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Shrimp: Disruption in 2018

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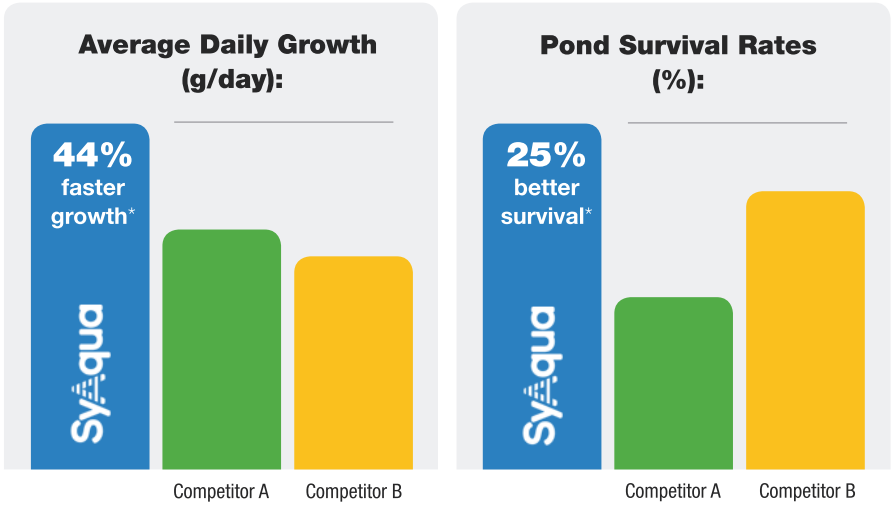

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Sampling at a farm in Sinaloa, Mexico. p8

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Zuridah Merican

The year ahead
Expect headwinds and more disruption

Asian aquaculture needs to move from a production-driven to a market-led industry. This applies to all farmed species. In shrimp, we know that there is an increased carryover of stock from 2018 in the pipeline. Buyers will restart their orders in April and if farms have already decided whether they wish to stock or not (amidst low prices in 2018, see the industry review on shrimp), the market will have a clearer picture then. There is now too much reliance on the Chinese market for shrimp. In comparison, there is too much dependence on the US market by Chinese producers for tilapia.

However, for shrimp supply, we can expect Asian producers to modulate output because of low prices and depressed margins. Adding to the equation, will be shrimp supply from Ecuador, where costs of production are expected to be lower than in Asia because of lower disease threats and higher survival rates. Asia has another hand to play with the monodon shrimp which is the 'flavour of the month' in China. As we expect more pull factor from monodon shrimp, will many switch from the higher volume per hectare vannamei shrimp and what will be the subsequent effect on prices?

As a consequence, the shrimp feed sector can also expect to see some changes. In an effort to lower cost of production, it would seem that, cheap is cheerful for shrimp farmers in Indonesia and Malaysia who have taken a 180-degree turn and opted for low protein feeds even for high intensity culture systems. This reverses the decade long thinking that here in Asia, we need high crude protein diets for our high-density culture systems.

Is genetic improvement providing sufficient growth for farmers to change their mindset? But this also means that we are not taking advantage of the fast growth genetics with dense feeds. This is analogous to flying on one engine to save fuel while two engines would certainly improve flying time. This situation also parallels what is happening in China's two directional shrimp farming (see page 51). We expect to discuss this polarisation in the shrimp feed segment at the forthcoming TARS conference which will be on *Aquafeeds: Fit for Future*. This year is expected to be a watershed year for fish meal and fish oil replacements. There are increasing alternatives available out there in the market. Afterall, trout fed feeds containing insect meal is already in a French supermarket. Insect meal in shrimp feeds opens the doors for more alternatives to fish meal.

Among Asia's seafood exports, unfortunately, tilapia from China is included in the list of products for the US-China war on tariffs. The US tilapia market is already saturated and prices have been at their lowest since 2015. China has been decreasing exports to the US, diverting exports to Mexico, Africa and the Middle East but still 33% of its production goes to the US. As the January 2019 tilapia globefish report indicated, despite this disruption with US tariffs, prices have been holding up.

Taking the cue from the title of this report, how will this US-China war continue to 'shake' the tilapia market? What will be the effect in the wider market, particularly as Vietnam and Indonesia, are ramping up tilapia production? While tilapia is increasing in Vietnam, pangasius volumes are expected to remain steady. In 2019, we can expect more pangasius production in Indonesia to supply local markets.

The sustainability of any industry depends on how it attracts investments. Asian producers, from shrimp to marine fish, envy the level of investments pouring into the shrimp industry in Latin America and salmon in the Oslo stock exchange. Investment money is still elusive as our Asian model is deemed too risky. In our quest to increase output, Asian aquaculture has overlooked real industrialisation which includes predictability and increasing control over production systems. Taiwan's innovators have various IOT and AI innovations for farmers to do real time monitoring and make accurate production predictions and even counter storms and typhoons. Using these innovations will help to manage risks and generate predictability in farming. While we remain unsure of new investments in 2019, we are hopeful that these key factors will attract investments in the medium term.

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Green field feed plant for Indian and West Asian shrimp feed markets

The 50,000 tpy shrimp feed plant in Thervoykandigai, Thiruvallur district, Tamil Nadu, India

Sheng Long Bio-Tech International Co has announced the production of shrimp feed at its green field feed plant in Chennai, India. Sheng Long is a leading aquafeed producer in Vietnam, its regional headquarters. It has leading positions in the shrimp feed markets in China, Vietnam, Malaysia and India. It is also present in the shrimp feed markets in Taiwan, Indonesia, Bangladesh, Ecuador and Iran.

The company entered the Indian shrimp feed market in 2013 and by 2017, feed imports from Vietnam grew to 30,000 tonnes. The new feed plant with a capacity of 50,000 tonnes per year (tpy) of shrimp feed will cater for the demand of customers mainly in Andhra Pradesh and Tamil Nadu states.

In 2018, the total feed sales of Sheng Long business unit in Vietnam is expected to reach more than 300,000 tonnes, generating an annual revenue of USD 266 million. The feed sales of its parent company, China based Haid Group, exceeded 10 million tonnes with a global turnover of more than USD 5.8 billion in 2018. Three million tonnes were various aquafeeds.

Three million tonnes were various aquafeeds. In India, Sheng Long Bio-Tech India Pvt. Ltd. was incorporated in 2014. In 2016, the company decided to invest in a feed mill and hatchery in Tamil Nadu, to provide the best quality shrimp feed, *Litopenaeus vannamei* post larvae, aquatic health products coupled with the best technical services for an all-round customer satisfaction. The state-of-the-art feed mill spans across an area of 5.57 ha located in the Sipcot Industrial area, Thervoykandigai, Thiruvallur district.

This feed mill has three pellet lines for vannamei shrimp feed production. There is space for further expansion to another 50,000 tpy of shrimp feed. The facility includes a unit to manufacture aqua health products, such as NutriProand Supermix. This feed plant will also supply markets in Sri Lanka, Bangladesh, Myanmar, the Middle East and African markets.

"The feed mill took two years to construct as we encountered various hurdles and obstacles during the construction, but with the strong determination of our Sheng Long team, we have managed to overcome these barriers," said Shi Ji Yang (Steven), general manager of Sheng Long Bio-Tech India Pvt. Ltd.

Three million tonnes were various aquafeeds. "The first production was scheduled to start right after Diwali, the Festival of Lights, where here in India, staff look forward to returning to home towns and villages for family reunions. However, our Indian team voluntarily sacrificed their festive mood to ensure that the production went on schedule. At the same time, Sheng Long Vietnam and the equipment supplier sent their best production teams to train and assist the Indian team."

Bagging feeds

Shi Ji Yang (Steven), general manager of Sheng Long Bio-Tech India Pvt. Ltd (centre, right) and Kumaresan, head of marketing (centre, left) with the Indian team.

The Aquaculture Innovation Challenge returns in Indonesia

After the success of the Aquaculture Innovation Challenge (AIC) in Vietnam in 2017, STIP, Solidaridad Network and Fresh Studio has partnered with Bogor Agricultural University (IPB) to bring the AIC to Indonesia. The Global Aquaculture Alliance (GAA), Hatch Blue and The Walton Family Foundation provide financial support and additional expertise.

This year's Aquaculture Innovation Challenge (AIC) Indonesia will kick off at DoubleTree by Hilton in Jakarta on January 23, starting at 13:00. The AIC is intended for students, start-ups, project teams, small and medium-sized enterprises and other companies who boast ground breaking ideas or innovations that can improve the shrimp industry but require knowledge, networks, finance or capital.

An inspirational group of speakers will discuss different aspects of the shrimp industry and how its sustainability can be improved through innovation and investment. Attendees will also find out more about the criteria, process and opportunities provided by the AIC. Registration for this kick-off event is open to participants, sponsors, and interested industry professionals. http://aquaculturechallenge.com/en/register-

AIC finalists will receive a travel package to join a boot camp from June 23-27, 2019. This is a three-day workshop with business plan coaches and pitch gurus who will support finalists in fine-tuning their business models and developing their (virtual) pitch. On the last day, finalists will present their pitch to a panel of industry professionals and potential investors to get feedback, exposure and opportunities for partnerships and investments. All finalists will also receive a year's STIP bronze membership, which includes access to the price portal, the knowledge library and a subscription to ShrimpTails.

Vietnam's Entobel, producing insect meal and oil, was the winner at AIC 2017

AIC is open for applications from January 23 to March 15. Participants can submit proposals with a focus on creating a more sustainable shrimp industry in Indonesia via the AIC website. For more information, visit www.aquaculturechallenge.com

China group acquires Sabah aquaculture farm

China-based Xinghe is expanding into the Malaysian aquaculture market with the proposed acquisition of Pegagau Aquaculture Sdn Bhd for MYR100 million (~USD 23 million) by its wholly own subsidiary XW Aquaculture Sdn Bhd.

Pegagau Aquaculture, based in Kampung Wakuba, Sabah was incorporated in 2000 and started farming the monodon shrimp in 2001. Currently, both monodon and vannamei shrimp are farmed. The acquisition includes a 97.9ha land and the entire development of ponds, plant as well as procurement of machinery, equipment, motor vehicles, shrimp stock and consumables.

Xinghe said the purchase will be funded via internally generated funds as well as borrowing and debt to be raised from fundraising exercises. The deal is expected to be completed within six months from the agreement signed in December 2018. In an exchange filing, Xinghe said the proposed acquisition of the aquaculture business in Sabah will enable the group to expand its business and strengthen its financial performance by having a new Malaysian-based resilient business to supplement its existing edible oil operations in China. Xinghe also stated that it had, however, been negatively impacted by the government campaign against environmental pollution in Neihuang County, Henan Province, where its production plant is situated. Xinghe added that the anti-pollution measures are not expected to ease in the near term as China seeks to reverse decades of environmental damage. (Source: Malaysian Reserve).

Continued from page 4.

"On November 9, 2018, two days after the Diwali festival, our first Indian feed mill went into trial and mass production successfully. Within 2 weeks, the first batch of Sheng Long's famous aquatic feed brand – "Royal Dragon "and "Lion Feed" feeds were tested locally and received excellent feedback from the customers across the Indian sub-continent. Today, Sheng Long is proud of its "Made in India" shrimp feeds through which it can satisfy customer's requirements for fresh and quality feed within hours from this new feed plant in Chennai." added Shi.

Next, Sheng Long India will start construction of its second feed mill in 2019, to meet its target of 100,000 tonnes of aquafeeds for the next few years and add to the global target of 20 million tonnes for the entire Haid Group by 2022.

"This shows Sheng Long's determination to be a leader with aquaculture total solutions and services for the industry in India. This includes the production of one billion vannamei post larvae from our hatchery as well as aquatic health products," added Jeff Jie-Cheng Chuang, general manager of Sheng Long .

News in Brief

EU lifts yellow card for Thailand

On January 8, The European Union removed Thailand from a list of countries warned over illegal fishing. In its statement, the EU Commission said that the lifting of the "yellow card" indicated that it "acknowledges that Thailand has successfully addressed the shortcomings in its fisheries legal and administrative systems." It also recognised Thailand's efforts to tackle human trafficking and forced labour in the industry. Thai Union Group CEO Thiraphong Chansiri thanked the Thai Government for its efforts to bring change to the country in the fight against illegal, unreported and unregulated fishing. He added that improvements to regulations and enforcement of the fishing industry have been significant, not only in terms of traceability and the sustainable development of the fisheries but also in terms of eliminating human rights violations. Shares of Thai Union and Charoen Pokphand Foods jumped. With yellow cards, Vietnam and Cambodia remain on the same EU illegal-fishing watch list. (asia.nikkei.com)

US-China trade war is shaking up the tilapia market

After its inclusion in the latest USD200 billion list of tariffs put forward by US President Trump's administration, tilapia from China has been subjected to a 10% duty as of 24 September 2018, rising to 25% in January 2019. The US is the largest market for tilapia and China is the largest supplier, so the implications for the wider market are potentially significant, according to a Globefish report. Global tilapia production is expected to rise 3–4% in 2018, reaching around 6.3 million tonnes. Around 30% of this volume comes from China. The relative importance of the large traditional markets is decreasing as tilapia consumption is declining in the US. Demand is more geographically diversified. Global tilapia prices have been declining steadily since early 2015 but the additional demand from emerging markets has helped to hold tilapia prices marginally above 2018 levels. This is despite the disruption resulting from the imposition of the new US tariff. The price of frozen whole tilapia imports into the US averaged USD1.81/kg (CIF) in the first 6 months of 2018, compared with USD1.70/kg in the same period in 2017, while prices for frozen fillet were flat at USD3.40 per kg (CIF). Prices for fresh tilapia fillet in the US were up by around 2% for the same period, to USD6.63/kg. fao.org/in-action/globefish/market-reports/tilapia/en/

Insect-fed trout now available to French consumers

In a landmark moment for aquaculture worldwide, trout produced and processed by Truite Service in France, fed Skretting feeds containing insect meal from InnovaFeed, has now reached the French consumer. Auchan, a leading French retailer committed to responsible aquaculture, has made the insect-fed trout available in 52 supermarkets in the north and Ile-de-France, with plans to sell throughout France by the end of 2019. The term 'insect-fed fish' applies only to aquaculture fish that meet two criteria – they have been fed a diet wherein at least 50% of the fish meal has been replaced by insect meal, and the fish have doubled in weight after the insect protein has been applied, according to Elodie Petit, marketing manager at Skretting France. The approach to make this project a success owes much to the pioneering value chain methodology, with the different players coming together to define the new specification to integrate and ensure optimal quality of the final product for the consumers. All of the partners are located in the north of France, which makes it possible to promote a local supply in the fish markets, a key focus for today's consumer.

2,500 tonne RAS facility in Russia

AquaMaof Aquaculture Technologies Ltd. a world leader in recirculating aquaculture technology and turn-key projects will design and construct a RAS (Recirculating Aquaculture system) facility, that will produce 2,500 tonnes of market-sized Atlantic salmon. The project is estimated at €25 million and is expected to be completed by the end of 2019. The new facility will include hatchery, nursery, and full grow-out areas, as well as management and operational zones. AquaMaof's advanced minimal liquid discharge (MLD) technology utilises proprietary water recycling techniques. At the core of the company's RAS technology is efficient power consumption, dramatically reducing costs of energy. No antibiotics and no chemicals in the process allow for the production of healthy, natural product. Biosecurity is paramount, and complete environmental control ensures that fish are grown in an environment which promotes their highest health and welfare status. With a robust design and construction, the facility requires minimal maintenance, while optimised feeding modes and advanced feeding management system, enable reduction of the feed conversion ratio (FCR) and operational costs.

Project partnership on insect production for Denmark

Aller Aqua, DTU Aqua, the Danish Technological Institute, Hanneman Engineering and Champost are partnering with the company Enorm to establish Denmark's first industrial insect production plant. The goal of the project is to produce 30 tonnes of insects per day four years from now. The project has been granted DKK15.9 million by the Ministry of Environment and Food, Denmark. One of the outputs from the project will be insect meal, and Aller Aqua's role will be to help develop and test products suitable for trout farming. Should this succeed, insect meal could also be tested as an ingredient for salmon and tilapia feed. "Insect meal has the potential to be a valuable raw material in fish feed due to its high protein content. Several trials have been carried out with the inclusion of insect meal to replace or partially replace fish meal in fish feed with promising results, but further research is needed before commercial application. Research and trials will be carried out at Aller Aqua Research in Büsum, Germany," said Dr Hanno Slawski, Group R&D director for Aller Aqua.

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Post EMS in Sinaloa, a shrimp farm moves forward

By Zuridah Merican

Recovering production after the EMS crisis, Acuícola 11 de Diciembre is moving forward with more market access

Ramsés A. Chávez Zazueta

Prior to 2013, the peak production for Mexico's shrimp farming industry was in 2009 with more than 120,000 tonnes. The early mortality syndrome/ acute hepatopancreatic disease (EMS/ AHPND) affected Mexico's shrimp farming industry in 2013 and brought down production to just over 40,000 tonnes or just over 33% of this 2009 production.

An informal estimate indicated that in 2018, production exceeded 140,000 tonnes., Sonora, Sinaloa and Baja California are the three leading shrimp farming states. The EMS infestation was in the two leading shrimp farming states, Sonora and Sinaloa in 2013 as well as Nayarit, followed by others, Colima, Veracruz, Chiapas, Yucatan, Campeche and Tamaulipas in 2014 and Baja California in 2015 (Soto-Rodriguez, 2018).

Mexico has a large domestic market, estimated at 200,000 tonnes, meaning that the current production is insufficient to meet the demand. The local market is dominated by small shrimp of 10-15g, mostly from intensive farms (>60 post larvae (PL)/m^2) in low salinity areas (5-10ppt) such as around Colima.

To this day, the industry in Sinaloa is still trying to recover, according to Ing. Ramsés A. Chávez Zazueta, head of operations for the shrimp farming company, Acuícola 11 de Diciembre SA and secretary of the aquaculture association Acuacultores de Ahome. According to a presentation at Conacua 2018 production in 2018 for Sonora was projected to reach 62,100 tonnes, a drop from that in 2017. C. Luis R. Campos Gonzaléz, president of Acuacultores de Ahome, said that in Sinaloa shrimp survival rates hover around 50-60%, much lower than the target of 80-90%. A recovery will be registered when there is an increase of 15-20% production in 2019. However, with disease, costs of production have increased to around USD3.47/kg and margins are thinner. There is a need to lower costs with better feed conversion ratios (see pages 14).

Caution and managing triggers

Some 20km from Los Mochis, capital of Ahome district, Sinaloa, Chávez Zazueta runs the 187ha farm. The group also has a smaller 115ha farm in neighbouring Sonora. The annual target production was 1.5-2.0 tonnes/ha in 2018. In 2017, the group produced 724 tonnes of 38-40g shrimp and survival ranged from 50-52%. In late November, after the yearly cycle ended, Chávez Zazueta estimated that his production could be around 755 tonnes for 2018 because of a higher survival at 55%. Some 80% of production is exported, particularly to the US. The rest goes to the local markets. Los Mochis has 10 processing plants and four of them have export licenses. Chávez Zazueta sends his shrimp to a plant half an hour away from the farm.

With regards to EMS outbreaks in Sinaloa, some farms saw shrimp dying at 20-35 days, and if shrimp are 6-7g, the crop is abandoned and if at 12g , the crop is continued to the end, said Chávez Zazueta. Today, survival remains low at an average of 55%. At his farm, "Prior to the EMS outbreaks, our survival rates were high at around 75%, if we did not experience white spot syndrome virus (WSSV). With the EMS, survival went down to as low as 10% with a total production at 75 tonnes."

In 2018, the production cycle started in the last weekend of March and continued until the first weekend of November. November is the start of the cold season and temperatures start to drop from 25°C until 20°C in early March. The start and ending of the farming season are regulated by the government to avoid temperatures as low as 20°C which are disease triggers. In between cycles, the farm undergoes a long preparation process of 90 days ready for the next cycle. This is also a period for general maintenance with less staff on duty. The sunny and dry weather is good for this stage of the production cycle. Not farming during the cold season is advisable as the ponds are only 1m deep.

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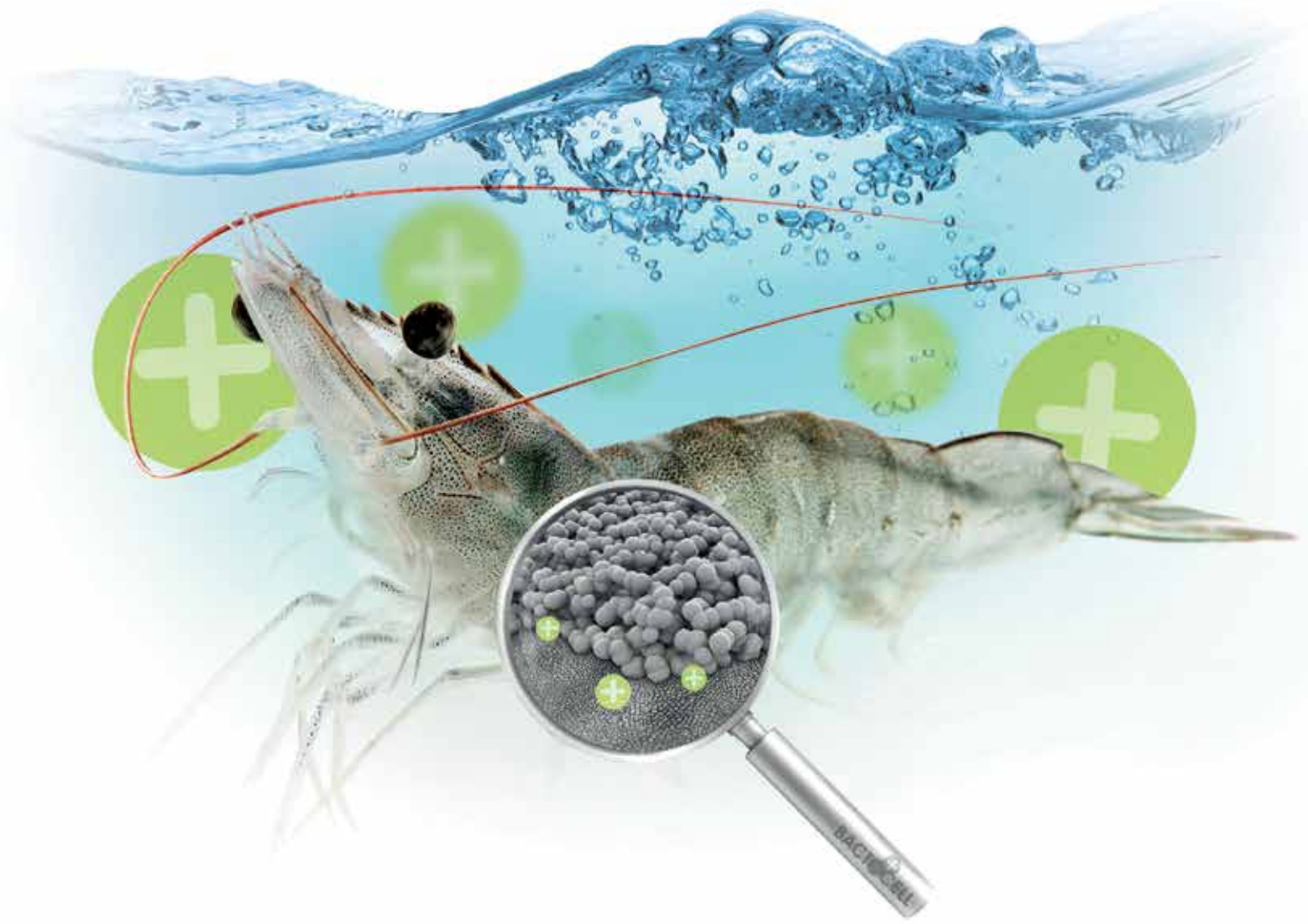

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Ramsés A. Chávez Zazueta (second left) with his team, Carlos Manuel Rubio (second right) and Radamés Armenta Ruelas (right). On the left is Miguel Ángel GuizarMolina, CONAFAB and in the middle, Juan Miguel Sánchez, regional manager, Vimifos

At Acuicola Topol, a harvester which will reduce the time to harvest by 50%, said Luis Alfonso Gutiérrez (centre).

Focus on environmental sustainability

This farm was designed and constructed by Chávez Zazueta's father, a pioneer in shrimp pond designs since the early days of shrimp farming in Mexico in 1985. All 31 ponds are rectangular around 6ha in size and 1m deep. The seawater intake is 2.5km away in an estuary and is channelled by gravity to the ponds via a wide intake canal. Waste water leaves the ponds through another canal to a separate estuary. Three pumps bring water into the 1-2km long reservoirs.

"We filter water coming in through 800 microns mesh nets and at the inlets into ponds, we use 300-micron filters. The law requires that we filter out the water with aquatic life and return them into the environment."

The farm name followed the date it was registered in 2003, It started with 90ha of land area and expanded to 187ha. Chávez Zazueta has fixed only one cycle per year production to produce large shrimp; stocking is at 10-18 of 400mg juveniles/m^2 and producing 40g shrimp over 200 days. Some other farms in Sinaloa can manage to have two cycles/year–a first cycle producing 20g shrimp and a second shorter cycle producing smaller 15g shrimp.

Interestingly, this farm and its sister farm Acuicola Topol with 120ha of 23 ponds are separated by a neighbour's farm. Criss crossing between farms meant passing through this neighbouring farm. This is not an issue, it just requires disinfecting the vehicles and passing through a tyre bath. "This is not a major problem as we all work together. If there is an issue with diseases, we inform our neighbours and vice versa."

