafood export value. Plans are ahead to increase production of farmed shrimp and contribute to seafood exports by 2024.

In 2019, productivity levels were 30 tonnes/ha for intensive culture systems and 10 tonnes/ha for semi-intensive systems. To grow the industry, MMAF looked at how farms areas can shift from semi-intensive to intensive systems and for productivity of intensive systems to increase to 45 tonnes/ha. According to MMAF, only 0.3% of the area under shrimp farming (300,500ha) is under intensive farming. By 2024, it wants to increase this to10%.

The shrimp estate concept is a cluster farming system and will be implemented all over the Archipelago. An example is a 10,000ha shrimp estate with 10 clusters in Aceh province, Sumatra. All facilities from hatchery to cold storage and processing will be available in each cluster. The idea is to raise the productivity of traditional farms with smaller and lined ponds and adapt to new technology and innovations.

Millennial Shrimp Farming

This millennial shrimp farming or MSF concept was developed to nurture farmers who are younger than 30-years old to be future entrepreneurs in vannamei shrimp farming," said Sugeng Raharjo, Head of the Centre for Brackishwater Aquaculture and Fisheries (BBPBAP) in Jepara, central Java. "There is digitalisation of operations using automatic feeders, water quality monitoring systems and aeration from nano bubble and oxygen systems. The diameter of the circular ponds can be from 10m to 40m. We chose circular tanks for uniform aeration as well as for easy sludge removal."

"The concept is moving towards sustainability of business and the environment," said Slamet Soebjakto. "The aim is to get the young generation as professionals in shrimp farming. BBPBAP Jepara has trained 28 degree-holders from reputable universities, all ready to dive into shrimp farming."

Another MSF project is at the Centre for Brackishwater Aquaculture (BPBAP) in Situbondo, East Java with 20 circular ponds of 20m diameter. Stocking density is 250PL/m^2. Nono Hartanto, Centre Head, said that the target production at this MSF is 1.5 tonnes/pond or 30 tonnes/ha/cycle. Each cluster has a sludge treatment unit, a reservoir and a sedimentation pond.

Circular tanks at the Centre for Brackishwater Aquaculture and Fisheries (BBPBAP) in Jepara, Central Java under the Millennial Shrimp Farming program to nurture a new generation of shrimp farmers. Picture credit, Rina Mahdiyu, Technical Support Manager, PT CJ Feed and Livestock Indonesia.

Optimism for Vietnam's pangasius exports

With the gradual recovery from two major export markets, the US and China, the Vietnam Association of Seafood Exporters and Producers (VASEP) has announced in April, that it expects the export value of pangasius to grow in the coming months. In Q1 2021, exports to the US were up by 13.2%; China, up by 5.4% but the largest increase of 104.5% was to the Russian market. Compared to the same period in 2020, pangasius exports to Brazil increased by 13.2%; Colombia, 33.4%, Mexico, 22.7% and the UAE, 35%. Exports of pangasius during this period were pulled down by markets in the EU, ASEAN (especially Thailand and Singapore) where consumption decreased.

Throughout 2020 and in the first 2 months of 2021, due to the pandemic, the supply chain was disrupted, especially with logistics. In 2020, pangasius export was only USD1.49 billion, lower by 25.5% than in 2019. Pangasius exported to main markets is mainly consumed in the horeca segments.

In 2020, with the pandemic severely affecting export demand, ex-farm prices in the Mekong Delta dropped to VND18,500-18,800/kg (June 2020) from VND26,500/kg (March 2019). In December 2020, prices fluctuated to around VND19,000-20,000/kg for grade 1 fish. In April 2021, it was reported that pangasius fish prices in Dong Thap province ranged from VND21,000-21,500/kg, a slight increase of VND1,500/kg over the same period in 2020.

In an analysis on market movements relative to the pandemic, Lê Hằng, Deputy Director of VASEP forecasted that with almost 17% growth in March, the seafood exports in the second quarter will continue to grow 10% to about USD2.1 billion. In 2020, total seafood exports reached USD8.4 billion, down 1.9% from 2019. Farmed seafood (shrimp, pangasius) accounted for 62% at USD5.2 billion.

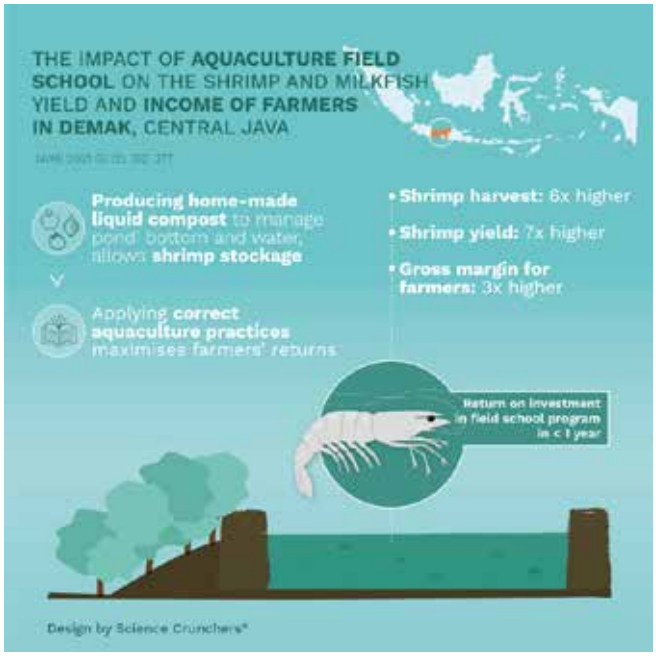
Hang added, "The picture of pangasius exports in the near future depends mainly on the US and Chinese markets. Exports to the EU cannot increase in the second quarter, when the signals of recovery in the food service segment are not clear. The US is increasing imports of Vietnam's pangasius and this trend will continue in the coming months. China's measures to control the spread of the coronavirus will continue to affect frozen seafood imports, especially when the coronavirus is currently booming in Asian countries." (Source: www.vasep.com.vn)

JWAS Editor's Choice Awards for April 2021

The impact of aquaculture field school on the shrimp and milkfish yield and income of farmers in Demak, Central Java

By Widowati LL, Ariyati RW, Rejeki S and Bosma RH

Successful training of traditional farmers to adopt new methods can have rapid and upscalable benefits in many aquaculture contexts. Widowati et al. followed the production performance of a group of 125 traditional milkfish and shrimp farmers in Indonesia following a 16-day aquaculture field training school teaching Low External Input Sustainable Aquaculture (LEISA), during one cropping season. They determined increase in yield of milkfish and shrimp and calculated economic benefits of the training. Adopters of the LEISA practices exhibited a threefold increase in shrimp yield and an increase of nearly USD1,000 per hectare per annum in economic yield. The payback time on investment for the USD1,060 course was less than a year and overall rate of return for adopters surveyed was around 1.8. Results clearly indicate the benefits of low cost training in vastly increasing economic yield to this group of farmers who represent nearly 80% of the production area in Indonesia. By quantifying these benefits the authors clearly show an economic value in training and indicate how overall agriculture productivity can be increased at a national scale through simple and upscalable environmentally beneficial vocational training activities. www.was.org.



Reference: https://doi.org/10.1111/jwas.12770

Changing the farming model

The Gokuldham farm in Gujarat did an infrastructure revamp, involving a four- step water treatment process, frequent sludge removal and a 2-phase nursery system

Nursery ponds and 1.35g juveniles after phase 1 nursery.

Second generation farmer, Hetal Shantila Patel, had specifically equipped himself with a MSC in Aquatic Biology to enhance his skills in aquaculture management and to take over the family's company, Mindhola Foods, LLP which focuses on shrimp farming, trading and an export business. He has been farming for 26 years. However, in 2020, he faced issues with diseases caused by the microsporidian *Enterocytozoon hepatopenaei* (EHP) and white faeces syndrome (WFS); Hetal knew that that he had to change the way of farming vannamei shrimp in his farm.

"We just could not continue in the same way. Creeks were contaminated. We had already added a nursery phase in 2016, but this was just not enough. In 2020 we started a two-phase nursery system at the Gokuldham farm. The idea is to reduce the time in the grow-out phase," said Hetal, during a presentation at the 2-day webinar conducted by the Society of Aquaculture Professionals on "Overcoming the hardships in shrimp farming -Lessons from India" in January 2021.

The company has two farms, one of them is the 170ha Gokuldham farm, which has a total of 220 ponds and production in 2020 was 390 tonnes from 34ha.

New model to improve productivity

Key to this new culture model is the refinement of several shrimp farming principles. Among these are clean and clear water, small ponds for easy management, aeration with long arm aerators at 10HP/10,000kg, recirculation to reduce disease risks and wastewater management. "Sludge removal is based on 2-3 hours/100kg of feed and we exchange water at a rate of 3-4 tonnes. We want to reduce any risk from the external environment and so we decided to recirculate water through our reservoirs."

***Hetal Shantila Patel** started farming in 1994. Faced with issues of diseases, Hetal knew that he had to change the way of farming vannamei shrimp in his farm.*

"Why did I need to restructure my farm? In the Gokuldham farm, in 2016 and 2017, productivity was good. I could harvest 154-159 tonnes from eight ponds at 20-21 tonnes/ha. But in 2018 and 2019, the situation became bad. In 2018, I harvested only 133 tonnes (17 tonnes/ha) and then in 2019, with 11 ponds, I could harvest only 109 tonnes (13.7 tonnes/ha). Feed conversion ratio (FCR) increased over these years from 1.39 to 1.71. Average survival rates were lower at 83% in 2019, from 96% in 2017. Stocking density was a constant 73-78 PL/m^2," explained Hetal.

In 2019, Hetal restructured his farm, comprising eight culture ponds and four nursery ponds. The water area ratio was 70:30 (culture ponds: treatment ponds). But it was not enough, and in 2020, he restructured again, reducing to 40% culture area and 60% water area, i.e. sacrificing culture ponds for water treatment ponds. The previously 1ha ponds with 1.8-2.0m depth were divided into 0.2ha and 1.2-1.4m deep ponds for grow-out and nursery culture.

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Cleaning and recirculating water to reduce risks

Hetal detailed the process of water treatment and how he recirculates the water. "We draw water from the Mindhola River, about 1.5km away. Water passes through a series of sedimentation ponds, then to a sequence of treatment, firstly with 3ppm potassium permanganate (PP), then 10ppm poly aluminium chloride (PAC) and finally 30ppm chlorine treatment. Water is then channelled to the ready to use holding ponds before going to nursery and grow-out ponds. We developed a process of slow and fast mixing of PP and PAC in the treatment ponds.

"We use the same source of water for both the nursery and grow-out phase. All ponds have shrimp toilets, and the sludge is pumped to a sludge pond. Used water is channeled back into our treatment system and we start cleaning the water again. We clean these ponds once fortnightly."

Water quality is critical and after the primary and secondary treatment, water quality improves from the very high 264NTU of creek water to 37.2NTU after the second settlement pond. (NTU= nephlometric turbidity units and is a measure of drinking water quality).

"By the time it is ready to use, we have really clean and clear water at 2.29NTU. As a comparison, drinking water is <1NTU. We started with 70.68 dissolved organic carbon (DOC) in the creek which is really polluted with many mills upstream and end up with DOC 5.58. This is a reduction of 12 times. This is how we have been managing," said Hetal.

Two phase nursery system

Five lined nursery ponds (900m^2) are used for phase 1 stocking at 1,500 PL/m^2 for 30 days to reach 1.35g juveniles. In the next nursery stage, these juveniles are stocked at 500/m^2 into 0.2ha ponds for 29 days to reach 9.1g. Finally, only 120 PL/m^2 are stocked in 23 grow-out ponds of 0.2ha. In both nursery phases, aeration is supplied by blowers and paddlewheels totalling 34HP. Blowers run over 24 hours and paddlewheels for 13 hours.

"In terms of survival, it was high at 91% after the first nursery phase and 89% in the second nursery phase. The average daily growth (ADG) was 0.05g during phase 1 and the cost to produce one 1.35g juvenile was INR1.25 in 2020."

Key lessons

All in all, the new culture model worked well for Hetal. The 2020 cycle took an average of 53 days in the grow-out phase at a stocking density of an average of 123PL/m^2. ADG was 0.42g. Production was 127.6 tonnes (27.7 tonnes/ha). Survival was 78% for 31.3g shrimp and FCR was 1.59. At an ex-farm price of INR369/kg (USD 5/kg), the return on investment (ROI) was 42%.

"This total survival was low and the lesson I learnt was that we need to shift out all juveniles from the nursery after each batch and clean up. In large farms, I recommend batch stocking for an effective utilisation of all facilities, to determine precisely the days of culture for harvesting and not to drag the culture duration.," concluded Hetal.

The different stages in water treatment include, from left, ponds for fast mixing of potassium permanganate and poly aluminium chloride, pipes to move water around for recirculation and right, ready to use water reservoirs.

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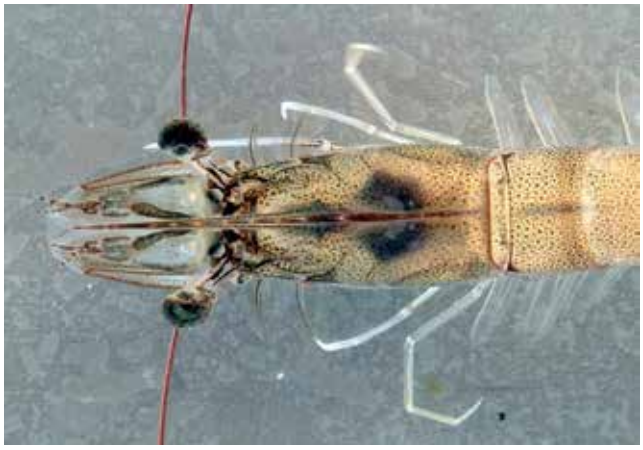
Non-ablation of female *Penaeus vannamei* broodstock improves offspring robustness to AHPND and WSD

This research demonstrates that ablation can also carry hidden negative costs through reduced ability of post larvae and juveniles to survive disease challenges.

By Simão Zacarias, Daniel Fegan, Siriroj Wangsoontorn, Nitrada Yamuen, Tarinee Limakom, Andrew Davie, Stefano Carboni, Matthijs Metselaar, David C. Little and Andrew P. Shinn

Shrimp (Penaeus vannamei) female broodstock

The global shrimp farming industry has been affected by regular outbreaks of diseases, causing catastrophic crop failures with severe financial losses (Shinn et al., 2018b). Acute hepatopancreatic necrosis disease (AHPND), or Early Mortality Syndrome (EMS) as it is more commonly known, the microsporidian *Enterocytozoon hepatopenaei* (EHP) and white spot virus disease (WSD) are the top bacterial, parasitic and viral diseases respectively, impacting whiteleg shrimp *Penaeus vannamei* production (Phuoc et al., 2009; Lightner et al., 2012; Sajali et al., 2019). The collective losses attributed to AHPND alone throughout a number of Asian countries (i.e. China, Malaysia, Thailand,



and Vietnam) and in Mexico across the period of 2009 to 2016 were USD23.58 billion (Shinn et al., 2018b). Since the first report of white spot syndrome virus (WSSV) infection in Taiwan and China in 1992 (Chou et al., 1995), the subsequent losses were estimated by Lightner et al. (2012), up to the point of their report, to be in the order of USD8-15 billion. In the same year, Stentiford et al. (2012) estimated that WSD accounts for an annual loss of almost USD1 billon. Therefore, finding ways to reduce the impacts of diseases and ensure high rates of survival has long been a key industry objective.

Eyestalk ablation of female broodstock remains a standard practice in most hatcheries worldwide but it is increasingly criticised for its impact on welfare, broodstock condition (nutritional and/or physiological status), and on the quality of offspring (e.g., post larvae) produced. The growth performance and final survival of the offspring of non-ablated female (NAF) is not different from those of ablated female (AF), but there is an improvement in their ability to cope with stress measured as survival after a salinity stress test (Zacarias et al., 2019). Salinity stress testing is a common method used by shrimp farmers to check post larvae quality when sourcing. However, this test

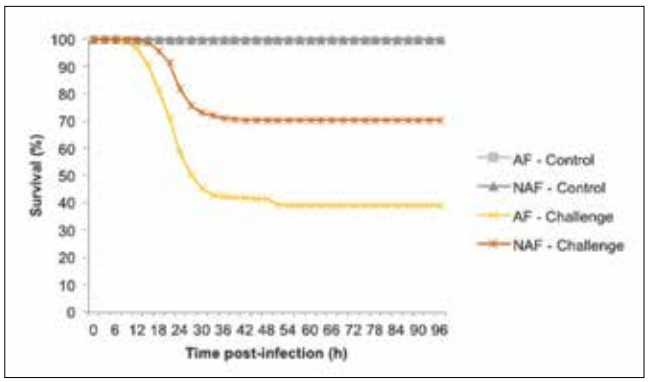


Figure 1. Survival of non-challenged and *Vibrio parahaemolyticus*-challenged *Penaeus vannamei* PL17 post larvae originating from non-ablated female (NAF) and ablated female (AF) broodstock.

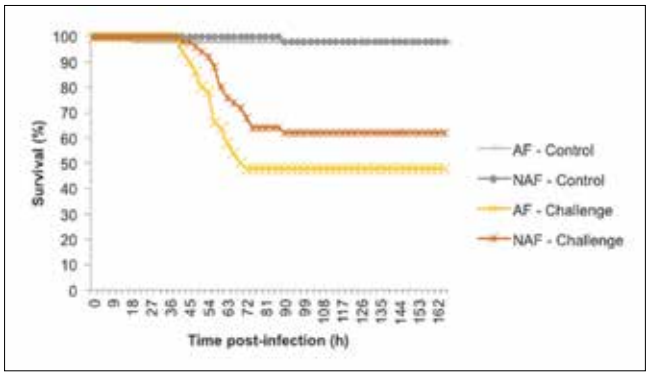


Figure 2. Survival of non-challenged and WSSV-challenged juvenile *Penaeus vannamei* originating from non-ablated female (NAF) and ablated female (AF) broodstock.

mainly relates to the ability of the post larvae to withstand environmental stress and does not give any indication of the shrimp's ability to withstand a disease challenge. Therefore, the objective of this study was to assess the resilience of post larvae and juveniles of *P. vannamei* produced from NAF and AF broodstock following a disease challenge and test the hypothesis that NAF offspring show higher resistance to disease when challenged with *Vibrio parahaemolyticus* (Vp_{AHPND}) and WSSV under controlled experimental conditions.

Study setup

Research trials were conducted in Thailand. Post larvae originating from a single population of *P. vannamei* female broodstock, half of which were ablated and the other half non-ablated, were produced at SyAqua Siam's Sichon hatchery and transferred to Benchmark's R&D (Thailand) for testing. To avoid bias, a double-blind approach was used throughout the trial and subsequent analysis. The ablation status of the females producing each group of post larvae (AF or NAF) was not disclosed by SyAqua Siam until the completion of the challenge trials.

Before starting the trials, a pooled sample of 150 post larvae (taken randomly from the holding tanks) per population (NAF and AF) were screened for seven key shrimp diseases, namely: Vp_{AHPND} by nested PCR; the fungal microsporidian *Enterocytozoon hepatopenaei* (EHP) and WSSV tested for by qPCR using OIE (2019) approved methodologies; for infectious hypodermal and haemotopoietic necrosis virus (IHHNV), infectious myonecrosis virus (IMNV), Taura syndrome virus (TSV) and yellow head virus (YHV) by iiPCR test kits (GeneReach Biotechnology Corporation, Taichung, Taiwan). Both populations were confirmed to be free from all seven diseases.

For the AHPND challenge tests, groups of post larvae (100 individuals; average weight 14mg) from either AF or NAF were placed in tanks (20L). Five replicates were stocked per condition (ablated or non-ablated) and water maintained at 15ppt and 29.05 ± 0.13°C. Challenge populations were exposed to 2.0 × 10^8 CFU/mL of a pathogenic isolate of Vp_{AHPND}. The control populations were not exposed to Vp_{AHPND}. Shrimp mortality was checked every 3 hours over the 96-hour post-challenge period.

The WSD challenge tests were carried out with juveniles from either AF or NAF (average weight 1.42 ± 0.07g). They were held individually in 1L vessels (50 replicates per condition). Salinity and temperature were maintained at 15ppt and 26.33 ± 0.73°C, respectively. Oral challenges were done by feeding a 0.1g ration of WSSV infected *P. vannamei* tissue (average 2.02 × 10^9 WSSV per ration) to challenge populations. Control populations were fed a normal diet. The shrimp were monitored every 3 hours to remove any dead or moribund animals over the 162 hours post-challenge period.

Further details relating to the experimental set up and challenges are detailed in Zacarias et al. (2021) https://doi.org/10.1016/j.aquaculture.2020.736033.

Results and discussion

The post larvae challenged with Vp_{AHPND} from AF had significantly (p = <1.3E-36) lower survival (38.8%) than those from NAF (70.4%) (Figure 1). Juveniles originating from NAF also had higher, but not significantly (p>0.05) survival at 62% than those from AF (48%) when challenged with white spot disease (Figure 2).

Shrimp broodstock condition is essential for production of good quality offspring (Racotta et al., 2003). The basis of this can be nutritional (Racotta et al., 2003) and/or physiological (Chamberlain and Lawrence, 1981; Palacios et al., 1999). Theoretically, NAF broodstock should demonstrate a better overall condition than their AF counterparts as the latter has been reported to register physical trauma and stress, physiological imbalance and activation/reduction of immune related genes due to the effect of eyestalk ablation (Sainz-Hernandez et al., 2009; Bae et al., 2013). This will consequently be reflected in the differential quality of their offspring, as clearly demonstrated in the current study where the negative impacts of ablation are carried over affecting the health/fitness of the offspring.

"Shrimp hatcheries adopting a non-ablation based system would produce more robust animals which may command a higher price based on quality and welfare."

Unilateral eyestalk ablation has been used in the industry for decades to ensure a steady supply of nauplii as this practice increases the frequency, productivity and consistency of nauplii production. The practice of ablation, however, has come under increasing scrutiny by retailers and consumers, threatening market access.

This research demonstrates that ablation can also carry hidden negative costs through reduced ability of post larvae and juveniles to survive disease challenges. These costs (and losses) may not be evident until the post larvae are stocked in farms. Hatcheries operating without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ablation may have to stock additional females to compensate although previous tests showed that nauplii production rates could be maintained through improved management and feeding regimes.

This novel work addresses important welfare issues of unilateral eyestalk ablation, antibiotic and chemical usage in shrimp production and in the management and control of shrimp diseases. Offspring from NAF are more resistant to commonly encountered diseases, resulting in higher rates of stock survival and reduced demand for expensive (and often ineffective) treatments. It reduces the probability of financial losses, contributing to the sustainability of the industry and, critically for small scale farmers, ensuring shrimp farming is a viable livelihood option.

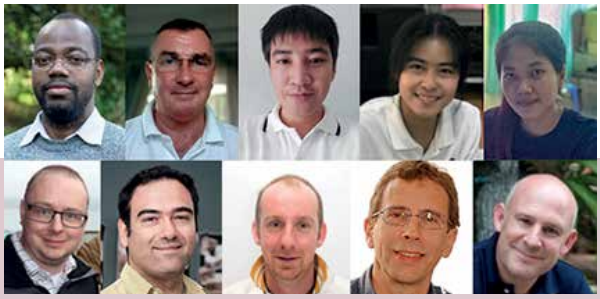
Running a WSSV disease challenge trial by individually challenging shrimp.

Conclusion

This innovative finding can be expected to become an important health strategy in shrimp farming going forward. Shrimp hatcheries adopting a non-ablation strategy would produce more robust animals which may command a higher price based on quality and welfare. Farmers should consider sourcing animals from non-ablated broodstock as part of a holistic biosecurity and management strategy, thus improving productivity during disease outbreaks without resorting to more costly and less effective treatments.

Acknowledgements

The authors would like to thank Labeyrie Fine Foods, Benchmark Animal Health, SyAqua Siam and Global Aquaculture Alliance for playing key roles in this innovative research; and Seajoy Cooke for supporting initial works on shrimp broodstock non-ablation which led to this research.



Top row: Simão Zacarias, Daniel Fegan, Siriroj Wangsoontorn, Nitrada Yamuen, Tarinee Limakom
Second row: Andrew Davie, Stefano Carboni, Matthijs Metselaar, David Little, Andy Shinn.

Simão Zacarias, PhD is currently a postdoctoral researcher at the Institute of Aquaculture, University of Stirling, Scotland, UK. He has been working on welfare practices in shrimp farming. His current research focus is on replacement of eyestalk ablation in commercial shrimp hatcheries. He started this work during his PhD at the University of Stirling and was the 2020 Global Aquaculture Innovation Award winner. Email: simao.zacarias1@stir.ac.uk

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India's farmed shrimp sector in 2020: A White Paper

A summary of the white paper released on February 22, 2021 by the Society of Aquaculture Professionals which outlined actions needed to address the current and future challenges for sustainable growth of the industry to reach a target of 1.4 million tonnes by 2024.