Nursery systems

In Mexico, some 60-70% of farms have an on-farm nursery or pay hatcheries to grow post larvae to juveniles. The on-farm nursery has 30 rectangular tanks, each of 4mX25mX1m deep. There are two reservoir tanks. Tanks lined with 1mm HDPE liners, are contained within greenhouse-like structures covered with thin white plastic sheets. These sheets are rolled away during the cleaning stage which also coincides with the downtime in grow-out operations. Its sister farm in Sonora is yet to have nursery facilities.

"We use PL8-10, supplied by an external hatchery. The post larvae may have come from specific pathogen tolerant (SPT) broodstock and cost around USD5,000/million PL. Hatcheries develop genetic lines from large size (30-40g) shrimp into broodstock after a cleanup process, to produce post larvae. In the nursery, stocking density is 7PL/L and juveniles are grown to PL37 (400mg) and the survival rates are from 90-95%."

Here, the temperature is 32°C during the colder months. In June to July, parts of the greenhouse covering are removed for ventilation and to ensure temperatures are kept at 34°C. Ten blowers, each of 10hp are used in the nursery tanks. "The carrying capacity in the nursery is 2.8kg/m^2, and if we allow the shrimp to stay in the nursery

Ponds at Acuicola 11 de Diciembre are 6ha and 1m deep

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While in Asia, one problem with a nursery phase has been the transfer process and associated stress, but Mexican nursery operators have been managing very well. Harvesting is by netting post larvae several times, approximately 15-20 times while lowering the water level. The balance is collected at the outlet sumps. Unlike in Asia, where the size of juveniles is capped to prevent transfer of shrimp with hard rostrums, in Mexico, this is not an issue.

Production

Chávez Zazueta who began to operate the farm in 2004, is proud that the average daily growth (ADG) of his shrimp is 0.24g when farmed in a high salinity of 35ppt to a low of 28 ppt. He achieves A3 colour shrimp. This is the grade preferred by buyers exporting fresh shrimp to the US. "Of course, achieving an A4 grade would be the best. Shrimp growth rates have been decreasing. The weekly growth rate used to be around 1.2g when stocking density was at 15 PL/m^2 in 2001-2002. Today, the stocking density has decreased to 10 PL/m^2. In older ponds, we find larger variation in temperatures," Chávez-Zazueta said.

In Mexico, buyers use the A1-A4 colour grading of shrimp based on taste and colour for uncooked shrimp. The A3 grade is measured with cooked shrimp. "This is an indication of premium shrimp. I do manage to get A4 shrimp in 1-2 ponds. By October, the salinity reaches 40ppt which perhaps helps me to achieve the A3 grade shrimp."

Ponds at Acuicola Topol

Nursery during the dry out season in late November and in operation. Picture credit: Miguel Ángel Guizar Molina.

The farm utilises 30 workers inclusive of managers at peak times. As expected, with lower survival rates, the costs of production have been increasing. Some 50% of the daily feed ration is given during night feeding. For example, feed costs have increased; his farm uses functional feeds with higher levels of betaine, magnesium and manganese for growing shrimp under high salinity conditions. This is required as shrimp spends too much energy for osmoregulation and for moulting, said Chávez Zazueta. This feed costs USD1,000/tonnes as compared to the conventional feeds at USD800-850/tonne.

There are no national electricity grids for this farm and the power generators are reserved for the nursery. At the beginning of the culture period, dissolved oxygen (DO) levels are 4 to 4.5ppm; with increasing biomass, DO can go down to 2-2.5ppm. The farm pumps in water and exchanges daily 10% of water to increase the DO levels.

The farm does partial harvesting, with workers walking down the length of the pond holding a net to capture shrimp. It also uses a harvester for the final harvest. "Time is of the essence. Aside from using less workers for harvesting, from 19 down to 10/pond, we also save time. Using the harvester, we require only 6 hours to harvest a 6ha pond. Harvesting by hand would take 12 hours for each 6ha pond."

Aside from an ongoing increase in the number of ponds, Chávez Zazueta has other plans, "We are also looking at differentiating ourselves from other farms in Mexico as well as globally. We want Mexico to become a leading producer of large premium shrimp. We do not use any antibiotics and have environmentally friendly practices. We plan to apply for Aquaculture Stewardship Council (ASC) certification. I understand that there will be additional investments in auditing etc., but this will open new markets."

Self-regulation in Mexico

Working together is critical to reinstate production.

Most shrimp farmers in Ahome, the northernmost and largest shrimp farming district in Sinaloa state, Mexico belong to the association of aquaculture producers -Acuacultores de Ahome A.C. but there is hope that more will join, said its president **C. Luis R. Campos González** during the annual industry event, Conacua 2018 held in Los Mochis in November 2018.

The event was organised by Acuacultores de Ahome A.C and the aquaculture group at CONAFAB, the national federation of livestock and aqua feed, pet food and additives producers. Grupo Acuicola (aquaculture group) of CONAFAB is the section that integrates food producing companies for aquatic species. The companies that are currently part of the aquaculture group produce more than 95% of the fish and shrimp feed in Mexico.

Campos González oversees the group of shrimp farmers on track in recovering from the EMS outbreak in 2013. That was a critical phase in the country's history of shrimp farming as members suffered huge losses, up to 100% mortality. In 2018, the production estimate in Sinaloa was higher than in 2017 at 43,615 tonnes. It was 35,487 tonnes in 2017 (González Alvarez, 2018). According to Campos González, "Farmers used to enjoy survival rates of 80-90% and today, the norm is only 50-60%. Our target is to produce 1,800 kg/ha as we only stock at 10-15 PL/m^2 and to increase survival rates by 15-20%."

Sinaloa has 777 farms covering 48,307ha. Ahome has 85 farms covering 10,072ha. He added that with diseases, the cost of production has increased. The current ex-farm price for 16g shrimp was MXN 68/kg (USD 3.38/kg).

Post EMS changes

Along the supply chain, Campos González explained some changes. Broodstock for Mexican hatcheries is now a mix of Mexican and Ecuadorian origins to enable the recovery from EMS. The focus is on disease resistance. With post larvae, the focus is on quality with good growth and with minimal size variation. Post larvae survival of 80% or more is acceptable, otherwise the stock is returned to the hatchery. The stress test is a quick temperature change from 20°C to 24°C. Disease checks are for white spot syndrome virus, EMS, and Vibrio bacteria.

"Some of our challenges are related to marketing. Some 40% of the farmed shrimp in Sinaloa is sold in the domestic market with low prices, sometimes below costs of production. We have three major buyers of farmed shrimp and they often press prices down." Campos González added that on the other hand, "The US market likes Mexican shrimp which they say has a colour similar to that of wild shrimp and when cooked, also has a similar texture to wild shrimp. Thus, for us, the US will continue to remain a major market despite the fact that US offer prices are much lower than those in European markets." Up to September 2018, the US imported 10,600 tonnes of shrimp from Mexico (nmfs.noaa.gov)

Risk management

With regards to investments and managing risks, Campos González said that for the former, these came from local investors. "We have self-regulation agreements. We have established the dates to stock ponds and to harvest as well as the period to dry out ponds. The local authority will do the inspections. If there is a problem among us, neighbours will whistle blow. We then talk to the errant farmer to fix the problem. My vision for the association members is to bring good and standard practices as well as innovations."

There is a close association with the aquafeed industry. Campos González said that the association is happy with the quality of feeds produced although they are not happy with the prices. The shift in prices is expected as Mexico's peso is now at MXN 20 per US dollar as compared to MXN14 in 2014.

Supporting shrimp farming

At CONAFAB, Director **Genaro Bernal Cruz** said that his group has been co-organising Conacua for several years. Association members have the capacity to produce 220,000 tonnes of aquafeed per year and in the case of shrimp feeds, they are ever ready to increase production if and when the shrimp farming industry recovers. Prior to the EMS outbreak, the consumption of shrimp feeds was 150,000 tonnes per year.

"We want to encourage shrimp consumption in Mexico, we want them to appreciate shrimp as a healthy food and stories that shrimp is high in cholesterol is not true", said Bernal Cruz. Mexico only exports large size shrimp at USD 7-8/lb. Some 30-40% of the country's production is consumed locally, mostly on the west coast (mainly Guadalajara and Mexico City), added Jesus Zendejas, an aquafeed expert.

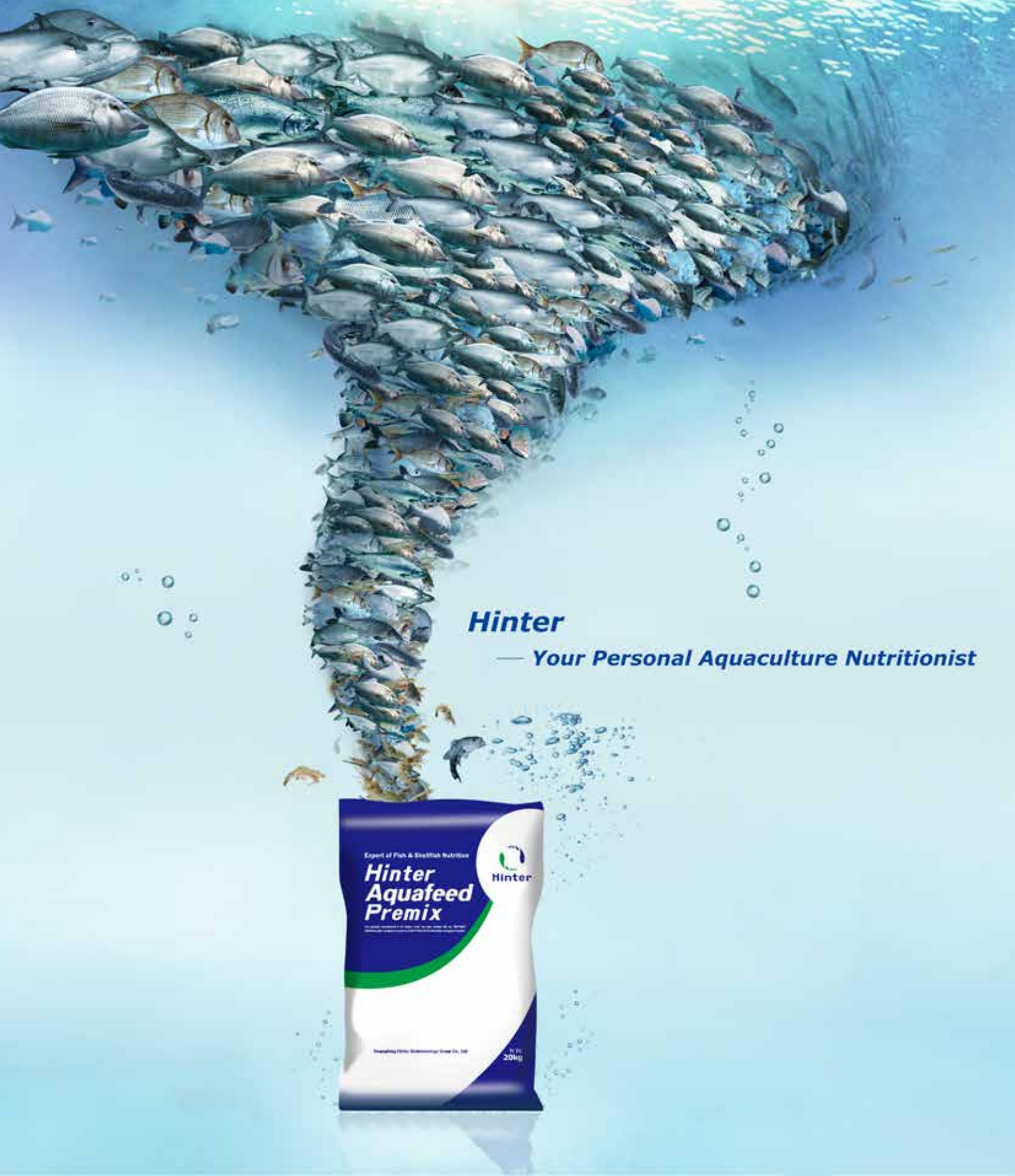
"For the feed industry, the main challenge is searching for alternative ingredients to replace fish meal. Today, the percentage of fish meal in shrimp feeds have been reduced from 30% to 3-5% only. Our shrimp farmers accept this as when they buy a feed brand, they are not worried about the lower fish meal content as long as the feed provides the same growth performance," said Bernal Cruz.

"Here in Mexico the aquafeed industry is changing too. In 2013, with the EMS, we suffered too with feed demand dropping by 50%. The industry gave 5-6 months credit, often with no guarantee to recover the money. Today, we have new players such as Peruvian feed producer, Nicovita, entering the market since 2017. There is also Skretting with imports of micro extruded feeds."

His vision for the shrimp industry is to overcome disease and indirectly, this will benefit the shrimp feed market. The industry is also looking at new technology and knowledge to do better.

C. Luis R. Campos Gonzaléz (right) and Juan Antonio Barragán Arias

Jesus Zendejas and Genaro Bernal Cruz (right) at Conacua 2018.



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Home grown broodstock in Asia

A new centre to boost the supply of genetically improved, specific pathogen free shrimp broodstock is strategically set up in Singapore.

In October 2017, the Blue Aqua International Group launched a breeding centre in Singapore. Named the Blue Aqua Breeding Center (BABC), this centre specialises in the production of genetically improved, specific pathogen free (SPF) *Litopenaeus vannamei* shrimp broodstock for the Asia-Pacific markets.

Singapore's ideal location, its proximity to Asian markets, coupled with the country's favourable business climate and its natural biosecurity, gives BABC an edge in the region. The centre allows for the swift delivery of the broodstock to shrimp farming operations and production sites across important markets in the Asia-Pacific region.

Dr Farshad Shishehchian, president and CEO of the Blue Aqua International Group said, "Our goal is to bring Singapore's aquaculture scene to new heights. Singapore is known as a centre of innovation and technology; our aquaculture scene, too, needs to catch up to this accolade." The broodstock production centre will serve as the first boost for industry, bringing in the innovation and tools required for our local scene, added Shishehchian.

From OI to Singapore

"The high-quality broodstock is grown in a state-of-the-art facility and is raised in a healthy environment with high quality feed, which is ideal for quick larval growth and allows for healthy broodstock which are free from specific diseases," said Shishehchian.

BABC receives its post larvae and close technical support from the Shrimp Department of the Oceanic Institute in Hawaii (OI). It will uses cutting-edge technology and innovation in order to reduce the dependence by industry in Asia Pacific on *L. vannamei* broodstocks from the US. OI's shrimp department is renowned as the leader in shrimp aquaculture research and technology innovation for two decades.

Next generation industry skills

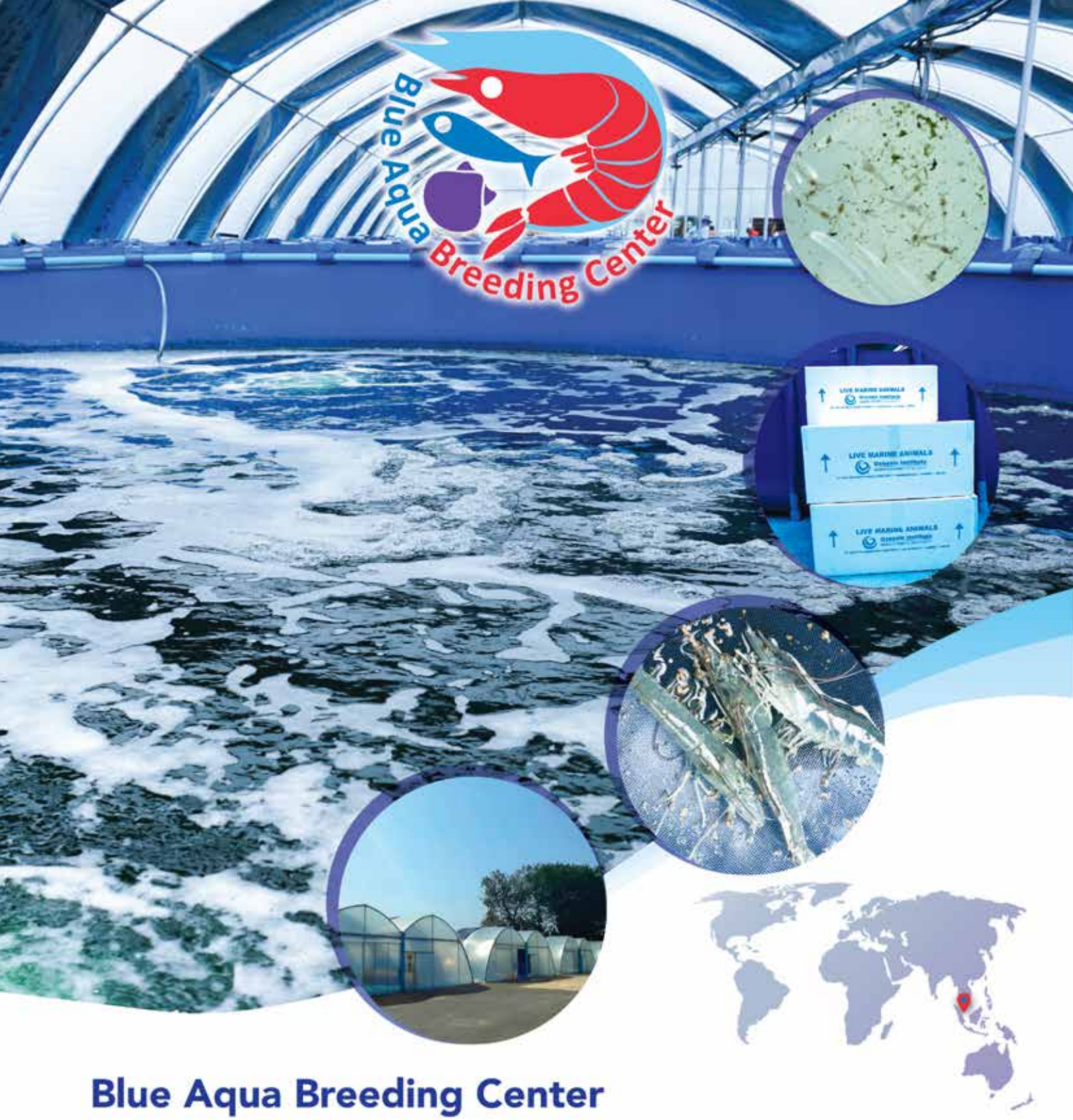
The state-of-the-art centre incorporating a modern and innovative design has biosecure greenhouse modules, a "Green to Clean" recirculating aquaculture system, laboratory, workers quarters and a broodstock processing house.

The SPF *L. vannamei* broodstock produced in BABC has the potential to mature and develop under intensive and super intensive culture conditions, tolerating a wide range of salinity and temperatures. The broodstock grown in the facility is known to be more resistant to diseases. Shrimp can mate and breed easily under captivity and the survival rates during the hatchery and rearing stages are generally higher.

Apart from providing quality broodstock, BABC has a joint R&D program with Temasek Polytechnic Singapore. BABC operates a research and development centre to provide students with industry skills and training in shrimp breeding, broodstock development and hatchery as well as farm operations and management.

Through the operation of BABC, the Blue Aqua International Group aims to strengthen its regional supply chain in order to meet the increasing demand for genetically improved shrimp broodstock and post larvae in the region.

Clockwise, post larvae, broodstock, packing and transportation at this centre in Singapore.



Blue Aqua Breeding Center

Located in Singapore, we specialize in producing genetically improved Specific Pathogen Free (SPF) *L. vannamei* shrimp broodstock and swiftly delivering them to shrimp farms, hatcheries and production sites across the Asia-Pacific region.

www.blueaquabreedingcenter.com

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A think tank for tomorrow's protein

OddGeir Oddsen believes that the entire aquaculture value chain will have to rethink which protein sources are the best and most sustainable.

"Imagine that you were born today. By the time you turn 30, you will be sharing this planet with 10 billion other people. In many ways all of you will be very different. But there is one thing each and every one of you will share. You will be dependent on access to proteins. Because proteins are not just food – they are the very building block of life. They perform a vast array of functions within organisms, including DNA replication, responding to stimuli, and providing structure to cells and organisms."

On the southwest coast of Norway, a company has set itself an ambitious mission statement. It wants to create a sustainable aquaculture industry through biotechnology and feed innovation, which will also contribute to a cleaner and healthier aquaculture industry. Sea Farms Nutrition Ltd is confident of paybacks; and not just for those engaged in aquaculture, but also for future generations.

Replacing fish meal

ProChaete is our leading brand of exceptionally effective aquaculture feed. Our company develops feeds based on nutrient dense marine worms that offer a safe protein alternative.

When we started, it was first and foremost to develop new ways to use proteins in the aquaculture value chain. Most of the protein in the aquaculture industry today comes from fish meal and soybean meal. Fish meal is generally manufactured from wild-caught, small marine fish, and usually deemed not suitable for direct human consumption.

Overexploitation

According to scientists, the challenge the world faces now is overexploitation of the oceans. Every year, 6 million tonnes of fish meal are produced around the world. Lack of regulations in some countries creates a situation where the seas are virtually emptied of some species. Since fish meal can be made out of almost all species living in water, some countries are fishing for almost anything that can be captured.

In the long run, as a non-renewable resource, the use of fish meal for aquaculture at the current level is not sustainable. We have to find good replacements, and that is what we are working on at ProChaete right now. In fact, finding good replacements for fish meal for the aquaculture industry, was one of the first goals we set out to reach as a company. We saw that the industry relied too heavily on fish meal and soybean meal as the main dietary protein sources. At the same time, we knew that feeds made from polychaetes represent an environment-friendly and effective alternative. Feed produced from polychaetes also contributes to better bacterial health for fish and animals. That is why we decided to go all out with the polychaetes.

World-wide experiments

ProChaete gets its polychaetes from bio-secure ponds in Europe. Experiments conducted by the company in several places around the world gave promising results on species such as sea bass, sea bream, salmon and shrimp. Our ideas proved to work in practice. When we knew that we have a competitive product, we went to market with a wide range of feeds for the shrimp industry, one which is close to our hearts.

We were certain that we were on to something that could make a significant difference – not only in the aquaculture industry, but other industries as well.

Back to the future

Now together with colleagues, I am returning to the starting point; to take this further for the development and management of proteins everywhere. We will focus on the development of sustainable proteins which can be sold to feed producers in many industries, not only aquaculture. The goal is to be an important contributor to making other manufacturers' value chains more sustainable, or a sort of think tank for tomorrow's protein.

Circular and renewable energy

Innovation has always been at the very core of the ProChaete brand. We look at our innovations as part of a circle economy, a major part of the solution to feeding a growing population sustainably.

For instance, let us take shrimp heads. They have traditionally been regarded as waste by the shrimp farming industry, when in fact they are an exceptional source of high-quality protein. Worms and other insects are a natural feed for many species. They have high protein levels and offer a unique probiotic effect. Likewise, trimmings from salmon production can be directly used in the cultivation of polychaetes, which in turn become nutritious feed for a variety of fish and animal species. By using a circle economy model, we want to make sure that every ingredient yields as much value as possible.

Sharing a vision

In my opinion the entire aquaculture value chain will have to rethink which protein sources are the best and most sustainable, just as the transportation industry is doing with cars and power suppliers are doing for homes and businesses. At ProChaete we want to serve aquaculture with new and innovative ways to produce high quality protein.

We want to share our vision of feeding a growing world with our customers worldwide. We hope that producers of feed view the challenges facing our rapid population growth in the same way as we do, and that they see that our innovations can help contribute to achieving a sustainable future. We want everyone to be a part of the solution.

Money, money, money

But is there anything in it for the feed producers? Are they willing to turn to other sources of protein even if these are not as profitable as the current ones?

With ProChaete, we strongly believe that buying products from us means accountability, and that opens up for more transparency. For us it is important that every measure is taken to reach our common goal of feeding a growing world. At the same time the end-users are increasingly moving towards demanding sustainable products. They want transparency. They want to know what they eat and where it came from. That is why I am certain that manufacturers who turn to a sustainable value chain will win in the market place.

OddGeir Oddsen is CEO of Sea Farms Nutrition Ltd. (Photo credit: Tord F Paulsen).

Innovation has always been at the very core of the ProChaete brand. We see innovation as part of the circular economy, contributing significantly to feeding.

We find good replacements for fishmeal for the aquaculture industry. Feeds made from polychaetes are an environmentally friend and effective alternative.
In 2016, we launched our complete shrimp feed range. In 2019, we will be launching our brand new fish feed range.

We hope that you share our feed innovation vision for a sustainable future.

ProChaete™

An innovative protein company

Haematococcus astaxanthin: Is it time to rethink astaxanthin use in white shrimp feeds?

By Martin Guerin

The dietary inclusions of astaxanthin in this shrimp have been constrained by low pigmentation efficiency of synthetic sources, despite known human health benefits of astaxanthin as well as anti-stress and disease resistance properties observed in shrimp. All these may change with higher efficacy and competitive prices of natural astaxanthin.

Astaxanthin (AX) is a natural carotenoid pigment found in many animals, for example in fish such as the salmon and red seabream, in crustaceans such as shrimp or krill, or in algae such as *Haematococcus pluvialis*. Astaxanthin is nature's most powerful antioxidant. Indeed, astaxanthin has demonstrated largely superior singlet oxygen and free radical scavenging properties versus other carotenoids or vitamin E (Miki, 1991). In recent years, its potential applications for human health have attracted a growing interest leading to numerous astaxanthin nutritional supplements with applications in eye and skin health, fights against inflammation and cancer, or even sports health (Guerin et al. 2003; Nakao et al. 2010). In these human health applications, natural astaxanthin extracted from *Haematococcus* algae (HAX) has become the standard, especially since the form of astaxanthin it supplies reflects the form in human diet throughout the ages. *Haematococcus* astaxanthin supplements have reached the GRAS (Generally Recognised As Safe) status in the USA since 2010.

Production of natural astaxanthin Haematococcus pluvialis in raceways in Atacama Desert, Chile. Photo by Atacama BioNatural Products SA.

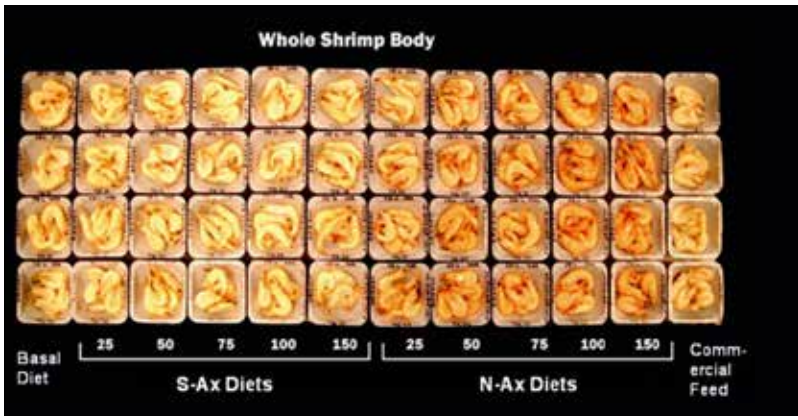
The increased interest in the health benefits of algal astaxanthin could also mean its increased value for shrimp. Today, salmon is a major source of astaxanthin in the human diet and shrimp can be one too as the growing production capacities of *Haematococcus* algae are allowing the supply of larger quantities of natural astaxanthin at more attractive prices.

In nature, astaxanthin comes in several forms. This can be confusing even to the initiated. Astaxanthin has several geometrical (cis and trans) and optical isomers (3S,3'S, 3R,3'R, 3R,3'S), and can come as free astaxanthin or esterified astaxanthin. To further complicate matters, these forms have varying degrees of utilisation and effectiveness among species.

Synthetic astaxanthin (SAX) comes as free astaxanthin in a combination of three optical isomers (50% of 3R,3'S, 25% of 3R,3'R, and 25% of 3S,3'S forms). It has become the norm for supplementing salmon feeds as to date it is the lower priced product and is very effective in the pigmentation of the salmon. This preference for SAX in salmon diets continues despite the fact that the astaxanthin profile of farmed salmon meat reflects the one of SAX and does not resemble that of wild salmon, where the 3S,3'S form largely dominates (Megdal et al, 2009). This same 3S,3'S form is also the main isomer found in shrimp (Moretti et al. 2006).

Natural pigmentation is better

Haematococcus pluvialis algae contain almost exclusively the desirable 3S,3'S isomer (Moretti et al. 2006), with AX representing about 90% of their total carotenoids content. These algae can accumulate higher than 3% astaxanthin in the dried biomass during their vegetative growth stage. As they also have an excellent image for human health, they offer a very attractive natural alternative to the synthetic form for use in aquafeeds, not only in organic or functional feeds but also regular feeds.



Colouration of cooked vannamei shrimp fed graded levels of synthetic astaxanthin (SAX) or Haematococcus astaxanthin (HAX) (Source: Ju et al. 2011).

In 2013, a study (Capelli et al. 2013) confirmed the superiority of HAX in the invitro capture of superoxide and peroxide free radicals over vitamin C, E, beta-carotene or pyctogenol but also over synthetic astaxanthin. One additional benefit of HAX is that it comes in an esterified form, which is naturally much more stable than free astaxanthin, and is found abundantly in the epidermis of shrimp or seabream. Finally, in both shrimp and red seabream and related species, algal astaxanthin has demonstrated superior biological and pigmentation properties versus the synthetic pigment.

In red seabream (*Pagrus major*), feeding 20ppm HAX for 45 days achieved superior red colour and astaxanthin deposition levels in the skin vs 40ppm SAX (Guerin & Hosokawa. 2001). Similarly, in red porgy (*Pagrus pagrus*), HAX gave better pigmentation results than the synthetic form (Kalinowsky et al, 2005).

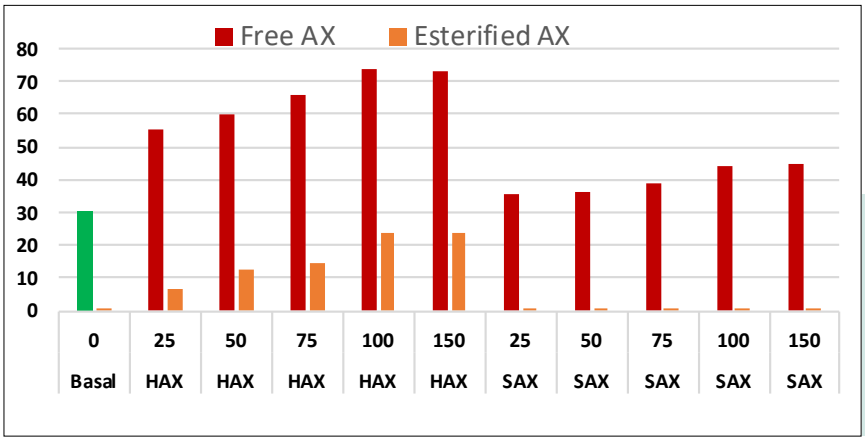
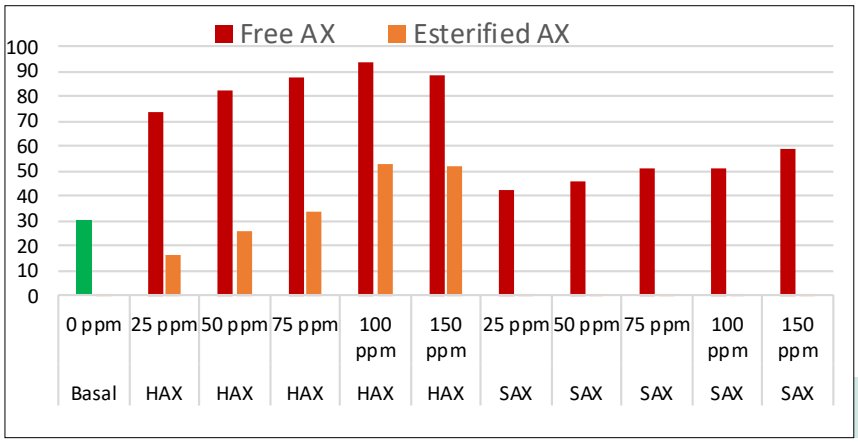


Figure 1. Free and esterified astaxanthin (AX) deposition in the *vannamei* shrimp fed *Haematococcus* astaxanthin (HAX) over shrimp fed synthetic astaxanthin (SAX) (adapted from Ju et al. *2011*).



(b) Deposition in the head and shell

Pigmentation of cooked shrimp

This is complex and is influenced by a number of factors:

- ***Genetics***
  In shrimp exoskeleton, astaxanthin binds to a protein: crustacyanin. Intense red colouration of cooked *Penaeus monodon* shrimp seems related to the abundance of this protein which is directly coded by specific genes. Pigmentation may vary with the degree of expression of these genes. Several of these genes have been found within and between crustacean species, which will lead to different pigmentation results (Wade, 2010).

- ***Environment***
  Penaeus vannamei reared with external light favours the deposition of astaxanthin against culture without light (You et al. 2006). On the other hand, shrimp (*P. monodon* or *P. vannamei*) reared in a black tank tend to have a stronger red colour when cooked (Pan et al. 2001, Parisenti et al. 2011). In the *monodon* shrimp, this appears to be due to higher expansion of the chromatophores and higher percentage of free astaxanthin deposition, leading to a stronger red pigmentation when cooked, compared to this shrimp reared in a light-colour tank, where astaxanthin is mainly deposited as esters, in shrunken chromatophores (Wade et al. 2017).

- ***Diet***
  The type and level of carotenoids ingested play a critical role. Shrimp can convert beta-carotene into astaxanthin but the process is highly inefficient, slower and variable as it requires several enzymatic reactions (Wade et al. 2017). Higher levels of astaxanthin fed will lead to higher astaxanthin deposition, higher pigmentation and stronger red colour when cooked.

- ***Species***
  Monodon shrimp respond well to SAX, although not as well as HAX. However, the *vannamei* shrimp respond poorly to SAX but well to HAX, as the algal source of astaxanthin helps achieve satisfactory pigmentation with much lower levels of supplementation than SAX (Ju et al. 2011).

Recently, researchers in Australia feeding the *monodon* shrimp with graded levels of SAX or HAX found that the minimum level and duration of feeding SAX to reach highest pigmentation levels were up to 20% higher and up to 14% longer than with HAX, depending on the season (Angell et al.2018). It also seems that in the monodon shrimp astaxanthin deposits to higher levels in the shell than in the flesh where astaxanthin levels seem to plateau after only 2 weeks of feeding 50ppm of SAX (Menasveta et al. 1993).

In the *vannamei* shrimp, Ju et al. (2011) found that feeding up to 150 ppm of SAX for 8 weeks failed to improve significantly colouration of cooked shrimp, even though they observed an increase in free astaxanthin deposition. On the contrary, *vannamei* shrimp fed levels as low as 25ppm HAX improved significantly the pigmentation which was superior to shrimp fed 150ppm suggesting that HAX was at least 6-folds more efficient.

They also observed that the lack of pigmentation efficacy of the synthetic pigment in the *vannamei* shrimp was accompanied with minimal deposition of esterified astaxanthin, unlike the shrimp fed algal astaxanthin which saw an increase in esterified astaxanthin deposition. Although feeding SAX helped raise the free astaxanthin deposition, it was also less efficient than HAX which led to approximately 20% higher levels of free astaxanthin. This lack of pigmentation efficacy of synthetic astaxanthin and the

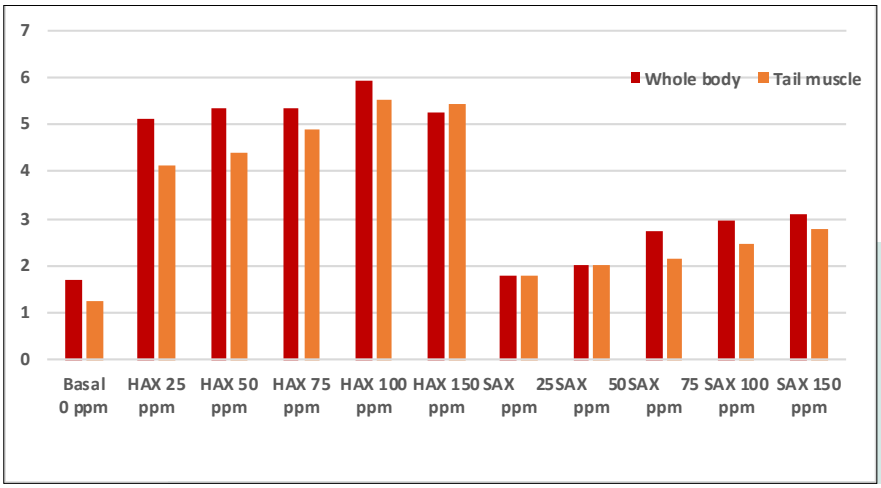


Figure 2. Redness A value (measured by colorimeter) of tails and whole body muscle in cooked *vannamei* shrimp, after feeding graded levels of *Haematococcus* astaxanthin (HAX) and synthetic astaxanthin (SAX) (adapted from Ju et al.2011). HAX was significantly superior to SAX ($P<0.05$).

lack of supply of algal astaxanthin for commercial shrimp feeds may explain why to date astaxanthin is hardly used in grower feeds for *vannamei* shrimp, although it is used in specialty feeds where other functions of astaxanthin are needed, such as in larval feeds or maturation diets.

Superior anti-stress and disease resistance properties of algal astaxanthin

Interestingly, the superior properties of HAX in shrimp over SAX for pigmentation extend to the antioxidant properties and related anti-stress benefits of astaxanthin.

In Thailand, researchers (Darachai et al. 1998) reported that HAX led to higher survival in zoea, mysis or post larvae (PL15) of the *monodon* shrimp versus larvae and post larvae fed the same amount of SAX. In addition, feeding HAX also resulted in better resistance to the low-salinity stress challenge. Earlier this year, researchers (Xiaohui et al. 2018) reported that the supplementation of 50ppm HAX to *vannamei* post larvae (PL15) for 35 days, led to better growth and astaxanthin deposition than 70ppm SAX supplementation, while supplementation of 90ppm HAX led to higher activity levels of the key antioxidant enzymes, superoxide dismutase and glutathione peroxidase versus the supplementation of 140ppm or 70 ppm SAX.

The 90ppm HAX level gave also the best survival in a *Vibrio parahaemolyticus* disease challenge superior to other levels of supplemented SAX or HAX. If *V. parahaemolyticus* strains were the leading bacterial pathogen in shrimp farming in recent years, the leading viral disease remains to date white spot syndrome virus (WSSV). In WSSV challenge studies, recent research demonstrated that astaxanthin can also improve resistance and survival against WSSV infection (Wang et al. 2015).

Conclusion

Vannamei shrimp largely dominate the world shrimp farming production, but the industry has so far been using astaxanthin sparingly due to the reported poor efficiency of the synthetic version in pigmenting this species. However, the increased supply of *H. pluvialis* astaxanthin at more competitive prices as compared to previous years, could see this situation change drastically.

Indeed, use of the HAX could help processors seek better shrimp prices with better pigmented shrimp. The superior biological efficacy, shrimp health benefits, as well as improved marketability of HAX-fed shrimp- thanks to HAX beneficial human health attributes, and the better consumer appeal through better colouration of cooked shrimp, are reasons for shrimp farmers and feed companies to take a new look at this source of natural astaxanthin.

References are available on request.

Martin Guerin is an expert in aqua nutrition based in Kuala Lumpur, Malaysia. He has more than 25 years of experience on feed formulation, production and with feed additives.
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A focus on shrimp hydrolysate

By Fabio Soller, Mikael Herault and Vincent Fournier

Marine protein hydrolysates are unique sources of functional peptides to improve the performance of farmed fish and shrimp.

In both vertebrates and invertebrates, countless metabolic pathways are driven by peptides (short chain amino acids) either produced via the animal's metabolism itself or derived from feeds during the digestion process. Many metabolic processes such as those in the immune, gastro-intestinal, nervous and cardiovascular systems as well as several other biological activities: antimicrobial, antioxidant, and immunomodulatory, are influenced by dietary peptides (Danquah & Agyei, 2012).

As such, these small peptides have been labelled as bioactive peptides, and can theoretically be produced from plant, marine or land based raw materials. However, marine raw materials have been found to be the most promising source of such bioactive molecules.

Feedstuffs used to formulate feeds for farmed animals are not all equal in terms of their peptide profile. The quality of the soluble protein fraction containing these bioactive peptides, is highly dependent on the freshness of the raw materials and the process applied to transform them. In meals and soluble feed ingredients, mostly medium and large size peptides (>10 amino acids) can be found. The peptide profile in meals and soluble feed ingredients are usually not standardised during the manufacturing process, thus leading to consequences on raw material functionalities. Furthermore, if protein hydrolysates show a very high level of small size peptides (<10 amino acids), their peptide profiles and standardisation will be highly dependent on the know-how of the manufacturer to drive the hydrolysis process and characterise the peptide specifications of the finished product.

Significance of peptides in animal feeds

The importance of soluble protein/peptides in the diets for livestock is known since the 1950s, while in aquaculture it remains an issue due to mistaken concerns of nutritional deficiencies originating from nutrient losses to the aquatic environment, and the prospect of water pollution. Nonetheless, in fish and shrimp hatchery, the larval amino acid requirements are derived from the endogenous hydrolysis of yolk soluble proteins and later from live feeds, which are similarly rich in soluble peptides. Thus, it is understandable that the contribution of these nutrients determines the success in larval growth and survival.

Focusing on the environmental and economic sustainability of the aquaculture sector, many feed manufacturers are utilising terrestrial plant meals to replace fish meal in their aquafeeds. Through the meticulous work of nutritionists and formulators, levels of essential amino acids and other essential nutrients are available in the diet at adequate levels through the combination of various terrestrial plant meals, vitamin/mineral supplements, and other ingredients. However, the dietary balance in soluble peptides is today not yet considered in the formulation procedures.

The importance of soluble peptides throughout the lifespan of the animal is significant, and partially explains poor growth performances and health issues during the production cycles when soluble peptide rich ingredients are overlooked while formulating diets. Marine protein hydrolysates are suitable ingredients for modern feed formulations; they provide an extended assortment of soluble peptides that have been demonstrated to possess beneficial bioactivities with very positive results on growth, disease resistance and gut health.

Shrimp hydrolysate

Shrimp hydrolysate is manufactured from fresh shrimp by-products (shrimp heads) from carefully selected seafood processing plants, and is a well-characterised functional ingredient. The raw material is inspected for freshness, temperature, and any bad odours on arrival before production. The shrimp heads are processed according to the state of the art hydrolysis process developed by Diana Aqua. Specifically, designed processing equipment is utilised to reach the highest yield of bioactive peptides and a standardised final product. In the same way, the hydrolysis process is the result of many years of research leading to the highest performing peptide profiles, combining the precise levels and balance of free amino acids, di and tri-peptides and bioactive peptides of higher molecular weight.

A PhD study, sponsored by Diana Aqua, identified about 1,000 different peptide sequences in the shrimp hydrolysate, many with antimicrobial activities (Robert, 2014). The study also showed that a significant fraction of the identified peptides in shrimp hydrolysate are derived from haemocyanin, a protein involved in oxygen transportation and in many other metabolic pathways, particularly immunity through its antimicrobial, antiviral, antifungal

and antiproliferative activities (Coates and Nairn, 2014; Zhang et al., 2009; Petit et al., 2016). Finally, it is worth noting that in addition to hydrolysis, pasteurisation is applied at the end of the manufacturing process to remove any microbiological contamination including shrimp pathogens. Thus, our shrimp hydrolysate manufacturing process and product meet the BAP (Best Aquaculture Practices) feed mill standard recommendations.

Benefits of dietary shrimp hydrolysate

The unique and standardised peptide profile of our shrimp hydrolysate provides exceptional benefits in palatability, nutrition and health, thus positively boosting the animal and feed performances.

For the modern aquafeed formulation, the consistent quality and composition of shrimp hydrolysate help to standardise the palatability and nutrition of feed even when the composition of other traditional ingredients varies from batch to batch. Furthermore, it helps in enhancing palatability, digestibility and nutrition of feed formulated with low levels of fish meal. Shrimp hydrolysate is especially beneficial during challenging conditions (wintering, hot weather, etc.), and during recovery after stressful operations (size grading, transportation, veterinary treatment, etc.).

As previously demonstrated with other functional hydrolysates produced by Diana Aqua, improvement in feed intake, growth and feed conversion ratio of different aquaculture species fed shrimp hydrolysate have been validated in various research and commercial trials in South Korea, Thailand, Ecuador, France and Spain (Khosravi et al. 2015; 2016; Gisbert et al., 2018; Leduc et al., 2018).

Focusing more on health benefits, we demonstrated that feeding fish and shrimp a diet containing shrimp hydrolysate successfully improved resistance to bacterial challenge (Figures 1, 2 and 3). In all the species studied, the inclusion of the shrimp hydrolysate resulted in a significant increase in survival during the pathogen challenge. Moreover, such good survival of fish and shrimp was correlated to an enhancement of the response of innate immunity in animals fed dietary hydrolysates. The immune system boosting effect can be identified from increased lysozyme level, antiprotease activity, bacteriolytic activity, cell count and total immunoglobulin levels, manifesting through better survival rates and shorter recovery periods even after stress episodes and disease challenges.

Another study conducted by Diana Aqua confirmed that dietary shrimp hydrolysate leads to a significant positive response of some genes involved in the immune system, and that supplementation of shrimp hydrolysate in a low fish meal diet allowed restoring the same pattern of gene expression like in fish fed high fish meal diets (Leduc et al, 2018). These new data give evidence for the significant effect of this functional ingredient on metabolic pathways in fish and shrimp.

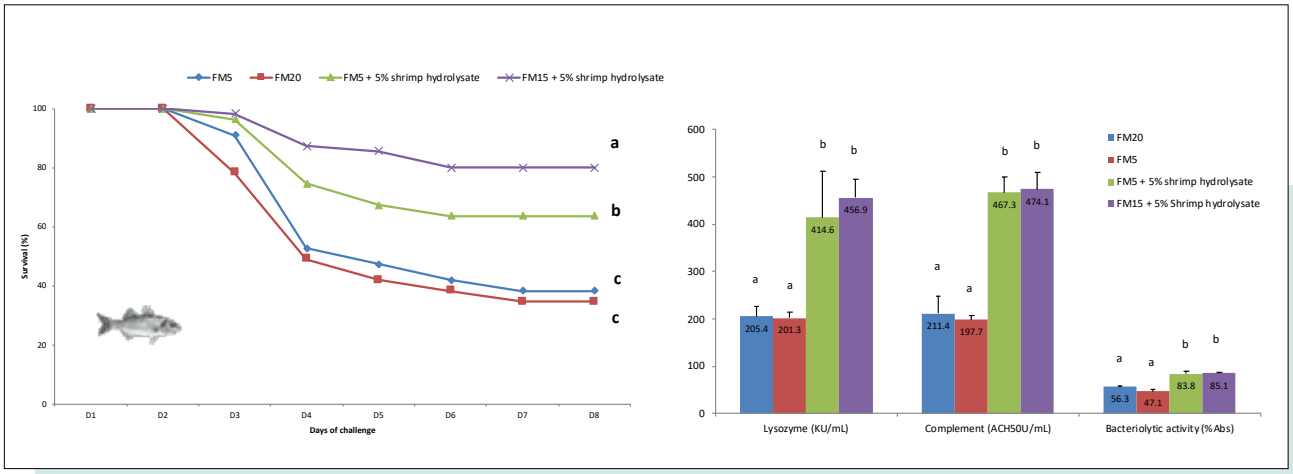

Figure 1. Survival and response on innate immunity in European seabass (*Dicentrarchus labrax*) challenged by an opportunistic strain of *Vibrio pelagius* after a feeding period of 110 days with a control diet (FM20), a low fish meal diet (FM5) and two other diets supplemented with 5% shrimp hydrolysate (FM5 + 5%SH and FM15 + 5% SH). Values are mean of five replicates. P<0.05. IRTA, Spain. Gisbert et al. (2018).

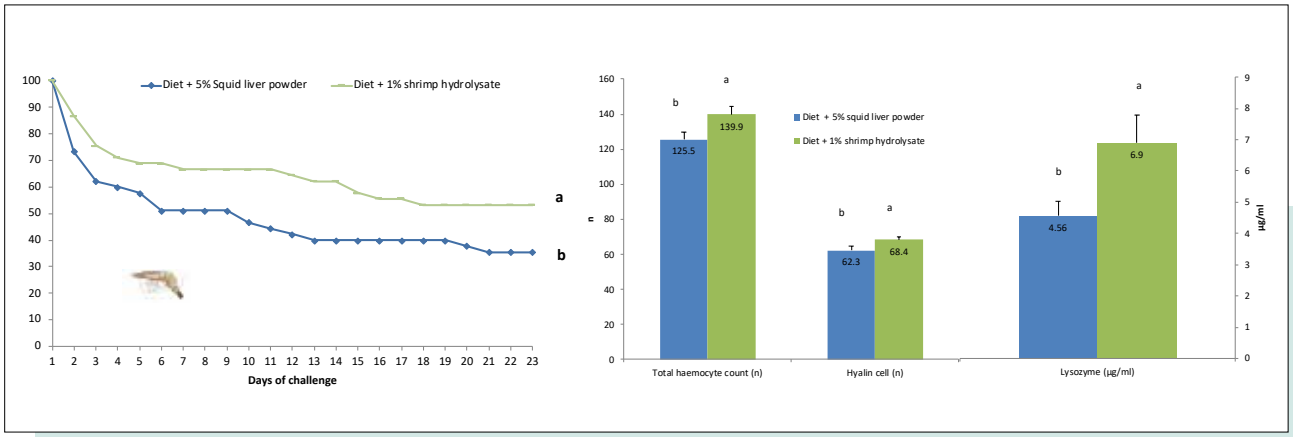

Figure 2. Survival of white shrimp (*Penaeus vannamei*) challenged by *Vibrio harveyi* after a feeding period of 70 days with a control diet containing squid liver powder and a diet containing 1% shrimp hydrolysate and no squid liver powder. Values are mean of three replicates. Shrimp were challenged by injection (10^5, dose defined on behalf of a LD50 trial). P<0.05. Jeju, South Korea

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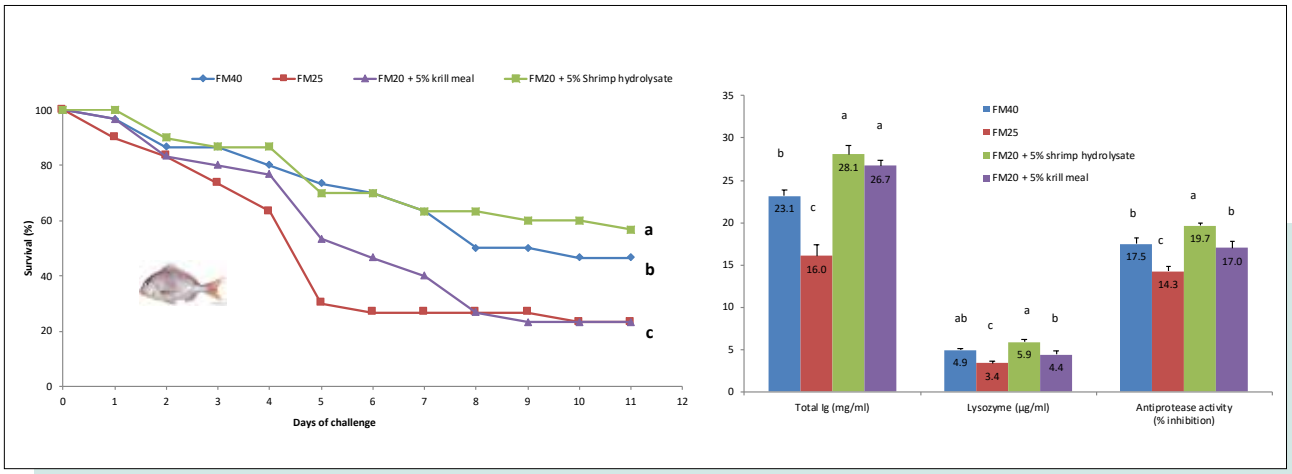

Figure 3. Survival and innate immune response in red seabream (*Pagrus major*) challenged by *Edwarsellia tarda* after a feeding period of 105 days with a high fish meal diet (FM40), a low FM diet (FM25) and two other low FM diets (FM20) containing 5% shrimp hydrolysate or 5% krill meal. Values are means of three replicates. Fish were challenged by injection ($10^{4.7}$, dose defined on behalf of a LD50 trial). P<0.05. Jeju, South Korea.