The white paper is the result of virtual meetings held among industry stakeholders on January 29-30, 2021 organised by the Society of Aquaculture Professionals, India (SAP). Farmed shrimp production in India for 2020 had declined by 19% from a record production of nearly 800,000 tonnes in 2019 to about 650,000 tonnes. While the COVID-19 pandemic and related lockdown contributed to the decline, continuing production challenges due to a host of disease problems had impacted production quite significantly.

India's Society of Aquaculture Professional (SAP) is a non-profit, non-government organisation established for and by a group of aquaculture professionals in 2003. It has more than 500 aquaculture professionals as life members.

The mission is to help aquaculture professionals advance the science and practice of aquaculture, by providing opportunities for continuous professional development of individuals. It is the voice of professionals to all stakeholders in the aquaculture industry.

The white paper recommendations include the following actions by stakeholders and government for farmed shrimp production to grow sustainably and achieve the target of 1.4 million tonnes by 2024:

- Resolve shrimp health issues on a priority basis:
  - Continue to fund and strengthen the national aquatic animal disease surveillance program with an exclusive focus on shrimp.
  - Undertake epidemiological and other studies to understand the extent and causes of white faecal disease (WFD), running mortality syndrome (RMS) and other emerging diseases in shrimp farming and to develop treatments.
- Increase carrying capacity of the ecosystems that support shrimp production:
  - Educate farmers on best aquaculture practices to enhance carrying capacity of their production systems and minimise organic loading of effluents.
  - Dredging of creeks supplying water to the farms and take steps to enhance tidal flow to improve water quality.
- Expand and diversify markets:
  - Develop or participate in a global program to promote shrimp consumption in the major overseas markets, especially in the USA.
  - Regain export markets, especially in Europe and Japan.
  - Invest in the "*Made in India Shrimp*" branding.
  - Develop the domestic market.

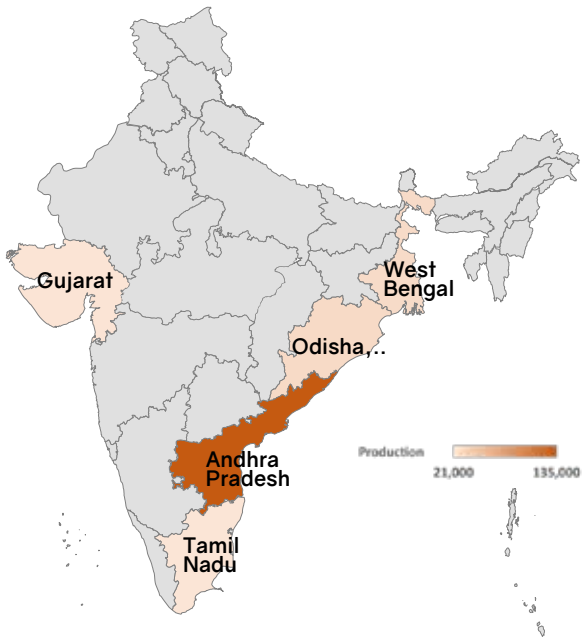
Farmed shrimp production in major regions

SAP's members from the major shrimp farming regions of the country estimated regional production figures as in the table.

Region	Estimated production in 2020 (tonnes)
West Bengal	50,000
Odisha	55,000
Northern Andhra Pradesh (Srikakulam to East Godavari districts)	126,000
West Godavari	135,000
Krishna	70,000
Southern Andhra Pradesh (Guntur to Nellore districts)	106,400
Tamil Nadu	21,000
Gujarat	23,400
Other States*	7,000
Unaccounted**	56,125
Total	650,000

* *Estimates for the states of Kerala, Karnataka, Goa, Maharashtra, Punjab, Haryana and Rajasthan.*

** *Refer to the white paper for explanation.*



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West Bengal and Odisha

Shrinibas Mohanty, Avanti Feeds estimated that West Bengal and Odisha registered a 15-20% decline in production; West Bengal was more impacted than Odisha. Stocking in these states normally start in mid-February and continued till end April. However, during the lockdown and reduced availability of post larvae, most stocking was during May-June 2020. Incidences of white spot syndrome virus (WSSV) was higher and more severe. There was a high incidence of RMS in the second half of the year resulting in lower production.

Andhra Pradesh

V. Punnaivanam, The Waterbase Limited, said that in the northern Andhra Pradesh districts, from Srikakulam to East Godavari, farmed shrimp production declined by about 16% in 2020. Most of the production losses were due to panic harvests during the early stages of lockdown and subsequent disruptions. The region performed better in the last six months of 2020 compared to the first half of the year and the last six months of 2019. *Enterocytozoon hepatopenaei* (EHP) microsporidian spread mostly in low saline areas. However, farmers who invested in infrastructure for improved biosecurity had good results in the control of EHP and WFD, even in high saline ponds. Farmers switched to shorter and more frequent crops. Combined with controlled feeding, this practice reduced the feed conversion ratio (FCR) and production costs.

West Godavari produces the most farmed shrimp, more than any other states, but there was around 20% drop in production in 2020. In the adjoining district of Krishna which also produces large volumes of shrimp, the drop was estimated to be about 10%. Dr Bangaru Ravikumar, Growel Feeds, said that arriving at precise production estimates in both these districts is challenging due to the practice of polyculture of shrimp with fish in low saline ponds. While lockdown was partly to blame for the production losses, other factors were weather related, particularly the premature drop in temperature in the last six months of the year. Associated were increases in incidences of WSSV which also contributed to the production decline. The persistence of EHP and WFD in the two districts was more of a concern than WSSV. While the problems were less in low salinity waters, the practice of multiple crops without draining the water and drying the pond bottom in between crops led to production challenges.

The new hatchery of Vaisakhi Bio-marine Pvt. Ltd in Pondicherry, India. There are more than 500 shrimp hatcheries in India which produced 70 billion post larvae in 2020.

Kumaresan, Sheng Long Bio-tech India Pvt. Ltd. reported that the dry weather over the past years in the southern districts of Andhra Pradesh resulted in poor water quality in creeks and borewells. However, there was good rainfall in 2020 which led to an overall increase in production. Premature harvest prior to the cyclone Nivar and the high incidence of WSSV post-cyclone reduced production to a certain extent in the second crop.

Tamil Nadu

Kumaresan said that Tamil Nadu, with about 2,700ha of production area, had an estimated production increase of 17% in 2020. This was attributed to sufficient rains in the state. Stocking density was higher than the national average; 41-60% of the farms stocked at 40-60 PL/m^2. With lower disease incidences, the state recorded a high productivity close to 4 tonnes/ha/cycle.

Gujarat

Jignesh Contractor, Vaishnavi Aquatech presented data from Gujarat, the major shrimp farming state in the west coast of India. In the past few years, Gujarat's production dropped from its peak of nearly 50,000 tonnes in 2017 to 23,000 tonnes in 2020.

Due to cooler weather, with rains in the middle of the growing season, most farmers only produce one crop a year. Its dependence on post larvae supply from hatcheries in the east coast and the shortage of migrant labour due to the pandemic were some of the reasons for the decline in production. The rapid expansion of farming in the past decade was another reason for the decline. Many farmers have nurseries and some of them are successful.

The introduction of disease resistant lines in 2020 helped in crop management amidst disease outbreaks. Black tiger shrimp is always favoured in the state since production is restricted to one crop a year. Jignesh predicted that the availability of specific pathogen free (SPF) black tiger shrimp in 2021 will result in large scale trials, but farmers would still prefer to go for shorter crops of 110-120 days to minimise their risk.

Production factors in 2020

A survey of regional trends in production by contributors of the 2020 review revealed the following:

- Stocking density in most regions was mainly in the 20-40 PL/m^2 range. Only in the southern districts of Andhra Pradesh and in the states of West Bengal and Tamil Nadu, it was in the 41-60PL/m^2 range.
- Crop durations were shortened to 110 days and even 90 days in most production regions. Wherever feasible, farmers did three crops a year or even four crops.
- Most production were for size 10-16g (61-100 count) while West Bengal and Odisha produced primarily 16-25g shrimp (41-60 count) and Gujarat targeted production of 25-33g shrimp (31-40 count).

In Andhra Pradesh, farmers investing in infrastructure for improved biosecurity had good results in the control of EHP as well as white feces disease (WFD). Photo credit: Ramesh Arji, Growel Feeds

- All regions reported that diseases are the most challenging during production. Less than 25% of production losses were due to diseases, said respondents from West Bengal, Odisha, Southern Andhra Pradesh and Tamil Nadu. Respondents from Gujarat, Northern Andhra Pradesh, West Godavari and Krishna said that 25-50% of production losses were due to diseases. WSSV was considered the most problematic, while EHP and WFD were ranked to be #2 and #3 concerns by those in Andhra Pradesh and Tamil Nadu. RMS was ranked to be the #2 concern in West Bengal and Odisha where EHP was ranked to be the #4 concern.
- Lockdown and farmgate prices of shrimp were flagged to be the most challenging aspects of production in 2020 by 75% of the respondents.
- Cost of production was considered as a key constraint by 50% of respondents. Those in West Godavari, Southern Andhra Pradesh, Tamil Nadu and Gujarat said that cost of production was a challenge.
- Availability of credit was identified as a major challenge by respondents from Gujarat, West Bengal and Odisha.
- Respondents predicted that West Bengal, Odisha, Northern and Southern Andhra Pradesh and Tamil Nadu may produce more shrimp in 2021 as compared to 2020. West Godavari may maintain production as in 2020 and Gujarat may register a further decline in 2021.

Sectorial assessments

Hatchery

Ravi Kumar Yellanki, Vaisakhi Bio-marine Pvt. Ltd. and Vaisakhi Bio-Resources Pvt. Ltd, said that the more than 500 shrimp hatcheries in India produced 70 billion post larvae in 2020 despite the lockdown causing disruptions in the import of broodstock and vital supplies such as bloodworms. About 70 large hatcheries accounted for about 57% of the production. The sector imported 252,000 broodstock in 2020. Less shrimp production in 2020 brought down the shrimp productivity index (tonnes/million PL), from 11.18 in 2019 to 9.28 in 2020 and is a cause for concern. In 2021, he expects the hatchery sector to produce around the same quantity of post larvae as in 2020 and post larvae prices to be stable but remain low.

***Ravi Kumar Yellanki** expects the 2021 production of post larvae to be at 70 billion as in 2020, and post larvae prices to be stable but remain low.*

***Jignesh Contractor** said that in Gujarat, the introduction of disease resistant lines in 2020 helped in crop management amidst disease outbreaks.*

***Dr Bangaru Ravikumar,** Growel Feeds, said that in West Godavari and Krishnan districts, while lockdown was partly t o blame for the production losses, other factors were weather related and increases in outbreaks of WSSV.*

Shrimp health management

Dr Shankar Alavandi, Central Institute of Brackishwater Aquaculture (CIBA) said that disease surveillance by CIBA indicated a rise in non-infectious diseases like WFD and RMS in farmed shrimp in 2020. CIBA estimated that EHP and WFD caused losses of around INR4,000 crores (USD551 million) and INR1,700 crores (USD234 million), respectively.

Dr A.S. Shahul Hameed at the OIE Reference Lab, Abdul Hakeem College said that the new strain of WSSV discovered in 2015 appears to be unique to India. It has a short replication time and therefore is highly virulent. D. Ramraj, President of the All India Shrimp Hatchery Association (AISHA) drew attention to the increasing occurrence of shrimp showing necrotic muscle tissues. He also expressed concern about the emergence of slow growth in many farming areas and asked that farmers go back to basics like pond preparation. He asked the government to facilitate SPF polychaete production to improve biosecurity in hatcheries.

Bangaru Ravikumar shared data from the shrimp samples submitted to his company's diagnostic labs. Incidence of EHP has been rising in the last three years while WSSV has been in retreat in the West Godavari and Krishna districts. Data on disease occurrences in southern Andhra Pradesh shared by Dr Patchala Srinivas of Avanti Feeds showed an increasing occurrence of white muscle disease.

Shrimp processing and exports

A panel with the participation of the Marine Products Export Development Authority (MPEDA), Seafood Exporters Association of India (SEAI), exporters and processors as well as SAP members addressed concerns on the competitiveness of India's shrimp exports.

Nitin Awasthi, East India Securities highlighted India's over dependence on the US market. Elias Sait, Secretary General of the Seafood Exporters Association of India (SEAI), was optimistic on the outlook for India's export market although in 2020 the export sector had to tackle several challenges such as migrant labour crisis, shortages in the availability of containers and reduced access to the Chinese market. In his opinion, Ravi Kumar Yellanki said that Ecuador is not well placed to supply the US market because the country's high labour cost does not allow it to be cost effective at value addition.

Checking shrimp health. Photo credit: Ramesh Arji, Growel Feeds.

MPEDA is implementing the National Residue Control Programme (NRCP) and monitors antibiotic residues in over 7,000 samples collected across the farmed shrimp value chain from hatchery, farm, feed and processing units. Anil Kumar, MPEDA, said Japan has removed the antibiotic testing for the export of black tiger shrimp from India. However, the requirement of many markets for frozen shrimp to be free of WSSV and other OIE listed diseases is emerging as a new market access challenge.

The complete report-India's Farmed Shrimp Sector in 2020: A White Paper

By the Society of Aquaculture Professionals (www.aquaprofessional.org) is available online. Questions and comments on the report can be sent to Dr Victor Suresh, President of SAP for the 2020-22 term at President@aquaprofessional.org

The game changer in Singapore's marine fish farming sector

An integrated closed containment farm is growing more fish in less space as it leads in Singapore's food security drive: self-sufficiency in an eco-friendly, yet efficient way.

In the last few years, trending in Singapore are controlled aquaculture technologies such as land-based recirculation aquaculture systems (RAS) farming several species of marine fish and shrimp. This push has been the Singapore Food Agency's (SFA) ambitious goal of producing 30% of Singapore's agro-nutritional needs by 2030 as part of its '30 by 30' plan, and it aims to achieve this by encouraging innovation (SFA, 2021).

With the COVID-19 pandemic, the importation of food was greatly affected and Singapore has renewed its commitment to safeguard food security in the city state. According to SFA, it is important that local production offers a buffer in times of food supply crises and in ways that must be sustainable for the environment and the future.

Singapore depends on imports of seafood for its population of 6 million; in 2019, seafood imports reached 130,382 tonnes, comprising 94,590 tonnes of fish (SFA, 2021). In 2019, coastal net cage farms, an industrial offshore Asian seabass farm off the southern island, and some land-based recirculation aquaculture farms together produced 4,707 tonnes of fish (SFA, 2021). In the budget for 2021, aquaculture and other agri-food sectors that support technology adoption will benefit from the SGD 60 million (USD 44 million) agri-food cluster transformation (ACT) fund which replaced the Agriculture Productivity Fund (APF). During the recent budget reading, the Aquaculture Centre of Excellence Pte Ltd (ACE) was highlighted as it uses advanced aquaculture technologies. "We want to contribute to Singapore's food security in the most sustainable way. Our fish production food mile from egg to packed fish is all within the Eco-Ark®, achieving the shortest food mile and minimal carbon footprint. Together with other farmers, we can achieve our food resilience as well as for a greener environment," said Leow Ban Tat, Founder and CEO.

Leow Ban Tat (right) and the team with Eco-Ark® in the background.

Closed containment farming

At the webinar organised by the Asian-Pacific chapter of the World Aquaculture Society in 2020, Leow introduced closed containment farming, which keeps fish from the external environment. Floating closed containment systems use either proven land-based recirculation or flow through water systems.

According to Leow, there are some principles of environmental sustainability governance (ESG) for any closed containment model. Economic sustainability is to grow more with less cost, harnessing solar energy and using an energy-efficient system to power the farm. It is to protect the environment with a lower carbon footprint, reduce impact by not discharging nutrient rich water into the ocean and have zero waste at every production stage. Social sustainability is producing safe and healthy food. Using these principles, Leow and partners at ACE have adopted a game-changing technology to farm several marine fish species in Singapore.

Eco-Ark® in shipyard and view of farm off Pulau Ubin.

With three units of Eco-Ark® and an Eco-Spark®, the production capacity rises to 500 tonnes.

Water treatment systems. Right, three pumps located in the bow section of the hull, designed to have a low pumping height are very cost and energy efficient and on the left, ozone generators.

An ideal technology for Singapore

The Eco-Ark® model EA-400, a SGD 4 million (USD ~3 million) floating closed containment farm, is housed on a novel offshore advanced hull system (NOAHS) developed with support from SFA. The existing four-tank Eco-Ark can produce 20 times more than a traditional net-cage farm with the same footprint. At a mere 48m x 28m, the size of an Olympic field, this patented system has a production capacity of 166 tonnes/year. With two more units, each with six tanks Eco-Ark model EA-600, ACE will have a production capacity of 500 tonnes/year which is more than 10% of the local production in 2019. It uses proven offshore and marine technology, utilises IOT and harnesses solar energy; it has advanced sensors for each tank with a capacity of 500m^3 and a flow through seawater exchange every hour.

In terms of infrastructure, there is a built-in photovoltaics (BIPV) solar roof which generates 98.5kWh for the whole farm. There are oxygen and ozone generators onboard too. It uses three large pumps to draw seawater. They are in the bow section of the hull, designed to have a low pumping height, and are very cost and energy efficient. Inlet seawater is first filtered and then treated with ozone for sterilisation before it reaches the culture tanks utilising the airlift aeration principle for high oxygenation.

The discharge water from culture tanks is siphoned off from the bottom to a discharge trough. It then goes through a second filtration system which removes solid waste before passing into a degassing chamber that treats the water before discharging it back to the sea. These steps ensure that the discharge water from culture tanks is almost as clean as when it is pumped into the farm. This is an ideal technology for Singapore and the region beyond.

Joie Lee, General Manager, ACE.

Shortest unbroken fish production mile

The shortest food mile is ACE's solution to farming marine fish sustainably while supplying consumers in Singapore with clean and healthy marine fish. The farm, anchored off Pulau Ubin, an island off the northeast coast, officially began operations in early November 2019 and had its first harvest of 20 tonnes, comprising Asian seabass *Lates calcarifer* in February 2020. On the upper deck of the Eco-Ark are the hatchery, nursery tanks and an approved post-harvest facility. During an interview with CNA news, Joie Lee, General Manager, ACE said, "When COVID -19 came, there was a shortage of fingerlings and we had to rethink quickly. We worked with a local vendor to supply eggs which hatched the following day."

"ACE rears fish from eggs to maturity, harvests, processes, and packs within the Eco-Ark. Thereby, achieving the shortest food fish production mile, " said Leow.

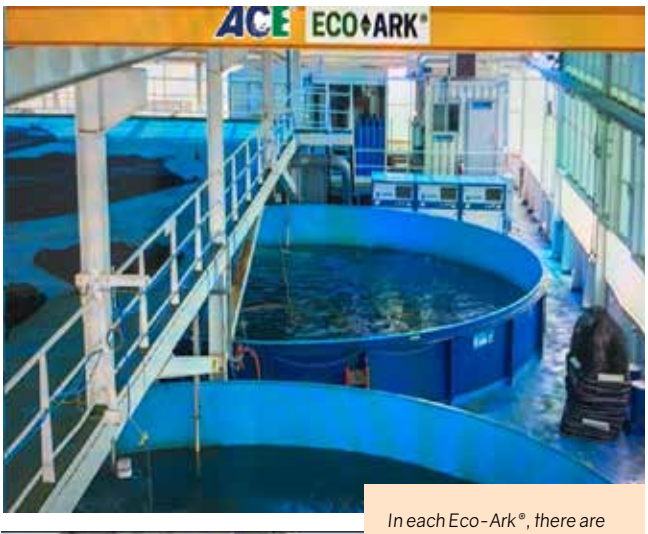
Self-sustainable

The Eco-Ark is the world's first purpose built closed containment system for marine fish. It is scalable, as 2-3 Eco-Arks can be placed side by side. "By September 2021, we will complete the construction of two more larger units of Eco-Ark, each will have six 500m^3 culture tanks. We will have one unit of Eco-Spark® to produce 5 million fingerlings annually. Together, ACE will produce 500 tonnes per year of healthy fish. We will contribute 10% of Singapore's current fish production per year from these three Eco-Arks."

ACE has integrated all production segments onboard. On the main deck are four culture tanks of 500m^3 submerged 6m into the sea, therefore, allowing water to flow by gravity. This simulates oceanic conditions for the fish in its grow-out stage. On the upper deck, there are 30 tanks, each of 6.5m^3 which serves as the hatchery cum nursery for larviculture to juvenile production. "No longer will we need to import fingerlings from Australia, Korea and Malaysia. With the processing plant sited on our upper deck, we no longer need to send our fish across the island to Jurong Fishery Port for processing. This pandemic has taught us that self-sustainability in food production is even more important than ever," said Leow.

Smart technology small footprint

On the upper deck are 30 tanks in the hatchery and nursery unit.



In each Eco-Ark®, there are four 500m³ culture tanks. Tank productivity is high, with a stocking density of 50kg/m³.

"Our generation of aquaculture farms do not only focus on productivity and climate resilience but also makes full use of available technology. Smart technologies are helping us in a high labour cost country like Singapore. With technology, our production of 166 tonnes/year uses only two workers for farming. At 80 tonnes/person, this is really efficient." Leow emphasises that all systems developed at ACE must be scalable and sustainable. "Not only is it smart technology, but the shortest food mile imaginable, 60m from hatchery to fresh healthy fish."

Feeding Asia in the next 10 years

In Singapore, ACE hopes to work with progressive farmers to expand its "queen bee colony" concept which will have 10 units of Eco-Arks in a sea space of 3ha surrounding a unit of Eco-Spark to produce 2,500 tonnes of fish. The target is 883 tonnes/ha. "We want to grow more with less, yet protecting the ocean," said Leow, adding, "We need to promote the image of aquaculture as a sustainable food production model and a new job sector for young locals." Naturally, Leow sees the potential to open Eco-Ark farm in every country. This innovative floating closed containment technology is patented and is readily adaptable globally.

Marketing is via their ecommerce site (www.ace-fishmarket.com). There is a range of products of Asian Sea Bass, Red Snapper, Pearl Grouper: whole cleaned and filleted, vacuum packed as well as creative products such as smoked seabass in three flavours. There is a focus on branding such as 'SG-Choose Fresh Local Produce.

Reference:

Singapore: Food security despite the odds (sfa.gov.sg)

https://www.sfa.gov.sg/docs/default-source/tools-and-resources/yearly-statistics/local-production.pdf

Local focus and research alliances to make a difference

Alltech's aquaculture team says that in today's aquaculture landscape, to fulfil the sustainability initiatives they need to work together with customers, governments and stakeholders.

In 1980, Alltech's Founder, the late Dr Pearse Lyons developed a product from the yucca plant as a solution to reduce ammonia from animal waste. Years later, armed with expertise in yeast fermentation, solid state fermentation and the sciences of nutrigenomics and metabolomics, Alltech has become a leading producer of yeast additives, organic trace minerals, feed ingredients, premixes and feeds.

The family-owned company based in Lexington, Kentucky USA, is guided by its founding ACE principle, which demands safety and benefit for the Animal, Consumer and Environment. Therefore, it developed products to improve the health and nutrition of plants and animals, resulting in more nutritious products for people as well as less impact on the environment.

Over the next few decades, Alltech has continued to be active in aquaculture, alongside a much larger presence in the animal and poultry production sector. Lyons once said that "the most successful businesses in the future will be the ones adapting quickly to innovative technologies in order to maintain a competitive advantage."

Once with a strong focus on feed additives, today the company now balances feed production and additives, a consequence of the 15 companies acquired globally since 2011. In 2016, it added Coppens International in the Netherlands, specialising in nutrition for recirculating aquaculture systems (RAS) and feeds for temperate and tropical marine and freshwater fish, for juvenile and adult stages with a strong presence in Europe and Africa. An asset is the Alltech Coppens Aqua Centre (ACAC), a bioscience centre conducting practical and applicable research. In 2017, Alltech formed a strategic partnership with Guabi in Brazil which produces extruded fish and shrimp feeds, effectively "linking two leading aquaculture feed producers from opposite sides of the ocean together to accelerate solutions for the aquaculture industry."

The above sets the scene for our virtual interview in March with **Jonathan Forrest Wilson,** President of Asia, based in Beijing, China. Wilson is responsible for leading Alltech's strategy within the world's largest feed market. He was joined by **Ronald Faber,** CEO of Alltech Coppens and recently appointed as its Global Aquaculture Lead who is based in the Netherlands.

Where is Alltech today in the aquaculture landscape?

JW: Alltech believes in local talent and we work closely with our local customers, partners to develop solutions for local issues related to nutrition and the environment. For example, we have research alliances here in China such as with the Ocean University of China in high value marine fish (turbot) and shrimp, and in Japan, with Kochi University, researching on the Japanese yellowtail. Solutions-wise we spend a lot of time in Asia over the last couple of years.

Jonathan Forrest Wilson *(right) is President of Asia. Based in Beijing, China, he joined Alltech in 2019 and is responsible for leading Alltech's strategy within the world's largest feed market. Since February 2021,* ***Ronald Faber*** *is CEO and Global Aquaculture Lead for Alltech and leads a global team of aquaculture experts who are experienced in fish nutrition, feed production and technical support.*

In South Asia, we put more focus on pond environments, in terms of water quality to reduce late-stage shrimp mortality with our De-Odorase® and organic minerals product lines. Both in fish and shrimp, we see gut health as the pathway to improve resistance against diseases. There has been a lot of work in South Asia in the past two years since I have joined Alltech, but we have also put a lot of effort in Vietnam and Indonesia.

China continues to be interesting. With the research alliance with the Ocean University, we are looking at yeast and organic minerals in high value marine fish diets. Just like in India, here we are going on-farm a lot to develop custom packs and customised approaches with farmers, either to directly add to pond water or do top dressing of the feed. We also work with some of the big feed mill players. We can say that we have a dual strategy.

Yes, China is a big market for Alltech and is getting stronger but size-wise, South Asia's shrimp market is leading in terms of penetration and applications. In Vietnam, interestingly, we have come up with total life cycle premixes for pangasius. As you know this is not an easy sell given the low farm gate prices recently. Our aqua nutrition strategy has been to put two or

three of our technologies together, whether it is the nucleotide, yeast proteins with minerals, De-Odorase for water quality or Actigen®, our second-generation bioactive product to optimise gut health. We approach these markets with blends rather than just one product.

RF: From a global perspective, it has been the strategy of the late Dr Pearse Lyons, to develop us into a global player in aquaculture and as the lead in global aquaculture, I see the combination of feed and additives as good. We are applying technologies and concepts around feeds, ranging from fish species like trout and salmon in Europe, to the more tropical species like shrimp and tilapia, and in Brazil with our new sister company Guabi. My new role as the Aquaculture Global Lead is continuing this global vision.

What is new from Alltech for aquaculture in Asia?

JW: What is new is a renewed focus, renewed energy and more corporate resources, and locally working on building collaborations with universities, whether it is in Malaysia, China, India or Thailand. We are trying to build an ecosystem around R&D collaborations to solve local problems. Aquaculture in Asia is still localised; although the same species are produced in different countries but some problems are quite often extremely local.

For us, we are looking a lot again at gut health products and mycotoxin management as raw materials prices have increased. We are bringing back some of the tried and true technologies of Alltech, like mycotoxin management and gut health but trying to put that into the aquaculture space. In terms of geographical expansion, recently we saw opportunities in the growing aquaculture markets in Myanmar and Australia. We have crafted a small business for our enzymes in aquafeeds in Myanmar and are now pushing for our prebiotics and gut health products. We have positive feedback with repeat orders. This is a change which we would not have seen happening two years ago.

RF: In Australia there is a dedicated person for aquaculture, especially in the fast-moving salmon industry. In the more tropical north, it is in shrimp and barramundi (Asian seabass) farming. We offer all the solutions and the four platforms that we have (mycotoxins, gut health, enzymes and minerals) and are building up a potential with the products.

Globally, we are working with research institutions in Norway (NOFIMA on Atlantic salmon) Brazil (Federal University of Santa Catarina Research on tilapia) and US (Kentucky State University on largemouth bass and shrimp). Then at the Alltech Coppens Aqua Centre (ACAC) we do a lot of work on aquafeeds, particularly in RAS feeds and on the additives side of them. Our facilities (temperature range from 6-20°C) allow us to work with freshwater and marine, temperate to tropical fish species. R&D on shrimp is conducted in Brazil or in Asia Pacific with partner research institutions but at the same time, we are looking at doing shrimp R&D at ACAC too.

In terms of research focus, based on the research budget, I would say that it is now 40:60 for nutritional and additives R&D. But note that all these research are interlinked.

Dr Zhang Yufan, China Aqua Business Development Manager at a trout farm of a customer.

Where are your current and future focus?

JW: This has to be around environmental issues — water quality and gut health are hugely important. Given the large increases in feed raw material prices, how we can use enzymatic processes to help farmers not get squeezed and how they can be more efficient. We are also paying more attention to recirculating aquaculture system (RAS), whether they are smallish local systems or large ones such as raceway RAS for the salmon. There are the nays who are not convinced on RAS and its profitability. But what I know about technology is that, if more people put in enough effort and time, they will figure out how to make it workable. At Alltech, we are obliged to put more attention and effort into this to move industry forward.

Species-wise, our focus will depend on countries but ultimately, we will focus on high value species. Of course, in Asia, it is the marine shrimp and groupers. In China, a rising species is the largemouth bass and our interest would be on gut health and minerals in feeds. Enteritis is an issue in largemouth bass farming and we think there is a potential market for our Actigen product lines. For large volume species such as the yellow croaker, we are already marketing minerals in premixes for feeds and working with a major producer of this fish. Then, we have some trials on our prebiotics Bio-Mos® for the golden pompano against ectoparasites. So far, our research is showing some positive results. The product has worked well for sea lice in salmon. In Vietnam, Professor Le Thanh Hung, Nong Lam University, showed that the product worked well with the pangasius too.

Then there is "Working Together for a Planet of Plenty™" — Alltech's vision of working together with industry to produce more nutritious and healthy food. This is through a sharing of stories on adoption of new technologies, the adaptation of better farm management practices and the ingenuity inherent in the human spirit for a more sustainable industry.

RF: There may be doom and gloom when it comes to feeding the global population, but we look at this from a positive angle. There are enough resources for all, but we need to use them in a sustainable and good way. Alltech Science has also committed to the UN's SDGs. Internally, at ACAC, we now live the principles of this "Planet of Plenty" and decisions are made on this vision. This is one of the pillars to bring industry forward.

For example, as Jonathan says, in Asia, we need to see feed extrusion from a sustainability angle. At Coppens, one of our roles is to work with some big players in Asia to train them to develop extrusion technology. Feed producers in Asia have been impressed at our feed quality, from floating and sinking feeds using the same machine. This is a major challenge of most feed millers who have issues with floatation of feeds. Therefore, next to selling our products, we are here to help and train our customers.

Alltech acquired Coppens and Guabi and with these, have you moved from feed additives to feed production? Which is your core business now, globally and in Asia?

RF: Our focus is still more on the additives business. Alltech is now at its current level because of these feed companies using our additives, although in North America with several feedmills, we are either the second or third market leader in terms of volumes of feed production.

JW: Here in Asia Pacific, we look at the aquaculture nutrition business through a systems approach. We do have great products and using them individually, we get the results. But going forward, we want to see how our products work together as a system. How can we blend them together into macro premixes or have blends in granular forms which do not stick to sides of blenders and are less dusty! We have blends where we put different technologies together to elucidate a nutritive effect for better growth of a species. This is where our technical people from around the world are making a big difference for us — going beyond product price per kg concept. These investments in technology help us get more solutions for industry to use.

RF: The stronghold of sales for Coppens is still the feed market in north western Europe but we have expanded into West Asian countries such as Uzbekistan and Turkistan. Russia is also a significant market for us. In West Africa, we are the leader in feeds for the African catfish. Guabi in Brazil is a more than 40 years old feed company and is a market leader in shrimp feeds in Brazil with its extruded feeds. Guabi has a strong focus in Brazil's feed market for the tilapia and some carnivorous freshwater fish.

Henry Wong, Alltech Asia 'Development Manager, at a cage farm in Indonesia.

As the global aquaculture lead, what are your plans for the next 5 years?

RF: We want to position Alltech as an innovative, sustainable and leading supplier of technology and solutions for the global aquaculture industry. We want to be in the forefront and leading in every segment that Alltech is active in and we have to make a difference. There is a lot of potential for Alltech, but we do need to reclaim focus. To be honest, over the last few years, the focus may not be there, as much as it should be, although we had individuals trying their best but were not unified and connected. My role is to connect everybody and use our resources cleverly and be reliable partners of different stakeholders – consumers to primary producers.

Nguyen Tan Duy Phong, Vietnam Aqua Sales Manager helps a customer to check water quality.

We talked about RAS and here in the Netherlands, such systems have been developed to grow fish over the last 40-50 years. We need RAS, therefore, there is a good fit here. We have a lot of expertise and knowledge to support and use Alltech's technologies as a strategic way forward.

Where do you see aquaculture's growth and what are Alltech's plans to be active in Asia's aquaculture industry?

JW: We are sitting in a huge aquaculture market, sending products from the region to around the world — Asia's shrimp goes to high end to normal grocery markets. I still think that there will be a huge growth in Asian aquaculture, but the problems and concerns around sustainability will be more at the forefront, as our products reach consumers who are more savvy. Working together in the Planet of Plenty vision, our sustainability initiatives need to work hand in hand with our customers, governments and stakeholders. This is on how to build up food safety, water quality etc, getting beyond kg of product type mentality to a system approach that makes industry sustainable for farmers, communities and people.

This I think is where industry is now heading. If we had this discussion a few years ago, aspects of sustainability would not be as deeply in our minds as they are today. Now, it is not us that are talking about sustainability but our customers, the farmers, integrators spending 50% of meeting time talking on this. This is real, it impacts business, efficiency issues with economic benefits.

I also echo what Ronald has said, that we want to be at the forefront. While Ronald is putting our resources around the world, my job is to allocate resources here in Asia on product development and application. We are starting with people, engaging with associations, governments and researchers in this space. This is the call of the entire company. When asked on the focus for 2021 and beyond, Dr Mark Lyons, Alltech's CEO would affirm that his personal and Alltech's focus area is aquaculture. In the coming months, we will demonstrate this in the marketplace.

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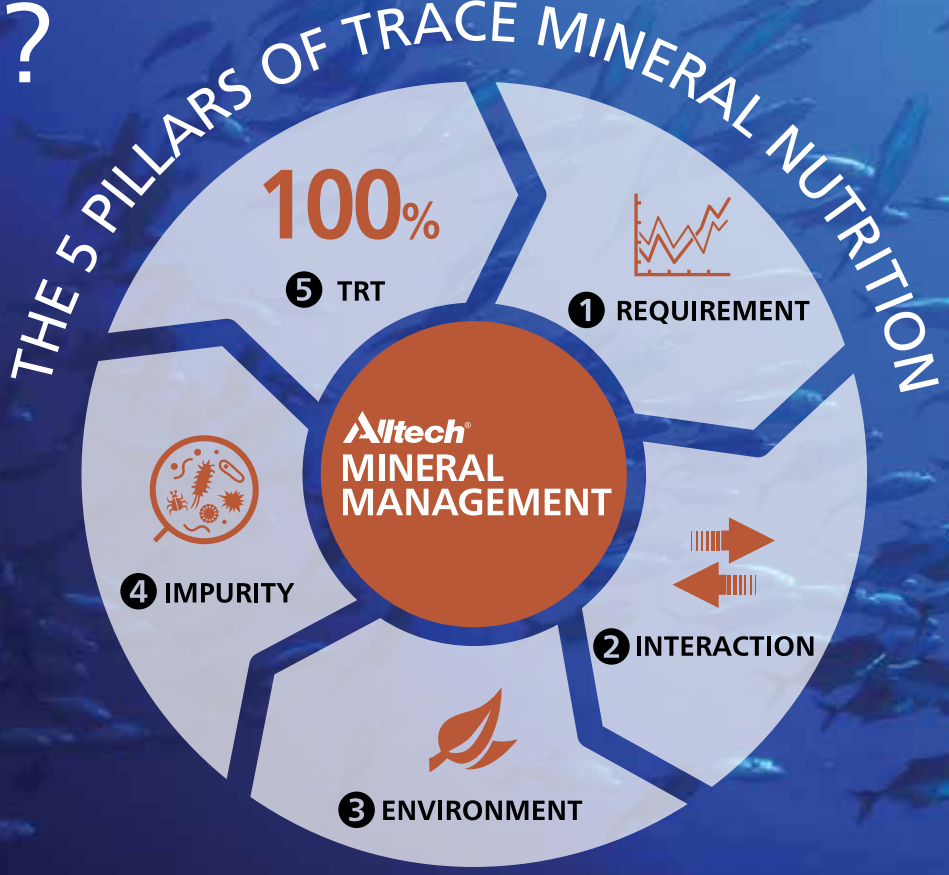

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Is a crisis in the works for Asia's aquafeed players?

In 2020, it was feedmillers supporting farmers managing volatility in prices and demand for fish and shrimp. In early 2021, doubts on achieving a profitable feed business came with skyrocketing prices for critical raw materials.

By Zuridah Merican

In the early part of 2020, Asia's aquafeed industry took into its stride disruptions in supply chain, logistics and operations. Mid-year, higher logistics costs also added to the cost of raw material imports for feed production. The worst came in September 2020 when prices for three main raw materials, soybean, corn and wheat began trending up. Many feedmillers described 2020 as painful, with one problem after another and they expect the worst to come in 2021.

COVID-19 pandemic on farming and feed demand

Throughout 2020, lockdown measures complicated feed production operations. However, the degree of disruptions varied with the pandemic situation in each country. Production disruptions were short-lived for the industry in China, Vietnam and Thailand, and mainly affected the first half of the year or even less. "In India, the lockdown affected logistics, production, processing, market and consumption," said Dr Arul Victor Suresh, Managing Director, United Research (Singapore) Pte. Ltd. "Low fish prices in Andhra Pradesh, India's main producing state, and continuing disease problems in shrimp farming led to loss of productivity."

In Table 1, feedmillers listed challenges in the farming sector which significantly affected feed production and demand. There was support from the government in India and Vietnam to ensure feed supply during the lockdown. In Vietnam, there was good control of the first wave and shrimp farming remained unscathed, except for lower domestic consumption in early 2020 (Panakorn, 2020). In shrimp farming, concerns were with broodstock supplies, poor post larvae quality, volatility in demand in international markets, inclement weather and diseases.

The inability of fish farmers to market live and fresh fish was a shared concern all over Asia, resulting in low ex-farm prices. Demand for freshwater fish feed dropped massively in Malaysia, which Hea Kok Wei, Assistant VP, Star Feedmills, explained, "With several lockdowns in the country, farmers continuously faced difficulties in selling the fish. Therefore, their strategy is to reduce and control feeding."

	General	Shrimp feeds	Fish feeds
India	Lockdown affecting logistics, market, processing and consumption. Disruption with DORB milling. High costs of ocean freight. Volatility of raw material costs. Higher fuel prices.	Low shrimp prices, limited supply of good quality post larvae. WFS, EHP affecting shrimp productivity. Weather and rains brought on WSSV. Farmers face cash flow problems with non-payment by buyers, affecting farming and feed sales.	Closure of fish markets. Low fish prices with low demand. Fish farmers had less working capital due to delayed harvests. Declining fish prices in 2021 due to lower demand.
Vietnam	Raw material prices up by 50%. Three times higher costs of ocean freight. Closed export markets.	Only in early 2020, lower domestic consumption and tough competition.	Low fish prices due to poor demand and market access led to lower feed demand.
China	COVID -19 affecting feed production and disrupting business activity.	2-month delay with first crop. Limited supply of good quality post larvae. Farmers shifted to fish farming	Negative impact of production and marketing.
Thailand	Increasing prices of SBM, corn gluten meal, wheat flour.	Low farm gate shrimp prices all year round.	Low farm gate fish prices all year round.
Indonesia	Decreasing feed demand. General drop in seafood consumption.	In early 2020, disruption in post larvae distribution. Issues with cargo services.	Lower feed purchasing power of fish farmers. Farmers unable to sell live/fresh fish.
2021* up to April 2021			

Table 1. Some significant challenges to aquafeed players in 2020 and 2021*

	Total Aquafeeds	Shrimp feeds		Fish feeds	
		Vannamei	Monodon	Freshwater	Marine
China	20,000,000	1,300,000	80,000	13,450,000	1,500,000
Vietnam	3,800,000 - 4,020,000	633,000 - 750,000	150,000 - 268,000	2,750,000-3,500,000	50,000
India	2,000,000-2,192,000	900,000-1,135,000	40,000- 100,000	1,000,000	-
Indonesia	1,646,334	392,419	8,600	1,223,512	31,406
Thailand	1,075,000-1,100,000	390,000-400,000	30,000	505,000-650,000	45,000-50,0000
Philippines	N.A	80,000		1,000,000	
Malaysia	N.A	70,000-80,000		43,000	64,000

Vietnam:-1.6 million tonnes of pangasius feeds; Indonesia-Data from the Indonesian Feedmills Association or GPMT; fish feeds mainly for *Clarias* catfish (23%), common carp (20%) and tilapia (19%); Thailand-Fish feeds are mainly for the tilapia (63%) and *Clarias* catfish (24%); Philippines – Data for fish feeds includes marine fish feeds; Malaysia-Includes imported shrimp and marine fish feeds, estimated at 24-36,000 tonnes.

Table 2. Aquafeed production in tonnes in 2020 for selected countries.

Aquafeed production in 2020

In this report on the aquafeed industry in Asia, based on information gathered from a selection of feed industry stakeholders, estimates on production in 2020 (Table 2) underlined uncertainties in feed demand. Total aquafeed production in China was 20 million tonnes, less than the official figures for production in 2019 at 22 million tonnes. In the 2021 Alltech Feed Survey, China's production data was reported at 22.28 million tonnes in 2020, which was higher than this industry estimate. Based on data presented in last year's review (*Aqua Culture Asia Pacific*, issue May/June 2020), there are some notable trends.

In China, tilapia feed production dropped to around a million tonnes from 2 million tonnes estimated for 2019. There were less feeds for vannamei shrimp and much more for marine fish but less for the seabass and large-mouth bass. In Vietnam, industry estimated only 1.6 million tonnes of pangasius feeds, down from 2-2.5 million tonnes in 2019. The production of freshwater fish feeds declined by almost 15% in Indonesia. In early 2020, industry in Vietnam expected a tough year with 10-20% lower shrimp production but with optimisation of farming model, production increased by 8-10%. A follow-up article, to be published in issue July/August 2021, will discuss trends in aquafeed production in selected countries in Asia.

Higher production costs of aquafeeds

During the GOAL conference in October 2020, feed prices were on top of the list of main challenges, after diseases. Since March 2020, the shortage of containers led to higher rates and charges when demand picked up. Feedmillers reported phenomenal increases in ocean freight charges, such as 30-40% for the December 2020-March 2021 period, depending on destinations for raw material imports and 30-650% for feed exports. There was also a long wait of 15-20 days for space availability and rates increased on a day-to-day basis.

Rising prices of SBM, corn and wheat

Since September 2020, there were general increases in prices for soybean, corn and wheat. Soybean prices rose 61% since September 2020, from USD973 to USD1,569/bushel. Corn prices rose 130% and wheat prices rose 45% since December 2020. Commodity websites cited corn prices at eight-year highs and soybean the highest since June 2016 (nasdaq.com).

Prices of by-products also rose in Southeast Asia - a marginal increase for dry distillers' grains with solubles (DDGS) at 14%, 20-30% for corn protein concentrates and 20% for HiPro soybean meal (SBM). In India, prices for HiPro SBM with 50-52% crude protein (CP) rose to INR80/kg (USD 1.08/kg) from INR46/kg (USD0.62/kg).

India is a producer of non-GMO soybean which comes at a higher price. "With higher global demand, suppliers of Indian SBM escalated exports in October-December 2020, which led to increases in local prices by almost 50%," said Dr Narashima Rao, Uno Feeds. The government has put up a temporary ban on exports to increase supply for the domestic industry and suspend futures trading in soybean to cool down the market (CLFMA, 2021). However, feed producers in India do not have choices as the government restricts imports of SBM. "The price of local SBM was INR79/kg (USD1.07/kg), up from INR40/kg (USD0.54/kg), a few months ago," said Kumaresan, Sheng Long India Pte Ltd.

Overcoming high raw material prices

Over the years, feedmillers have worked to replace as much as possible the fish meal portion in shrimp feeds. The first option as the alternative to fish meal has been SBM. When the fish meal price was in the USD1,200/tonne range, the inclusion rate of fish meal in a 35% protein shrimp feed was 20%. Today, fish meal in a 35% protein shrimp feed is around 10-12% and the rest of the protein is SBM.

According to a nutritionist in Thailand, at the new prices for SBM, maintaining the same % inclusion in shrimp feeds, means that the feed price will increase by 10%. However, Wen Che Wen, Sales Manager, Uni President Vietnam, said, "While suitable alternatives are limited in Vietnam, it is very critical that we keep up the quality of our feeds to ensure farmers get the best feed conversion ratio."

Jeff Chuang Jie-Cheng, General Manager of Sheng Long Bio-Tech International, said he does not see specific solutions to overcome the sky-high price of SBM, corn and wheat. "This problem can be temporarily solved by increasing the selling price; but in the future, cheaper vegetable protein materials will be developed to replace the use of SBM with fermentation or hydrolysis methods."

In Vietnam, some possible replacements for SBM in fish feeds are rapeseed meal and peanut meal. To replace corn and wheat, cassava add, broken rice were suggested but these would require processing technology to improve bioavailability.

Haris Muhtadi, Chairman, Aquafeed Division, Indonesia Feedmills Association and Associate Director, PT CJ Feed and Livestock Indonesia, said that Indonesian feedmillers have not taken steps to substitute for SBM and wheat, although Indonesia does have local sources of corn, rice bran, cassava, fish meal and fish oil as feed ingredients. However, the issue is sustainability of supply of these local sources. Erwin Suwendi, Head of Nutrition and Feed Technology, PT Japfa Comfeed Indonesia, commented that there is not much in terms of choices to match imported corn and SBM in terms of quantity and quality.

The situation in China was described by Zhou Enhua, Aquaculture Technical Manager, U.S. Soybean Export Council. "Feedmillers use plant ingredients like rapeseed meal, but its price always goes up simultaneously with SBM. The final solution is to increase feed price. However, I see that some are thinking of exploiting new protein sources for aquafeed." Other alternatives like cottonseed meal, pea meal and barley could replace wheat. An option is fermented meals. In the Philippines, a novel feed formulation by SEAFDEC/AQD incorporated minimal fish meal for sustainability and sourced locally available ingredients to reduce feed cost. The alternative protein sources included distiller's dried grain with solubles, poultry by-product meal and protein enriched copra meal.

> "It has been a difficult 2020 for Asia's aquafeed businesses. Competition is high and formulating finished feed at a given price matrix is a big task. Feed nutritionists are always thinking of different strategies from time to time to survive."
> Ajay Baskar

Challenges in India

In May 2021, industry reported that corn prices increased from INR14/kg (USD0.19/kg) to INR17/kg (USD0.23/kg) and wheat from INR20/kg to INR22/kg (USD0.27/kg to USD0.29/kg). India is a large producer of rice bran and deoiled rice bran (DORB) which at around INR10-11/kg (USD0.13-0.15/kg) is the main carbohydrate source in feeds for Indian major carps (IMC) such as the rohu. Dr Ajay Baskar, Nutritionist at IFB Agro Industries, said that although fish feeds, such as for the rohu have been impervious to the recent changes, low fish prices are affecting farmers and therefore feedmillers. "Other alternative ingredients for fish feeds are degossypolled cottonseed meal (gossypol removed meal using acetone extraction), corn steep liquor, peanut meal and mustard deoiled cake," said Rao.

Suresh said, "Due to import restrictions, animal by-products are limited and locally produced meat and bone meal (MBM) and poultry by products meal (PBM) have quality and antibiotics issues." Another opinion is that the situation can change if the government allows the import of SBM. "We have tried to replace SBM with alternative raw materials but since the demand is high, suppliers have also increased their prices from 10-60%," added Ajay. "Increases are also with other raw materials too, such as peanut meal, DDGS, MBM, jawla (sun dried *Acetes*), lecithin, soybean oil and rice bran oil in the last two months. The formulation costs have risen by INR4-10/kg (USD0.05-0.13/kg). In fact, the increase in corn prices is manageable. We can substitute it with DORB, broken rice and other low-cost grains."

Increasing feed prices

Post lockdown in China, the aquafeed industry grappled with the shortage of fish meal and raised prices for shrimp feeds. However, feedmillers in many countries helped the farmers overcome challenges with the COVID-19 pandemic by absorbing cost increases in their feed production. In Thailand, the Department of Fisheries controls feed prices and no changes were reported in 2020 and 2021. Malaysian feedmillers did not increase the prices of shrimp and fish feeds in 2020. In Vietnam, Chuang said, "For fish feed, continuous price increases added up to USD80/tonne."