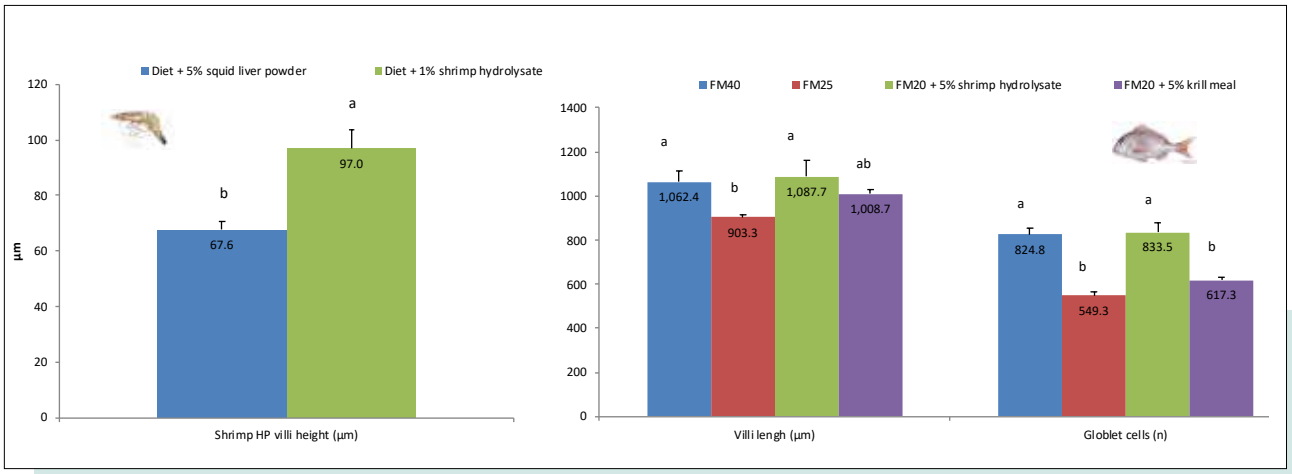

Figure 4. Effect of dietary shrimp hydrolysate on villi height of hepatopancreas in shrimp, and on villi length and goblet cell number of anterior intestine in red seabream. Feeding periods: 70 days in shrimp and 105 days in red seabream. Values are means of five analysis. P<0.05. Jeju, South Korea.

In addition, all these trials conducted in fish and shrimp provide evidence that the enhancements on diet digestibility and absorption of nutrients by the animals consuming shrimp hydrolysate are directly linked to gut health improvement, which can be perceived from the improved intestinal morphology, enterocyte height, increased villi length and globlet cell count. Such benefits of shrimp hydrolysate on gut health have also been very well documented in marine fish (Figure 4; Leduc et al. 2018; Khosravi et al. 2015; 2016), and patented (Fournier V. WO2014114767A1).

Conclusions

Greater utilisation of fish meal alternatives in modern aquafeed formulation is critical for the environmental, sustainability, and economic aspects of the industry. With this adjustment in feed formulations, one of the adverse consequences for the animals is the decrease of soluble protein and small size bioactive peptides, which can only be obtained from fresh animal protein or specifically developed products such as protein hydrolysates. Bringing back these soluble protein and bioactive peptides to feed formulations is considered one of the best and cheapest approaches to restore fish and shrimp production performance and overall health, particularly nowadays with rampant disease outbreaks and production losses taking place during the production cycle.

Shrimp hydrolysate is today one of the best candidate ingredients to supply high bioactive peptides to fish and shrimp feed formula. Its high level of standardisation and characterisation as well as its performance demonstrated in fish and shrimp, are proof that it is the preferred solution to boost immunity and to support gut health in aquaculture species.


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Fumonisins in aquaculture: Occurrence, impact and counteraction

By Rui A. Gonçalves and Michele Muccio

Negative effects range from reduced growth rate, feed consumption, feed efficiency ratio and impaired lipid metabolism in fish, to myosin thermodynamic properties in marine shrimp, not taking into consideration the synergistic effects of the combination of fumonisins and aflatoxins.

Fumonisins are a group of mycotoxins discovered in 1988 in South Africa (Gelderblom et al. 1988). The group includes FB1, FB2 and FB3. They are mainly produced by a number of *Fusarium* species, notably *F. verticillioides* (formerly *F. moniliforme* = *Gibberella fujikuroi*), *F. proliferatum* and *F. nygamai*. The most abundantly produced mycotoxin of the Fusarium family is fumonisin B1 (FB1).

Fumonisins are characterised as having a long-chain hydrocarbon unit (similar to that of sphingosine and sphinganine) which play a role in their toxicity (Wang et al. 1992). Fumonisins inhibit the sphinganine (sphingosine) N-acyltransferase (ceramide synthase), a key enzyme in lipid metabolism, resulting in a disruption of this pathway. This enzyme catalyses the acylation of sphinganine in the biosynthesis of sphingolipids, together with the de-acylation of dietary sphingosine, and the sphingosine that is released by the degradation of complex sphingolipids (ceramide, sphingomyelin and glycosphingolipide) (Wang et al. 1991). Sphingolipids are important for membrane and lipoprotein structure and also for cell regulations and communications (second messenger for growth factors, (Berg *et* al. 2003).

Can fumonisins negatively affect aquaculture species?

In aquaculture, fumonisins have been generally associated with reduced growth rate, feed consumption and feed efficiency ratio, as well as impaired sphingolipid metabolism (Goel et al. 1994; Li et al. 1994; Lumlertdacha and Lovell 1995; Tuan et al. 2003). However, information on the effects of fumonisins on marine species is scarce; most of the available research focus is on freshwater species.

Freshwater fish

Channel catfish (*Ictalurus punctatus*) is the most studied (Goel et al. 1994; Li et al. 1994; Lumbertdacha and Lovell 1995). According to these authors, channel catfish can tolerate relatively high levels of fumonisins with a sensitive level of around 10ppb.

It is known that rainbow trout liver is sensitive to fumonisins, inducing changes in sphingolipid metabolism at levels lower than 100ug/kg (Meredith et al. 1998) and inducing cancer in one-month old trout (Riley et al. 2001).

Adverse effects of fumonisin-contaminated diets have also been reported in carp (*Cyprinus carpio* L.). One-year-old carp showed signs of toxicity at 10,000ug FB/kg feed (Petrinec et al. 2004). The experiments reported the presence of scattered lesions in the exocrine and endocrine pancreas and inter-renal tissue, probably due to ischemia and/or increased endothelial permeability.

In another study, one-year-old carp fed with pellets contaminated with 500, 5,000 and 150,000ug FB/kg of body weight, resulted in a loss of body weight and alterations of haematological and biochemical parameters in target organs (Pepeljnjak et al. 2003).

For tropical species, Tuan et al. (2003) demonstrated that feeding FB_1 at levels of 10, 40, 70 and 150mg/kg feed for 8 weeks affected growth performance of Nile tilapia fingerlings. Fish fed diets containing FB_1 at levels of 40,000ug/kg or higher had decreased average weight gains. Haematocrit was decreased only in tilapia fed diets containing 150,000ug FB_1/kg. The ratio between free sphinganine and free sphingosine (Sa:So ratio) in liver increased to 150,000ug FB_1/kg in the fish feed.

Marine shrimp

FB_1 has not been extensively studied as a shrimp feed contaminant; however, the few studies available suggest that *Litopenaeus vannamei* is sensitive to FB_1. García-Morales et al. (2013) showed that white shrimp fed FB_1 at levels from 20 to 200ug/kg had a reduction in soluble muscle protein concentration and reported changes in myosin thermodynamic properties after 30 days of exposure to FB_1. The same authors reported marked histological changes in the tissues of shrimp fed a diet containing FB_1 at 200ug/kg, and meat quality changes, after 12 days of ice storage, when fed diets containing more than 600ug/kg FB_1.

Are marine species sensitive?

Aquaculture species tested for fumonisins sensitivity so far include *I. punctatus*, (Lumlertdacha and Lovell 1995, Goel et al. 1994, Li et al. 1994); *Oreochromis niloticus*, (Tuan et al. 2003); *C. carpio*, (Pepeljnjak et al. 2003, Petrinec et al. 2004) and *Oncorhynchus mykiss*, (Meredith et al. 1998). All the above species are omnivorous or herbivorous and all of them are freshwater species.

Contrary to freshwater species, the liver in marine fish plays an essential role in lipid metabolism, and it is sensitive to lipid metabolism, which might influence the essential pathways of n-3 LC-PUFAs (long chain fatty acids such as eicospentanenoic-EPA and docosahexanenoic-DHA acids) biosynthesis and metabolism (Li et al. 2018). A known mode of action of fumonisins is the inhibition of ceramide synthase, a key enzyme in lipid metabolism and biosynthesis. Fumonisins intake may have negative consequences on hepatic lipid inclusion in marine species. Based on this assumption, BIOMIN had performed some game changing studies on marine species, which will be available soon (Gonçalves et al. In Press).

According to these studies, marine species are highly sensitive to fumonisins, affecting growth performance and immune status, at relative low fumonisin levels (<5ppm). This brings extra concerns to the marine aquaculture sector as, according to the European Commission (2006) the guidance values for fumonisins (B1 + B2) in complementary and complete feedstuffs for fish is 10ppm (Commission Regulation (EC) No 1881/2006).

Synergism: the most important concept

As previously described, fumonisins are the most predominant mycotoxin in plant meals and subsequently in finished feeds. However, 80% of all finished feed samples were contaminated with more than one mycotoxin (Figure 2). This means that we cannot focus our knowledge on only single mycotoxin effects. It is important to know the effects of fumonisins and their interactions with other mycotoxins present in the feed.

Synergism is not very well described in aquaculture. It is known from the literature that aflatoxin (AF) B1 and fumonisins undertake synergistic interactions in fish (Carlson et al. 2001; McKean et al. 2006; Adeyemo, et al. 2018) and shrimp (Pérez-Acosta et al. 2016). The study conducted by Mckean et al. 2006 in mosquito fish (*Gambusia affnis*) described perfectly the synergistic effect between AF and fumonisins. The author observed that mortality starts to increase only above 2,000ppb of fumonisin (17%) and similar mortality rate is obtained for AF levels of 215ppb. However, when combining both mycotoxins, (McKean et al. 2006) the authors observed that the mortality increased to 75% at concentrations of 1,740ppb fumonisin combined with 255.4ppb of AF. This same synergistic effect was also observed in the rainbow trout (*O. mykiss*); AFB1=100:FB1=3,200ppb; (Carlson *et* al. 2001); in pacific white leg shrimp (*L. vannamei*); AFB_1= 300:FB_1= 1,400ppb (Pérez-Acosta et al. 2016) and in African catfish (*Clarias gariepinus*; AFB_1=7.3:FB_1= 15,000ppb) (Adeyemo et al. 2018)).

Direct mortality described in previous studies, especially in short-term feeding trials (4 weeks), is an extreme consequence of the combined levels of AFB1:FB1. In commercial aquaculture conditions lower levels of AFB1 and FB1 are expected to generate a decrease in growth performance and increase disease vulnerability.

Fumonisins occurrence in Asia

The occurrence, level of the contamination and implications of mycotoxins entering the feed chain through cereal grains have gained global attention over the last years, and aquaculture is not an exception.

Table 1 shows the mycotoxin contamination in important commodities and finished feeds sampled worldwide from January to September 2018. The results are based on the BIOMIN Mycotoxin Survey, the largest and most comprehensive commercial survey that compiles results from a large number of commodities sourced worldwide. Commodities such as corn, corn gluten meal (CGM), dried distillers grains with solubles (DDGS), finished feed and rice bran samples, presented a high occurrence of fumonisins, in some cases close to 100%, which suggests an increase in the overall fumonisins risk.

The plant-ingredient survey of Asia reveals that 80% of samples analysed are contaminated with fumonisins, with an average level of 1,507ppb. Rice bran showed a prevalence of 63% fumonisins which is a relatively low level if compared to other commodities such as corn and corn gluten meal (2,786 and 13,686ppb respectively). However, even low levels are shown to produce negative effects in some species such as the white shrimp (*L. vannamei*). Corn, corn gluten meal (CGM) and DDGS presented a prevalence of 99%, 100% and 95% respectively, indicating that basically every sample analysed contained fumonisins. The average contaminations detected were 2,786, 13,686 and 5,378ppb respectively. These concentrations are high and may harm production, especially if we consider the risk of synergism with other mycotoxins, pathogens and antinutrients. As fumonisins are relatively stable to heat and processing conditions, it is expected to find this mycotoxin in finished feeds. This was in line with the observations (Table 1b) on collected finished feed samples in the same reported period. In 2018, finished feeds showed a prevalence of 96% fumonisins and an average concentration of 1,103ppb.

1.a - Plant meals samples	Afla	ZEN	DON	FUM	OTA
Number of samples tested	2316	2327	2324	2301	2270
% Contaminated samples	29%	64%	81%	80%	15%
Average of positive (ppb)	49	150	671	1507	7
Median of positive (ppb)	8	37	284	584	3
Maximum (ppb)	4890	9573	53796	123444	124

1.b - Finished feeds	Afla	ZEN	DON	FUM	OTA
Number of samples tested	1081	1089	1089	1081	1072
% Contaminated samples	39%	80%	92%	96%	20%
Average of positive (ppb)	26	78	331	1103	7
Median of positive (ppb)	7	34	257	672	3
Maximum (ppb)	697	2089	6126	27352	124

1.c - Corn	Afla	ZEN	DON	FUM	OTA
Number of samples tested	353	353	353	346	328
% Contaminated samples	31%	61%	84%	99%	4%
Average of positive (ppb)	51	243	611	2786	6
Median of positive (ppb)	15	44	364	1161	3
Maximum (ppb)	605	5087	7632	47485	26

1.d - Corn gluten meal	Afla	ZEN	DON	FUM	OTA
Number of samples tested	17	17	17	15	15
% Contaminated samples	59%	94%	94%	100%	20%
Average of positive (ppb)	130	2407	989	13686	15
Median of positive (ppb)	56	725	298	3802	16
Maximum (ppb)	411	9573	8194	60275	17

1.e - Rice Bran	Afla	ZEN	DON	FUM	OTA
Number of samples tested	27	27	27	27	27
% Contaminated samples	63%	78%	59%	63%	19%
Average of positive (ppb)	8	95	112	275	4
Median of positive (ppb)	3	26	51	33	2
Maximum (ppb)	34	691	580	1742	13

1.f - DDGS	Afla	ZEN	DON	FUM	OTA
Number of samples tested	39	39	39	39	39
% Contaminated samples	18%	95%	95%	95%	15%
Average of positive (ppb)	21	242	1994	5378	5
Median of positive (ppb)	23	103	1531	1521	3
Maximum (ppb)	39	1712	7368	43610	15

Table 1(a-f): Mycotoxin contamination in plant commodities and finished feeds sampled in Asia from January 2018 to September 2018

Fumonisins counteraction

Although the topic of mycotoxins in aquaculture is still relatively novel, there is no doubt that the industry and the scientific community should pay greater attention to this class of antinutrients, especially their effects on terrestrial animals. Fumonisins show a great stability -that makes them resistant to most processing methods. They actively target living cells such as the ones in gastrointestinal and immune systems. Bearing in mind that occurrence of fumonisins is global, managing these mycotoxins can be crucial to ensure robust productivity in the era of fish meal reduction.

Countering fumonisins using binders is a common practice. Although the literature shows good binding proprieties in vitro, this does not apply in vivo due to the pH dependency. In fact, adsorption tests have always been investigated at low pH, whereas in reality, greater desorption is observed at medium to higher pH, suggesting that binders are not a good solution for *in vivo* applications. At the current state, enzymatic detoxification is the only way that brings effective results, in targeting fumonisins directly in the gastrointestinal tract.

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Spray-dried plasma protein in shrimp diets

By Eric De Muylder, Lourens Heres and Carine van Vuure

Despite the heat sensitive nature of the immunoglobulins in plasma proteins, in this study, growth and survival of shrimp were not affected by feed processing temperatures.

Spray-dried plasma (SDP) is a high-quality protein derived from blood. The plasma is made by separating the blood into a plasma fraction and a cell fraction with red and white blood cells. After separation, both fractions are spray-dried resulting in SDP and haemoglobin, also called red cell powder. The relatively mild heating step at spray-drying preserves the proteins of the product.

SDP is well known for its use in piglet feed and pet food. Beside the animal nutritional applications in feed and pet food, it is also used for technological purposes in meat (food grade) products and wet pet food for its binding and emulsifying effect. To date, its use in aquafeeds is limited because the price is too high in comparison with other highly digestible protein. On the contrary, in weaning diets for pigs, SDP is extensively used as the benefits outweigh its costs. The young piglets, which this feed is targeted have to make the transition from milk to solid feed. Their digestive system has to adapt to less digestible proteins and is vulnerable to infections. In this situation SDP has a positive effect on gut development and the proteins in SDP can easily be digested by the young piglets.

These positive effects have frequently been described. The effect on gut development is likely due to the high level of immunoglobulins which have a central role in the immune system. They bind bacteria and viruses and in piglets fed with SDP, longer intestinal villi are seen, and less inflammation in the gut wall is noticed.

The positive effects of SDP are not only seen in piglets, but also in other animal species. especially in young poultry and calves. It is expected that positive effects of SDP on the immune system and digestibility of nutrients may also be seen in young fish and early stage of the shrimp. In this article, we present effects on the plasma tested as an ingredient in shrimp feeds.

Immunoglobulins in SDP

Disease caused by opportunistic bacteria, such as *Vibrio* spp. forms a continuous threat for the global shrimp farming industry. This is an important reason for antibiotic use in shrimp farming. Various products have been tested to decrease the presence of Vibrio in the intestine and hepatopancreas of shrimp. Increasing the disease resistance is another strategy, which can be used simultaneously. SDP may have this supportive effect on gut health, besides being a highly digestible protein.

Immunoglobulins are complex proteins which are heat sensitive. Therefore, often the question is whether feed pelleting or extrusion has a negative effect on the bio-functionality of SDP. In the present study, the effect of heat on the functionality of the immunoglobulins in SDP was tested by either adding SDP directly into the ingredient mixture and consequently undergoing the heat treatment during the pelleting process (90-95°C) or lowering the temperature post-pellet coating (20°C) of SDP after pelleting.

Growth trial

The growth trial was for six weeks and consisted of five treatments (Table 1). Details on the list of ingredients and composition are given in Table 2. Feeds were produced with a pellet mill on a 2mm die. Three different diets were produced.

- Control diet, high in fish meal
- Plasma 2P (pressed) with 2% fish meal replaced by 2% Plasma 70P(70% protein, Sonac, The Netherlands)
- Plasma 2C (coated): 2% Plasma 70P is vacuum coated post pelleting at low temperature. The plasma was coated on a feed with a composition similar to the control feed but with 2% less fish meal. To coat the feed, Plasma 70P was mixed with water 50/50 and then 4% w/w was coated.

There were five treatments as shown in Table 1. The control feed was devoid of plasma. Two groups received plasma (either pelleted or coated) during the first 3 weeks followed by the common diet (the control diet) and two groups had plasma in their feed during the entire 6 weeks (either pelleted or coated).

There were four replicates for each diet, and the trial was carried out in 60L baskets. There were 20 baskets in total and each basket held 25 shrimp *Litopenaeus vannamei* of 1.7g. All the baskets were placed in a large tank. In this way, all the baskets were subjected to the same water quality. Water quality in the big tanks was maintained with bioflocs. Each basket was equipped with a belt feeder.

Growth performance

Results indicated that there was no effect on growth with the inclusion of plasma after 3 weeks. However, after 6 weeks, at the end of the trial, there was a positive effect with the inclusion of 2% plasma in the feed (Figure 1 and 2).

After 3 weeks, the shrimp fed plasma in the feed pellet had higher survival rates than the shrimp fed diets without plasma or diets with plasma coated feed. After 6 weeks, shrimp fed plasma in the feed pellet still had higher survival rates. The high survival persisted till the end of the experiments, even though the plasma application was stopped after 3 weeks. (Table 3. Figure 3)

Digestibility

Two conical tanks were used to compare the effects of the control feed with plasma 2P feed. Shrimp were fed 1g of feed 4 times/day. Faeces were collected twice a day after the morning and mid-day feeding.The amount of faeces collected from shrimp fed diets with plasma was consistently lower than the amount collected from shrimp fed the control feed.

Histology

Following the growth trial, 10 shrimp from each treatment were collected and prepared for histological examinations. They were sent to IMAQUA (Ghent, Belgium) for the preparation of histological sections of the intestinal epithelium.

Figure 4 shows a clear effect on epithelium height when plasma was included in the diet. This effect was lasting, even though shrimp were only fed plasma for 3 weeks and then proceeded with the control diet without plasma.

Groups	Treatments	First 3 weeks	Last 3 weeks
1	Control	Control	Control
2	Plasma 2P	Plasma 2P	Plasma 2P
3	Plasma 2P/Control	Plasma 2P	Control
4	Plasma 2C	Plasma 2C	Plasma 2C
5	Plasma 2C/control	Plasma 2C	Control

Table 1: Treatment diets and an experimental setup

Treatments	Control	Plasma 2 (2P or 2C)
Ingredients		
Corn gluten	4.5	4.5
Danish fish meal LT	25	23
CPSP G	2	2
Wheat flour	37	37.15
Rice bran	4	4
Soybean meal	15	15
Soya lecithin	2	2
Fish oil	2	2
Wheat gluten	2	2
Salt	0.5	0.35
Yeast	1	1
Premix	2	2
Plasma	0	2
Composition (% dry matter)		
Crude protein	38.15	38.18
Crude lipid	7.36	7.32
Crude fibre	1.80	1.79
Ash	7.50	7.38

Table 2: Ingredients in the experimental diets: control diet versus diets with plasma 2.

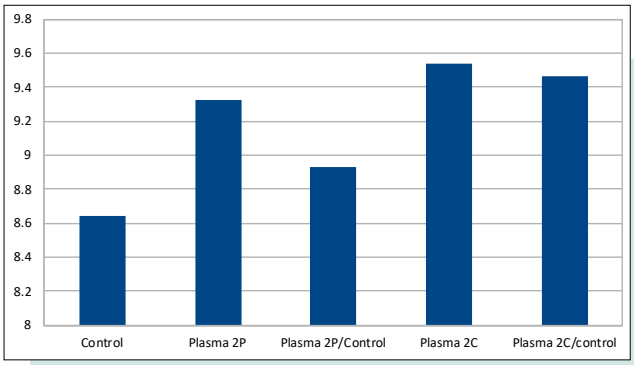

Figure 1. Average weight of shrimp after 6 weeks of feeding.

Week	start	1	2	3	4	5	6	Survival Week 0-3	Survival Week 4-6	Total survival
Control	25.0	23.8	23.0	20.8	18.8	16.3	14.3	83.0%	68.7%	57.0%
Plasma 2P	25.0	24.8	24.3	23.0	21.8	17.5	15.0	92.0%	65.2%	60.0%
Plasma 2P/ Control	25.0	25.0	24.3	22.8	22.0	20.3	17.0	91.0%	74.7%	68.0%
Plasma 2C	25.0	24.5	22.5	20.8	19.0	16.5	12.8	83.0%	61.4%	51.0%
Plasma 2C/ control	25.0	25.0	24.0	22.3	19.3	15.5	13.5	89.0%	60.7%	54.0%
The numbers are the average numbers of shrimp in 4 replicates										

Table 3: Average number of shrimp during the trial period. The numbers are the average numbers of shrimp in the four tanks.