In the Philippines, shrimp feed prices increased twice in 2020. The average price, across all brands was PHP63/kg (USD1.30/kg), according to a farmer. In Indonesia, Haris said, "Feedmillers cancelled increasing prices for freshwater fish feeds even though they saw their costs increasing with higher raw material costs."

It was reported that in India, pangasius feed (24% CP) was sold at INR33/kg (USD0.44/kg) throughout 2019 to 2021. Ajay said that in general Indian feed companies can handle or absorb raw material hikes to a certain level like up to 10%. Beyond that feedmillers will be forced to increase feed costs. Furthermore, market prices for freshwater fish had fallen by INR10-15/kg (USD0.13-0.20/kg). "Sadly, the aqua farmers are not making any money in paying more for feed and getting less for their harvests."

Table 3 shows feed prices in 2020 and price increases initiated in 2021. In general, feed millers still find it difficult to catch up with raw material costs. According to Wen, all markets in Malaysia, Indonesia and India saw increases of USD30-USD50/tonne of shrimp feed increase in 2021. Uni-President Vietnam exports shrimp and marine fish feeds to the region. In China, the industry increased feed prices in March 2021, by CNY100-400/tonne (USD15.5-62.2/tonne) with shrimp feeds at the higher range.

According to an industry source, shrimp feed prices are relatively stable in Malaysia and annual increases are around 2-3%. Malaysia's small shrimp feed market is competitive, with five local players and several imported feed brands. Some feedmillers began increasing shrimp feed prices by 3% from March 2021.

"In Indonesia, SBM is included at 30-35% in fish and shrimp feeds. The industry had to increase prices to align with these costs increases," said Haris in business.com. Indonesian feed producers raised prices twice in 2021 (January and March) and with high prices of ingredients, another increase is most likely, said an industry source. In May 2021, increases of IDR3,000 or USD 0.21/bag (25kg) for freshwater fish feeds (tilapia, milkfish and gourami) was

"Feedmillers cancelled increasing prices for freshwater fish feeds even though they saw their costs increasing with higher raw material costs."
Haris Muhtadi

Country*	Vannamei shrimp feed/kg (2020)	% increase in 2021	Freshwater fish feed/kg (2020)	% increase in 2021	Marine fish feed/kg (2020)	% increase in 2021
India (INR 73.32)	75-80 (35%CP)	2.7-6.3	33 (pangasius 24%CP)/ 32 (rohu 28%CP)/50 (rohu 28%CP -floating)	0	85 (40% CP)	6%
Indonesia (IDR14,292)	14,500-14,750	1.4-3.5%	8,500 -9,300 (tilapia 30% CP)	3.2-5.9	15,400-17,000	5.9
China (CNY 6.43)	8.2-8.6	3.49-3.66	4.2-4.5 (tilapia, 28-30% CP)	6.7-7.1	7.2-8.9	4.2-6.7
Thailand (THB 31.06)	35-40	0	19-27	0	40-50	0
Vietnam (VND 23,110)	26,000 -31, 800 (42% CP)	3.8-5.5	9,800-10,200 (pangasius)	16%	30,700 (40%CP)	4.5
Malaysia (MYR 4.11)	4.25-4.40	3	3.00	3	4.80	4

Table 3. Some feed prices in local currencies for 2020 and % increases in prices up to May 10, 2021. *The conversions of local currency to USD1 are given in brackets.

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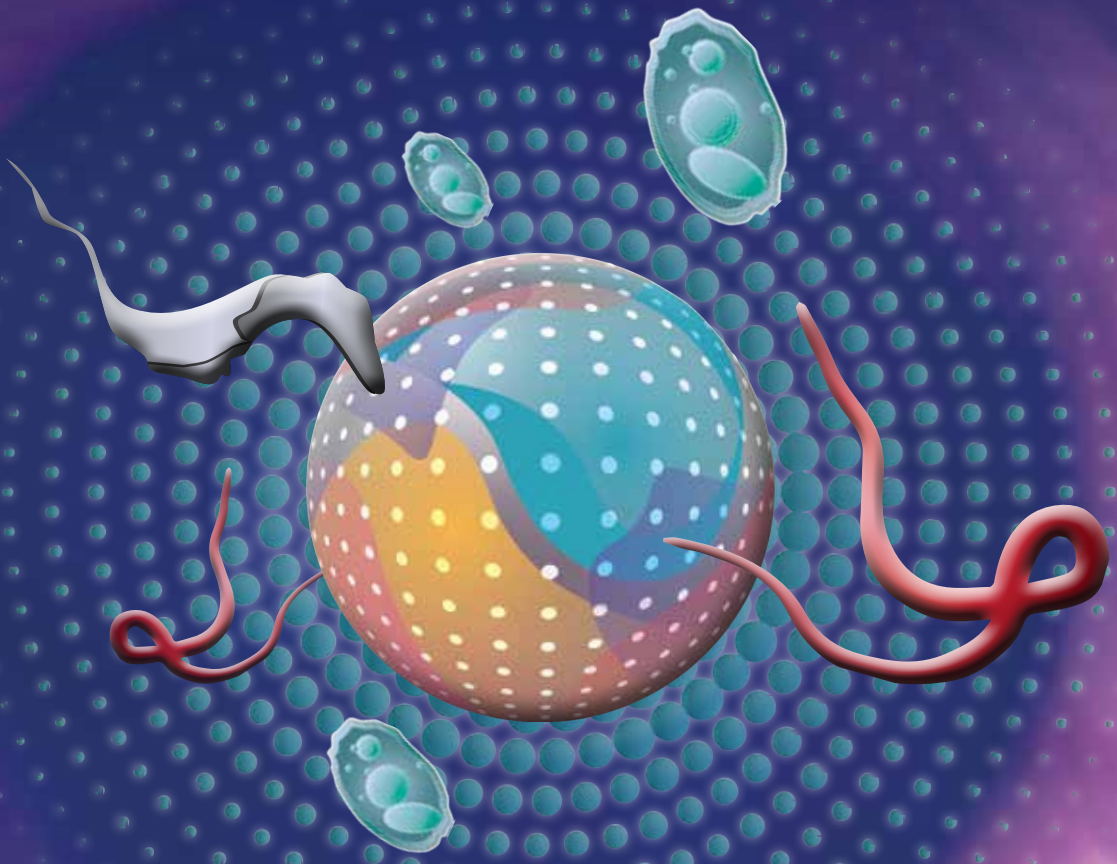

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"We estimated that the demand for fish feed in the first quarter will decrease by 10-15% compared with the same period in 2020...Unless fish prices are better and at profitable levels, we are not so optimistic on fish production and feed sales in 2021."
Jeff Chuang Jie-Cheng

announced.

In India, shrimp feed prices rose by a total of INR5/kg, it was INR2/kg in April and there was another increase of INR3/kg in May. "It has been a difficult 2020 and early 2021 for the shrimp feed segment, which is almost at a standstill, more so as shrimp prices in May decreased by INR50/kg (USD0.68/kg) for each count and farmers are afraid to stock ponds. In May, only 40% of ponds have been stocked. Now we are just waiting for this raw material dilemma to go away," said Kumaresan.

Sustainable ingredients

Some feedmillers also gave their views on sustainable ingredients to replace fish meal, new protein sources such as single cell proteins and insect meal, and novel sustainable sources of omega-3-rich DHA and EPA from algae. Some feedmillers see the future with these ingredients from a sustainable viewpoint. There is interest to use single cell proteins and algal oils when these are available at competitive prices. Aside from farmers' insistence for feeds to contain fish meal and fish oil, feedmillers are concerned on cost and the effect on feed performance with replacements. For them, it is important that farmers should not have doubts on their feeds and feed conversion ratios. In Thailand, several feedmillers have included DHA algae meal in shrimp, seabass and hatchery feeds. One company will launch such feeds in 2021.

"With regards to the use of insect meal, the concern is on cost, availability in commercial quantities and consistency in quality. In India, the current price of local insect meal is INR200/kg (USD 2.7/kg)," said Ajay. Rao expressed interest to try insect meal for inclusion in fish feeds but is concerned on supply in commercial quantities.

"Insect meal is a potential raw material, but more evaluation will be required on its use in different species in China," said Dong Qiufen, Guangdong Nutriera Group, China. Chuang said that there is the potential to use insect meal in marine fish feeds as the meal has a high protein level, balanced amino acid profile, antimicrobial peptides for fish health and palatability. In Thailand, the Department of Livestock has not regulated insect meal in aquafeeds but if they do so, most likely they will regulate a B2C label "Fed insect".

Outlook for 2021

It has been a difficult 2020 for Asia's aquafeed businesses. Competition is high and formulating finished feed at a given price matrix is a big task. "Feed nutritionists are always thinking of different strategies from time to time to survive," said Ajay.

Chuang summarised the industry sentiments in 2021. "The cost of feed ingredients has risen sharply in 2021; the range of increase is around 15-35%, which has caused feed prices to rise several times. In Vietnam, shrimp prices are maintained at a high-level. But combined with a continuous optimisation of production models, both shrimp production and shrimp feed demand remain high."

Like his counterparts elsewhere, Rao said that the concern is with fish feeds where prices have increased but fish prices are low. "Feedmillers assisted farmers by enhancing credit limits, helping them postpone harvests. When they could not delay any longer, they harvested when prices were better but then with low consumption because of the ongoing pandemic, prices fall." This is the cycle for freshwater fish in Asia and the prognosis is not good for the fish feed market.

Chuang said that for some freshwater fish in Vietnam, profit margins are thin. "Most agents lost interest in fish feed distribution, and farmers also reduced stocking and feeding rate. We estimated that the demand for fish feed in the first quarter will decrease by 10-15% compared with the same period in 2020. In 2021, the overall animal and vegetable protein feed resources will be at a high level throughout the year. Unless fish prices are better and at profitable levels, we are not so optimistic on fish production and feed sales in 2021."

Acknowledgements

This is a review on the aquafeed industry in Asia published annually. The author would like to express her sincere gratitude to those mentioned in this article and other industry stakeholders who have willingly provided information but have requested to remain anonymous.

Next issue: A follow-up article on developments in aquafeed production in selected countries in Asia.

Smart demand feeders and financing for bulk feed purchase to fish marketing

eFishery is making waves as it moves along the aquaculture supply chain, from the smart feeders to marketing.

When Indonesia's pioneering startup eFishery first introduced a fish demand feeder, there was skepticism on the The technology itself and on the design of the first prototype. That was in Bandung in 2013. Year by year the team made structural changes to the fish feeder, moving from aluminium casing to fibreglass and then to plastic. By 2019, the hardware had a modern and appeasing look to be well received by farmers.

Feeders in a shrimp farm

"Back in 2013, we looked at feeders since 80% of the production cost in the grow-out phase in fish farming was for feeds. Initially, there was skepticism with our first innovation - feeders incorporating IoT targeting tilapia and catfish farms," said CEO Gibran Huzaifah. At Digifish 2020, an annual gathering of Indonesian startups in aquaculture, Gibran chronicled the difficulties they encountered during those early days. He gave his appreciation to academics and industry stakeholders for their feedback and support, in particular to farmers, when eFishery's team persevered to innovate to meet market demand. eFishery's smart feeding machines sense fish appetite and data are stored in the cloud and farmers can access via smart phones. In 2018, an eFishery ShrimpFeeder was introduced into the market.

Today eFisheryFeeders have been adopted in farms in 24 provinces in Indonesia. "The data collected showed that we can use data and technology to solve even bigger issues facing the industry today. Data can give us information on the number of fish in the ponds and the volume of feeds used."

Galih Husni Fauzan, Head of Marketing at eFishery, gave some testimonials from farmers using the fish feeder. In pangasius farming in South Kalimantan, the feed efficiency improved by 10%/cycle for farmer Suhardi and he could harvest 74 days earlier (128 days compared to 202 days). FCR improved from 1.9 to 1.6. The shrimp farm, PT USBG in Lampung uses 70 units of the eFisheryFeeder and market size of shrimp was achieved 22 days earlier and savings in feed was IDR122 million/cycle (USD 8,441/cycle). Another farmer is Ajat Sudrajat in Cikalong, West Java; he uses eight feeders and could harvest 36 days earlier and FCR improved from 1.33 to 1.19.

Feed distribution

With the data collected, eFishery could provide other services. "The aggregated prediction data of feed at the farm level (type of feed to daily usage) enable us to distribute feed with almost zero inventory, order bulk purchase and delivered on demand; all these can reduce the farm's operating capital," said Gibran. eFisheryFeed is a service to bulk purchase feed for a group of small farmers in a specific locality. Farmers benefit with better prices. This contrasted with the common practice of feed distribution through distributors to feed retailers and finally to farmers.

eFishery's field technical support teams are on stand-by mode in case farmers need technical assistance.

Mastria is one of the many successful female farmers managing catfish farms with eFisheryFeeders.

Pangasius farmer, Suhardi could harvest 74 days earlier by using the smart feeders.

In January 2020, the startup created the eFisheryFund credit scheme for feed purchases, with Kabayan program as its key component. Kabayan ('Kasih Bayar Nanti', translates to 'Pay Later') is an online platform that provides eFishery's farmers with funding that can be paid later in instalments. Farmers apply for loans via the digital platform and the eFishery team will assess and determine if they are eligible for funding. Upon approval, its financial partners will then disburse the credit line which farmers can use to purchase products, such as eFisheryFeeder and feed.

In one example, Gibran showed how this fund is managed with credit limit from 1-3 months, SKUs and all-inclusive pricing. Gibran said that fish farmers find it challenging to get financing from banks and other conventional sources. "This is where eFisheryFund comes in - connecting fish farmers directly with financial institutions so they can expand their business."

Therefore, Gibran was pleased that in October 2020, Investree collaborated with eFishery to provide loans for small and medium sized aquaculture enterprises. "This is the first time that this P2P investor looked at fish farming and now it has invested IDR30 billion (USD 2.1 million) through eFishery. Previously, Investree's portfolio was mostly in the creative industry." To date, thousands of farmers have been supported by the eFisheryFund, with more than IDR68 billion (USD 4.7 million) of financing and 7,000 tonnes of feed disbursed to farmers.

Marketing fish

Next entered the eFisheryFresh, an on-demand marketplace. Traditionally, the fish marketing chain in Indonesia has several players, from collectors, to middlemen, and wholesalers, before reaching restaurants and consumers. The markup for each player in this chain is 11% with the final markup of retail price at almost 60% of the farm gate price. "Farmers have no control on prices. Our algorithm predicts harvests and lists the product at the marketplace; buyers make the purchase before the harvest. We have also developed some value- added products. In the case of the gourami fish, which is often sold as live fish, we can now offer frozen or ready to cook items," said Gibran.

"During the pandemic we saw how some freshwater fish farmers had problems selling their live harvests. In April 2020, we took 850 tonnes of the unsold freshwater fish and kept them in cold storage. Working with an NGO, we donated the fish to COVID-19 front liners in Indonesia."

Growing fast

eFishery has now moved along the aquaculture value chain. "In the past 4-5 years, we have grown. We are now present in 180 cities with 108 eFisheryPoints acting as community centres. We target 200 points. We have created an impact with 13,000 ponds, with farmers handling 1,000 tonnes of fish and 3,000 tonnes of feed linking 2,000 restaurants and buyers. Today, farmers in North Sumatra to West Nusa Tenggara and Maluku have been growing their business with ease, using our smart feeders and services. Since 2013, the number of users has grown by 3,321%. The number of feeders used increased 5,449% from 2016 to2020."

This startup continues to make waves. In 2020, eFishery achieved Series B Funding led by Go-Ventures and Northstar Group and with the participation of Aqua-spark and Wavemaker Partners.

eFisheryPoint coordinator, Rizky discussing a feed transaction with an agent in Subang.

Global Feed Survey 2021

Globally, feed tonnage increased by 1% to 1.187 billion tonnes in 2020, and global aquafeed production rose by 3% to 49.39 million tonnes.

Alltech shared some insights from its annual Global Feed Survey during the January session of the Alltech ONE Virtual Experience. There were five emerging trends in this year's survey, the tenth since it was initiated in 2011. Annually, this feed survey assesses compound feed production and prices through information collected in the last quarter of 2020 by Alltech's global sales team in partnership with local feed associations. This survey continued to be an invaluable barometer for the state of animal feed production. Fortified by a decade of documentation and research, it is the strongest evaluation of compound feed production and prices in the industry and is the most complete data source of its kind.

The survey covered 28,414 feed mills in 142 countries. The number of feed mills covered was down 4% compared to those covered in 2019. The report said that an estimated 1,000 feed mills closed in 2020, and in the countries that responded, around half included on-farm feed mills. With regards to the challenges in 2020, the survey cited that COVID-19 had varying effects, while Africa had more challenges than other continents. Some 58.5% of respondents said that the pandemic significantly affected ingredient suppliers, and 85% said that prices of ingredients have affected the industry.

The positive effect of this pandemic was the growth in feed production of pet food as people adopted more companion animals.

More production in 2020

The Alltech Global Feed Survey estimated that global feed tonnage in 2020 increased by 1% to 1.187 billion tonnes. China rebounded with a 5% growth and reclaimed its position as the top feed-producing country, with 240 million tonnes. The 2020 global feed survey had cited declines in swine feed production due to African swine fever (ASF) , and in this 2021 survey, China's production bounced back significantly from ASF. In contrast, other countries such as the Philippines and Thailand, continue to struggle with the disease.

There was more consolidation in the industry with Latin America growing at the highest rate of 4%. The top ten feed-producing countries, in terms of tonnage (in million tonnes) and growth percentage were as follows: US (215.9, +1%), Brazil (77.6; +10%), India (39.3; -5%), Mexico (37.9; +4%), Spain (34.8; 0%), Russia (31.3; +3%), Japan (25.2; 0%), Germany (24.9; 0%) and Argentina (22.5; +7%). Altogether, these countries account for 63% of the world's feed production and can be viewed as an indicator of the overall trends in agriculture. These countries had an average growth of 1%.

The report also covered the progress in antibiotic free (ABF) feed production where the movement towards this is greater in parts of Europe and Latin America. In Italy, ABF feed production is via regulation whereas in UK and Brazil, consumer demand is pushing adoption by producers.

In terms of feed production by species, it was broilers, 28%; swine, 24%; layers, 14%; dairy, 11%; beef, 10%; other species, 7%; aquaculture, 4%; and pets, 2%. In 2020, the predominant growth came from the broiler, pig, aqua and pet feed sectors.

Global aquafeed production

Globally aquaculture saw the strongest growth at 3%, the strongest of any of the primary food producing species. Global aquafeed production rose to 49.39 million tonnes in 2020, an increase of 20% as compared to the 2019 volume at 41 million tonnes. The strongest growth was in Latin America and Oceania; Latin America's growth at 8% was led by Brazil, Ecuador and Mexico. Oceania's growth was 6% where the leading producer is Australia at 180,000 tonnes.

While aquafeed production in Asia-Pacific grew at 3%, declines were reported for Africa and Europe at -1%. Egypt's production decreased to 600,000 tonnes in 2020 from 800,000 tonnes in 2019. Other leading producers in Africa are Zambia and Zimbabwe. In Europe, the two largest producers, Norway and Turkey increased aquafeed production by 16% and 3% respectively.

Region	2019	2020	Growth
Africa	1.5	1.49	-1%
Asia-Pacific	35.47	36.5	3%
Europe	4.15	4.11	-1%
Latin America	4.54	4.9	8%
Middle East	0.5	0.5	0%
North America	1.71	1.71	0%
Oceania	0.17	0.18	6%
Total	**48.04**	**49.39**	**3%**

Source: Alltech Global Feed Survey 2021, January 2021.

Global aquafeed production in 2020 in million tonnes.

It is expected that this sector will continue to grow at an upward trend associated with increasing consumption of healthy seafood. Its lower environmental impact will encourage a wider adoption among consumers. In terms of developments, the survey also indicated that some type of recirculating aquaculture system (RAS) feed production is developing in many countries.

Asia-Pacific aquafeed production

Production in this region increased to 36.5 million tonnes in 2020. China is the primary leader, growing at an astonishing 34% to 22,280,000 tonnes from 16,527,000 tonnes in 2019. Other leading producers, Bangladesh, Philippines and Vietnam, also increased production. Bangladesh's production rose 54% while it was 11% for the Philippines and 5% for Vietnam. Together, these three countries contributed an additional 910,000 tonnes to production in the Asia-Pacific region in 2020. However, aquafeed production declined in India, Indonesia, Japan, Korea and Malaysia. The survey continued to present aquafeed production from smaller emerging producers in the region. There were marginal increases in feed production from Sri Lanka, Cambodia and Pakistan.

The 2021 Alltech Global Feed Survey results, including species-specific feed production numbers, interactive graphs and maps, are available at_one.alltech.com/2021-global-feed-survey.

Country	Tonnes in 2020
China	22,280,000
Vietnam	4,274,000
India	2,147,000
Indonesia	1,706,000
Philippines	1,551,000
Bangladesh	1,546,000
Thailand	1,370,000
Japan	500,000
Taiwan	445,000
Myanmar	400,000
Korea	150,000
Malaysia	128,000
Sri Lanka	20,000
Pakistan	20,000
Cambodia	10,300
Nepal	10,000
Laos	6,000

Source: Alltech Global Feed Survey 2021, January 2021.

2020 Aquafeed production in Asia-Pacific.

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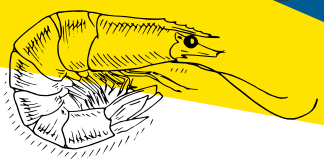

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Feed and total solutions for snakehead fish farmers in Vietnam

The demand is for cost effective high protein feeds for fast growth and health solutions to overcome skeletal deformities and fatty liver.

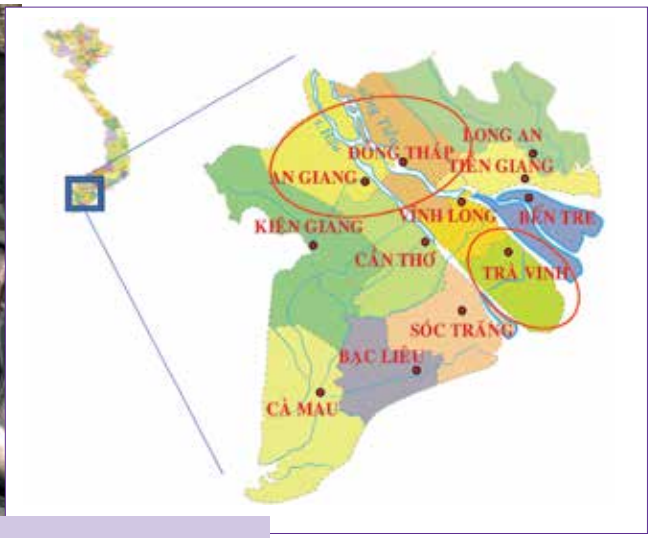
By Haibin Hu

There are many species of the carnivorous snakehead farmed in Asia. Its farming is especially popular because of its perceived curative properties and important role in post-surgical operation care. In Vietnam, farming of the fish has been going on for more than 60 years in the Mekong Delta (Su Shi et al., 2010). Today the main snakehead farming provinces are An Giang, Dong Thap and Tra Vinh, where the main species is *Channa striata*. Snakehead fish tolerate low levels of oxygen and therefore can be cultured intensively in large ponds. It is usually farmed in freshwater but it can tolerate up to 12ppt salinity. Optimal temperature ranges from 25 to 30°C.

In 2020, snakehead fish production reached 200,000 tonnes and feeds for the snakehead reached 300,000 tonnes. In terms of fish production, snakehead fish was the third largest aquaculture species in Vietnam after the pangasius catfish and tilapia. In 2020, the share of snakehead feeds was 11% out of the 2.8 million tonnes of fish feeds produced. The attractive price for the fish which was high at VND40,000 (USD1.7/kg) in 2012 led to the mushrooming of farms. An oversupply led to low prices such as VND23,000/kg (USD1/kg) in 2017 (Vietfish, 2012).

In its farming, farmers screen 3-4 week old larvae from hatcheries and immediately stock them into net cages or hapas in a pond. When fish are 10-15g in size after 3-4 weeks, farmers will open the net cages and release the fish into the pond. Pond sizes are around 0.3-0.4ha and the stocking density is generally around 100-200 fish/m^2. The culture duration is 5-6 months for marketable fish of 500-800g size.

A snakehead fish farmer and Sheng Long technician holding harvest of 1.2kg in Dong Thap province. The farmer has been farming the fish since 2010 and his average production is 200 tonnes/year.