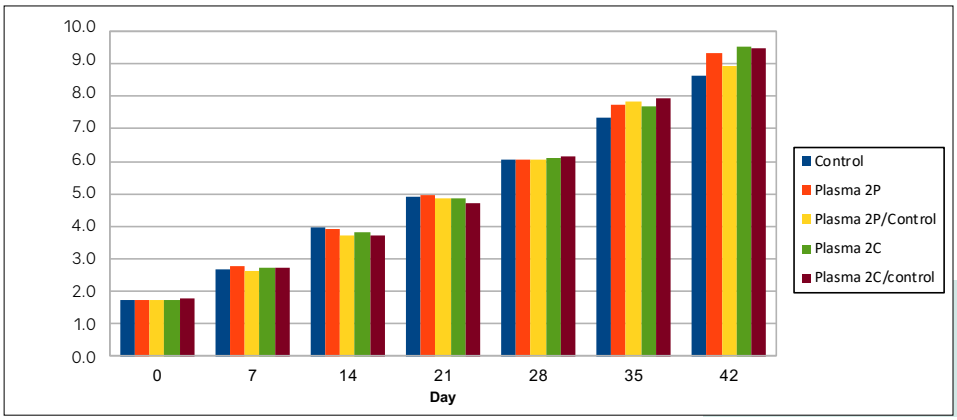

Figure 2. Average weight of shrimp receiving the control and plasma containing diets at 3 and 6 weeks.

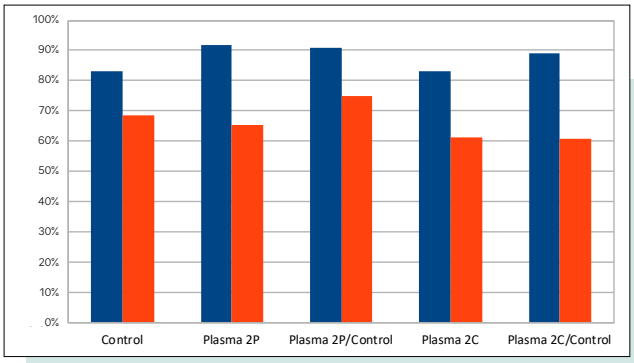

Figure 3. Percentage survival after 3 weeks of feeding (shown by the blue histogram) and after 6 weeks (shown by the red histogram) for shrimp fed the control and plasma diets for 3 and 6 weeks.

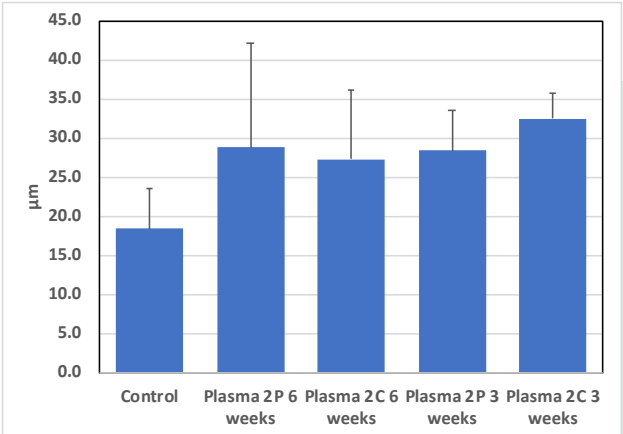

Figure 4. Midgut epithelium height in shrimp fed the control and plasma diets during 3 and 6 weeks

	Control		Plasma 2P	
Data	Wet weight(g)	Dry matter(g)	Wet weight(g)	Dry matter (g)
Average	0.64	0.17	0.42	0.1

Table 4: Amount of faeces collected from shrimp fed plasma 2P versus control diet over a 30-day period.

Conclusion

Shrimp fed diets with SDP showed better growth notwithstanding the methods of SDP inclusion (mixing before pressing or post pellet coating). Feed with SDP was better digested since less faeces were collected. In the group of shrimp fed diets with coated plasma, no positive effect was seen with regards to survival as compared to the shrimp fed the control diet. In the shrimp fed diets containing plasma mixed into the feed before pressing an improved survival was observed. The inclusion of plasma in the diet for 3 or 6 weeks increased epithelium height.

This study indicated that there are positive effects of SDP on growth performance, survival and gut wall morphology for the shrimp. Based on the survival data. this study suggests that inclusion of plasma during the feed production process was better than post pellet coating. From the differences in growth performance, it was however, not clear whether pressing or coating is better. There is, however, a potential risk that pressing might damage the immunoglobulins by the heat during preconditioning and pressing process. The presented data do not support such a conclusion. Based on the present results, it can be hypothesised that pelleting does not damage the functionality of the plasma protein, and some plasma is lost by leaching when coated on the feed pellet, thus giving less improvement.

The positive effects from these experiments require further investigations on the duration for the inclusion of plasma in the formulation of feed for the shrimp. Based on this study, it is possible to include plasma in the diet of *L. vannamei*. The use of SDP can help to reduce the need for antibiotics in shrimp farming, as shown in this trial, indicated by better shrimp growth, higher survival rate, and increased epithelium height.In this way. plasma can be a very sustainable choice.

Eric De Muylder

Carine van Vuure

Lourens Heres

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Science in the aquaculture economy

At the World Nutrition Forum 2018: how can aquaculture, a source of protein for the growing population, benefit from progress in science?

Rui Gonçalves (left) and Anwar Hasan, Biomin, Singapore (right) with presenters at the Aquaculture Breakout session during WNF 2018.

At BIOMIN's World Nutrition Forum (WNF), held in October in Cape Town, part of the program was a breakout session for each of the sectors: dairy, swine, poultry and aquaculture. Befitting the WNF theme, S.C.O.P.E or the Scientific Challenges and Opportunities in the Protein Economy, the list of presentations at the aquaculture breakout session looked at the role of science in catalysing the global aquaculture industry.

Organiser, Rui Gonçalves, Scientist, Biomin Austria, , said, "The excellent selection of renowned scientists and diversity of topics would give us the overview of aquaculture challenges but also what are the next steps in the worldwide industry".

Dr Julian Conway McGill, LMC International Ltd, UK started the session with his take on "Plenty of Fish: How will the choice of species being domesticated influence aquafeed demand?" Compared with livestock, aquaculture exemplified by the salmon is efficient; the salmon can achieve a 1:1 feed conversion (FCR) ratio. This makes fish 20 times as efficient at converting feed to meat as cattle. However, the science of fish nutrition is far behind that for land animals. Fish nutrition is also far more diverse than that of livestock. In aquaculture there are over 400 species, each with specific nutritional requirements. As a company involved in commodities, LMC is interested in how the choice of species influences aquafeed demand.

***Julian Conway McGill** said that the real challenge is how to keep to the exponential growth trajectory of species when we do not fully understand their nutritional requirements.*

McGill added that there are groups of aquaculture species of importance. The bulk of the production is of low value white fish: carps, tilapia and catfish. In the "luxury fish" category, the salmonids dominate, and the Atlantic salmon industry is the most advanced as it is highly consolidated, attracting investments. The high value white fish is dominated by the seabass, seabream and amberjack but only a small share of the total volume is from aquaculture. White shrimp leads in the crustacean group. The two latter groups are largely dependent on fish meal. Two drivers to reduce the cost of production is to reduce fish meal usage or switch to cheaper sources of protein. In turn, the latter will require more investments in alternatives for fish meal.

"As incomes increase, the demand for protein will increase. In aquaculture, the problem is the number of species and that nutritional knowledge is not enough (as compared to land animals). The obligate fish meal users are the species growing fastest. The real challenge is, how to keep to the exponential growth trajectory of species when we do not fully understand their nutritional requirements," concluded McGill.

Novel development of probiotics

Jørgen Schlundt, Nanyang Technology University, Singapore discussed efficient animal production without antimicrobial growth promoters (AGP) by using probiotics in feeds. Due to the intensive nature of aquaculture, antibiotics are commonly used to control diseases which generate significant concerns with food safety and risks to public health. Improved efficiency and sustainability can be achieved by improving the health status of the fish and thereby reducing the use of antibiotics. In addition, it is expected that novel feed formulations and vaccines, early detection systems, and risk assessment strategies can provide science-based solutions, enabling safer and more sustainable fish production.

Schlundt discussed probiotics as alternatives to antimicrobials in aquaculture production. Studies have shown a positive effect

***Jørgen Schlundt** said that the combination of metabolomics and metagenomics can generate a system for functional profiling of the host microorganisms and help in the understanding of the interactions between hosts and gut microbiota.*

*According to **Süreyya Özkizilcik**, the nutrition of an animal involves considering the benefits and problems of each nutrient from numerous different raw materials as well as their metabolic effects in an interactive way.*

of probiotics on fish growth and health in aquaculture and that benefits are driven, in part, by the modulation of the fish microbiota. The novel potential for microbiota investigations, using next generation sequencing and metagenomics analysis was described. The combination of metabolomics and metagenomics can generate a system for functional profiling of the host microorganisms and thereby help in the understanding of the interactions between hosts and gut microbiota. However, to evaluate the effect of probiotics, baseline data of the gut microbiota of the relevant fish species is required.

Nutritional and performance consequences of fish meal replacement

In his presentation with the above title, **Dr Süreyya Özkizilcik**, Nutra Yem, Turkey, looked at three aspects: nutrition, anti-nutrition and nutrient-nutrient interactions. According to NRC (1993), fish need the following; 10 amino acids, n-3 and n-6 fatty acids, 6 macro-minerals, 6 trace-minerals, 4 fat soluble vitamins, 11 water soluble vitamins, nitrogen and energy. "The magic of fish meal is the 68% protein comprising soluble proteins, peptides, amino acids and nucleotides, as well as fats comprising n-3 fatty acids and phospholipids. So far, no single meal has shown to be the full replacement of marine meals for commercial applications."

Juvenile seabream (0.6g) fed a nucleotide (inosine monophosphate) supplemented diet for 76 days, showed a growth of more than 50% and 120% better survival than the control, and 18-20% more intestinal folds. "To replace fish meal, we need to look for raw materials with nucleotides," confirmed Özkizilcik.

Among the common raw materials, fish meal has 1.4% of purines and pyrimidines but levels are higher in fish solubles (2.8%), yeast extracts (2.3%) and single cell proteins (2.1%). Feeds with a high percentage of plant origin raw materials are often devoid of essential nucleotides. "Not all lipids are fats and fish meal have 1-3% phospholipids comprising phosphatidylcholine (PC), phosphatidylethanolamine, phosphatidylinositol and phosphatidylserine. Thus, it is essential to seek raw materials with phospholipids. PC is found to improve growth and feeding activity. PL affects growth and survival rate, reduces stress resistance and improves immune responses. The PC requirements for marine fish larvae is 2-12%; freshwater fish larvae are 3-5% and in juveniles 1.5-7%."

Özkizilcik discussed substitutes for fish meal such as processed animal proteins (PAP), plant meals as well as new ingredients such as single cell meals (yeasts, microalgae) and insect meals. He also discussed the anti-nutritional factors in some of these ingredients and their effects on fish. In the PAPs, these are putrescine, cadaverine, histamine, allergenics and TVN. "Unfortunately, almost all feed ingredients have undesired properties limiting their use in feed formulas. These anti-nutritional compounds can either be intrinsic to the genetic make-up of the raw material or extrinsically contaminated during production."

In nutrient-nutrient interactions, Özkizilcik discussed a case study of vegetable oils conducted by Dr Eric Lund (E. Lund, 1998, unpublished) who found the same growth retardation in striped bass when fed omega-3 deficient soya oil compared to fish oil diet. "How did a 'seemingly' harmless vegetable oil result in lower growth? Lund adopted an 'inverted sleeve' method to measure the intestinal absorption rate of amino acid proline. Proline is known to be absorbed by Na-K dependant ATPase transporter proteins. The results showed that the high n-3 diet had nearly double the absorption rate of the low n-3 diet. Moreover, fatty acid analyses of the intestinal surface clearly demonstrated that docosahexaenoic acid (DHA) played a determining role in the function of transport proteins and resulted in better nutrient uptake.

In conclusion, nutrition of an animal is a rather complex problem. It involves considering the benefits and problems of each nutrient from numerous different raw materials as well as their metabolic effects in an interactive way.

Bioenergetic and dynamic nutrient-based models

As they develop feed formulations, the feed industry assesses growth and economic performance as well as environmental impact with digestibility trials which may take a month and growth performance trials, lasting as long as 3 months costing thousands of euros per diet tested. "Bioenergetic and dynamic nutrient-based models are predictive tools to evaluate aquafeeds," said **Dr Luís Conceição** from Sparos Lda, Portugal. Models are useful particularly to study effects of feed formulation and protein

Kumuda Chandra Patra, Biomin's Business Director – Aqua in India (second left) with the team from Avanti Feeds Ltd, from the right, K. Venkata Raju, Anuj Tyagi and Venkata Sanjeev Alluri.

Luís Conceição *said that we can develop better models with better prediction, and for more species such as for the shrimp.*

Andy Shinn*'s message was that by raising awareness with industry, the threshold of acceptable loss, and/or disease prevalence can be lowered.*

digestibility on retention efficiency and fish growth, which with the introduction of plant- based ingredients in feeds, can have a major impact on nitrogen and phosphorus outputs to the environment.

In poultry and swine production, bioenergetic mathematical models are commonly used to reduce costs, and maintain growth and animal welfare at optimal levels. Conceição said that in aquaculture, to date, some bioenergetic models are used mostly for developing feeding tables and are less often used in novel feed formulation development. Several models have been published since the 1980s , but none of these models have been adopted by the aquaculture industry.

Two models were introduced in the presentation. The WASTEst tool is a practical tool to compare the impact of different fish feed formulations on seabream, seabass, carp and salmon waste outputs, based on bioenergetic principles. This web tool allows the estimation of phosphorus, nitrogen and total waste outputs based on (inputs) performance variability, combined with statistical models on fish biochemical composition. This model gives output estimates including confidence intervals based on incomplete data (only growth and feeding), but gives more precise estimations when detailed data on nutrient digestibility are available.

Conceição described a practical hypothetical scenario, where two gilthead seabream feeds (low cost and premium, both with 45% CP, 10% ash and 1.1% phosphorus) were compared against each other based on their performance (i.e., fish initial weight, final weight and FCR) in a typical fish trial (3 tank replicates/feed). This showed that, even when incomplete information was provided to the tool, it was still possible to perform some quantitative predictions on relative environmental impact. In this case, there was no information on whole body composition and apparent digestibility was only roughly estimated.

The FEEDNETICS model is a computer application to predict nutritional and environmental effects on growth, carcass composition, environmental impacts and feed costs. This dynamic simulation model predicts the effect of changes in feed formulation, feeding and temperature on downstream performance (e.g. growth, FCR, feed costs), environmental impact (e.g. total released nitrogen and phosphorus) and consumer-value parameters (e.g., fatty acid profile) of fish. It can generate a realistic prediction of scenarios, interactions between feeding level, feed formulation and water temperature and accurately predicts performance differences due to dietary amino acid imbalances. It may be used to optimise feed formulations and feeding regimes.

In an example, Conceição showed a simulation of the FEEDNETICS model using three diets: 32% fish meal (FM), diet with 60% fish meal replaced (PP60) and diet with 100% fish meal replaced (PP100) fed to 180g seabream. "It was no surprise that the FM diet was the best in performance and FCR, but this diet had the poorest economic FCR and diet PP100 had the highest nitrogen and phosphorus discharges to the environment. FEEDNETICS also allows the comparison of formulations to optimise feed cost and growth performance, adjust feeding to meet growth targets and predict effects of restrictive feeding on growth performance and FCR.

"We believe that in the future, in combination with -omics technology, we can develop better models with better prediction, and for more species such as for the shrimp. The use of reliable farm data can also improve simulation accuracy, by using non-linear reverse calibration of the model."

Counting losses in aquaculture

In the presentation, "Diseases in aquaculture – counting the costs of the top 100," **Dr Andy Shinn**, Fish Vet Group Asia, Thailand said that the largest threat to sustainable aquaculture is diseases. "Out of the aquaculture production of 127 million tonnes of fish, mollusc and shrimp in 2016, losses were estimated at 30% due to diseases costing at around USD 60 billion," said Shinn.

"Diseases are associated with factors such as poor water quality, as well as a broad range of events that might stress farm populations. Untangling the impacts of disease from those linked to other causes becomes very difficult or, in some cases, near impossible. Losses may come from several factors- from genotype developmental defects to management decisions."

He divided disease outbreaks into two categories: unpredictable/sporadic and predictable/regular events. In both cases, there are costs in treating and managing infections once established, but for predictable infections there will also be costs associated with prophylactic treatment/management.

"Many diseases go unspotted, undiagnosed and unreported to the extent that the true severity of a disease is unknown. Loss calculations raise awareness with governments. Without knowing and factoring for the risks, the growth of an industry is slow."

The first step is to recognise the problem and have financial preparedness before and during disease outbreaks at the farm, national and regional levels. Farmers will be able to budget for the implementation of early disease diagnostics, biosecurity measures and contingency plans within their business plans. "Unfortunately, in Asia this is not always the case and farmers are happy if they still have 40-50% of their stock. But then disease goes unreported and perils of ignorance becomes a problem. Ideally, farmers should make sure that their stocks are disease free."

Shinn listed some of the top 40 diseases in aquaculture, which is part of an ongoing exercise. Some examples of viral diseases include tilapia lake virus (TiLV), an orthomyxo-like RNA virus, which is an emerging disease of cultured tilapia. Mortality rates range from 20-90%. Small and large fish are affected and at one undisclosed Asian site, the loss was USD26,000.

In the case of bacterial pathogens of fish, Shinn focused on streptococcal infections in tilapia farming, particularly in Bangladesh, China, Malaysia and Thailand. He calculated annual losses at USD 713 million, assuming a mortality range of 3.75 to 7.5% of the 4.165 million tonnes produced in 2015 across Asia and applying USD1657/tonne price.

In fish there is a long list of parasites, such as *Argulus*, common in cyprinids and *Benedenia* and *Neobenedenia* causing 22% of production losses, up to USD400 million/year on *Seriola* spp. Loss from *Ichthyophthirius multifiliis* affecting small sized fish is USD141 million/year.

Over the last decade, shrimp diseases have resulted in huge national income losses, despite compensatory price rises in response to supply shortage, amounting to at least USD45 billion in Asia. Direct losses because of the bacterial disease, acute hepatopancreatic necrosis disease (AHPND) in Thailand, China, Malaysia and Vietnam are in USD billions. The main parasitic disease affecting the shrimp farming industry is the microsporidian *Enterocytozoon hepatopenaei* (EHP) causing shrimp to grow slowly. Farmers can cut losses by harvesting. Shinn noted that new threats like SHIV (*shrimp haemocyte iridescent virus*) are emerging.

Finally, Shinn pleaded for data. "By raising awareness with industry, the threshold of acceptable loss, and/or disease prevalence, can be lowered as each respective industry drives for improvements in health and farm management. With transparency on the costs of disease outbreak, it is hoped that the aquaculture sector will be able to reduce instabilities, improve profitability and achieve greater sustainability."

***Clifford Spencer** discussed the future of aquaculture production, challenges and opportunities in Africa, a continent with a quarter of the global population with an average age of 18 years.*

Aquaculture in Africa

With WNF in Africa, **Clifford Spencer**, Chairman Aquaculture without Frontiers (AwF), UK, and Goodwill Ambassador, NEPAD (a development agency of the African Union) presented on the future of aquaculture production, challenges and opportunities in Africa. The continent has a quarter of the global population with an average age of 18 years. Nutrition of the population varies between regions. The EU has fisheries programs which are jointly implemented by NEPAD/AU-IBAR (African Interafrican Bureau for Animal Resources) and the World Fish Centre. Recognising that there is a need to develop aquaculture broadly on the continent, NEPAD is entering into partnership arrangements to boost aquaculture research for the continent. AwF will focus on development of marine and freshwater aquaculture for efficient and cost-effective production of healthy and nutritious seafood.

Driving sustainability and innovation in aquaculture

DSM tackles challenging issues from marketing, production, environment to feed processing.

Robert Redman, general director, DSM, Thailand and Dr David Nickell, vice president Sustainability, DSM, Switzerland with recipients of the "DSM Innovation and Sustainability Award" (Viet Thang Feed, Green Feed and Proconco in Vietnam and Thai Union Feedmill, TRF Feedmill, Betagro and Charoen Pokphand Foods, Thailand.) These companies use Ronozyme phytases to improve phosphorus digestibility of phytate-P in plant ingredients and reduce reliance on inorganic phosphate supplementation. Seven awards were presented at the conference in Bangkok. Photo credit: DSM

In 2018, the DSM Nutritional Products Aquaculture Conference Asia Pacific reached its 24th year. It was held in two locations; Jakarta, Indonesia on November 21 and in Bangkok, Thailand on November 23. Although the programme remained the same for the two locations, the audience in Jakarta came mainly from industry in Indonesia while the event in Bangkok attracted an international audience of more than 300 participants.

The conference theme, "Driving sustainability and innovation in aquaculture," was in line with the United Nations' Sustainability Development goals for the global aquaculture industry. In Jakarta, Dr Fidelis Fru, senior director marketing –nutritional solutions and innovation sales, DSM Asia Pacific, Singapore welcomed the smaller audience of 80 participants, with the message that "each one of us can contribute to these goals through what we do best.

"Sustainability is driven by innovation and DSM sees the challenges with aquaculture in five main areas; marketing, infrastructure, institutional, production and environmental. Marketing depends on retailers while production has huge challenges. Being in the business of food production, DSM has selected some of UN's sustainability goals to focus on; among them, production and environment."

This year, the conference engaged stakeholders in several areas; marketing from a retailer's point of view and in shrimp production, understanding shrimp signals and challenges for better health and disease management, and the role of nutrition in managing white faeces disease (WFD). In aquafeed production, it was understanding raw materials and enzymes with various microscopy technology and reaching for a more efficient feed mill management.

A retailer´s view on marketing seafood

Globally, the goal is to produce seafood successfully in a sustainable and profitable way. However, producers are not the only players; retailers are the dominant players on the marketing/sales end. The success of a seafood product often depends on how the retailer markets it, sometimes leading to the situation where the retailer determines the market access and success of a product in a certain market. Producers could thus learn, to their advantage, lessons from how retailers manage seafood marketing.

Benoit Vidal-Giraud, founder of Via Aqua, France, a consulting company to assist with services and market studies in the seafood marketing, presented on how "Documented responsible production is decisive for your future success: a retailer´s view."

For the consumer, eating farmed fish for dinner is not an obligation, said Vidal-Giraud. "Hence aquaculture producers cannot assume that there is no strong competition." To be number one in the market, producers need to defend their market shares. In 2016, consumer expenditure for food was low, with European households spending only 12% of budget for food and beverages. Furthermore, the expenditure for food is decreasing.

It is important to bear in mind, added Vidal-Giraud, "The consumer is always looking for cheap food. Protein from seafood is a mere 5% of the total protein intake of a person in Europe, competing with other sources of protein. Within seafood, there is competition; on average 26% is from aquaculture. The rest are from capture fisheries."

The message was, "We cannot take our markets for granted. It is a battlefield in retailers' stores."

Journey into the consumer's shopping basket

Some 80% of seafood products go to the supermarkets; hence retailers largely control the seafood distribution. Out of the consumers' average of 35 minutes weekly in a supermarket, only a minimum of 17 seconds/week to a maximum of 1 minute 27 seconds/week is spent looking at the seafood counter. This means that the consumer usually decides on a purchase after a short scrutiny, explained Vidal-Giraud.

"There is an interplay of store related and personal factors when a consumer is making a choice to buy or not to buy. Store related factors include how the product range, furniture, prices, promotions etc. are organised. So, in this context, at the point of sales, if producers ask what can they do to trigger a purchase, the answer is nothing," said Vidal-Giraud. Conversely, some of the personal factors, e.g. buyer's sensitivity to the type of seafood are within reach of the producer.

Purchasing decisions depend on certain criteria and insights. "Defending stomach shares implies a need to build on understanding the consumer. Research has grouped consumers based on criteria; age, gender, purchasing power, social order etc. and on psychological factors such as what is important for them such as protecting the environment or spending little time in purchasing food, etc.," added Vidal-Giraud.

"These criteria and insights of consumers drive innovations, although sustainability is clearly in the list of demands. However, we are not bringing recipes or defining what responsible production should be, but to stress that industry has to translate all these into producing what the consumer wants. If we want our products to end up in the consumer's trolley, we will need to have a convincing marketing mix."

In theory, marketing mix is defined as the 4Ps of product, place, price and promotion. "Creating the best marketing mix at the point of sale is not just within the retailer's power but it is also the duty of producers. The pull approach is an insight. No consumer has actually said that they want omega-3 oils for health or insect meals in feeds, but they have asked for healthy products, thus implying that having omega-3 oils and sustainable production with insect meals in feeds is the way for producers to go. Consumers should not belong only to end retailers, and producers can be one-step ahead of retailers."

Pull of retailers

Insights and criteria are continuously scrutinised by retailers and translated into product specifications as they want to give consumers what they ask for. Retailers cannot afford to display products which the consumers do not want. If the product is not being shaped by the upstream industry, they then force the upstream industry to shape the product.

This chasing of an insight is the pull approach adopted by retailers and Vidal-Giraud cited the case of the French hypermarket chain, Carrefour. In the 1990s, Carrefour began to translate research on consumer understanding into product specifications; transcribing consumer expectations into product features. "It asked the suppliers to respect such obligations. In 2000, Carrefour went further; it took control of the supply chain and producers not only had to match specifications but also embraced add-ons like animal welfare and water quality etc. It then created strong links with the producers.

"Today, aside from the combination of product specifications and obligations by producers, retailers talk to producers about themselves. Retailers portray themselves as the 'hero', promoting no GMOs (genetically modified organisms), no antibiotics etc. They act as responsible retailers. Carrefour has the "Act for food program.

"This means that retailers are actually putting a lot of pressure upstream. Today, in the EU, 35% of products are retailer brands, where the producer's name is not seen. Producers need to be ahead yet with loss of degrees of freedom," added Vidal-Giraud.

"Producers need to be ahead yet with the loss of degrees of freedom." – *Vidal-Giraud*

Photo credit: DSM

At the Q&A session, Santosh Lall (right) and Ninfa Rangel Pedersen. Photo credit: DSM

To be one-step ahead

Producers need to be vigilant about consumer expectations and perceptions. The sad fate of the pangasius in Europe which took consumer worries (food safety, sustainability) too late into consideration, was one example. "The message to learn is, do not wait. In spite of robust credentials, communication and image initiatives, the sharp decline in pangasius sales continued all over most of Europe; Netherlands, Germany, Belgium, Spain and Italy. It was too late for retailers to push for improvements."

On the contrary, social interest leading to commercial success was displayed by the Irish organic salmon industry which managed to emerge and differentiate from Norwegian and Scottish competitors and bigger players. Organic production was created by producers who think it is important for them and for their customers. No GMOs and natural ingredients in feed, low stocking densities, sustainable practices and waste reduction were translated into benefits for the environment and for human health.

In 2014-2015, NGOs and retailers were influencing consumers not to buy smoked eel products since eels are in an endangered position. DUPAN, the Sustainable Eel Foundation created by the Dutch eel industry (eel farmers, fishermen and processors) overcame a 50% to 60% drop in sales of smoked eel because it cleverly got consumers to contribute to solving the problem. It indicated on packs that part of the retail price will go towards restocking initiatives and scientific research on eel, i.e. co-financed by the industry and the consumer.

In his conclusion, Vidal-Giraud said, "The end consumers are coming up with rules which powerful retailers and influential media are closely tracking and interacting with. For the producer to be successful, the advice is not just obeying an imposed 'to do' list, but being one step ahead and proactively documenting what consumers and retailers want and shaping its production strategies accordingly.

The new frontier in formulating aquafeeds

Adjunct Professor **Dr Santosh Lall**, Dalhousie University, Canada, gave an overview of the changes in aquafeed formulation in the past three to four decades, from the push in the 1980s and 1990s for more economical and efficient grow-out feeds, larval feeds and feeds for new species, as aquaculture production took off, followed by the need for highly digestible and low-pollution feeds. Extrusion technology revolutionised aquafeed processing and allowed the addition of high levels of fats into fish feeds.

The team from PT Suri Tani Pemuka, Indonesia from left; Narendra Santika Hartana, Erwin Suwendi, Marlinda Fredriksz, Sandi Eka Prawiranegara and Elly Khoirunnisa.

"In the 2000s, we anticipate future shortfalls in fish meal and fish oil supplies and a move to focus on alternative protein and lipid sources. Since 2010, the emphasis is on molecular nutrition and more complex issues. Today, it is on eco-friendly and sustainable feeds, feeds for better growth, feed conversion and health. It is on high product quality-production of healthy products (low in POPs, high in omega-3 fatty acids). Industry also needs to adhere to stringent feed regulations." Below are some snapshots on current and future needs from Lall's presentation.

Feeds for all potential farm fish species

Aquaculture will continue to grow and will require 80 million tonnes more aquafeeds, some 2-3 million tonnes/year. "The question is, do we have enough feed ingredients to produce feeds for all species commercially? To be in the aquafeed business is to be profitable for the long term. We have many farmed species but data on nutrient requirements are limited to a few species," said Lall.

Aquafeed formulators must use less fish meal and fish oil and replace them efficiently while at the same time work with more regulations than before on feed ingredients in aquafeeds. Fortunately, there are many available additives (enzymes, immunostimulants, pre- and probiotics) for fish disease prevention and EPA and DHA (eicosapentaenoic and docosahexaenoic acids) and micronutrients to support better human health. An important segment is feeds for the critical early stages: larval and brood stock feeds.

"In the last 10 years, there has been some success in salmonids with fish meal free diets but at lower feed conversion ratios. This means, for now, we need to depend marginally on fish meal and use 10% fish meal or less in diets."

Search for alternative feed ingredients

There is a long list of current and new protein sources for aquafeeds, ranging from plant proteins, modified plant proteins to new protein sources such as silkworm pupae, earthworms, maggot/black soldier fly larvae, other insect meals, macroalgae, microalgae, polychaetes, copepods, single cell protein and mesopelagic fish meal. With alternative lipids, the research is to ensure diets meet fish species' essential fatty acid (EFA) requirements and ensure that the final market product meets consumers' demand, particularly in terms of EPA and DHA levels.

"For health reasons, consumers want to see high levels of EPA/DHA, possibly as much as is present or more than in wild salmon. The health benefits of fish will decline as alternative ingredients, such as vegetable oils, replace fish oils in feeds. A strategy is finishing feeds to tailor fatty acid profiles such as the use of marine fish oil or algal oil. The amount and duration of feeding will depend on the species."

Lall emphasised, "The bottom line is that EPA and DHA requirements of several fish species particularly marine and salmonid fishes cannot be met by plant oils and genetically modified plant oils are also not acceptable in some countries."

Amino acid requirement and lysine as reference amino acid

Formulators should be looking at amino acid requirements, rather than crude protein. Lysine is often used as the reference amino acid for several species to get an estimate of requirement. Data for lysine is generally the most abundant among all essential amino acids and absorbed lysine is mainly used for protein synthesis contrary to other essential amino acids (EAA) which have other metabolic functions as well. "However, these estimated values do not replace data obtained in studies conducted on amino acid requirements. Our biggest challenge is to refine the amino acid requirement." In the absence of precise nutrient requirement data, application of meta-analysis of published data may provide estimates of amino acid requirement values for feed formulation.

Lall added, "Precise data on lysine requirement can help us apply the ideal protein concept in fish/shrimp nutrition, which we are still unable to solve." The ideal protein profile or amino acid ratio is the perfect ratio of EAAs and nitrogen required for maintenance and optimal growth. With a constant composition of the ideal protein, the requirements for all EAAs can be calculated when the nitrogen requirement (ideal protein-N) has been determined.

Benefits and limits of enzymes

There is a wide variation in the composition of feed ingredients and enzymes that help to improve digestibility as well as reduce effects of anti-nutritional factors (ANFs). Phytase is commercially successful with ANF, phytic acid. Advances in biotechnology have resulted in more effective enzymes to supplement the insufficient enzyme secretion of young fish such as amylase, protease etc. Cellulases hydrolyse plant storage polysaccharides such as cellulose to improve the availability of starch, lipid and proteins.

There are limits to the use of enzymes. Lall said, "Today, use of enzymes is limited by cost, method of delivery and species-specific application. Phytase, protease and xylanase have been promising with certain fish species such as tilapia. Certain blends of enzymes and digestibility enhancing additives may show synergistic effects on feed utilisation and growth."

Obviously, we have to look further at the excretion and efficiency of phosphorus use which is estimated as 31% for aquaculture as compared to 10 % for animal and 70% in plant production." – *Lall*

Minerals

When fish meal is taken out of the feed formulation, there is a need to focus more on mineral composition of diets. The range of magnesium in fish meal is 1.9- 2.6 (g/kg) but is only 0.4- 5.5g/kg in plant meals. The range for manganese is 6-23 mg/kg in fish meal but from 8-1,802 mg/kg in plant meals.

The phosphorus footprint and future availability are issues. In fish meal, phosphorus is available as phosphorus and in plant meal, mainly as phytic phosphorus. Notwithstanding, the source of phosphate, solid and soluble wastes have an impact on water quality and on the environment. "The target is to improve retention and reduce excretion. Furthermore, there is no substitutes for phosphorus and stocks are non-renewable.

"Aquafeed competes with agriculture in the global phosphorus supply chain where a shortage is predicted by 2030. Obviously, we have to look further at the excretion and efficiency of phosphorus use which is estimated as 31% for aquaculture as compared to 10 % for animal and 70% in plant production. However, the excretion of phosphorus is much higher due to their higher level in aquafeeds to meet the dietary requirement of fish."

Future directions

As industry moves into functional feed additives for fish performance, health and disease prevention, Lall suggested working with molecular biologists and immunologists to better understand the interactions of functional components in the feeds and physiological functions of fish. This is a complex area but is the key to better define the role of functional feeds in animal health and their future development". Caution should be exercised with new functional ingredients introduced as "immune modulators" to add value to feed. Extensive and rigorous research may be needed to validate the benefits of such ingredients to target fish and shrimp species."

Research directed to better understand the biological processes through gene expression, molecular interactions and the cellular environment using high-throughput techniques would improve our understanding of the immune system of major farmed fish species. Lall added, "In the future, metabolic integration will be a fundamental aspect of nutritional science. Genomics and metabolomic technology will be the driving force in aquatic nutrition science."

Visuals on enzyme activities

Exogenous feed enzymes are well accepted as feed additives in diets to overcome the negative effects of anti-nutritional factors as well as to improve the digestion of feed ingredients. Enzymes work in the presence of substrates and the right pH and time. **Dr Ninfa Rangel Pedersen**, science manager, Novozymes Denmark uses microscopy to visualise fibre structures in feed ingredients and enzyme activities. In her presentation on "Asian feed ingredients and how to improve their bioavailability for aquatic species," Pedersen, described the use of various microscopic methodologies to view cell walls and their breakdown with enzymes to release nutrients in both plant energy sources as well plant protein meals.

Compatibility of enzymes in aquatic animals

The gut transit time of shrimp is very fast, from less than 1 hour to 4 hours. The transit time also depends on the culture temperatures ranging from 28-32°C, or as low as 26°C during the colder season. The gut transit time of tilapia and catfish is typically 8-12 hours. Carps do not have stomachs and their gut is mostly active at neutral-alkaline pH, similar to the shrimp.

"In a wheat slurry incubated at 40°C, pH 5, with 100ppm Ronozyme®WX (monocomponent xylanase), we showed maximum solubilisation of xylan within 60 minutes of incubation. This implies that it will work in the shrimp gut at pH 4-8 and also within the shrimp gut transit time. We also demonstrated the stability of two batches of the enzyme at pH 3-12."

Cell wall degrading enzymes

With scanning electron microscopy (SEM), it can be seen how cell walls enclose starch, a non-structural carbohydrate (amylose and amylopectin). Cell walls are structural carbohydrates (fibre). With light microscopy and staining starch with iodine, it was clear that milling and digestion do not release all of the starch and protein in cereals. "If the cell wall is not broken during processing, then the cell wall will not be broken in the fish stomach due to the absence of endogenous cell wall degrading enzymes," said Pedersen.

> **"To apply relevant enzymes, first, it is important to know the chemical composition of cell walls." – *Pedersen***

Cell walls in cereals are complex structures comprising arabinoxylan, ß-glucan and cellulose. Using autofluorescence, the breakdown of arabinoxylan with xylanase is shown. The non-polysaccharide (NSP) content are much more complex in protein sources and they differ within the raw materials, such as xyloglucan, galactomannan and pectic polymers. The cell wall architecture also differs. "To apply relevant enzymes, first, it is important to know the chemical composition of cell walls and knowing cell wall architecture is an added plus."

"Monogastric fish species do not have endogenous enzymes to degrade cereal cell walls. The addition of microbial cell wall degrading enzyme/s can open up the cell wall cages and improve the nutritional quality of cereals and protein sources," added Pedersen. The microbial enzymes discussed are Ronozyme®Multigrain, containing xylanase and ß-glucanase/xyloglucanase produced by *Trichoderma reesei* and Ronozyme®WX, a xylanase produced by *Aspergillus oryzae*.

Microscopy to demonstrate enzyme hydrolysis

Optical and electron microscopy were applied to a range of plant proteins commonly used in Asia: rice bran, cassava meal, soybean meal, canola meal, copra meal and wheat, to visualise enzyme activities as well as fibre structures.

Deoiled rice bran and cassava meal

To visualise the effect of NSP enzymes on different fibre types in deoiled rice bran (DORB) and cassava meal, the immunofluorescence technique was used. First, there was treatment with enzyme and labelling of the remaining substrate after enzyme treatment. In DORB, cell walls are arabinoxylan and xyloglucan and their solubilisation with Ronozyme®MultiGrain is visible via specific staining technique. "Incubation with the multicomponent enzyme product at 400ppm for 1 hour showed the removal of arabinoxylan and xyloglucan," said Pedersen. "Cassava has two layers of cell walls (xyloglucans and pectins). Partial solubilisation of the xyloglucan was with Ronozyme®MultiGrain and subsequently of the pectin cell wall with a pectinase (Ronozyme® VP, containing ß-glucanase, hemicellulase and pectinase produced by *Aspergillus aculeatus*) to release starch.

Sunflower, canola and soybean

The degradation of full-fat soy and soybean meal (SBM) with a pectinase (for 1 and 3 hours) containing product was seen with fluorescent dyes. To release the protein, degradation of pectin components and mannan in SBM with a multicomponent enzyme product must take place. "Regardless of harsh procedures used for oil removal from protein rich oilseeds, not all of the cell walls were broken down, meaning that the protein is still encapsulated within the cell walls and not available to the animal," said Pedersen.

Canola and sunflower cell walls are different than that for soybean. "Using the same enzyme degradation process, cell walls for canola were still intact. A possible structure of canola (rapeseed) or sunflower cell wall is an outer xyloglucan layer and an inner pectin layer. The outer layer was degraded by Ronozyme® Multigrain and the inner layer by a pectinase product (Ronozyme®VP).

Copra and palm kernel meals

Using immunofluorescence, the breakdown of mannan in copra and palm kernel meals was observed. This required both Ronozyme®MultiGrain and Ronozyme®VP. The mannan hidden behind glycan cell wall structures was solubilised by Ronozyme®VP after removal of the cellulose layer by Ronozyme®MultiGrain.

Wheat bran

The prebiotic effect of the soluble arabinoxylan oligomers (AXOS) generated by Ronozyme®WX using wheat bran was evaluated in vitro using a caecal microbiota fermentation. The effect of the xylanase on the microbiota composition in vitro showed significantly ($P<0.05$) lowered genus levels of Bacteroides and significant ($P<0.05$) increases in genus *Faecalibacterium* and *Intestinimonas*, indicators of a healthy gut. Thus, the action of monocomponent GH11 xylanase to generate AXOS may have potential positive gut health implications when the enzyme is used as an additive in feed.

Phytase and protease

In the visualisation of phytic acid using transmission electron microscopy (TEM), it was shown that in soybean, the phytate globoids are inside the protein storage vacuoles. As such, Pedersen speculated that if protease could breakdown the protein vacuole, it will release more of the phytate from the vacuoles. Her

Wim van Lanen (centre) with Orapint Jintasataporn and Pornlerd Chanratchakool (right). Photo credit: DSM

take home message was, "We believe that phytase efficiency may be improved when used together with a protease."

Pedersen concluded, "Cereals and oil seeds have different cell wall structures, but difference also occur between them (e.g. soybean and rapeseed meals). It is important to have the right enzyme activity to match the substrates. Since substrates are also different, it is important to have a diverse portfolio of enzymes to solubilise them. The combination of amylases, proteases and phytases can further increase digestibility of energy, amino acids and minerals."

Towards efficient feed mill management

"As managers, do we know enough about our raw materials to understand and develop processing parameters for product quality and machine capacity?" asked **Wim van Lanen**, feed mill specialist, The Netherlands, as he began his presentation on "Efficient feed mill management and modern techniques in feed production."

Van Lanen has more than 30 years' experience in animal feed processing, including shrimp feed processing in Southeast Asia. He has made more than 250 feed plant and premix plant audits, for de-bottlenecking, capacity optimisation and investments. In his presentation, he discussed three issues: feed management-including management of raw materials, production efficiency, quality assurance and reduction of energy consumption; environmental issues, and modern techniques in feed production.

Effectiveness of feed mill

There are many definitions on what constitute an efficient feed mill management. "It is clear that often there is confusion and misunderstanding between production management and company management." He added that in general, the company management understands to a small extent, properties of raw materials, processing and plant efficiency or effectiveness. Overall equipment effectiveness (OEE), a term introduced by Seiichi Nakajima in the 1960s is defined as the evaluation of how effectively a manufacturing operation is utilised. "Still this simple system is poorly adopted," said van Lanen.

OEE equals availability x performance x quality. Availability is the real net production hours/total availability hours. Real, not production hours is the theoretical number of days x 24 hrs, excluding planned holidays, maintenance and production stops. Total availability is the total hours the plant is available for production minus unplanned maintenance, break downs, product changeovers and routine machine cleaning. This also indicates the reliability of the plant. Performance is defined as the percentage of good saleable or sold product/total product produced. "It is common for feed mills to be built for over capacity to meet seasonal and local demand."

"OEE monitoring system can be introduced to obtain standardised information regarding plant availability, performance and quality." – *van Lanen*

In his example, van Lanen explained that an OEE of 67% is quite normal when there is 90% availability, 80% performance and 93% quality. "Therefore, OEE monitoring system can be introduced to obtain standardised information regarding plant availability, performance and quality. The score of these three factors identifies the areas which need attention for improvements."

On how to improve OEE, he said, "Breakdowns during peak season are more likely and as such, availability can be improved by high level maintenance, optimising product change-over time, cleaning time and reducing unplanned stops. It is also a stricter control on production parameters and procedures and improving quality of operations."

The conclusion was for large companies to appoint a dedicated process engineer as a quality assurance officer, reporting to the operation manager to start or keep a continuous improvement program going. For small companies, he suggested the establishment of a project group to develop an action plan, analyse and undertake corrective actions. The group may comprise production managers, shift supervisors, maintenance managers and operators.

Energy is usually a major production cost, ranging from 25 to 50% of the total production cost. The main energy consumers in the production process are grinding, pelleting, extrusion, drying and cooling. In aquafeeds, more energy consumption/tonne is common due to the need for pellet durability. "In my years in feed milling, reducing energy in processing has been challenging. Potential energy savings can come with better attention to new drier technology which can save up to 50% in drying energy."

Feed plant environmental issues

Odour is a current challenge in feed mills and van Lanen discussed three odour systems: chemical scrubbers, bio filters and active oxygen (ozone). Effectiveness of the systems ranges from 70 to 95%. Plasma technology has the highest possible odour reduction efficiency and is the easiest to install and to maintain in good operation. Chemical scrubbers are difficult to keep in stable condition, and chemical consumption and the bleeding of water high in nitrogen are expensive processes. Bio-filters have a stable operation and can absorb large variations in air volume and odour load. However, they have a large footprint and therefore are only suitable when space is available.

Waste water from extruder feed plants poses some environmental issues, with risks of Salmonella when cleaning the extruder barrel and area. Waste water contains solids which are high in nitrogen. It is important to keep the feed plant as dry as possible to reduce risks from Salmonella contamination. Solids and sediment separations are recommended followed by water treatment using oxygen and microbial digestion. The quality of final effluent water will depend on local rules.

Modern techniques in feed production

Van Lanen introduced "precision processing" controlled by a qualified process engineer. The aim is to analyse all operational parameters and to establish "best practice" guidelines and procedures. This includes grinding to meet particle size distribution to specifications decided by nutritionists. Mixing and the time involved in the process should be established by monitoring homogeneity tests to reach a coefficient of variation below 5%. Pelleting and extrusion processes were not covered in detail as these subjects are so variable due to the wide range of raw materials, formulas, and feed types.

Reading the shrimp signals to avoid diseases

Well known in the global shrimp industry as a person dedicated to finding ways to manage shrimp farming well, **Dr Pornlerd Chanratchakool**, head of technical service-aquaculture at Novozymes, Thailand, presented on "Reading the shrimp signals, understanding causative factors and management." For farmers, the goal is a healthy pond and healthy shrimp. Pornlerd's approach is to have a strategic and integrated good aquaculture practice that manages disease risks of the shrimp in the culture system and associated environmental risks.

"Consequently, anaerobic and toxic conditions stress shrimp. This is the root cause of disease." – *Pornlerd*

Reminding the audience of the interactions between host, pathogen and environment (Snieszko, 1974), Pornlerd said, "The careful management of three factors are important to avoid disease: stable pond environment, healthy host (strong and robustness), and pathogens in the system and in shrimp. This is a balancing act to fit with culture system and stage of culture. If one or more of these factors are not well managed or balanced, disease and mortality will occur.

Water and soil quality

To obtain optimal and stable water quality requires an understanding of the relationship between the soil and water interface. A key factor is dissolved oxygen which should always be 4ppm or more. Illustrated by different scenarios of pond water with stable blooms or otherwise, Pornlerd commented on one frequent mistake farmers often make. This is disinfecting pond water to a very clean level and then adding fertiliser. "What is happening is that benthic algae are developing at the soil surface and will build up with fertilisation. Consequently, anaerobic and toxic conditions stress shrimp. This is the root cause of disease. Then at the later stage, with high nitrogen and phosphorus levels, a phytoplankton bloom will then occur at the pond surface, but oxygen is not going into the soil and the situation deteriorates with hydrogen sulphide at the pond bottom. Lower temperatures and rains stress shrimp further.

"Farms usually flush sludge into the central areas of ponds. Weaker shrimp tend to stay in these areas and die before or after moulting or if they survive, they often feed on 3-4-hours old feed and sludge laden with bacteria. "Such shrimp will have a black gut as compared to brown coloured gut for those fed on fresh feed. We can see that the Vibrio bacteria number in black gut material is three times higher than in the water at the pond bottom bringing about WFD," added Pornlerd.

How do shrimp get infected?

After each moult, the shrimp gets new and clean stomach walls but soon after, as feed, water, sludge and bacteria flow into the stomach, the inner surface of the stomach changes and bacteria colonise and damage the hepatopancreas. These were illustrated with a series of scanning electron microscopy (SEM) micrographs of the inner surface of the digestive system of farmed *Penaeus monodon* suspected of having an infection.

"In the case of WFD, there is no doubt that bacteria are part of the problem. Toxins from the bacteria damage the hepatopancreas. Infected shrimp show soft shell, shrunken hepatopancreas and loose body," said Pornlerd.

Vibrosis versus EMS/AHPND

The difference between vibriosis and early mortality syndrome/acute hepatopancreatic necrosis disease (EMS/AHPND) was explained in the following way. "Vibrosis is when the shrimp is infected with various Vibrio spp. other than *Vibrio parahaemolyticus* which specifically is implicated with EMS/AHPND causing mass mortality. With vibriosis, mortality can be prevented when waste material is removed to prevent toxic conditions." Pornlerd summarised some measures to avoid EMS/AHPND. Toxic conditions include low pH in ponds, salinity less than 6ppt, and inappropriate densities of filter feeders and zooplankton vectors. "It is critical to manage feeding well, increase microbial biota in the pond water and remove sludge promptly."

Pornlerd said, "Today, with EMS/AHPND, it is clear at low rates of infections of the bacteria or with lesser pathogenic strains, recovery is possible whereas it is impossible at higher doses or a virulent strain. However, in the last two years, there has been overnight mass mortality in Thailand, a pattern similar to EMS/AHPND but no AHPND strain has been detected. Mortality was avoided by removal of waste material."

Vilas Autade, DSM India (left) with participants from India. From second left, M V D Malleshwar, A V Subramanyam and A V Seshadri (Deepak NexGen foods & feeds Pvt Ltd); Rizwan Ahamad Basha (Godrej Agrovet Ltd), Devan Suresh (The Waterbase Ltd), Ramesh G (SAP India) and R. Sridhar Varma (Rudra Techno Feeds). Photo credit: DSM

There are many scenarios for mass shrimp mortality. "In the case of shrimp dying without any AHPND strains or toxins, the hepatopancreas was soft, reddish brown or sometimes pale in colour, but normal in size and soft-shell shrimp will die post-moult."

White spot disease

This disease is still everywhere since its appearance in 1993. In Thailand, farmers used to be cautious when stocking during the colder and rainy months (October-November) but today, WSSV is appearing at any time of the year. "Testing for infections in post larvae is the norm but fluctuations of temperature, salinity and pH can trigger an outbreak. Farmers overcome the disease by flushing and water exchange but unfortunately, they are spreading the virus. There is a need to treat waste water before discharge and cooperation between farmers is important so that when one farm discharges, another is not drawing in water from the same water source."

"A stocking plan to avoid low temperature farming (below 28°C) is one of the most effective ways to reduce risks," added Pornlerd. "If stocking is at this low temperature, there are two recommendations from Dr Chalor Limsuwan for WSSV risk prevention. The first is to culture post larvae at 32°C for 6-7 days before harvesting for stocking in grow-out ponds. Secondly, sampling of 150 post larvae for PCR analysis may not be an accurate sample to represent the health status of the post larvae population."

White faeces disease

There are many links for the white faeces disease or slow growth. These range from aggregated transformed microvilli (ATM), organic matter, *Enterocytozoon hepatopenaei* (EHP), antimicrobials, *Vibrios* and feed ingredients/nutrition. An epidemiological analysis by Dr Kallaya Sritunyalucksana, Biotec, Thailand (surveyed during April-November 2017) showed shrimp with ATM are mostly EHP positive and vice versa," said Pornlerd. "In infected ponds, stressed shrimp which did not die have high levels of EHP with white faeces disease. More on the prevention of white faeces disease through nutrition was discussed by Orapint Jintasataporn.