Harvest of 500-800g snakehead after 120-180 days of culture. The main farming areas are in the Mekong Delta.

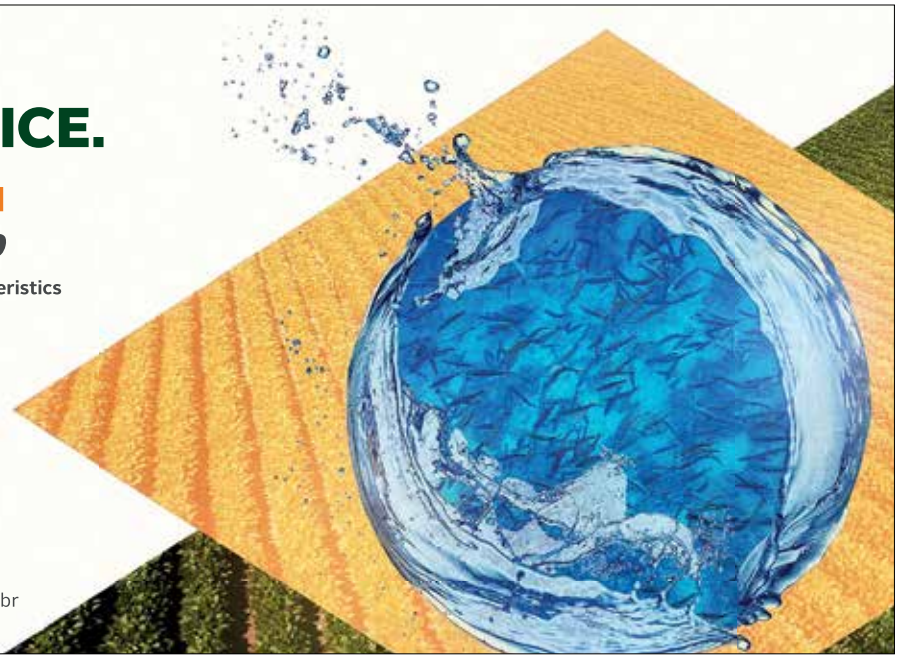
Feeding the snakehead

Traditionally, snakehead fish are fed trash fish or farm-made feeds mainly comprising trash fish. However, such feeds led to water quality and disease problems. In 2008, Guangdong Hinter Biotechnology Group Co., Ltd developed floating extruded feeds for snakehead in Vietnam which led to most farmers shifting to extruded feeds (Su Shi et al., 2010). At that time, the 38-41% crude protein extruded feeds were formulated with high levels of fish meal imported from Chile and Peru. Feed conversion ratio (FCR) was 1.24 to 1.31. Farming the fish was still profitable as fish prices were high at USD1.6/kg. Today, even at lower FCRs of around 1.1 to 1.4, farmers struggle to get good profit margins.

Extruded floating snakehead feed sizes range from 4mm to 9mm for fish sizes of 50g to 800g. The feeding rate starts with 9-10% for 3g fish to 1.4-1.6% for fish larger than 500g. In one crop cycle, 56% of the feed used comprise the largest feed size range. In a culture cycle of 180 days, growth accelerates after 120 days, from 300g to 800g within 60 days.

Extruded floating snakehead feed sizes range from 4mm to 9mm for fish sizes of 50g to 800g.

There are several challenges in the farming of the snakehead and among them is skeletal deformity, where in some cases, it can be 5-20% of the stock. Another problem is feed palatability where fish will refuse to eat and uneaten feed will pollute ponds. Other problems include fatty liver disease, enteritis and poor water quality control. The latter is due to intensive farming and farmers who hand broadcast more feed to push for higher growth performance to reduce the culture period.



Extensive facilities for pond and tank trials at the Sheng Long Research Centre in Soc Trang province, Vietnam.

Nutrition, disease and fish health management

Over the past six years, Sheng Long Bio-Tech International, a leading aquafeed producer in Vietnam, has been carrying out research on nutrition, disease and fish health in snakehead farming at its R&D centre in Soc Trang Province. The centre has carried out some 200 trials on the nutrition of fish and shrimp. With the snakehead, research showed that the fish requires 51.6% to 56% crude protein (Hua et al., 2019) when dietary lipid is 12%. The snakehead requires high lipid levels such as 18% when the dietary protein level is 45% (Ghaedi et al.,2016). In terms of amino acids, the requirement for methionine is 2.84% of dietary protein while that for lysine is 7.31% of dietary protein (Hien et al., 2018).

Nutritional research to replace fish meal without compromising on growth performance is crucial. Our research, coupled with information from other studies, showed that poultry meal is a suitable replacement for for fish meal for the snakehead and can reduce feed costs. Kuah et al., (2015) showed that the snakehead can utilise plant oils (linseed oil and corn oil and a blend of both) by nutritional regulation of *fads2* and *Elovl5* genes. Another challenge is feed attractability. Poor feed palatability slows down feed intake and growth performance. Our research with several feed attractants showed that one attractant may work to increase feed intake while another another gave positive effects at the beginning and negative effects at the later stage. Another produced no effects.

Skeletal deformities can arise from various reasons: raw material quality, poor vitamin premixes and phosphorus levels as well as genetic factors and heavy metal pollution (Figure 1). Deformities affect the market price of the fish; prices can decrease by 20% when the deformity level is high. Sheng Long's strategy is to research and develop the best feeds for the snakehead taking into consideration all these issues; it will strive to prevent skeletal deformities and secure good profit margins for the farmer.

Fish health

Working with researchers at Can Tho University on white spot diseases in snakehead farming, we isolated 31 Gram negative bacteria. PCR analyses of the bacteria showed that 100% of isolates were highly similar to *Aeromonas schubertii*. Challenge test showed that the LD50 of the bacteria isolates ranged from 6.6 to 8.1 x10^3 CFU/mL. We observe focal granulomas in the liver kidney and spleen of the snakehead.

The research to develop an enterohepatic protector to improve liver and intestine health has been successful. Added into the feed, we saw improvements in vacuolation in the liver and healthy microvilli structures in the intestine (Figure 2). Sheng Long has developed a total program for snakehead farming to improve fish health

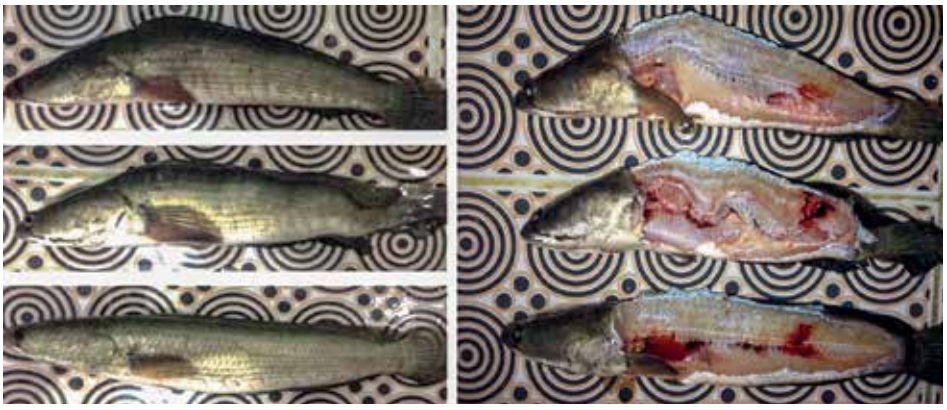


Figure 1. Skeletal deformities in snakehead farming is a major challenge, occurring in 5-20% of the stock and affecting its market value.

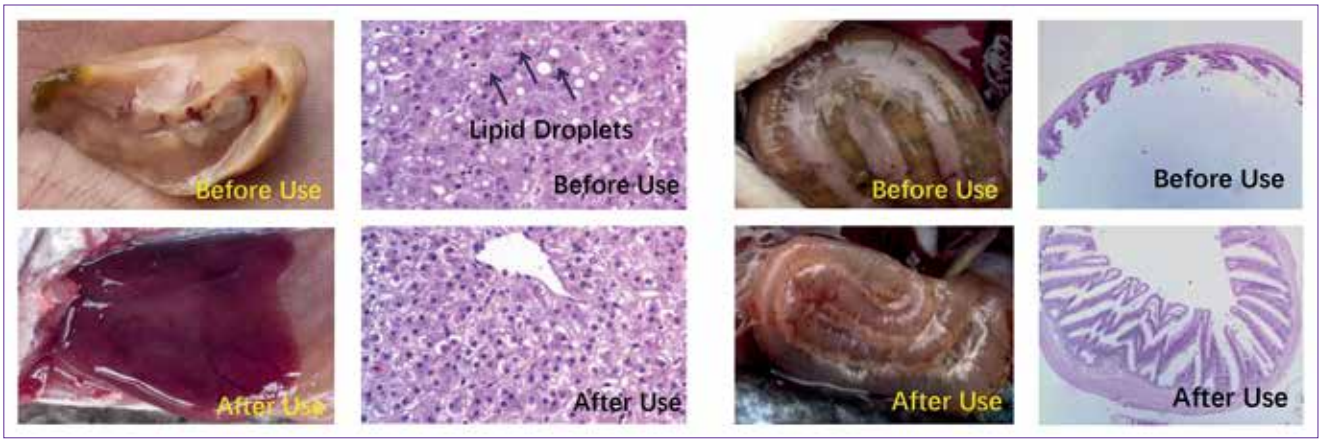


Figure 2. Improvement of liver and intestine health with Sheng Long's enterohepatic health protector, BOGACA. Left, top, fatty liver and bottom healthy liver. Right, effects on intestinal health and change in villi composition.

and growth performance. The use of liver and intestine health protector BOGACA, fermented feed to stabilise water quality and PSP products for water treatment is accompanied by technical advisory services to assist farmers.

Cost analysis

Feed costs around 80% of the production cost (Figure 3) in snakehead farming and since fish prices are relatively unstable, there is demand from farmers for cost effective feeds to lower their costs of production. Furthermore in 2020, ex-farm prices were volatile and low. Prices were high in 2019, at VND47,500/kg in October before dropping to VND35,000/kg in December. In 2020, prices ranged from VND25,000/kg to VND35,000/kg (Figure 4).

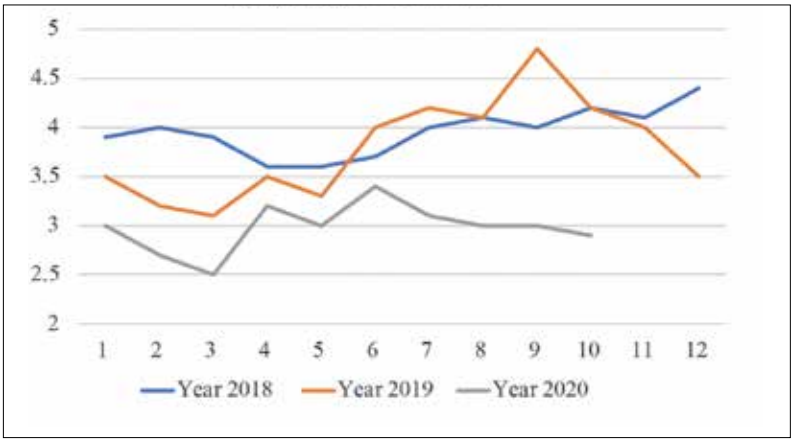


Figure 4. Evolution of snakehead fish prices in VND in 2018, 2019 and 2020.

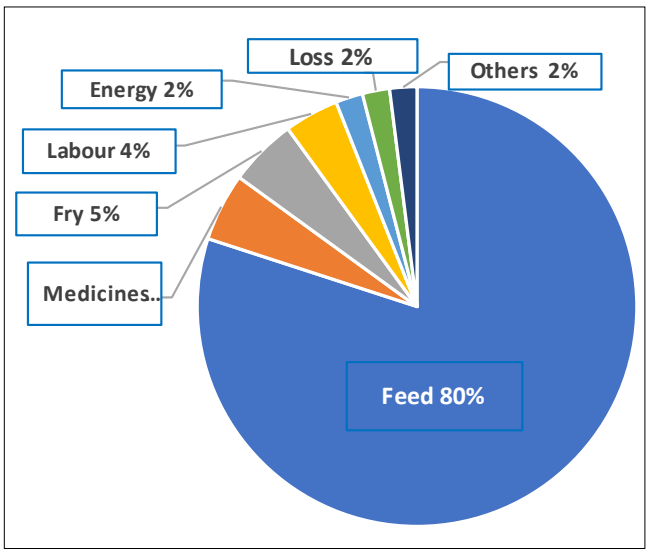


Figure 3. Cost of production in snakehead farming in Vietnam

After years of conducting feed trials and research on processing technology, we have developed a nutritionally balanced feed with monthly average FCR, ranging from 1.27 to 1.34 in the 2020 crop cycle. Based on feed costs per tonne of fish, we estimated a savings of around USD45/tonne of fish produced. Since 2017, Sheng Long has been increasing sales of snakehead feeds annually and in 2020, it sold 100,000 tonnes of snakehead feeds. It is now among the top two brands of snakehead feeds in Vietnam.

References are available on request.

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Lyso-phospholipid supplementation to replace lecithin and improve growth performance in Pacific white shrimp

A low inclusion of a strong emulsifier can replace a higher inclusion of a weak emulsifier and maintain lipid digestion and absorption.

By Yu-Hung Lin, Marleen Dehasque and Waldo G. Nuez-Ortín

In shrimp and other crustaceans, weight gain responses to different levels of dietary lipid indicate that highest gains are generally achieved at dietary levels of 5-6% inclusion (NRC, 2011). Higher levels (>10%) often retard growth because of the inefficiency of shrimp to use lipids. Shrimp lack the bile juice system, which results in a less efficient emulsification process and a subsequent decreased formation and absorption of lipid micelles, leading to a reduced hepatopancreas function.

Digestibility enhancers based on natural emulsifying agents selected for their compatibility with the digestive system of shrimp can complement the process of emulsification, digestion, and absorption. These facilitate the break-down of lipids into small droplets that can be dispersed throughout the water, thus allowing for more efficient action by lipases. Emulsifiers are also associated with the products of lipid digestion and contribute to the formation of small micelles that are more easily transported and absorbed by the hepatopancreatic cells. As a result, the ability of shrimp to efficiently use lipids as essential nutrients and sources of energy for growth is improved.

Lecithin is the most common form of phospholipids used in animal nutrition and as such has traditionally been used as emulsifier in shrimp feeds. The two lipophilic fatty acid tails contained in the phospholipid molecule make lecithin an efficient emulsifying agent for water-in-oil emulsions (i.e. limited amount of water is added to a lipid rich environment) but a weak emulsifier for the oil-in-water conditions (i.e. limited amount of lipids is added to a water rich environment) such as those of the digestive tract of shrimp (Figure 1). Lyso-phospholipids are obtained by controlled enzymatic hydrolysis of phospholipids whereby one of the fatty acid tails is removed. Since lyso-phospholipids have only one fatty acid residue per molecule, they are more hydrophilic than phospholipids and therefore have increased potential to serve as an oil-in-water emulsifier in the digestive tract of shrimp. The present study evaluated the efficacy of lyso-phospholipids to replace lecithin and promote growth performance in Pacific white shrimp.

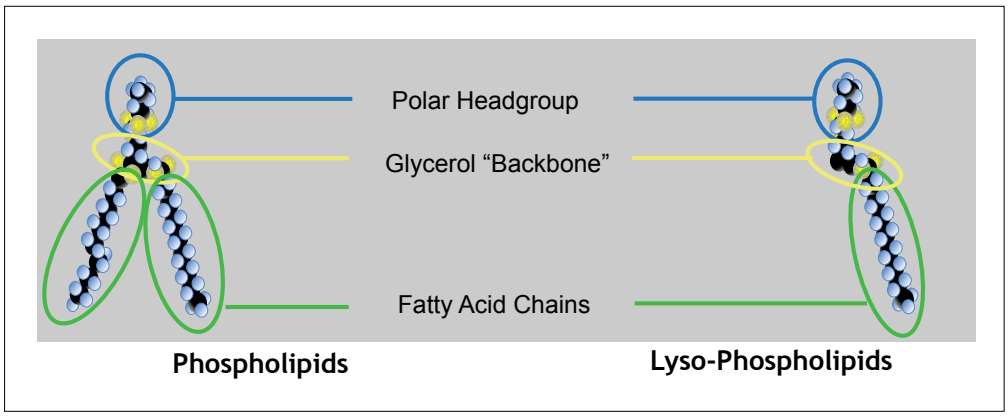


Figure 1. Structure of phospholipids and lyso-phospholipids. Lyso-phospholipids are obtained by enzymatic hydrolysis of phospholipids. The removal of one fatty acid increases the hydrophilicity and therefore lyso-phospholipids serve as better oil-in-water emulsifiers than phospholipids.

Experimental diets

The formulation and proximate composition of the experimental diets are described in Table 1. A total of three experimental diets containing 15% fish meal and 1.7% fish oil were formulated. The positive control (Pos CTRL) contained 1.5% lecithin, while lecithin was reduced from 1.5% to 0.75% in the negative control (Neg CTRL). A lyso-phospholipid-based emulsifier (Aqualyso STD® Adisseo, France) at 0.1% was supplemented in the negative control diet (Neg CRTL + Aqualyso STD) aiming to compensate for the reduced inclusion rate of lecithin. Sinking shrimp pellets were produced using a mincer with a 2mm diameter die, dried in an oven at 60°C and stored at -20°C until used.

Experimental set up

Experimental feeds were randomly assigned to 12 tanks (70L, four replicates per treatment) in a close recirculation system. The system consisted of a common filter, biofilter, protein skimmer and UV light to maintain the water quality. The water temperature of the rearing system was controlled at 28±1°C. Shrimp *Litopenaeus vannamei* were fed at 6% of their wet weight four times per day at 07:00, 12:00, 17:00 and 22:00 h. Shrimp were weighed once every 2 weeks and half of rearing water was exchanged after weighing. Shrimp were fed the experimental diets for an 8-week period. At the end of the feeding trial, shrimp were weighed individually and growth performance including weight gain (WG), specific growth rate (SGR) and survival rate were calculated.

Data were assessed for normality and variance homogeneity using the Kolmogorov-Smirnov test and Bartlett's test,

	Pos CTRL	Neg CTRL	Neg CTRL + Aqualsyo STD®
Ingredients (%)			
Fish meal	15	15	15
Corn protein concentrate	5	5	5
Soybean meal	30	30	30
Rice bran	10	10	10
Wheat	20	20	20
Squid liver meal	4	4	4
Shrimp head meal	4	4	4
Fish oil	1.7	1.7	1.7
Lecithin - Soy (70%)	1.5	0.75	0.75
Trace mineral premix	1	1	1
Vitamin premix	2	2	2
Gluten (wheat)	2	2	2
Alpha-starch	3.3	3.3	3.3
CMC	0.5	1.25	1.15
Emulsifier	0	0	0.1
Proximate composition (%)			
Moisture	9.65	9.92	9.79
Ash	7.22	7.14	7.16
Crude protein	36.86	37.29	37.64
Ether extract	7.99	6.34	6.23

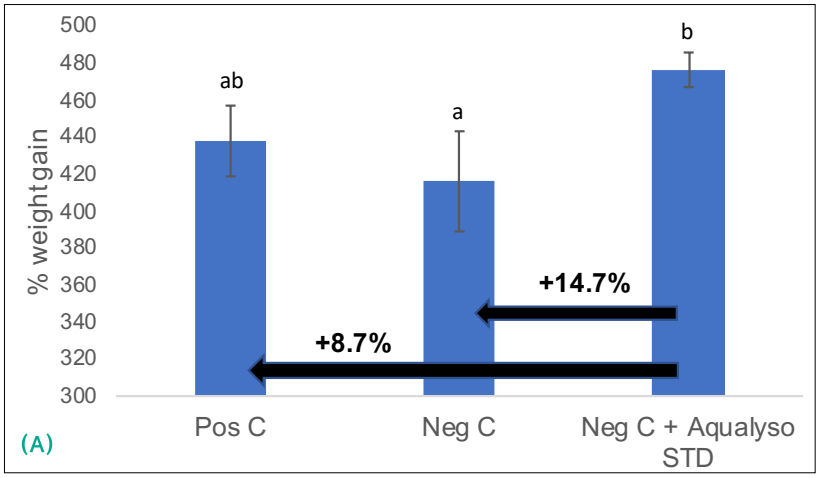
Table 1. Formulation of the experimental diets.

respectively. The results were analysed by a one-way analysis of variance (ANOVA). When the ANOVA identified differences among the groups, multiple comparisons were made among the means using the Duncan's multiple range test. Statistical significance was determined as $p<0.05$

"..replacement of a large inclusion of a weak emulsifier by the small inclusion of a strong emulsifier is an effective strategy to at least maintain lipid digestion and absorption as well as growth performance."

Results

Shrimp fed the negative control diet (0.75% lecithin) showed numerically lower weight gain and specific growth rate (SGR) than shrimp fed the positive control diet with 1.5% lecithin (Figure 2). This can be attributed to insufficient emulsifying capacity and consequently to poorer lipid digestion and utilisation. However, lyso-



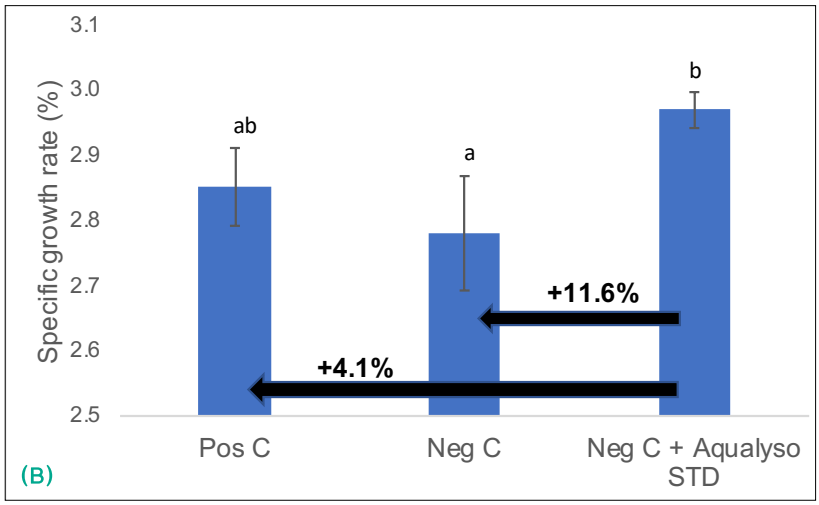


Figure 2. Weight gain (A) and specific growth rate (B) of *Litopenaeus vannamei* shrimp fed different diets for 8 weeks. Each bar was presented as mean with standard deviation from four replicates (n=4) of all dietary treatments. Percent improvement achieved with treatment diet (Neg CTRL+ Aqualyso STD®) is given relative to Neg CTRL and Pos CTRL. Different superscripts indicate significant ($p<0.05$) difference among the dietary treatments.

Pos CTRL: positive control; Neg CTRL: negative control. WG = (final body weight – initial body weight)/initial body weight×100. SGR = (ln final body weight – ln initial body weight)/feeding days.

phospholipid supplementation (Aqualyso STD at 0.1%) in diets with low lecithin levels (0.75%) significantly enhanced % weight gain and SGR by 14.7% and 11.6%, respectively, in relation to the negative control group. Numerical improvements in the same performance parameters were also detected in relation to the positive control. These results suggested that the replacement of a large inclusion of a weak emulsifier by the small inclusion of a strong emulsifier was an effective strategy to at least maintain lipid digestion and absorption as well as growth performance.

Hosseini et al. (2018) reported that the performance benefits of lyso-phopholipid supplementation may be attributed to their effect on cell membrane enterocytes. Lyso-phospholipids can positively alter membrane permeability and fluidity and consequently promote a higher flux rate of nutrients across the cell membrane (Chen et al., 2019). Several studies have reported positive growth effects of lyso-phospholipid supplementation in fish, including turbot and channel catfish, as well as an increment of lipase and alkaline phosphatase activities (Liu et al., 2019; Li et al., 2019). These observations could be explained by the more efficient oil-in-water emulsification achieved by lyso-phospholipids in the digestive tract and therefore the more active surface for enzymatic action.

In summary, the present study provides evidence on the efficacy of lyso-phospholipid as a strong emulsifying agent and a replacement for lecithin in shrimp feeds. Supplementation of 0.1% Aqualyso STD can spare 0.75% of lecithin and enhance growth performance of Pacific white shrimp.

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Zearalanone in aquatic species

Problems surface with contamination in fish and shrimp diets.

By Roy Rosen

Zearalenone (ZEN) toxicity and its effects on animals have been described in the literature since the 1920s. This nonsteroidal mycoestrogenic toxin is produced by some species of fungi from the *Fusarium* genus. It is often found in field crops and other raw materials used in the production of human food, as well as in both terrestrial and aquatic animal feed.