Management concepts to prevent infection

Pornlerd provided some recommendations, ranging from how to maintain stable pond water and soil conditions, manage and prevent toxic conditions to control and prevent pathogens in the system and in shrimp. He also focussed on feed management and illustrated a feeding table. "Farms usually use feeding tables but, in my opinion, in general feed increase should be 0.5kg/day per 100,000 shrimp. Often farmers attempt to feed more to get higher growth. However, the extra feed given does not translate to significantly faster growth. During TARS 2018, the participants recommended feeding 150-250g/m^3/day. However, I would recommend on this basis: for 20g shrimp, 2% body weight which works out to only 60g/day at 3kg/m^3 biomass.

Finally, Pornlerd said that the target is to have shrimp grow-out in ponds no longer than 50-60 days to avoid disease. To this end, nursery culture for shrimp sizes of 1-2g is recommended to cut culture duration. Furthermore, shrimp biomass at beyond 60 days is above pond carrying capacity.

His message was that farmers need to be together; they cannot stand alone.

Connecting white faeces disease with nutrition

Today, white faeces disease or WFD is a bane in shrimp farming in most of Southeast Asia, albeit with varying degrees of impact. The disease is detected only by white faecal strings floating on the surface of the shrimp pond, and affected shrimp show a whitish hind gut and loose carapace. As the disease is linked with reduced feed consumption and growth retardation, **Dr Orapint Jintasataporn**, associate professor, Kasetsart University, Thailand was at this conference to discuss "Understanding white faeces disease: Connections with feed nutrition and harmful pathogens."

Orapint started her presentation with the three factors associated with WFD outbreaks: shrimp health and disease; feed quantity and quality; and culture system and water quality management. Associated with WFD are thread-like gregarines, the *Nematopsis* spp, Vibrio spp, the microsporidian parasite *Enterocytozoon hepatopenaei* or EHP and aggregated transformed microvilli or ATMs. ATMs are live structures in the hepatopancreas.

Frequently, farmers have asked whether WFD occurs with EHP. Orapint clarified, "If the microsporidian is detected at over 10^4 cells per gram tissue then WFD will occur in 2-3 weeks and possibly followed by early mortality syndrome (EMS) caused by *Vibrio parahaemolyticus*. Microsporidian spores accumulate in the pond bottom soil. With ATMs, we saw them in the hepatopancreas of shrimp infected with WFD in 2012-2013. In 2015, we discovered that the spores can transfer between shrimp but with good water quality and good pond management, shrimp will still grow well. This explains the spread between ponds even though the ponds have been thoroughly cleaned up."

Shrimp health and disease

Some culture conditions encourage EHP and WFD. "Researchers have indicated that before stocking, if Vibrio levels are high at 10^3-10^4 CFU/mL in the post larvae and in the pond water, these are conditions for WFD to manifest in the crop within a few weeks. Therefore, it is important to control post larvae health and pond conditions during culture periods, i.e. maintain healthy pond bottom soil, water and shrimp."

Orapint gave her take on how to control EHP. "Looking at the life cycle of the microsporidian, pH greater than 8-9 will induce hatching of spores. The idea is to allow the spores to hatch and remove as many as possible by flushing with water. Ponds can be cleaned up at pH 9-10 with reduced EHP density."

Feed quantity and quality

With WFD, the floating white faecal strings are high in lipids and undigested material, most probably due to a combination of factors ranging from feed consumption, feed quality, anti-nutritional factors (ANFs) to climate changes. "Microsporidian cannot synthesise energy (ATP) by themselves, so this is taken from the shrimp. Infection sets in when shrimp are in a stressful state, and when they consume less and cannot get enough energy from the feed. With disease infection, there is a decrease of copper in the haemolymph." To illustrate this, Orapint showed how stress arising from infection with yellow head virus over 72 hours, reduced copper concentration in the haemolymph by 32% as compared to only 11% when the infection is only 8 hours.

"Within the shrimp, the chronic effect of stress reduces cell membrane integrity and causes intestinal inflammation. This results in a decrease in the mucus layer and poor tight junction protection which in turn allows pathogens and chemicals to pass through (called leaky gut). As the animal utilises more energy but reduces feed consumption, protein synthesis is poor and protein degradation increases. There is sloughing of the epithelial cells, increase in the number of abnormal cells, cell death and immune suppression. However, high levels of ammonia, nitrite and hydrogen sulphide also reduce tight junction protection."

Over the years with rising cost of fish meal and lower supply, there is a reduction in its inclusion in shrimp feeds, from 30% to only 7% in some instances. Fish meal is being replaced by animal and plant protein meals, but these raise the issues of poor digestibility and ANFs in some shrimp. "It is not clear whether WFD is caused by poor digestibility of some ingredients coupled with poor shrimp health or vice versa. Nevertheless, we need to improve the digestibility of such raw materials for better shrimp health. Protein digestibility of poultry by product in *Penaeus monodon* and *P. vannamei* was 77.6% and 84.22% respectively. We need to seek good replacements for fish meal," said Orapint.

It is important to avoid oxidation of dietary lipids in feeds. Different feeds have different feed composition and following the feeding tables supplied by feed millers is always recommended. However, to improve shrimp health and reduce stress, Orapint proposed that with WFD or other disease, farmers should change and feed their shrimp with a more nutrient dense feed (such as from 32% protein to a 40% protein feed), with added attractants. "The shrimp may still consume less but will get more protein. During moulting, shrimp will need more energy from starch and cooked starch is 30% more digestible. At all times, controlling water quality, and not only dissolved oxygen is important."

Prevention of cell inflammation is important in shrimp, as with livestock. Zinc and herbal extracts of alkaloids can limit NF-kB signaling (which regulates inflammation and immune responses, cell growth and survival, and the expression of certain viral genes) and stop pro-inflammatory gene expression. Biological antioxidants such as astaxanthin quench free radicals, preventing activation of NB-kB and leave inflammatory genes inactive.

Orapint summarised that best practices are a combination of physiological, biological and nutritional factors. "Initially we should focus on specific pathogen free (SPF) or disease-free post larvae and well-prepared ponds. During grow-out, reduce organic matter in the pond to promote shrimp immunity and health. Additionally, in feed, lipid digestibility can be improved with emulsifiers, bioavailability of phosphorus with phytase, and digestion of fibre and an increase in energy levels with a cocktail of carbohydrase enzymes. Garlic extracts, essential oils, eucalyptus, cinnamon oil and turmeric can control pathogens and act as antioxidant for epithelial cells."

"Infection sets in when in a stressful state, shrimp consumes less and cannot get enough energy from the feed." – *Orapint*

Photo credit: DSM

Marine shrimp in Asia: Disruption with lower prices in 2018

While farmers were living with diseases, low survival rates and increasing production costs, disruption came in the form of lower ex-farm prices since April 2018.

PT Delta Marine Indonesia's farm on Sumbawa Island. Photo credit: Rizky Darmawan

New ponds at Mayank Aquaculture, Gujarat ,India Photo credit: Manoj Sharma

The long period of high global shrimp prices that began in 2014, ended in mid-April 2018, when ex-farm prices started dropping. As farmers saw margins going down, responses varied from: delay in stocking and wait for better prices, grow shrimp to large sizes for higher prices, cut back on stocking ponds, and market locally with better prices. For several years, farmers lived with diseases as high shrimp prices compensated for reduced survival rates and higher costs of production.

White faeces disease (WFD) was already a large problem in Thailand but by 2018, it was compounded with the emergence of white spot syndrome virus (WSSV). Dr Loc Tran, ShrimpVet Laboratory Vietnam described the situation in his country, "In the third quarter of 2018 when ex-farm prices in Vietnam was already low (VND110,000/kg or USD4.74/kg for size 60/kg) coupled with inclement weather conditions, we saw low success rates in farms. Just as we thought that ex-farm prices were trending upwards, there was a massive WSSV outbreak which wiped out crops."

The shrimp production estimates for 2018, provided by various sectors of industry, vary greatly (Table 1). Production in China increased by 10% from that in 2017 and was calculated from feed volumes (1.3 million tonnes) and post larvae consumption. Thailand's production decreased in response to low prices. Production in Vietnam grew 10-15%. With regards to vannamei shrimp production in the Philippines, the figure shown is an estimate from industry. The official figure (total 52,057 tonnes from the Philippines Statistical Bureau) was mainly monodon shrimp (76%).

"Year 2018 could be viewed as a tough year for our shrimp industry. The sluggish domestic and international economy has caused a huge blow to shrimp prices, which hampered the enthusiasm to farm. It is difficult to have exciting news about the production of farmed shrimp in 2018," said Jeff Jie-Cheng Chuang, Sheng Long Bio-Tech International, Vietnam.

2018 shrimp demand, supply, prices and margins

For the first time since 2014, supply has significantly exceeded demand. The two notable countries contributing to this supply increase have been India and Ecuador. India hailed 2017 to be the best year ever for the country, crossing the 600,000 tonnes level, but in the second quarter of 2018, Indian farmers were reluctant to stock due to poor ex-farm prices. Ecuador is expected to finish 2018 with close to 400,000 tonnes, an increase of approximately 7% compared to the previous year.

However, demand in the traditional markets (EU, USA and Japan) has remained relatively stagnant. The China market has been growing year on year, pulling in more imports as local production decreased due to disease outbreaks and increase in land cost challenging aquaculture for land use. While most Asian producers have been steadily developing exports into China, 2018 saw significant exports from Ecuador; approximately 60% of Ecuador's production was exported to China. Towards the last quarter in 2018, the high buying season in preparation for the lunar New Year, the Chinese market seemed saturated with *vannamei* shrimp. It is interesting to note that while India and Ecuador are traditional exporters of large size shrimp (16-20/kg and 20-30/kg), China prefers sizes of 50-60/kg and 60-70/kg.

"Year 2018 could be viewed as a tough year for our shrimp industry. – *Chuang*

Jeff Jie-Cheng Chuang (right) with Kenneth Tay, Shrimp Improvement Systems, Singapore at Aqua India 2018, held in Chennai in February.

"IMNV is causing mortality at earlier days of culture (DOC) and showing a faster mortality pattern." – *Anwar*

U Win Latt (second right) with Dr Nyan Taw (second left), Steve Arce (left) and Jerry Jianguo Shi (right), Kona Bay, USA, at the 8th International Conference of Aquaculture Indonesia (ICAI 2018), Jogkarta, Indonesia, in October 2018.

Consequently, prices dropped in 2018. The end of 2017 saw a carryover of shrimp in the pipeline and prices started to ease from February onwards. This was made worse with lower offer prices for Indian shrimp in the second quarter of 2018. Then, eventual pull back from stocking in India helped prices from sliding further and prices started to improve in August, by which time prices had fallen by 20% compared to the beginning of the year. The year ended with a minor increase in prices, but downward pressure is mounting.

The current weak prices are impacting farmers more than before. The last time ex-farm prices were this low was prior to the occurrence of early mortality syndrome (EMS), but since then the average survival rates have decreased from 80% to 50%. It has increased production costs by at least 40% and this is before counting the failed crops and emergency harvests. Margins have been severely affected and farmers need to decide if it is worthwhile continuing to stock at this rate.

Coping with diseases

During TARS 2018, Anwar Hasan, Biomin, listed diseases occurring in Asia in 2018. WSSV, WFD and *Enterocytozoon hepatopenaei* (EHP) are common in many parts of Asia. The early mortality syndrome/acute hepatopancreatic disease (EMS/AHPND) is present in farms in China, Malaysia, Philippines, Thailand and Vietnam but the impact is now less. Co-infections with two or more pathogens are frequently seen in most countries. Farms in India have reported mortalities from running mortality disease (RMS).

Unique to China is the latest disease, shrimp haemocyte iridescent virus (SHIV), in addition to covert mortality nodavirus (CMNV). However, in terms of impact to the industry in 2018, the highest came with WFD and WSSV as compared to CMNV, EMS and EHP. The lowest was with SHIV and infectious myonecrosis virus (IMNV).

In December, in a presentation at the Aquaculture Asia 2018 Conference, Thailand, Ravi Yellanki, Vaisakhi Bioresources said that WSSV is the single largest contributor to crop failures in India and the industry has never seen this kind of widespread outbreaks throughout the country as in 2018. There was no respite and continuous stocking was not possible. Similarly, in Thailand, farmers used to be cautious when stocking during the colder and rainy months (October-November) but in 2018, WSSV began appearing at any time of the year (Chanratchakool, 2018, page 45).

Indonesia's industry continued to face IMNV, which according to Anwar became more virulent in 2018, causing mortality at earlier days of culture (DOC) and showing a faster mortality pattern. IMNV has spread to new areas. WFD also lowered production. In general, the main diseases in Malaysian farms are EMS, EHP and WSSV as well as co-infections. In 2018, WFD disrupted production more than EMS and WSSV.

In Vietnam, the most damage came with WFD in 2018 followed by WSSV and EMS while the least damaging was EHP. Loc Tran noted, "Even if HDPE ponds have been thoroughly cleaned, EHP can be the most damaging disease with rainwater runoffs entering ponds and exacerbating its impact. The impact of each disease is seasonal."

Country	Vannamei shrimp	Monodon shrimp
China	700,000	100,000-150,000
India	590,000-630,000	20,000-40,000
Indonesia	280,000-310,000	35,000-45,000
Vietnam	420,000-580,000	100,000-170,000
Thailand*	290,000	9,477-11,847
Philippines	65,000	7,000
Malaysia	40,000	8,000
Bangladesh		35,000
*Monodon shrimp production according to estimates by the Thai Shrimp Association (2018)		

Table 1: The range in estimates by industry on production in tonnes in 2018

Vannamei shrimp harvest at the Aderma Farm in the Philippines. The harvest sizes range from 13g to 40g. Photo credit: Christopher Adrian Domingo Anglo.

Maria Abegail A. Albaladejo (centre right) with Dr Grace Chu-Fang Lo, National Cheng Kung, University Taiwan (centre right), Mary Anne C Solis, Biosolutions International (left) and Roselyn C Usero, Negros Prawn Cooperative, Philippines (right) at TARS 2018 held in Thailand in August.

Managing culture with diseases

In general, farms focus on managing water quality and trigger factors to decide on the next action to prevent diseases. Indonesian farms used probiotics, reduced plankton density and dissolved oxygen fluctuations, and increased aeration. Indian farms used organic products from turmeric powder to garlic pastes against WFD and EHP. Functional feeds are popular in Vietnam and China.

In Vietnam, those with finances tried new farming models and invested in modern facilities and equipment to improve shrimp immunity and reduce stress with pond liners, treatment ponds, and redesigning inlets and outlets. Chuang said, "What we are seeing now is science-based farming. Previously, farmers used to check water colour based on experience without measuring any water quality parameters. Nationwide, we have set up laboratories to help small-scale farmers with water quality data, which indicate what is correct for stocking. This helps them to apply the right treatments before stocking."

In Vietnam, there was a rapid adoption of digital monitoring of water, and artificial intelligence (AI) in farming. This real-time monitoring and using historical data enabled predictions of temperature changes, salinity, dissolved oxygen and feeding rates. The result has been less human error and better control of production.

Dr Manoj Sharma, Mayank Aquaculture noted that in India, the expansion of shrimp farming since 2014 to 2016 has created an imbalance in the carrying capacities of creeks and other sources of water channelled into farms. There is overcrowding with new ponds facilitating rapid transfer of disease. "We installed double settlement ponds and double reservoir systems for water intake and use clean water. Farms also reduce stocking density and implemented pond rotation."

Reducing stocking density, from 70PL/m^2 to 40PL/m^2 in South China and using good quality post larvae were common practices in 2018. Often this included good water exchange and using probiotics regularly, mixed into feeds. Thailand's farmers have increased the use of liners and auto feeders. Encouraged by the Thai Department of Fisheries, more probiotics were used. Farms adopted the 3Cs (clean post larvae, clean water, and clean pond bottom) concept introduced by Chareon Pokphand Foods (CPF) a few years ago. "Some opted to stock at a lower density and others waited for better conditions, which may mean that the cycle is reduced from 3 to 2 per year," noted Dr Jarin Sawanboonchun, Ridley Corporation (Thailand).

"We faced disease outbreaks in 2018, with more than 25 ponds affected. We then strengthened our biosecurity efforts, asked hatcheries to send post larvae to independent laboratories and established our own in-house laboratory to check on *Vibrio* spp on a weekly basis," said Zainah Zaid, Zaiyadal Aquaculture in Malaysia. A common protocol in Malaysia is to have early detection and just flush out when pathogens are detected. Hatcheries also help with better terms such as a two-week trial and non-payment if an outbreak occurs. This has encouraged continuous stocking.

In the Philippines, there has been a strict implementation of biosecurity, which also included structures such as installation of a central drain, nursery ponds or tanks. "Health screening was introduced to the grow-out farms too. There is also the development of a new pond side water quality monitoring kit, which is locally produced and easily available. This kit is much cheaper than imported ones," said Maria Abegail A. Albaladejo, Bureau of Fisheries and Aquatic Resources (BFAR).

An interesting development in Malaysia was the use of large size (CPF's Super PL) post larvae (PL25-26) sold at higher prices (MYR0.046/PL). Farmers claimed an average weekly growth of 7-9g before harvest. "The advantage of stocking this post larvae saves a month in the culture period and also in operational costs," said Karunanithi Mathusami at Golden Spring, a new farm in Perak, Malaysia.

Managing rising costs of production

In China, local prices are the highest in the region. Therefore, cost of production is not a problem at all, said an industry source based in China. In the Philippines, farmers monitor international prices and if these are too low, they opt to sell locally where prices are higher. The trend has started in Thailand to bypass the broker or middleman. Farmers use social media to market directly to consumers and sell shrimp at shopping centres and offices. In this way, they gain extra in the selling prices. At the same time, farms grow shrimp to larger sizes to secure higher prices.

An option is to cut back on the use of ponds. In Malaysia, by stocking only 40-50% of ponds, farmers reduce risks and can focus more on technical improvements. To them, risks are higher with more ponds. Shrimp farmers associations in Gujarat, India also advised farmers to operate 50% ponds in some areas to avoid losses due to repeated disease outbreaks

In Indonesia farms reduced feed costs. "This is the new normal. Farmers use low crude protein feed (<30% CP) but they ensure that the feed conversion ratio is less than 1.2 for the 3 months culture period by using auto feeders. Farmers use our 26% CP feed for moderate intensive stocking (100 – 130PL/m^2) and for moderate average daily growth (ADG) and FCR from 1.2 to 1.4. Costs are lower for the farmer as our 26% CP feed is sold at USD0.75/kg," said Haris Muhtadi, CJ Feed Jombang.

New farming models

Farmers in Vietnam are focused on learning and applying new farming techniques and models, "Widely applied are liners, high density stocking and a 3 stage farming. The advantages are increased harvests, improved output, and better disease control. However, disadvantages are heavy investments, high production costs and repeated water exchanges which will adversely affect the environment," said Chuang. Similarly, in Indonesia, there is the practice of growing shrimp in small circular tanks at high density and the change in pond designs to small ponds with maximum sizes of 2,500 m^2.

Somthida Pakdeepak (bottom, left) Ao Kho farm in Thailand and other young farmers on social media selling shrimp

Cooked monodon shrimp in Malaysia. Picture credit: Catherine Lee.

In Thailand, as was detailed in an article on the Thai shrimp model (issue November/December 2018), farmers have learnt to adjust stocking density to fit into the system they developed based on their experience and capability. Farms focused on stocking fast growing post larvae and interestingly, some farms do not use paddlewheels and have changed to using bubble jets and protein skimmers. According to Robins McIntosh, CPF, the ADG of such shrimp will depend on the environment, under best conditions, its genetic potential can reach an average growth rate of 0.8-0.9g/day but in the pond environment, 0.3-0.4g/day is common.

More or less shrimp in 2019?

There are mixed views on projections for production in 2019. Manoj expects 15% less production, as many farmers plan to adopt low stocking density. Farms in Gujarat, which contributes 10% to the national shrimp production, may produce only 40,000 tonnes compared to 55,000 tonnes in 2018. Production will be mainly of size 50-60/kg. The overall production may also decrease as in addition to WSSV, white gut disease will be a major problem for farmers in Andhra Pradesh. However, there is a possibility that the current production of vannamei shrimp may remain or even increase by 10% because of the expansion in production areas in East and West Godavari in Andhra Pradesh state.

Albaladejo expects production to increase in the Philippines when extensive farms, carrying out polyculture move to semi-intensive farming. BFAR has the Moreso program where the private sector and government conduct training on Good Aquaculture Practices (GAqP) to encourage traditional farmers to increase productivity. BFAR is also establishing shrimp schools to train stakeholders and produce skilled technicians for the industry. There are also more investments in shrimp farming in Mindanao. However, many natural calamities affecting the Philippines remain a threat to its industry.

Despite the challenge with IMNV, which some farmers are able to handle. production in Indonesia will rise by 8-10%, according to Haris and Anwar, as there are new farms under construction in Sulawesi, Bengkulu, West Java, Lombok, Sumbawa.

"With farms running out of cash with poor prices early in 2018, some have not begun stocking." – *Loc Tran*

More monodon shrimp

Lured by demand from processing plants and higher prices, farming is moving to the monodon shrimp in Malaysia. Stocking density of the monodon shrimp ranges from 30-40PL/m^2 but be higher at 50PL/m^2 with the SPF strain. An example is Zaiyadal Aquaculture, which will stop farming vannamei shrimp and move to only monodon shrimp in 2019.

The prediction is that monodon shrimp production will increase in Thailand and in Malaysia in 2019. However, in the future, Catherine Lee, Wynntech Star, cautioned, "We can expect monodon shrimp production to either increase or remain unchanged in 2019. In 2018, production answered the demand by processing plants creating an export market. In 2019, two to three processing plants will come up in Malaysia and thus may create more competition for the monodon shrimp supply."

A vannamei shrimp conundrum in 2019: to farm or not to farm

In 2019, as farmers plan to reduce stocking density to 60-80PL/m^2, uncertainties abound. Although various factors influence the decision to farm or not to farm, ex-farm price is the deciding factor, which many do not expect to rise. This is the conundrum faced by small and medium scale farms. Supply is not expected to ease and may in fact increase with supply from Latin American producers as well as emerging producers such as Myanmar (see box).

The current negativity in the industry was expressed in Vietnam where industry expects no change in the production of the vannamei shrimp and less of the monodon shrimp. "With farms running out of cash with poor prices early in 2018, some have not begun stocking. Usually stocking would have started early to be ready for the Vietnamese lunar new year or Tet holidays. Of course, the recent tropical storms also deterred stocking of ponds," said Loc Tran.

Chuang gave his take on the industry in Vietnam, "In recent years, shrimp farming techniques have significantly developed in Vietnam which led to the increase in farming success. However, the global economic downturn is forecasted to continue in 2019. We expect that low ex-farm prices, would be the most important determining factor. If there is no severe economic fluctuation, shrimp production in 2019 is estimated to remain as in 2018 and even show a slight decline. Vannamei shrimp may maintain a relatively stable output while the ex-farm price of monodon shrimp has dropped sharply, compared with that at the beginning of 2018. Farmers' enthusiasm for monodon farming will surely be lost."

In China, industry expects lower production in 2019 and future years with environmental regulations being imposed on farms. "Most likely, we will shift production to other countries such as Vietnam, India and Indonesia," said an industry stakeholder. In fact, this has begun in December as China's Xinghe group has acquired a leading shrimp farm (see page 6) in Malaysia. However, notwithstanding major disease outbreaks, production volumes may be sustained with the interest in intensive indoor farming of the vannamei shrimp.

Producers in Thailand expect production of the vannamei shrimp to be 10% lower, a consequence of the low prices and disease outbreaks. Farmers have been looking for better business opportunities to replace the vannamei shrimp. The monodon shrimp is a good choice with much higher ex-farm prices.

Acknowledgments: We thank all mentioned in this review as well as others who have willingly assisted with information but wished to remain anonymous. This review would not have been possible without their participation.

Broodstock, hatchery and nursery

The vannamei post larvae market is very large in China at 300 billion annually for an estimated 700,000 tonnes shrimp production. This means a post larvae efficiency (tonnes/million PL) of only 2.3. In contrast, Thailand's efficiency reached 21 in 2017 (McIntosh, 2018) and India was 10.4 in 2017 (Ravikumar, 2018). Vietnam produced 110 billion vannamei shrimp post larvae PL in 2018, and Chen Ho Van, Inve Aquaculture calculated that PL efficiency was 5.27 only.

Chen also noted changes in the hatchery business in Vietnam. "The change is not significant with post larvae quality. The price variation between smaller hatcheries, selling post larvae (PL10-12) at VND 20-22/PL and medium size hatcheries selling VND 35-45/PL continued. The large groups sold PL10-16 at VND100-120/PL. Promotions with offers of buy one get one free or 10-30% free post larvae continued as the demand for post larvae has been affected by the changes in stocking density. Depending on the season, demand for post larvae has declined by 5-10%." (Note: 2018 exchange rate was VND23,197 to 1 USD).

"With this uncertainty in the business, medium-size hatcheries decreased their post larvae supply by 50%. We also saw many smaller hatcheries closing or being taken over by the larger hatchery groups such as Viet Uc and Nam Mien Trung."

F2 and SPR broodstocks

In the last couple of years, disheartened shrimp farmers in China have faulted post larvae quality as a cause for industry woes. Major hatcheries in China realise that the combination of good quality post larvae and good quality larvae feed are dramatically helping farmers achieve better harvest results. But some focused on just good broodstocks to achieve the same results.