Almost 100 years ago, ZEN caught the attention of the scientific community largely due to its estrogenic properties which are attributed to its molecular similarity to the female hormone estradiol (Figure 1). The estrogenic effects of ZEN were observed in pathologies of farm animals. Later, it was also described in game and wild animals in their natural environments and in relation to pathologies in humans.

Zen in aquaculture

In most aquaculture practices, a close contact exists between the natural aquatic environment and the cultured animals, for example, in culture systems such as sea cages, lake hapas and coastal ponds (Figure 2). In addition, studies revealed that ZEN can enter natural aquatic environments via pasture and agricultural run-off. Moreover, the toxin was also found in water and sediment originating from aquaculture. Understanding this agricultural-ecotoxicological relationship is an important step in making aquaculture a sustainable and responsible industry.

The main entry route of ZEN in cultured animals is through contaminated fish and shrimp diets due to the increasing use of plant-based protein. The BIOMIN Mycotoxin Survey has revealed that ZEN is present in 48% of the >200 samples of finished-compound aqua feed that were analysed between 2016 and 2020 (Table 1 and Figure 3). Additional survey data on ZEN contamination in raw materials used in aquafeed production such as wheat, corn (and corn products like dried distillers grains with solubles (DGGS), gluten), soy, rice and more, strengthen the conclusion that ZEN is widely present and unobtrusively affecting the aquaculture industry.

Figure 2. Farming within nature, fish cages require responsible farming, specific mycotoxin deactivation may help reduce their effect on the natural habitat. (Photo: BIOMIN)

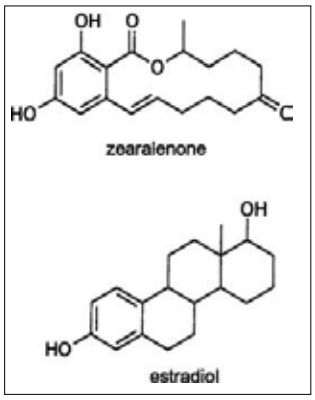

Figure 1. Chemical structures of zearalenone, and estradiol. These compounds induce similar responses due to binding and stimulation of estrogenic receptors.

Parameter	ZEN
% Contaminated samples	207
% Contaminated samples	48 %
% Above risk threshold	18 %
Average of positives (ppb)	78
Median of positives (ppb)	36
Maximum (ppb)	888

Table 1. ZEN in compound aquafeed between 2016-2020 (source: BIOMIN global mycotoxin survey)

Recognising and understanding ZEN in aquaculture

This requires answers to the following questions:

- What actually does ZEN do?
- How does it affect aquatic animals?
- Which species are affected and what can be done about it?

The in-vivo effects of ZEN can be divided into three aspects: direct toxicity, general endocrine effects and reproductive disruption.

Direct toxicity of ZEN was evaluated in the brine shrimp *Artemia* where lethality was observed in concentrations as low as 10µg/kg which increased with time and concentration. *In vitro* work on fish cell-lines (originating from Atlantic salmon, rainbow trout and common carp) demonstrated direct cytotoxicity of ZEN and recognised glucuronidation as the main cellular metabolic pathway. However, this cellular metabolisation of ZEN did not prevent its cytotoxic and genotoxic potential that was accompanied by oxidative stress.

Endocrine and reproductive disruptions, like many biological and physiological processes are interconnected through the interaction between ZEN and estrogen receptors (ERs). Many studies described those ligand-receptor interactions. In fish, ZEN and ZEN metabolites readily bind to ERs; this binding leads to a cascade of various responses, the majority of which affect the reproductive system. However, other important effects were also observed.

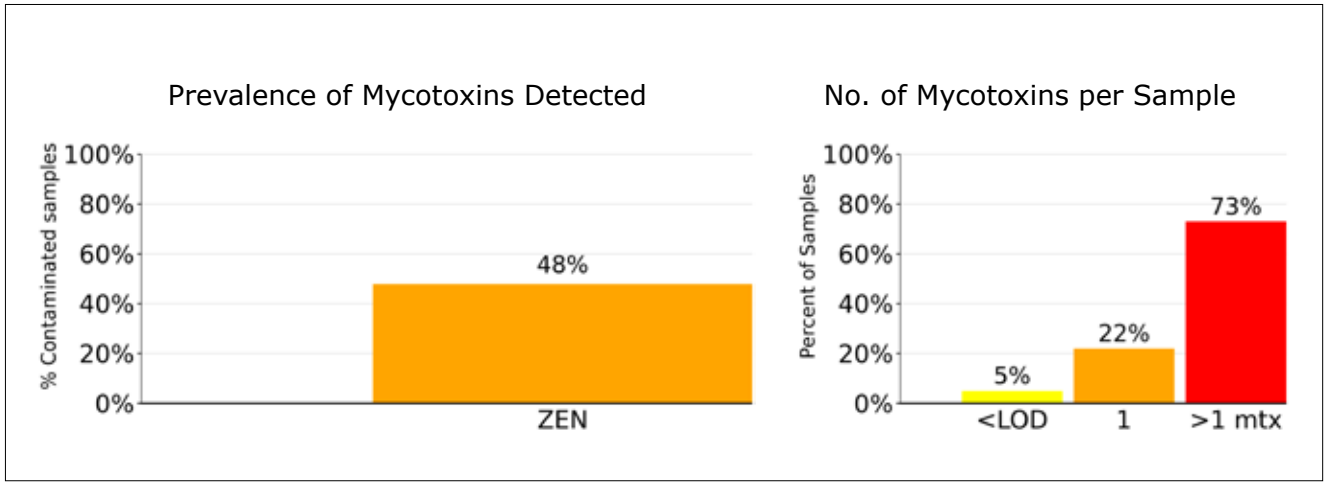

Figure 3. Prevalence of ZEN and its co-occurrence with other mycotoxins in finished shrimp and fish feed between the years 2016-2020. (source: BIOMIN global mycotoxin survey)

For example, rainbow trout fed diet contaminated with ZEN, showed immune and blood changes such as increased respiratory burst, leukogram alterations, biochemichal changes and changes in cytokine expression. Most of these parameters did not normalise after ZEN contaminated feed was withdrawn, suggesting irreversible effects of ZEN on immune functions.

Can ZEN cause irreversible effects on immune functions?

The connection between the generalised and reproductive effects of ZEN can be seen in fish larvae. ZEN induced developmental defects like pericardial edema, hyperemia, yolk sac edema, spine curvature and a heart rate reduction in zebrafish (*Danio rario*). Neurotoxicty, DNA damage, cell apoptosis and structural histological changes were also reported in embryos of this model fish species. These, shed light, not only on ZEN's toxic effects and mechanisms but also on the importance of the toxin exposure timing.

Similar to other animals, the system and the stage most notably influenced by ZEN are the reproductive system in breeding animals and early organ-system development in the offspring during embryonic/larval and juvenile life stages.

Some frequently reported developmental and reproductive pathologies in aquatic species include:

- Mosaic, intersex and feminisation where we see simultaneous/merged presence of male and female gonadal tissue. The occurrence of feminised males exhibiting a feminine phenotype in a fish of masculine genotype was observed in trout fed diets with ZEN below the European guidance value.
- Gonadal abnormalities with macroscopic-morphological changes in males which include fragmented testicular lobes and abnormal testicular development. Changes in females include asymmetric ovarian development, early ovarian maturation and ovarian hypertrophy. Consequently, differences in the gonadosomatic index can have direct economic importance as higher percentage of the fish total weight is coming from the viscera rather than the fillet.
- Effects on sperm include a reduction in the quantity and quality of spermatozoa and pathological increase in sperms' relative concentration. This is a possible result from the reduction in seminal fluid production.
- Effects on female fecundity, fertilisation success, survival rates and developmental pathologies include reduced hatchability, abnormal and un-timed reproductive development and behaviour, malformations and mutations. Furthermore, offspring of parents chronically exposed to ZEN had significantly higher risk of early mortality.
- Induction and expression of estrogen-responsive genes and proteins show a dose-dependent induction of estrogen-responsive egg yolk genes and consequent production of vitellogenin and zona radiata proteins. These proteins also serve as biomarkers for ZEN and other xenoestrogens' exposure and are used in a number of OECD test guidelines.

Therefore, so far, research has revealed that ZEN in aquatic animals can be a serious problem when unnoticed in some of the most important commercial aquaculture species of salmonids, cyprinds, crustaceans and others.

"ZEN in aquatic animals can be a serious problem when unnoticed"

It is clear that this kind of exogenous sex-hormonal-like disturbance throughout the animal's life should be avoided. There are different motives for taking action. Whether it is for welfare, environmental or commercial reasons, we should monitor and minimise the effects of ZEN on aquatic animals, both in the natural environment and in aquaculture. Monitoring fish and shrimp health status through biomarker analysis, sampling feed and raw marterials and applying mycotoxin mitigation measures need to be taken. The newly developed enzyme-based mitigation strategy called ZENzyme® is specifically designed to detoxify ZEN and provides a promising hi-tech solution for the problem.

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New insect derived ingredient can drive performance and boost health in shrimp aquaculture systems

An advanced growth of the industry increases feed demand, whilst the industry faces feed limitations and a need for performance gains.

By Andrew Richardson and Maye Walraven

With average global year-on-year growth ranging between 5-10%, the shrimp industry, based mostly in Southeast Asia and Ecuador, has shown tremendous growth over the past decade. It has also shown its resilience throughout the recent pandemic with production remaining stable. As the world's population climbs towards 8 billion, our food production systems are faced with the challenge of producing more output, with less input. Animal feed is no different; its production is compounded by competition between various animal feed industries for common feed ingredients. This strong growth and competition are putting pressure on the availability of conventional ingredients which rely on limited supply of non-renewable natural resources. In this context, pushing production systems to be more efficient and shifting towards a circular production model will be the hallmarks of a sustainable growth in shrimp aquaculture.

In this article, we describe how InnovaFeed is exploiting the intrinsic benefits of insects to drive an increase in both growth performance and health resistance in the shrimp with a new high-performance feed ingredient, NovaGain™, especially designed for shrimp feed.

Novel performance ingredient to boost shrimp production

The insect farming industry is a rapidly growing segment of the animal feed industry. It seeks to upcycle low value co-products of the agro-industry, converting them into high-value animal protein and oil sources for the feed industry. Increasingly used in the Northern European aquaculture industry as a replacement for high quality fish meal in salmonid diets, insect protein meal is establishing itself as a key novel ingredient in the pursuit of sustainable growth for aquaculture. In particular, the black soldier fly (BSF - *Hermetia illucens*) meal is not only a natural bio-concentrate of nutrients, but also a new source for molecules such as chitin, antimicrobial proteins and fatty acids - which have functional properties that are able to boost growth performance and increase health resistance of animals.

After 3 years of product development and running multiple (>10) trials in partnerships with independent research centres around the world on several shrimp species, InnovaFeed is launching NovaGain which leverages BSF's unique properties whilst tailoring them specifically for shrimp. This product has demonstrated gains in growth performance, both in feed conversion ratio (FCR) and specific growth rate (SGR) for the shrimp as seen in the results of the latest trial (Figure 1). InnovaFeed believes that this bioactive meal, which combines nutritional and functional benefits, has the potential to become a game-changing novel ingredient at inclusion rates of 5-10% in feed ingredients to boost shrimp production, in particular, *Litopenaeus vannamei*.

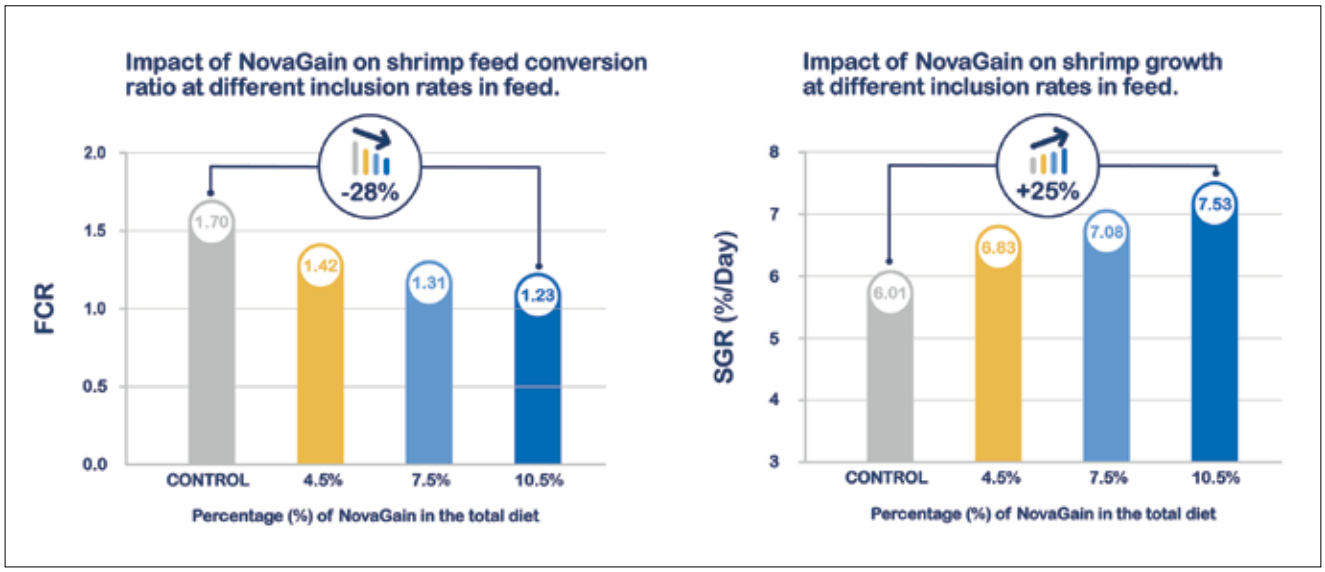

Figure 1. An improved growth performance was demonstrated when NovaGain™ was added in the diets, regardless of the inclusion level tested. FCR was significantly higher in the control diet than in the 7.5% and 10.5% NovaGain™ diets. SGR of shrimp fed treatment diets significantly improved with increasing dietary inclusion; an increase of up to 25.29% compared to shrimp fed the control diet.

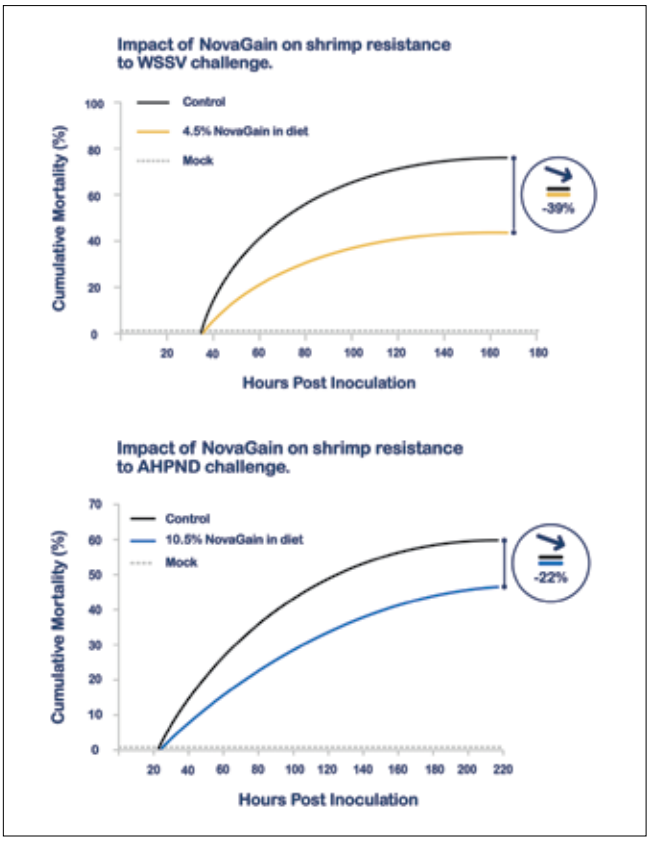

Figure 2. Cumulative mortality of *L. vannamei* fed diets containing NovaGain™ when challenged against WSSV and APHND respectively, showing health performance gains.

Supporting health and welfare to drive down losses and increase yields

Beyond supporting better harvest output, this bioactive meal could also be part of the solution to address some of the common diseases which pose considerable challenges to global shrimp production capacity today. There are two diseases in particular – white spot syndrome virus (WSSV) and acute hepatopancreatic necrosis disease (APHND) otherwise commonly referred to as early mortality syndrome (EMS), both of which could be reduced with the dietary inclusion of NovaGain.

As aforementioned, ingredients derived from BSF, are rich in compounds that can support the innate immune response of shrimp. Chitin is a natural compound which, in the wild, shrimp consume regularly when they feed on moulted exoskeletons. The chitin in the exoskeleton of BSF acts as an immunostimulant (Wang et al.,.2005) by modulating the diversity of the gut bacteria. Lauric acid is a short chain fatty acid, and is also a known antimicrobial agent (Lieberman et al., 2006). Finally, antimicrobial peptides act as a strong defence mechanism to help insects survive in harsh conditions in the wild and have proven protective effects against these specific diseases in shrimp. These molecules can provide a multitude of defensive actions for the shrimp, from breaking down bacteria (Gasco et al., 2018) to guarding against WSSV (Xiao et al., 2020).

Building on these unique properties, InnovaFeed has derived the true value of this insect derived meal by capitalising on these functional elements, and being more than simply a novel source of nutrition. NovaGain positively impacts the survival of the shrimp when challenged against both WSSV and APHND (Figure 2). An increased resistance to WSSV is shown with a dietary inclusion rate starting from 4.5% and is shown across each diet containing this insect ingredient. Evidence for increased resistance to APHND, is also shown at an inclusion rate of 10.5% in the total diet.

Shrimp health is important for farmers to increase yields, but it also addresses more recent constraints of the industry – such as improving animal welfare conditions and managing a reputational risk due to disease related losses.

Generating value from farm to fork

By combining the benefits of growth and health performance for the shrimp, our product can generate economic value for farmers. This value is derived directly from feeding efficiency improvements and indirectly through growth rate improvements and a reduction of risk due to health concerns. The ingredient can also be used to reduce the amount of fish meal in shrimp diets at more than a 1:1 ratio – which also means an increased percentage of the diets can be reformulated with considerably cheaper plant-based meals whilst maintaining the health benefits of the diet for the shrimp.

Value is also generated by diets containing this feed ingredient through an improvement in final shrimp product quality. This insect derived meal has been shown

InnovaFeed's production unit in Nesle, France is the largest active insect production site in the world. It opened in November2020 and is co-located with Tereos (starch manufacturer) and Kogeban (biomass plant).

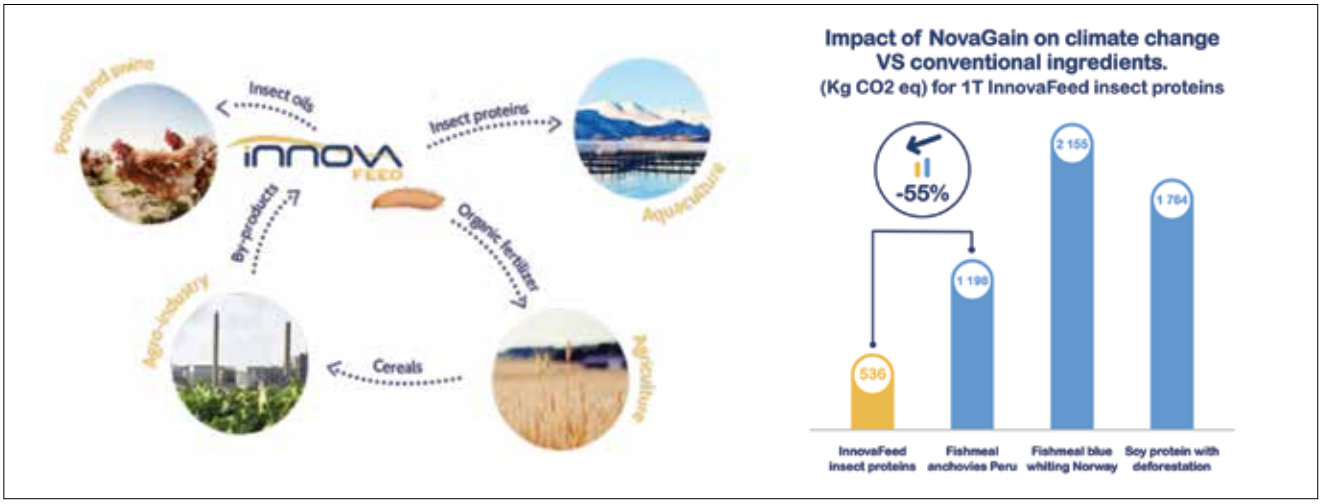

Figure 3. InnovaFeed's circular model drives the competitiveness of NovaGain™. An independent LCA (life-cycle assessment) shows the positive role feed choices can have on CO_2 impact.

to contain lower levels of heavy metal pollutants and polychlorinated biphenyls (PCBs), thus improving shrimp product quality. Furthermore, as drivers such as traceability and feed sustainability are increasingly sought after by leading labels, accreditations and discerning consumers, NovaGain™ provides a strong communication platform for shrimp farmers and their clients with regards to product differentiation.

Clear market differentiation

Novel ingredients such as NovaGain™ can not only alleviate some pressure on conventional feed ingredients, but their use can be directly translated into commercial messaging through direct B2C labels – such as the "vive l'insecte" label in France. This is true of B2B style communications as well, for instance when launching efforts to reduce FIFO (Fish-in Fish-out) in line with international certification standards such as that of the Aquaculture Stewardship Council (ASC). The key to this style of messaging hinges on quantifying impact with data-driven evidence, which ensures that communication is clear and effective.

The model that InnovaFeed has developed – one of circularity and co-localisation utilising only GMP+ certified co-products from existing industrial processes as the only feedstock – unlocks the potential of the insect farming industry. By integrating the insect meal industry into existing infrastructures, InnovaFeed reduces the carbon footprint of their processes by 80%. Standout innovations include sourcing 60% of the energy from heated exhaust vents at a local renewable energy plant and using wet co-products directly piped to the insect rearing facility. A detailed analysis of the process and scientific write up of the independently gathered results has been reported by Phan Van Phi et al. (2020).

InnovaFeed, one of the largest insect meal producers in the world, currently operates two facilities in the north of France, and has global ambitions. In late 2020, it announced a partnership with ADM to build another record-breaking plant in Decatur, Illinois, USA. This plant will be co-located with the largest corn processor in the world and is projected to have a yearly capacity of 60,000 tonnes of BSF protein products. Corn-based by-products from ADM's Decatur operations will be locally upcycled to feed insects and will be directly conveyed through infrastructures connecting both companies. This production model will also allow InnovaFeed to use 27MW of residual energy recovered from the ADM process.

Through a focus on industrial scale volumes, automation, co-product upcycling and quality products, InnovaFeed is set to have a strong impact on shrimp aquaculture and on global agriculture more broadly.

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Origins of lysed yeasts – Benchmarking for shrimp performance

Comparing the effects of dietary autolysed and hydrolysed yeast products on growth performance of juvenile white leg shrimp.

By Holger Kühlwein and Pradeep P. J.

Yeast (*Saccharomyces cerevisiae*) is highly regarded as a valuable nutrient source for the livestock, pet food and aquaculture industry. It is an excellent source of protein and other nutrients like minerals and trace elements, amino and nucleic acids, vitamins (especially B vitamins) and enzymes as well as many micro-nutrients, e.g. a biologically active form of chromium (Ferreira et al., 2010).

More recently, yeast and its various derivatives are considered as "functional ingredients" and are incorporated in animal feeds, due to the fact that they can have an impact on health benefits or other desirable physiological effects in addition to their nutritional function. One of the most significant components which gives the yeast both nutritional as well as functional importance is the richness in native nucleotides that are derived from its intracellular contents. The yeast, however, has a complex and thick cell wall with the external mannoprotein layer likely being the barrier to digestion and reduced digestibility (Nasseri et al., 2011) and thus also interferes with the bioavailability of nucleotides. Therefore, if fed as whole yeast, the cell wall must first be lysed during its passage through the gastrointestinal tract to release these nutrients and this process is done by gut microbes, which is a time-consuming process (Shurson, 2018).

Alternatively, in a commercial environment the yeast may be subjected to a lytic process using various additional biotechnological measures to stimulate an effective break-up (perforation) of the yeast cell wall. As a result, all highly valuable intracellular contents are released and can therefore be made available more easily and faster to the organism during their intestinal passage. The benefits of disrupting the yeast cell wall prior to feeding to cultured animals have strikingly been demonstrated previously (Rumsey et al., 1991a, b).

From a commercial perspective, however, factors such as raw material quality and origin/fermentation substrate (yeast from brewery, bioethanol/molasses or bakery industry) and even the manufacturing process including purification, lysis, processing aids and drying technique may all affect the efficacy of the final lysed yeast product. Hence, the objective of this investigation was to evaluate and compare the performance of three commercially available lysed yeast products from various origins produced under different manufacturing process. All three products were evaluated by comparing their efficacy in terms of growth performance and feed conversion when administered through the feed to juvenile white leg shrimp *(Litopenaeus vannamei*) under non-challenging conditions.

Experimental design

The experiment was conducted at the Aquacultural Research Institute, Chinese Academy of Fishery Sciences (Guangzhou, China). Healthy shrimp larvae were acclimatised to the experimental facility for 2 weeks. Following acclimatisation, a total of 480 shrimp with an average initial body weight of 2.4g were allocated to 16 tanks. There were four replicate tanks per treatment (n = 4; 30 shrimp/tank). Each tank contained 600L of water with temperatures and salinity ranging from 29-32°C and 30-32ppt, respectively and the tanks were connected to a recirculation system. Water exchange (30%) was conducted daily to maintain optimal water quality. All water parameters (oxygen, ammonia nitrogen and nitrite) were measured weekly and were maintained within the normal physiological values during the entire trial.

Four isonitrogenous (42% crude protein) and isolipidic (6.3% crude fat) diets were produced by supplementing 0% (control diet), 0.2% hydrolysed yeast competitor 1 (COMP 1), 0.2% hydrolysed yeast competitor 2 (COMP 2) and 0.2% autolysed brewers' yeast Leiber® CeFi Pro (Leiber GmbH, Germany) with the basal diet (formulation in Figure 1). The products were supplemented at the expense of wheat flour. Throughout the experimental period of 8 weeks, shrimp were fed three times daily at 9 am, 4 pm and 10 pm.

Statistical analysis was performed with SPSS statistics version 23.0 (SPSS Inc., Chicago, IL, USA) by using Duncan's multiple comparison. Statistical significance was accepted at the $p<0.05$ level and all the values are presented as means ± standard deviation.

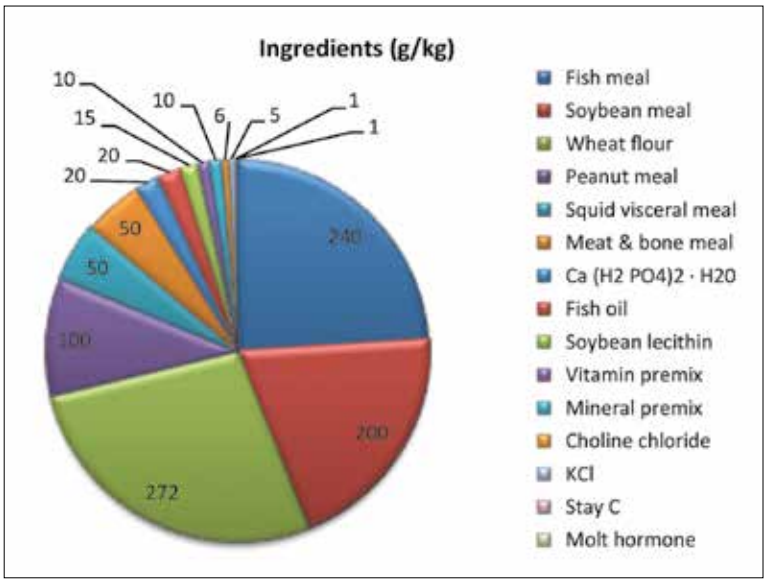

Figure 1. Formulation of the basal diet (in g/kg)

Results and discussion

The present trial conducted under the non-challenging conditions revealed a high performance with specific growth rates of over 3% and very low mortality rates (survival > 97.5%). The growth performance (final weight, weight gain ratio and specific growth rate) of shrimp and feed conversion ratio (FCR) are presented in Figure 2.

At the end of the 8-week feeding trial, the shrimp fed with CeFi Pro and COMP 1 showed significantly improved growth performance and feed conversion ratio compared to the other two treatments (control diet and COMP 2). Though not statistically significant, the CeFi Pro group also performed better than COMP 1 in terms of growth performance and FCR.

The relative difference (in %) of the test diets over the control diet is illustrated in Table 1. Compared to the two other commercially available hydrolysed yeast products, autolysed CeFi Pro has shown the best performance, and the product was able to improve the final body weight by 8.2 %, weight gain ratio by 11.3%, specific growth rate by 4.7 % and feed conversion ratio by 6.9 %.

Although all three tested products were lysed yeast derived from *S. cerevisiae*, various factors may be responsible for the differences observed in growth performance and feed conversion with the CeFi Pro group performing best. First and foremost, the raw material quality and the origin of the yeast are of crucial importance. Leiber CeFi Pro was the only product in the trial derived from brewer's yeast. Unlike many other yeast types originating from industrial

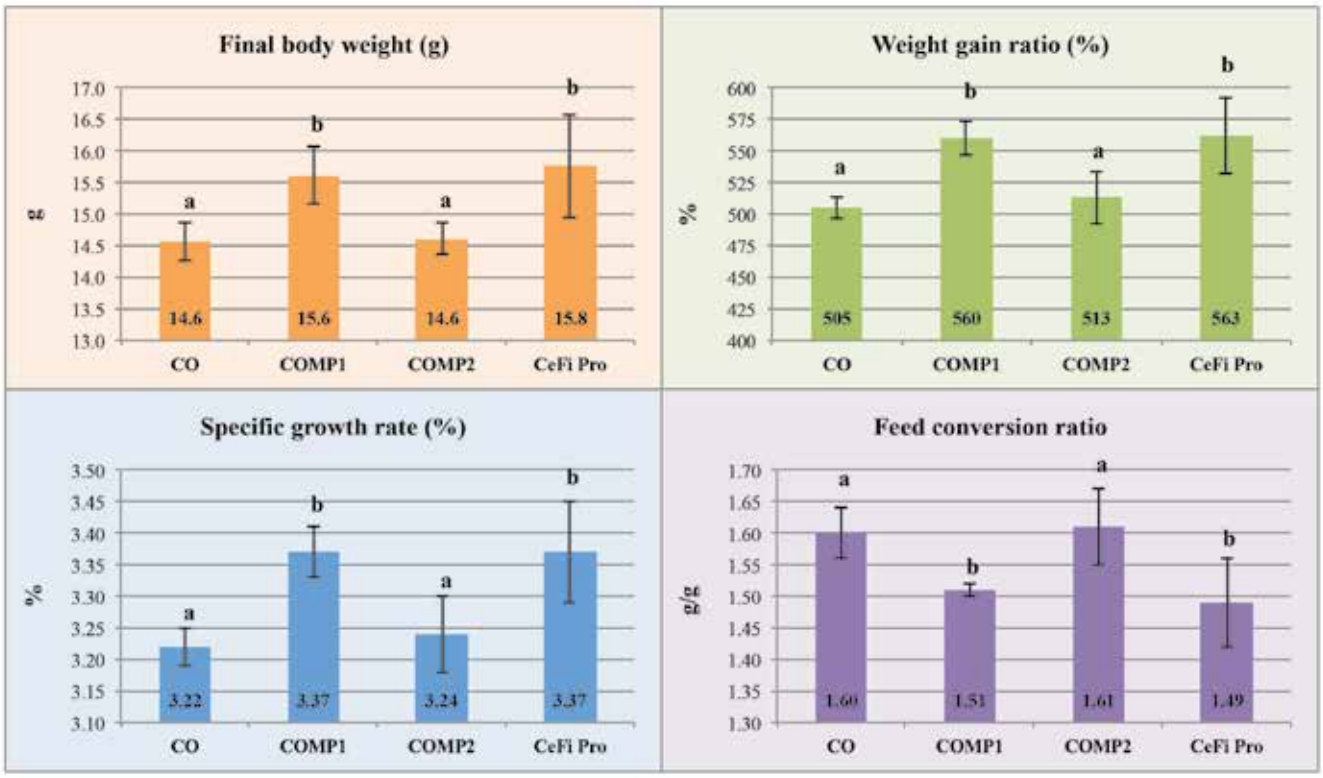

Figure 2. Effects of lysed yeast products on shrimp growth performance and feed conversion after 8 weeks of feeding (n = 4). [a,b] Different superscripts indicate a significant difference (p < 0.05).

	COMP 1	COMP 2	CeFi Pro
Final body weight	+ 6.7 %	+ 0.3 %	+ 8.2 %
Weight gain ratio	+ 10.9 %	+ 1.6 %	+ 11.3 %
Specific growth rate	+ 4.7 %	+ 0.6 %	+ 4.7 %
Feed conversion ratio	- 5.6 %	+ 0.6 %	- 6.9 %

Table 1. Relative differences (%) in growth performance and feed conversion ratio of shrimp fed with the experimental diets vs the control diet for 8 weeks (*n* =4).

scale production processes, CeFi Pro comes from a high-quality, food-grade production process with clean, clearly defined and GMO-free raw materials of the brewing industry. Therefore, its continuously high quality level can be guaranteed. Furthermore, the lysis process applied to the above mentioned yeast cell wall degradation (acid hydrolysis or enzymatic autolysis) can also influence the amount of free amino acid content and the molecular weight of peptides in the lysed yeast products (Podpora et al., 2015). An acid hydrolysis process has high overall production yields and is relatively more convenient for mass scale production, as compared to enzymatic autolysis with lower extraction yields and highest purity. Furthermore, acid hydrolysis leads to a high probability for the presence of carcinogenic compounds (monochloropropanol and dichloropropanol) and to relatively high salt contents (Podpora et al., 2016).

In contrast, Leiber's CeFi Pro, being processed under superior enzymatic autolysis conditions is able to offer a high quality source of free amino acids, nucleotides and nucleosides, vitamins, trace elements and high levels of peptides with low molecular weight. In species with a short and complex digestive tract such as shrimp (Ceccaldi, 1989), a high bioavailability of these valuable nutrients is very useful and the nutrients will be readily absorbed through the enterocytes along the alimentary tract. This potentially explains the better growth performance observed.

In addition, the substrate on which the yeast cells are grown might be of significant importance to the nutritional composition of the final product. As Podpora et al. (2015) described, also the wort/slurry remaining from the brewing process, in which the yeast cells are suspended, is rich in proteins, peptides and free amino acids derived from barley and other components used in beer production. Yeast products derived from other substrates may be less rich and complex in nutritional composition. In this context, also the hops used during beer production is contributing beneficial antioxidative and bacteriostatic effects through a range of bioactive constituents (polyphenols, flavonoids, etc.) to the final product (Leiber GmbH, internal communication, 2009). Yeast products fermented on other substrates do not possess this feature.

Conclusion

Better performance of the autolysed Leiber CeFi Pro at the same dosage as the two other commercially available hydrolysed yeast products in the present study proves that production processes influence the product efficiency. Many factors – especially the fermentation substrate used, the lysis method, separation of cell walls from cell contents, nutritional concentration and composition of the final lysed yeast, etc. – will eventually impact the performance of the end product.

Autolysed brewers' yeast CeFi Pro, is high in natural DNA and RNA components with free nucleotides and nucleosides, present in highly digestible free amino acids, and in short-chain peptides. It is recommended for use in aquaculture species at 0.2-0.3% in a complete feed. Remarkably, when it was added to feed, the inclusion of other feed additives for immune boosting and attractability/palatability can be reduced or removed completely. This is due to the fact that Leiber's CeFi Pro also contains yeast cell walls consisting of both ß-glucans and mannan oligosaccharides (immune enhancers) and nucleotides (palatant and attractant), respectively. Overall, this product contributes to the economic benefit to the feed industry with added value.

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Advances in fish meal and fish oil replacements

Production and technology development of insect proteins and soy based raw materials

The F3 Challenge began a series of webinars in 2021 bringing together groups of producers of alternative ingredients to replace fish meal and fish oil. In February, it was Insects in Aquafeeds: Progress towards fish meal/fish oil substitution. In the follow-up webinar in March, it was the turn of producers of soy based raw materials. The third webinar in April featured innovators of single-cell and novel proteins for aquafeeds and in the fourth in May, algae and seed oil manufacturers will discuss latest research, and fish oil replacement successes for their products. Reports on the latter two webinars will be published in issue July/August 2021.

The moderator was **Professor Kevin Fitzsimmons,** Chair of the F3 Challenge and Judge, Professor and Director of International Programs at The University of Arizona, USA. Future of Fish Feed (F3) is a collaborative effort between NGOs, researchers, and private partnerships to accelerate the commercialisation of innovative, substitute aquaculture feed ingredients to replace wild-caught fish.

Black soldier fly larvae. Picture credit: Nutrition Technologies

Insects in aquafeeds

Fitzsimmons introduced six major insect protein producers from the US, China, Southeast Asia and Europe. US based **Chapul Farms** is a current contestant in the F3 challenge, carnivore edition, salmonid category. Chapul Farms was started 9 years ago. It works with the black soldier fly, *Hermetia illucens* (BSF) and is building and scaling modular insect farms. There are seven projects in development.

Patrick Crowley, CEO said, "Our strategy is a low variability feed stock as the starting point of our systems design. However, a crucial element of project development is offtake from the farms. We focus primarily on BSF in aquafeeds. In terms of trials, there are numerous academic studies, even up to 100% replacement fish meal, demonstrating at least no negative growth factors.

"We are seeing price limiting inclusion rates more than nutrition itself. We are also seeing some of the immunological stress tolerance benefits of the BSF even at lower inclusion rates," added Crowley.

Guangzhou FishTech Biotechnology is in insect meal production since 2009 working on the BSF. Production capacity is >10,000 tonnes which can be easily expanded. It wants to build up insect meal production in China. The company has various types of BSF products such as hydrolysed insect peptides. Numerous application research for BSF in aquafeeds have been conducted such as with the vannamei shrimp, Japanese seabass, hybrid snakehead, largemouth bass, etc.

Dr Wingwang Lu, CEO emphasised the functional value of BSF. "BSF can replace a certain level of fish meal in different aquatic species without affecting growth, but the amount will vary with species. There is a strong growth-promoting effect too. BSF could replace squid and fish paste and other attractants to improve palatability. There is an immunity effect such as improving the survival rate of fish and shrimp and disease resistance."

Nutrition Technologies, founded in 2015, is Southeast Asia's leading insect meal producer. Nick Piggott, CEO and Co-Founder, said, "Southeast Asia offers vast access to agro-industrial by products and the ideal climate for BSF larvae production." After extensive R&D, Nutrition Technologies opened its first factory in March 2018 in Malaysia. Here, it is ramping up its industrial scale facilities. "Our long-term objective is to produce a sustainable and staple ingredient for the feed industry which can compete with fish meal and soybean meals."

The company has pioneered a new and more efficient insect rearing process using its own bacterial inoculants. "In order to offer high quality, sustainable and competitively priced products, our research and innovation team is actively pushing the boundaries conducting trials for and with customers while testing new formulas and ingredients," said Tom Berry, Co-Founder. Future expansion plans are to Thailand, Vietnam and Indonesia.

Kees Aarts, Founder and CEO, set up the award-winning **Protix** in the Netherlands in 2009. In the last couple of years, the trend is towards innovative products and system changing with reduced production footprint. "At Protix, for every kg of protein we produce, we can reduce well over 4kg of CO_2 out of these systems as well as reducing land and water use by 80 to 90%. At our world class flagship facility in Bergen op Zoom, we are already producing beyond design capacity. Protix recently introduced an improved strain of insect that is fast improving production."

Aarts gave three main reasons for insect meals in aquafeeds. Composition and quality where insect meals have suitable amino acid and fatty acid profiles, high digestibility as well as high palatability. Inclusion levels at 20-60% have successfully replaced dietary proteins and helped promote liver and gut health and immune response modulation. "The body of evidence in peer reviewed scientific publications are mounting. We are committed to mass adoption of insect based nutrition." A recent article showed improved antioxidant activity of BSF proteins. Insect based proteins have proven themselves in terms of productivity and

bioactivity. "The Protix derisked technology platform with 100% production capacity allows for rapid rollout and volume expansion," added Aarts.

In 2018, **InnovaFeed**, based in France launched its insect meal (BSF) ingredient ProtiNova with an amino acid profile close to fish meal for salmonids. At the R&D level, 100% of fish meal was replaced for the salmonids and tilapia. "Beyond R&D, we have included the insect meal in commercial feeds for trout and salmon. Trout fed with insects are commercialised in a supermarket chain across France," said Maye Walraven, Head of Business Development. In 2021, it launched a shrimp ingredient Nova Gain, which can improve FCR by 30% and growth by 20% and resistance to several diseases (see article on pages 49). InnovaFeed is in the process of adding this into commercial feeds.

Since 2020, InnovaFeed has launched a full scale industrial plant. By co-locating with a starch plant, it has a unique symbiosis model and is pioneering sustainability with 57,000 tonnes of saved CO_2 per year. "LCA of InnovaFeed's insect meal products show environmental performance. For ProtiNova, kg CO_2 eq is -55% less than fish meal and 3 tonnes of forage fish is saved per tonne of insect meal." It will replicate this concept across several plants around the world. A new plant in Decatur, Illinois, USA will be next to an ADM plant. By 2030, InnovaFeed plans to produce between 300,000 to 500,000 tonnes of insect proteins for the aquaculture market.

Ynsect, France with USD 372 million series C funding, uses wheat husk, corn husk and derivatives of cereals as feed substrates. There are two factories in France, the first produces 1,000 tonnes and a second plant will produce 100,000 tonnes/year.

Alain Revah, Chief Marketing and Strategy Officer, said, "We have been publishing extensively research results, showing the performance of our insect protein, increasing yields by 35% and decreasing mortality by 40%." On replacing fish meal with insect proteins, Revah said, "Today I do not think that completely replacing fish meal will occur. We can be complementary to fish meal and fish oil. We can reduce the stress on fish stocks. But if aquaculture farmers want to, our ingredients can be used to completely replace fish meal.

"Regulatory wise in the European Union, we can use our protein to feed fish and shrimp. We just received a favourable notice from the EFSA to use *Artenaria molitor* protein for human food. We also expect some decision on poultry feeds and wish to see some regulatory approval for the US markets for aquaculture and petfood market."

Revah added that Ynsect is the highest in rank in terms of sustainability with its circular economy. It has a carbon negative plant, as it sequesters more carbon than it emits. In 3 years, Ynsect will have the world's largest plant as well as a second plant in the US.

"Today I do not think that completely replacing fish meal will occur. We can be complementary to fish meal and fish oil. We can reduce the stress on fish stocks. But if aquaculture farmers want to, our ingredients can be used to completely replace fish meal."
Alain Revah

Image credit: USSEC

Soy ingredients in aquafeeds

Six major producers of soy products for aquafeeds presented on the latest progress in developing new products. The role of **USSEC** or US Soy Export Council is to optimise utilisation and value of US soy in feed, aquaculture and human consumption in international markets. Lukas Manomaitis, Aquaculture Program Technical Contractor said that soy is well established as a replacement for fish meal. Product developments have progressed from low 45-50% crude protein (CP) soybean meal (SBM) to soy protein concentrates (SPCs) of 50-70% CP with removal of anti-nutritional factors. "As we move away from fish meal and fish oil, we have a variety of products, but we need to understand the ingredients, their specific nutrients and strengths."

As part of the work with industry, USSEC worked with collaborators to develop an alternative database (www.IAFFD.com), specifically to fill a need since many commercial databases, though available, are not comprehensive enough for aquafeed formulation work. Manomaitis encouraged commercial feeds formulators to use this database, as an addition to the existing database in the factory or for benchmarking to improve their formulations.

Jiangsu Fuhai Biotech Co., Ltd currently has 200 tonnes of products and expects to scale up to 15,000 tonnes annually by 2025. The company has two products: 38%CP SBM and SBM with 48% CP. Zhijun Hu, CEO showed that the enzyme treated SBM could replace Peruvian fish meal in 42% CP vannamei shrimp diets with no significant effects on weight gain as compared to a fish meal diet. There was better survival and mitigation against WSSV. Similarly, the enzyme treated SBM could replace 15% fish meal in feeds for yellow head catfish and large mouth seabass. He concluded that the price can be less than Peruvian fish meal and that with scaling up, this can be further lowered. Funding can accelerate production.

Benson Hill Bio-Systems uses artificial intelligence (AI), data and a variety of breeding techniques to create innovative food and ingredient products. It is one of the top companies funded by AgFunder. It has developed a non-GMO, "ultra-high" protein soybean with ultra-low oligosaccharide (HPULO). The crop was grown in 2020 and is currently being processed as SBM. Hannah Lucas, Business Development Manager showed how the meal has 48-51.5% CP, depending on the process.

HPULO is highly digestible in rainbow trout at 89% for protein digestibility. Benson Hill has tested the meal in several species-salmon, trout, yellow tail, vannamei shrimp and cobia. "There was no evidence of enteritis in salmon or trout. Diets with HPULO outperforms diets with fish meal. With this product, we show LCA to enable sustainable farming and new aquaculture value models."

Taiwan based DaBomb Protein Corp. has a functional peptide product where the annual production is 36,000 tonnes in Taiwan. DaBomb also produces 12,000 tonnes of functional peptide plus probiotic in Fujian, China for the domestic market. The company expects to produce 72,000 tonnes of products by 2024. Jeffery Jiang, Manager, Agribusiness Unit said, "This 51% CP functional peptide, has high protein digestibility, improves gut health and enhances immunity. Trial data showed no adverse effects on growth with replacement of 15-30% fish meal in diets for the green grouper and Asian seabass and up to 75% in low fish meal diets for the vannamei shrimp. Immunity was also studied and results indicated that our functional peptide could induce an immune response." Jiang added that, as the raw material is SBM, with rising prices, the company now faces competitive issues, such as the price gap with other materials, in particular fish meal.

US based **Menon Renewable Products,** Inc. utilises agriculture wastes as inputs to create a functional peptide called Mr Feed. The company has a production capacity that can support 500,000 tonnes of finished feeds and will be able to upscale to provide for one million tonnes of aquafeeds in 3 years. The peptides are less than 1kDa. "Mr Feed is being used successfully in more than 15 countries. With the vannamei shrimp, trials in 7 markets showed 40% better survival and better protection against early mortality syndrome, white faeces disease and white spot syndrome virus. In trout, snapper and tilapia, the growth improved by 30%, survival by 9% and there was a 40% reduction in parasites," said Dr Suresh M. Menon, Founder and CEO.

With 37 years in the industry, **CJ Selecta** now produces one million tonnes annually and is the largest producer of soy protein concentrate (SPC). SPC is produced via aqueous alcohol extraction of defatted soy flakes. "SPC with 65% CP is a fish meal replacer in salmon diets. Digestibility is high at 90%," said Dr Patricia Sugui, Sustainability Manager. She showed that the product X-Soy 600 had a digestibility coefficient as high as 93% in shrimp and fish. CJ selecta also has a micronised SPC, with a particle size of 180µm. "In response to current socio-environmental concerns around Brazil's soy industry and the growing demand for sustainable products, the company has implemented sustainable actions. We improved our traceability, using only certified GMO and non-GMO soybeans and reduced carbon footprint of SPC. We ensure than our purchases are free from deforestation and social issues."

Malaysian Fish Farm for Sale

Located in beautiful clean waters in Tasek Kenyir, Terengganu, this technologically advanced business is now up for sale as a going concern, complete with everything needed to function from day 1 of acquisition.

The fish farm is well known for the production of the finest quality Tilapia, pangasius, Baung (Bagridae), Jelawat (sultan fish or *Leptobarbus hoevenii*) and other local Malaysian species.

Exclusively with the Department of Fisheries, Aquaculture Zone in Kenyir lake and surrounded by protected National Park the farm boasts one of the most stunning scenic locations to work from. Situated about 25 minutes from Kuala Berang and 45 minutes Kuala Terengganu, Terengganu, it is ideally located for markets, distribution network and amenities.

With the capital city of Kuala Lumpur just 5 hours drive from the farm and motorway network serving most of the trans peninsula area and with a custom fitted live fish transportation lorry, the farm can move large volumes of live and chilled fish and dry goods back and forth across the peninsula with relative ease. *More details, email: info@sgcomofarms.com/Margaret@sgcomofarms.com*

Functional brewers' yeast in sustainable aquaculture and MSc Scholarship award ceremony

Virtual award ceremony, from top left to bottom right: Dr Daniel Merrifield and Dr Holger Kühlwein congratulate the two recipients of the MSc scholarships, Jack Sears-Stewart and Luciano Brincat.

An increasing prioritisation of a sustainable production of food and protein for the rising global population is apparent across all agricultural sectors and manifested in the Sustainable Development Goals adopted by all United Nations Member States in 2015. The aquaculture sector is no exception to that.

The MSc Sustainable Aquaculture course at the University of Plymouth, UK contributes greatly to train the next generation of young aquaculture scientists in this context and covers topics such as the sustainable use of resources for aquaculture production, aquatic animal health, reduction of environmental impacts and socio-economic factors. A further significant pillar of the course is the industry guest lectures delivered by representatives from leading companies and organisations along the value chain. These lectures aim at giving insights from a commercial perspective and counteract potential misconceptions and unawareness of the students regarding industrial operations and procedures, respectively.

The sustainable upcycling of by-products of the beer brewing industry and the application of the refined end products in various aquaculture scenarios were the core topics of the recent lecture given by Dr Holger Kühlwein, Global Key Account Manager Aquaculture at Leiber GmbH.

His lecture included aspects such as different yeast cell fractions/products, raw material sourcing, quality assurance and applications in aquafeeds and aquatic animal health and how these products can contribute to an overall more sustainable aquaculture. The product types covered included nutrient-rich autolysed yeast, prebiotic yeast cell walls/MOS (mannan oligosaccharides) and purified ß-glucans as boosters of immune-competence. The presentation was concluded by reporting on initial trial results of the recently launched new product range of yeast extracts, which aims at alleviating the potential negative side-effects of challenging diets.

Industry Scholarship Programme

As a continuation of its investment in sustainable aquaculture R&D and education, **Leiber GmbH** is also proudly providing funding again for two of the students as part of the Aquaculture Sustainability Industry Scholarship Programme. Both will be able to deepen their knowledge and laboratory skills by participating in feeding trials and subsequent analytical work with selected brewer's yeast products. "The society's rising awareness with regards to food production and its impact on environmental sustainability and animal welfare is driving sustainability initiates along the value chain on a large scale" said Kühlwein. "By refining by-products of the brewing industry Leiber GmbH's has been exemplifying sustainability and upcycling since 1954. It is only a logical conclusion that we further support R&D and training programmes directed towards aquaculture sustainability. This programme at University of Plymouth combines all these aspects in a holistic manner."

Dr Daniel Merrifield, University of Plymouth, added, "Our industry guest lecture series and associated Aquaculture Scholarship Programme provide an excellent opportunity for our students to engage with world-leading players from the industry." www.leibergmbh.de

A successful trade show for the shrimp farming sector in Vietnam

At the ribbon cutting ceremony, from left: Marc Le Poul, General Manager of Skretting South Asia; Lê Văn Quang, Chairman and CEO of Minh Phu; Nguyen Viet Thang, Chairman of Vietnam Fisheries Society (Vinafish); Tran Dinh Luan, Director General of the Directorate of Fisheries; Nguyen Ngoc He, Vice Chairman of the Peoples Committee of Can Tho City; Hou Hsu Kuang, Vice President, Sheng Long Bio-Tech and Duong Xuan Hung, Editor of Vietnam Fisheries Magazine.

Despite the ongoing challenge of the severe global pandemic COVID-19, the third VietShrimp Aquaculture International Fair 2021 attracted 200 exhibitors. This was after a year-long hiatus; the last show was in 2019. The 3-day trade show was held from April 14-16 in Cần Thơ City in the Mekong Delta, which is the centre of aquaculture in Vietnam. Spread over 2,262 m^2, VietShrimp 2021 hosted a wide variety of foreign and local companies operating in Vietnam. It was the largest international aquaculture event in the last two years.

Along with the trade show, there were three conferences focused on the theme of "Sustainable Destination" with aquaculture solutions attained through the applications of science and technology to improve the sustainability of shrimp farming in Vietnam. International and local experts as well as industry speakers led discussions on the latest in Vietnam's shrimp aquaculture–status, public/private cooperation, modern shrimp aquaculture technology, feed and nutrition, and high-quality shrimp post larvae production.

The conference focused on recent developments in high technology shrimp farming models with the hope that it will bring more sustainable development to Vietnamese shrimp aquaculture in the future. Farmed shrimp is a key export sector of Vietnam. Although overseas speakers were unable to visit Vietnam in person due to the pandemic, they were able to share their expertise through pre-recorded videos. Approximately 100 participants attended the first seminar in person.

Aquaculture solutions toward sustainability

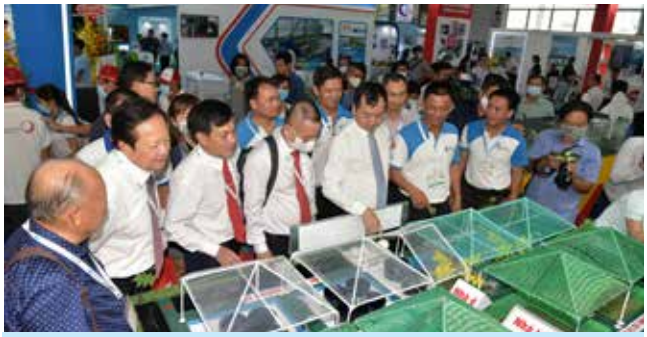
Some messages presented were:

Trần Đình Luân, Director General of D-Fisheries, Ministry of Agriculture and Rural Development said that shrimp farming must be further improved to ensure environmental protection and traceability.

Nguyễn Việt Thắng, Chairman of the Vietnam Fishery Society said that the targets in 2021 is to farm shrimp in an area of 740,000 ha and achieve a total output of 930,000 tonnes, with a revenue of USD 4 billion from shrimp exports.

At the opening ceremony, Lê Văn Quang, Chairman of Minh Phú Seafood Corporation said that Vietnam has controlled the pandemic COVID-19 well, and so shrimp processing plants have been operating normally. However, he warned that if the Vietnamese shrimp farming industry does not improve its technology and adopt new solutions, it will face stiff competition in the coming few years. This article was contributed by Milan Vu, Vietfish Magazine.

VietShrimp 2022 will be from March 20 - 22



C.P Vietnam introduced innovative farming technology named "CPF Combined Model" to apply in its shrimp farms in India, Vietnam and the Philippines.

The trade show attracted 200 exhibitors and 12,000 visitors.

Skretting Vietnam wins two prestigious prizes

Skretting Vietnam's sales, technical and marketing teams at its booth which won two prizes at VietShrimp 2021.

VietShrimp 2021's outdoor fair is the country's largest shrimp-focused exhibition. It was the ideal platform to showcase the achievements and raise the global profile of Vietnam's shrimp industry, as well as the perfect opportunity to discuss its future prospects and ambitions. It was held on April 14-16 and attracted more than 12,000 visitors, VietShrimp 2021 also offered an excellent networking environment for industry players to make new connections and explore future business ideas. As well as being able to visit 200 company booths, the event's attendees could also participate in a number of workshops relating to different aspects of Vietnam's shrimp aquaculture.

Skretting Vietnam was active during the event with the following two seminars:

- 'Life Start: The importance of early nutrition for life performance' was presented by Michael Leger, Technical Manager, Nutreco SEA
- 'Skretting brings global shrimp experience to Vietnam' was presented by Arjen Roem, Marketing Director, Nutreco SEA

Both speakers delivered extremely interesting and thought-provoking presentations. These were well received by an audience comprising many enterprises, authorities and farmers.

Meeting customers

Members of Skretting Vietnam's sales, technical and marketing teams were also present at VietShrimp 2021 to promote the company's products and services. In addition, their booth provided information on all current products and also introduced two new products, *Jade* for nursery and *Impact* for vannamei. The benefits that Jade and Impact can offer farmers were also communicated during the seminars.

At the booth, a SUCCESS demonstration farm attracted a lot of attention from customers.

Skretting Vietnam used the event to launch SUCCESS, a sustainable shrimp farming programme designed to maintain biosecurity in order to help manage the risks posed by disease outbreaks. SUCCESS is also capable of increasing farm profits by 30-40% compared to traditional farming models.

Not surprisingly, a SUCCESS demonstration farm attracted a lot of attention from customers. The event also enabled representatives from Skretting Vietnam to engage with numerous visitors, with many attendees expressing interest in Skretting products.

As well as the visitor interactions at Skretting Vietnam's booth, more than 300 Skretting customers were invited to the exhibition and to attend the seminars. Most were impressed with the warm welcome they received from Skretting staff and enjoyed the activities organised at the booth, including a prize draw, food and flamenco-style entertainment. They also appreciated being introduced to the *Jade*, *Impact* and SUCCESS innovations.

Successes and prizes

As well as securing a strong attendance, VietShrimp 2021 portrayed Vietnam's shrimp industry in a very positive light. Subsequently, Skretting Vietnam has already seen an increase in business and has further enhanced its already very good reputation in the marketplace. Skretting Vietnam is also proud to have won two prestigious prizes, namely the best designed booth, and the most visited booth. The event has enabled Skretting Vietnam to strengthen its relationships with customers and partners. www.skretting.com

Marc Le Poul, General Manager of Nutreco International (Vietnam) and SEA and Bui Thuy Tien, General Manager of Skretting Vietnam.

Arjen Roem, Marketing Director, Nutreco SEA presented on 'Skretting brings global shrimp experience to Vietnam'.

DSM launches a first-of-its-kind intelligent sustainability service

Sustell™
Sustainability Intelligently Applied


David Nickell

Royal DSM, a global science-based company active in nutrition, health and sustainable living, has launched Sustell™ – a first-of-its-kind intelligent sustainability service that delivers accurate, simple, and actionable farm-level solutions – to improve the environmental footprint and profitability of animal protein production. Through Sustell™, DSM is underlining its commitment to its strategic initiative *We Make It Possible*, which is driving a robust and achievable global transformation toward sustainable animal protein production. By leveraging digital and data-driven solutions such as Sustell™, DSM is advancing its precision animal farming journey towards a brighter future.

Sustell™ was developed together with Blonk, a recognised independent expert and leader in Life Cycle Analysis (LCA) and sustainability performance in the food and agriculture fields. The Sustell™ service is built around a state-of-the-art Intelligence Platform that is connected to the Blonk APS-footprint tool, together with an 'Expert Center' made up of a team of DSM and Blonk experts in LCA, animal nutrition and sustainability.

The Expert Center partners with animal protein producers, assessing the baseline environmental footprint of their animal production using their actual farm and feed data rather than industry averages and proxy data sets and then developing case-specific intervention scenarios known as 'what-if' models to make measurable sustainability improvements. In this way, Sustell™ combines an advanced, powerful sustainability calculation tool that utilises real farm data, with expert knowledge, tailor-made, practical solutions and business development projects to unlock the value of sustainability.

Sustell™ is a global service, built on validated protocols, calculation methodologies and proven processes that meet international standards. It provides accurate, globally recognised, comparable analyses and results of environmental impact assessments, interventions and improvements throughout the animal protein value chain:

- Compliant with the internationally recognised FAO LEAP (Livestock Environmental Assessment and Performance) and Product Environmental Footprint Category Rules (PEFCR). Following calculation guidelines from IPCC, and in alignment with ISO 14040/44. Built on credible and sound food, feed and agriculture databases like the Agri-footprint database and GFLI (Global Feed LCA Institute).
- Covers the 17 largest agricultural producing countries in the world where the animal production systems can be defined in detail thanks to country-specific data.
- Analyses the environmental impact of 19 different categories including climate change, resource use, water scarcity, marine and freshwater eutrophication, ozone depletion, to name only a few, corresponding to impact assessment method Environmental Footprint 2.0. providing global recognition for the results.

By providing deep insights into farm-level emissions Sustell™ opens new possibilities for the wider value chain, including the ability to certify and incentivise sustainable farm practices. For example, retailers and financial institutions will be able to objectively manage the risks and opportunities relating to the environmental footprint of animal protein. In addition, Sustell™ enables farmers to accurately forecast the impact of sustainability measures on financial performance.

Hans Blonk, CEO Blonk Consultants & Blonk Sustainability Tools said, "We are excited to be launching Sustell™ today alongside DSM – a truly intelligent sustainability service that is front and centre to our mission at Blonk – to support organisations in addressing the challenge of making the global production and consumption of food more sustainable."

David Nickell, VP Sustainability and Business Solutions DSM Animal Nutrition and Health said, "Sustell™ achieves the seemingly impossible – simplifying the complexity of measuring, validating and improving the environmental sustainability of animal protein transparently, scientifically, farm by farm, system by system. Animal farming companies and the associated value chain, have, for the first time, a powerful solution to measure, compare and improve the sustainability of animal protein."

Ivo Lansbergen, President DSM Animal Nutrition and Health added, "To sustainably feed almost 10 billion people by 2050 within our planetary boundaries, we must apply new thinking, technologies and business models. Together, we must shift away from criticising animal farmers for their environmental impact and instead help and support them by providing the tools and systems to improve the sustainability footprint of animal farming. In line with this ambition, Sustell™ is a first-of-its-kind service that will enable positive change for business and the environment – and help deliver on our purpose of creating brighter lives for all."www.dsm.com




World Aquaculture 2021

#AquacultureNow

November 15-19, 2021

Mérida, Mexico

Centro International de Congresos de Yucatán, CIC

Annual global meeting of the World Aquaculture Society

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WA2020

World Aquaculture 2020

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AFRAQ 2021

Sustainable Aquaculture – Feeding Africa

AQUACULTURE AFRICA 2021

Alexandria Egypt • December 11-14, 2021

The 1st Annual International Conference & Exposition of the African Chapter of the World Aquaculture Society (AFRAQ2021)

Egypt is the biggest aquaculture producer in the continent. Both local and international aquaculture delegates will converge for the event at the beautiful City of Alexandria, the Pride of the Mediterranean Sea.

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US Trout Farmers Association
World Aquatic Veterinary Medical Association
Zebrafish Husbandry Association

For More Information Contact:

Conference Manager | P.O. Box 2302 | Valley Center, CA 92082 USA

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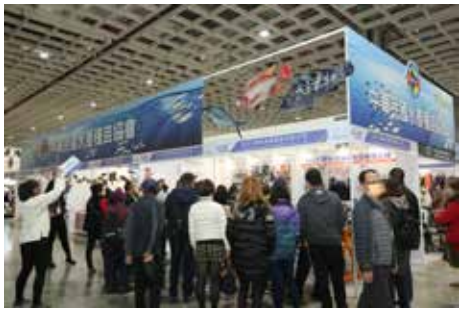
Trade Show Contact: mario@marevent.com

Taiwan's only B2B fishery trade show invites international aquaculture industry players to expand sales to global markets



The 7th Taiwan International Fisheries & Seafood Show (TIFSS 2021), which is Taiwan's leading exhibition for fisheries and aquaculture, will be held in Taipei Nangang Exhibition Center, Hall 1 from September 2 – 4. It will be as in 2020, a hybrid event.

TIFSS is co-organised by TAITRA and My Exhibition Co., Ltd. In 2019, nearly 180 domestic and foreign firms from 14 countries around the world participated in the exhibition, attracting nearly 7,000 domestic and foreign buyers from more than 20 countries.

In 2020, under the impact of the global COVID-19 pandemic and with industrial resources, professional exhibition experience and businesses' support, the exhibition turned out to be one of the few physical professional exhibitions in the world that was still held as scheduled, with nearly 100 domestic and foreign firms from 11 countries participating in the grand event, and nearly 5,000 domestic and foreign professional buyers from more than 10 countries participated in the online and offline exhibition and procurement negotiations.

As before, there will be four major themes presented at TIFSS 2021. These are

- Ocean Fishery & Fishing Equipment;
- Smart Aquaculture & Fish Seeding Technology;
- Seafood & Value-added Process; and
- Fishing Tackle & Water Equipment.

In addition to the physical exhibition, the online exhibition will also be launched simultaneously to capture every possible business opportunity through push notifications on online platforms.

Furthermore, all firms participating in the 2021 physical exhibition can get a virtual booth in the online exhibition for free, not only to experience the digital trends, but also to increase marketing reach across borders. During the exhibition, peripheral activities such as diversified digital marketing, one-on-one video conferences, fishery innovative product launches, and industry international forums will be launched simultaneously online and offline, and the benefits of the exhibition will be doubled!

Taiwan is surrounded by the sea and has a strong fishing industry, which brings about NTD 90 billion in economic output every year. Aquatic products are one of Taiwan's most important export products. According to statistics from the Ministry of Finance, Taiwan's aquatic product exports in the past three years have exceeded NTD40 billion.

Taiwan International Fisheries & Seafood Show will be an effective platform to display products, learn about international industry trends, seek global business opportunities, and explore online business opportunities. Organisers invite domestic firms to support the and move towards a new milestone together!

Important dates

Registration for the Taiwan International Fisheries & Seafood Show 2021 is now open! In addition, exhibitors signing up before **May 31** can enjoy a 10% discount. More information: www.taiwanfishery.com

Taiwan International

Fisheries & Seafood Show

Sep,2-4 2021

TaiNEX 1

Virtual Exhibition : Sep 2 - Oct 1

Taiwan's Only Professional B2B Tradeshow for the Fishery Industry
Online and Offline Dual-tracks Elevate Global New Level for Exhibition

TIFSS 2021 is anticipated to attract **180** exhibitors from more than **10** countries around the globe, and **7,000** domestic and foreign visitors from over **20** countries worldwide.

2021 highlights

Online exhibition

Taiwan fishery innovative product launch

One-on-one procurement video meetings

Fishery international conference

Actively invite target buyers from worldwide

Distributors

Importer, exporter, agent, dealer, chain store, eCommerce, system integrator...etc

Industry services

Aquatic products packhouse, restaurant and hotel, institute and school, enterprise central kitchen...etc

Fisherman groups

Fisherman's association, production and marketing group, aquaculture industry...etc

Academy and research alliances

Agriculture, forestry, fishing, and animal institutions, seedling and breeding organizations...etc

Early bird discount is offered with registration before May 31, 2021.

Taiwan External Trade Development Council
Exhibition Section VI, Exhibition Department
Tel: +886-2-2725-5200
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Email: taiwanfishery@taitra.org.tw

My Exhibition Co. Ltd
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Production of industry leading starter feed now in Indonesia

In May, **Cargill** announced that it has started producing AquaXcel® feed in its Serang plant with the aim of enabling aquaculture customers to thrive by achieving more sustainable growth. As a leading starter feed in the industry, AquaXcel® can enable faster fry growth, increase survival rate, and reduce feed waste.

To commemorate this occasion, a video conference was held which was attended by government officials and Cargill aqua feed customers and partners in Indonesia. Ir Mimid Abdul Hamid, Director of Feed from the Ministry of Marine Affairs and Fisheries of Indonesia, delivered a keynote speech.

"We value the partnership with Cargill Indonesia in our effort to elevate the domestic fishery sectors and look forward to continuing this partnership in various initiatives to educate our breeders on latest technologies and know-how in the market so that they can remain competitive."

"AquaXcel® means a lot to Indonesia's aqua industry. In collaboration with our customers and partners, we hope to enhance the productivity of the industry and hence help meet the demands of Indonesians for healthy and sustainable fish products," said Sarawoot (Pop) Chittratanawat, Managing Director of Cargill Aqua Nutrition, Malaysia and Indonesia.

Finding a good starter feed can be challenging for aqua farmers in Indonesia, due to lack of options of starter feed, low survival rate of fingerlings, as well as prolonged days of cultivation. AquaXcel®, which adopts a formulation with specialized immune boosting ingredients, can help farmers address these challenges and achieve more sustainable growth.

Cargill Aqua Nutrition strives to offer the right nutrition to support healthier fry growth, helping serve the needs of the producers and consumers. "Cargill Aqua Nutrition's expertise in the global supply chain and risk management allows us to offer distinctive value to our customers through the production of high-quality feeds and efficient distribution," said Chittratanawat.

"At Cargill, we believe in better nutrition for better lives. In this unusual business environment, we are committed to serving the nation as part of our role in the essential food supply chain. This is how we help farmers improve their animals' productivity, sustainability, health and well-being." www.cargill.com

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IFFO appoints new Technical Director

Professor Brett Glencross will join IFFO, The Marine Ingredients Organisation from June 2021. Glencross will take over the position as IFFO's Technical Director. He has for the last 20 years been an important contributor to the aquaculture sector and academic research work. Since 2016 Glencross has been the Professor of Nutrition at the Institute of Aquaculture at the University of Stirling in Scotland. He was also Chair of the Scientific Committee of the International Society for Fish Nutrition and Feeding (ISFNF).

Before then, and from 2008, Glencross was one of the former editors of the journal Aquaculture Nutrition. He has worked in various academic, institutional and industrial roles across Australasia, Asia, the Middle east and Europe. Throughout his career he has worked closely with many major international aquaculture feed companies across the world. He has Honours and Masters Degrees in Biochemistry from the University of Western Australia and a PhD in Animal Nutrition from the University of Queensland.

"I am truly happy that Brett Glencross has decided to join us to contribute to the marine ingredients industry's science-based approach. Brett is a very experienced aquaculture professional and has an excellent track record in managing research programmes. He has a highly acknowledged profile in the aquaculture industry, with a research background spanning the application of functional feeds for animal health, refining nutritional requirements and the use of nutritional modelling strategies, as well as a strong background in raw material assessment. We are very much looking forward to having Brett on board", said IFFO's Director General Petter Johannessen.

Glencross added: "I am delighted to be offered this opportunity to join the team at IFFO at a time when science is crucial to understand the future trends affecting the development of fish feed ingredients. Technical projects led by IFFO contribute a great deal to increasing our knowledge on marine ingredients and driving change for the benefit of the whole value chain, and especially the aquaculture sector."

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For more info on the TRADESHOW :
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For more info on the CONFERENCE :
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Proof of concept for precision aquaculture

Kings Infra Ventures Limited and NEC Corporation Japan achieved a remarkable landmark in precision aquaculture when the proof of concept (POC) project using recirculated aquaculture system (RAS) based shrimp aquaculture along with Artificial Intelligence and IOT was launched in May 2021. The successful completion of the POC has the potential to disrupt the aquaculture technology globally by multifold increase in growing densities with more predictability and traceability.

The POC is a joint initiative by NEC Corporation and Kings Infra Ventures Limited with the objective of utilising information and communication technologies (ICT) such as Internet of Things (IoT), networking, sensors technology and artificial intelligence (AI) to improve the farming key performance indicators (KPIs) such as density, survival and feed conversion ratios to create optimum growth conditions for shrimp.

The inaugural ceremony was held at the POC Site in Tuticorin and Shaji Baby John, Chairman and Managing Director, Kings Infra Ventures Limited released the first post larvae in the experimental facility. The E-launch meeting which followed was attended by key members of the NEC team and the Kings Team.

NEC is a USD28 billion (FY2020) Japanese multinational information technology and electronics company established in 1899 and employing over 100,000 people worldwide. In India, NEC's presence has been significant especially in the various government projects.

Kings has been the pioneers in the field of aquaculture, introducing the first semi-intensive integrated aquaculture project in the country, in Tuticorin, Tamil Nadu in 1987, adapting Japanese technology to Indian conditions. Involved in the operations of shrimp hatcheries, grow-out farms, contract farming, feed distribution and other ancillary services related to aquaculture as well as seafood processing, international trade of marine products, aquaculture consultancy, food related infrastructure development and venturing into domestic marketing and supply of retail packed marine products, Kings is listed on the BSE.

Aquaculture Europe 2021 in Madeira,

The recent announcement by the President of the Regional Government of Madeira that events can now take place on the island with 50% seating capacity came as good news to the EAS Board of Directors.

Deadlines:
Abstract submission for oral-requested: May 15
Eposter presentation: August 28.
Booths are still available for the AE2021 Exhibition.
https://aquaeas.org/Meeting/AE2021

WAS events in 2021

The World Aquaculture Society has announced that all planned events will go ahead as in person events in the specific location. "If there are any changes, we will inform participants. We will continue to monitor the COVID-19 situation and as we get closer to any meeting we will let you know of any precautions/restrictions required for the meeting."

- Aquaculture America 2021: August 11-14, San Antonio
- World Aquaculture 2021: November 15-19, Mexico
- World Aquaculture 2020: December 5-8, Singapore
- African Aquaculture 2021:December 11–14, Egypt

More information: www.was.org

2021

August 11-14
Aquaculture America 2021
San Antonio, Texas
www.was.org

August 18-20
TARS 2021:
Shrimp Aquaculture
VIRTUAL
www.tarsaquaculture.com

August 25-27
Vietfish 2021
Ho Chi Minh City
www.vietfish.com.vn

September 14
SPACE 2021 DIGITAL
www.space.fr

October 4-7
Aquaculture Europe (AE2021)
Madeira, Portugal
www.aquaeas.org

October 13-15
Aquaculture Vietnam
Can Tho City
www.aquafisheriesexpo.com/vietnam

November 15-19
World Aquaculture 2021
Merida, Mexico
www.was.org

December 5-8
World Aquaculture 2020
Singapore
www.was.org

December 11-14
African Aquaculture 2021
Alexandria, Egypt
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