Today, according to an industry source, the trend in farming is split in two directions: farm at high cost, high yield, efficiently with fast growing post larvae in expensive indoor systems or compromising growth rate with low price post larvae in earthen ponds. "In the first direction, farms will require not only specific pathogen free (SPF) broodstock but those that are highly resistant to the high stocking density (such as 1,000 PL/m^3). Otherwise the farm will not be able to get back its return on investment. Such post larvae cost more than CNY300/10,000PL (USD44.31) as compared to CNY100/10,000PL (USD14.7) for those to be stocked at low density in earthen ponds."

"Most nurseries grow the shrimp to 100-300mg although farmers love larger sizes ." – *Anil Ghanekar*

Traditional farms are looking at post larvae resistant to diseases; they prefer using post larvae from locally reared second generation imported broodstocks or specific pathogen resistant (SPR) broodstocks. The trend is moving toward SPR broodstocks. This wish to have disease resistant broodstocks was echoed by Chen in Vietnam.

Nursery phase

The three phase vannamei shrimp farming which includes either an on-site or off-site nursery, is common in Latin America, but not homogenous in Asia. "The addition of a nursery-phase and the use of probiotics have led to better control of production in Vietnam when housed in greenhouse type enclosures," said Loc Tran. Chen added that there were 30% more nurseries in 2018 as compared to 2017. However, many are within farms, using available small ponds and tanks. They produce PL20-25.

In Indonesia, Manuel Poulain, Inve Aquaculture said, "The interest in a nursery phase is building up. IMNV and WSSV continue to affect farms. Many farms find maintaining crops after DOC60-70 risky. In Indonesia, intensive farming practices are preferred, I believe that the removal of this last 30 days in the grow-out and replacing it with a nursery month upfront is a good step."

Anil Ghanekar, Ecosecure Systems, India developed a stand-alone closed system nursery away from both the hatchery and grow-out farms in Andhra Pradesh, India. "Many nurseries have been set up all over India and which are biosecure and well managed. Most nurseries grow the shrimp to 100-300mg although farmers love larger sizes. However, many nurseries still have issues with pathogens and survival rates." Anil still believes that with the many crop failures with EHP, white gut disease and others, on site nurseries may not be useful.

Delivery of post larvae at Ao Kho Farm, Thailand. Photo credit: Somthida Pakdeepak.

Insight into the potential in Myanmar

Long regarded as the next frontier in marine shrimp farming, little is known of the in-situ developments.

An intensive farm in Myeik in the Tanintharyi region, Photo credit: MSA

In 2016, FAO reported a production of almost 54,200 tonnes of the monodon shrimp from Myanmar. However, a more realistic figure presented by Myanmar Shrimp Association (MSA) was 33,200 tonnes comprising 3,200 tonnes of vannamei shrimp and 30,000 tonnes of monodon shrimp, according to the Solidaridad Network.

Most of the production was from Rakhine state with 44,487ha of shrimp farming areas in 2018 (DoF, 2018). These comprised mainly extensive (66%), extensive plus (34%) and a negligible semi-intensive farming area. Other shrimp farming regions are Ayeyarwaddy, Tanintharyi and Yangon with a total of 34,183ha but mainly extensive farming (33,981ha).

"The extensive (traditional trap and hold) farming uses wild post larvae which are in short supply recently," said U Win Latt, shrimp consultant, Myanmar. Extensive plus farming usually uses hatchery reared post larvae, with some feeding at the later stage of the farming. Win Latt added that the actual farming area could be only 50% because of insufficient supply of post larvae, according to farming industry feedbacks, figures and information from field visits.

Changes in culture practices

Recently, there has been some significant changes in the industry. "In intensive vannamei shrimp farming, ponds are lined with HDPE liners. We still need to improve pond designs. A dilemma is that often vannamei hatchery operations start and stop. Probiotics are used especially when the culture density is high such as in farms in the Tanintharyi region. In terms of cost of production, most inputs are imported, and thus effective feeding management is one way to reduce cost."

WSSV is the main pathogen affecting traditional farms culturing the monodon shrimp and intensive vannamei shrimp farms. Other diseases are vibriosis and black gill. "Imports of post larvae from neighbouring countries posed a direct threat to biosecurity in farms as well as to adjacent aquatic natural environments. This is because we have limited capabilities in quarantine and inspections." On managing diseases, Win Latt said that usually farmers adopt practices from other countries. "In 2012, through the Marine Fisheries Federation (MFF), I introduced management with polyculture, but this was then adopted mainly by carp and freshwater prawn farms."

Post larvae supply

The bottleneck is post larvae supply; monodon shrimp hatcheries are dependent on wild broodstock. A need is quality post larvae as well as better transportation. Nearly 100% of vannamei post larvae are imported from neighbouring countries. There was a proposal to set up a hatchery using broodstock from the US in 2017. A reliable supply of locally-produced high quality post larvae from SPF broodstock would be essential for the industry to grow and MSA's Kyaw Tun Myint, envisaged that the vannamei shrimp will replace the monodon shrimp, as it is best suited to modern farming methods.

"The European Union's MYSAP (Myanmar Sustainable Aquaculture Program) project include hatchery production for fish and shrimp but the project's target species does not include the vannamei shrimp." said Win Latt in giving his insight into expected production volumes in 2019. "In monodon shrimp production, I expect 10% less due to declining supply of wild post larvae in northern Rakhine state. Although the supply of wild monodon post larvae is less, the traditional shrimp farming area in the Ayeyarwady region is expanding. For the vannamei shrimp, a 15-20% increase in production is likely due to the expansion of intensive ponds in Ayeyarwaddy and Tanintharyi regions."

Beyond 2019

Shrimp farming and the rest of aquaculture in Myanmar are gearing up for further development. International, intergovernmental organisations, governments, international NGOs and institutions are supporting Myanmar's aquaculture and fisheries sector with various small scale and rural projects. The €22 million MYSAP being implemented by GIZ is by far the largest 5-year aquaculture project in collaboration with DoF. It started in 2017.

In early 2018, MFF initiated a plan to increase farming area and production especially for intensive vannamei farming together with aquaculture training facility for both shrimp and fish culture in Yangon region.

A main obstacle is financing for the industry. Aquaculture financing is not easily available. Effective and secure mechanisms as well as adequate loan facilities are currently lacking. Certain farms have been successful in securing loans from private commercial banks to facilitate expansion. A semi-government fisheries development bank was re-established as a commercial bank with continued loan facilities to the fisheries and aquaculture sector. However, its capacity is limited in both resources and management.

Win Latt cautioned, "Further development in marine shrimp farming must be undertaken carefully and with proper considerations; adequate planning, proper and effective education, stakeholder participation, and a balanced institutional setting and infrastructure support must be in place.

"Quality post larvae supply is not the only solution to improve production especially for extensive farming areas; biosecurity, proper knowledge and education must also be emphasised. Once there is an abundant post larvae supply, traditional farms will be gradually converted into semi-intensive ones with higher stocking density. We need effective education, good governance and stakeholder participation to be in line with development pace to have a sustainable shrimp farming industry."

"A need is quality post larvae as well as better transportation." – *Win Latt*

Picture credit: John Benedict Bernando

Using brine to deep freeze shrimp

By Herve Lucien-Brun

A system to deep freeze shrimp for a product with excellent texture to meet the quality demands of high-end niche markets.

Part 1: The science of freezing shrimp with brine

Post-harvest, shrimp are prone to biochemical reactions catalysed by enzymes (oxidation, proteolysis, lipolysis), leading to deterioration. This alteration of food is also due to the action of microorganisms. Thus, before any preservation process is carried out, microbial contamination can be prevented simply with good hygiene. Appropriate preservation techniques keep shrimp fresh regardless of place and season.

Low temperatures can slow down or inhibit food alteration by microorganisms and biochemical reactions. Refrigeration is the process of lowering the product temperatures close to the temperature of melting ice. This slows down the development of microorganism and biological processes, however, without stopping them entirely. During freezing, the water in the shrimp solidifies to ice. Below -18°C all microorganisms and biochemical changes are arrested and the shelf life of frozen products changes from several months to more than one year.

The quality of the product depends on the speed of lowering the temperature of the product to any point below -18°C and on the crystallisation of all the water in the shrimp. In general, freezing is a preservation technique which, when done well, preserves the original qualities of the food with maximum freshness.

However, the freezing process can also induce problems related to the expansion of water as it changes from a liquid to a solid state. The breakage of cell walls will release intracellular fluid during thawing. The exudation of intracellular fluid easily damages cell walls, depending on the size of the ice crystals in the cells. During slow freezing, there is progressive development of extracellular ice crystals which causes the cells to be emptied by osmosis, thus causing significant damage. On the contrary, during rapid freezing, small intracellular and extracellular crystals are formed with minimal damage.

There are three main techniques used to freeze shrimp. In air blast freezing, the cold fluid is the air circulating between an evaporator (where the temperature of the air is lowered) and the shelves with blocks of shrimp. The spiral freezers use the same principle with the freezing airflow. Contact plate freezer is where the cold fluid circulates in the plates and freeze them. This system needs a contact between the box and the plates. Brine freezing technology is discussed in detail in this article. Other techniques include cryogenics with liquid nitrogen and impingement freezers which is very efficient for IQF (Individual Quick Freezing) but not for boxes.

Table 1 shows the different types of refrigeration and freezing processes, and their main applications. It also shows the maximum values of heat transfer coefficients achieved in practice for comparing the performance of each of the technologies.

The heat transfer coefficients of water or aqueous solutions are 10 to 50 times higher than that of air and may reach up to 900W/m² °K. In terms of processing speed, these solutions have interesting characteristics. Immersion of the products to be frozen in aqueous solutions is one of the fastest cooling techniques but is currently.

Process	Refrigération (T > 0 °c)	Freezing (T > 0 °c)	Heat transfer coefficients (W/(m2K))
By air (blast freezer,...)	Fruits, vegetables, carcasses of meat, seafood,...	All products	20 to 50 (air blast tunnel) 60 (fluidised bed freezing)
Immersion (water or aqueous solution)	Poultry, fruits and vegetables, fish and crustaceans,...	Fish, crustaceans,...	900
Cryogenics (liquid nitrogene or carbone dioxyde ...)		Flash freezing, crusting products	100
By contact	Liquid products (milk, etc.), fish (flake ice)	Milk, fruit juice, Fish fillets, vegetable purees	100

Table 1: Application and performance of different methods for chilling and freezing.

Brine freezing

Brine freezing, with its high heat transfer coefficient, also requires much less energy than traditional methods. Immersion in chilled brine (aqueous solution), is commonly used by industrial cookers to chill shrimp after cooking them. For several years, brine freezing is common in packing plants in Mexico and widely used to deep-freeze farmed shrimp, or to temporarily freeze shrimp before processing into value-added products.

Since freezing in brine is very rapid, the crystals formed in the tissues are very small, causing very little rupture to cell membranes. Therefore, there is very little liquid left after defrosting and the loss of water is substantially less than that observed with the more traditional techniques such as air blast tunnel or contact plates freezer. The penetration of the salt in the superficial flesh (almost 2.5g/kg shrimp) allows for a better cooking yield compared to the other freezing techniques.

More importantly, the shrimp texture remains very similar to that of fresh shrimp. Texture is a critical taste criterion. This is the reason why brine freezing is valued by buyers in the most demanding markets.

Although the most efficient transfer is obtained with immersion in aqueous solution, the problem is that the water becomes solid at 0°C and it is necessary to go down to -18°C to obtain a frozen product. The addition of salt (sodium chloride) to the water will lower the freezing point of the water to ice; this is known as a eutectic system.

A eutectic system is a mixture of substances that has a single chemical composition that solidifies at a lower temperature than any other composition. This composition is known as the eutectic composition and the temperature is known as the eutectic temperature. When the salt, (Na^+Cl^-), meets the ice, the ions arrange themselves around the water molecules that are polarised ($H2^{\delta+}$ $O^{\delta-}$) and come to form a compound ($Na^+Cl\_H_2O$) This rearrangement requires only small movements of atoms and is therefore the solid phase. When the exact proportions are observed (about 22% NaCl which means a density of 1.170 kg/m^3), the mixture behaves as a pure product, and is described as "eutectic". The melting of this eutectic $Na^+Cl\_H_2O$ is about -21.2°C.

The phase diagram (Figure 1) illustrates the melting temperature of the mixture depending on the water-salt ratio. When salt levels are lower than the proportion of the eutectic composition, we get a mixture which melts at a temperature above -21.2°C. For salt levels above it, we get the eutectic mixture which solidifies at a lower temperature.

The rearrangement of the salt and water eutectic system can be done only at points of contact between the ice crystals and salt i.e. the ice surface. A layer of eutectic melts (if the temperature is higher than -21.2°C) is formed; as the salt is supersaturated, it dissolves in the eutectic melt, and can react with ice that lies beneath the liquid film. As it spreads, the lack of water or salt forms a new eutectic system.

Components of brine for shrimp freezing

Brine freezing is a two-step process; the first step is to decrease the temperature of the shrimp to -8°C to -12°C with the brine. The energy for this phase for 1.5 tonne/hour is 396kW. The second step is to reach deep-freezing temperature of -18°C in an air blast tunnel. This second stage is fast, 20-minutes to 2 hours, depending on the design of the tunnel. Since the product is already at below 0°C, the energy requirement to bring it to -18°C is much lower. This shortens the duration of the second phase of freezing. For 1.5 tonne/hour, 88kW is required.

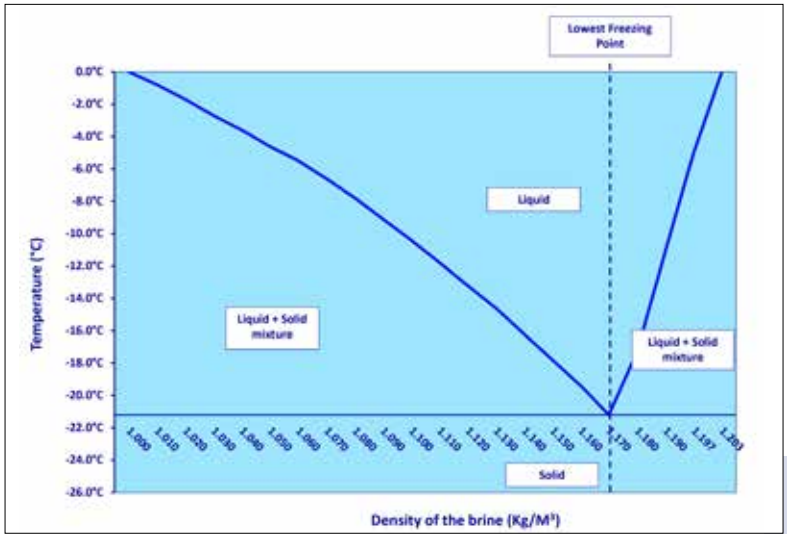


Figure 1: Phases diagram of salt (NaCl) water at atmospheric pressure.

Mass of salt in % per 100 kg of water	Mass of salt in % per 100 kg of brine	Density at 15 ° C		Freezing point
		Baumé degrees	Density Kg / dm³	
0,1%	0,1%	0,1 B°	1,000 Kg/dm3	0,0°C
1,5%	1,5%	1,6 B°	1,010 Kg/dm3	-0,8°C
3,0%	2,9%	3,0 B°	1,020 Kg/dm3	-1,7°C
1,5%	4,3%	4,3 B°	1,030 Kg/dm3	-2,7°C
5,9%	5,6%	5,7 B°	1,040 Kg/dm3	-3,6°C
7,5%	7,0%	7,0 B°	1,050 Kg/dm3	-4,6°C
9,0%	8,3%	8,3 B°	1,060 Kg/dm3	-5,5°C
10,6%	9,6%	9,6 B°	1,070 Kg/dm3	-6,6°C
12,3%	11,0%	10,8 B°	1,080 Kg/dm3	-7,8°C
14,0%	12,3%	12,0 B°	1,090 Kg/dm3	-9,1°C
15,7%	13,6%	13,2 B°	1,100 Kg/dm3	-10,4°C
17,5%	14,9%	14,4 B°	1,110 Kg/dm3	-11,8°C
19,3%	16,2%	15,6 B°	1,120 Kg/dm3	-13,2°C
21,2%	17,5%	16,7 B°	1,130 Kg/dm3	-14,6°C
23,1%	18,8%	17,8 B°	1,140 Kg/dm3	-16,2°C
25,0%	20,0%	18,9 B°	1,150 Kg/dm3	-17,8°C
26,9%	21,2%	20,0 B°	1,160 Kg/dm3	-19,4°C
29,0%	**22,4%**	**21,1 B°**	**1,170 Kg/dm3**	**-21,2°C**
31,1%	23,7%	22,1 B°	1,180 Kg/dm3	-17,3°C
33,1%	24,9%	23,1 B°	1,190 Kg/dm3	-11,1°C
35,3%	26,1%	24,2 B°	1,200 Kg/dm3	-2,7°C
35,7%	26,3%	24,4 B°	1,203 Kg/dm3	0,0°C

Table 2: Thermo-physical properties of sodium chloride solution.

In this first phase to deep freeze shrimp, water as solvent and salt are required. Water is fresh water which must be drinkable and tasteless. Salt used is sea salt, sodium chloride (NaCl, food salt). Apart from its actions on the organoleptic quality of the product (salting) and on the microbiological quality (bacteriostatic effect), it is a solute with the property of lowering the freezing point of water. It will move the freezing point from 0°C to a temperature below zero.

Table 2 gives the thermo physical properties of the sodium chloride aqueous solution, with the freezing point based on the NaCl concentration. The dissolution of the salt in water is expressed by the ionic dissociation of the NaCl molecule releasing free Na+ and Cl- ions in water.

A very common mistake is the confusion between the concentration of salt in the water and the concentration of salt in the brine. To avoid this risk, the easiest way is to consider only the density when preparing new brine.

"Sugar is used as a "coater" to prevent the shrimp from being too salty. This is the reason why peeled shrimp can also be frozen in brine with sugar, but not in brine made of salt and water only."

Sugar

Sugar, generally cane sugar, is used in the brine mainly for its coating properties and to avoid strong salting of shrimp. Sugar is mainly sucrose, a non-reducing sugar with a high molar mass of 342g/mol. It is higher than sodium chloride (NaCl), which is only 58.5g/mol.

Once dissolved in the brine, the viscosity of sugar is quite different than brine made from salt and water only. This high viscosity, as well as its higher molecular weight relative to that of the salt, allows the sugar to form a barrier or a protective layer reducing the penetration of the salt into the product. Thus, sugar is a "coater" to prevent the shrimp from being too salty. This is the reason why peeled shrimp can also be frozen in brine with sugar, but not in a brine of salt and water only. This layer of surface protection will also give the shrimp a shiny appearance, well appreciated by consumers.

Another advantage of using sugar is that it facilitates remoulding: the less sugar there is, the more the shrimp stick firmly on the walls of the mould making it difficult to remove from the mould. Moreover, sugar has a synergy with the salt by lowering the temperature of brine solidification. Therefore, adding sugar makes it possible to lower even further the freezing (solidification) temperature of the brine.

Technological additives

These include chlorine and antifoaming agent. If necessary, chlorine can be used to render water for the brine portable. The concentration depends on the quality of the local water. Up to 25ppm can be used to reduce bacterial contamination. The antifoam agent is to prevent foaming of the brine during tank return, during freezing and to break foam in the tank. Silicone-based antifoaming agents are commonly used. It is a food additive presenting no health risks for frozen products.

Concentrations

These must be according to the objectives: product temperature, refrigeration or deep-freezing, freezing rate and lastly, according to customer recommendations. If the brine is badly prepared or poorly managed, the main risk is icing of the system. This will then require a complete stop in production to raise the temperature for melting. The appearance of solid ice is mainly due to the decrease in salt concentration. However, the use of sugar would reduce the risk of icing.

Typically, for the brine used to deep-freeze at -18°C, the shrimp will have the following or similar composition:

- Salt: 28~29%, i.e. 29kg of salt in 100 litres of water.
- Sugar: 14~15%, i.e. 15kg of sugar in 100 litres of water.

Increasing the sugar concentration in the brine and the temperature of the tunnel during the second phase, means that the temperature of the shrimp coming out of the tunnel can reach -22 to -24°C. This is not suitable and even dangerous. Indeed, legally the cold chambers in which the clients store shrimp are generally regulated at the legal temperature of -18°C.

The amount of brine remaining on the shrimp will not be frozen (solidified in ice) at -18°C. This brine will therefore remain in the liquid phase with two consequences. Firstly, it will drip little by little and after a few weeks the cartons will have a damp appearance. Secondly, spoilage will not be arrested and even with treatment with sodium metabisulfite, black spots of melanosis may appear in the wetter areas. The shrimp will not be accepted by demanding markets.

Next issue: Part 2: Brine freezing systems

A shower brine freezer

Hervé Lucien-Brun is an independent consultant based in France. He has more than 32 years of experience in tropical marine shrimp and finfish aquaculture and in quality control of shrimp, pangasius and seafood processing and auditing of facilities and procedures in Latin America, Asia Pacific and New Caledonia. He is an ADEME, France Carbone Footprint certified auditor and certifier for HACCP. Email: hervelb@gmail.com

Innovations from Taiwan

By Yvonne T Nathan

Aquaculture IOT and green technology heads the list from enterprising innovators at TIFSS 2018

Taiwan International Fisheries and Seafood Show (TIFSS) event launch. The tradeshow was launched together with Taiwan Agriculture Week, by Taiwan ministers and international delegates.

Reputed for its vibrant aquaculture industry, Taiwan opened the gates for the fourth edition of the Taiwan International Fisheries and Seafood Show (TIFSS). Held in Kaohsiung, the annual tradeshow was organised by Taiwan External Trade Development Council (TAITRA) and My Exhibition Co., Ltd alongside Taiwan Agriculture Week from November 21 to 23.

An estimated 12,000 visitors attended the expo at the Kaohsiung Exhibition Centre (KEC), of which a sizeable 6,800 focused on the fisheries tradeshow. Business owners and visitors came from Bangladesh, United Arab Emirates, Russia, Singapore, Italy and Romania.

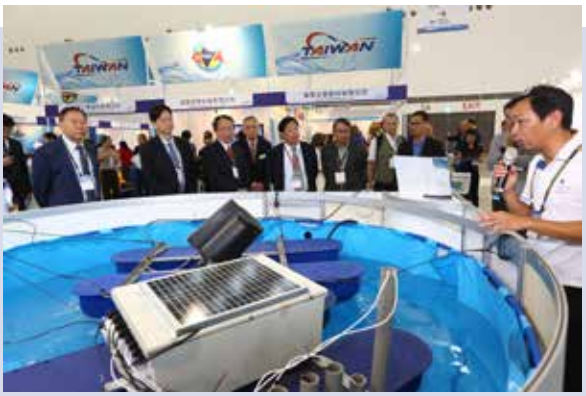
The exhibition was divided into five specialised areas for fishing equipment and technology, aquaculture, seafood processing, seafood and value-added products, as well as marine biotechnology. Industry experts and pioneers from 18 countries participated, with over 300 booths occupied by 160 exhibitors. These included South Korea, India, Latin America, and countries in the South Pacific. A seminar covering 'World Aquaculture Techniques and Marketing Outlook' was held on the day prior to the exhibition. The international tradeshow acted as a platform to share new developments and create business opportunities for the traditional fishing industry. Among the country's top seafood buyers are Malaysia, China, Japan and Vietnam.

Farming made easy

Several Taiwanese companies were in the race to head the IOT (Internet of Things) game by rolling out innovative versions of automations both to monitor and control aquatic farming. A common thread among the systems is their customisation and integration of sensors with standard aquaculture equipment such as autofeeders, paddlewheels and aerators.

Blutech Inc., introduced iAqua in July 2018 following four years of R&D. Characterised as a smart, unmanned farming service, iAqua was developed as an Artificial Intelligence of Things (AIoT) device. It links multiple sensors to aquaculture equipment, feeding data to cloud computing through a wireless transmission. Blutech's CEO Deral Chen explained that the sensors currently available primarily measure water quality. This involves the temperature at different depths, dissolved oxygen (DO) levels, and oxidative reduction potential (ORP). "The sensors can be integrated with equipment to operate automatically," he said on reducing power consumption costs. "We have also integrated weather risk prediction sensors that alert farmers up to seven days before." Chen added with plans to integrate cameras and other sensors within a year or two.

Data from the solar-powered sensors will be collected every 5 minutes through industrial grade AIoT for analysis. The company also plans to use the large amount of data collected from farms for research purposes. Blutech is concentrating on Taiwan's market with a target to export the product worldwide, starting with the South East Asian market, by end of Q1 2019. *www.blutech.com.tw*



Bluetech Inc., CEO Deral Chen (right) introducing delegates, ministers and the visitors to the newly launched integrated Internet of Things equipment, iAqua.

Actively developing toward becoming Asia's premiere smart farming industry provider, **Quadlink Technology Inc.** dipped both feet into the growing IoT infrastructure. It was established in 2010 with a focus on applying IoT into the aquatic farming industry. Quadlink president Otto Tsai said they began forming an integrated aquaculture system in 2014. They have hardware developed for water quality smart monitoring system and equipment control system connected to the QIoT software. Products have since been exported to the Philippines, Indonesia and South China.

Utilising the system, farmers can easily control shrimp mortality rates by monitoring real-time temperature fluctuations, water pH levels and ORP. "It helps farmers by giving them early warning signs and acts as a reminder, so they can rely on the equipment."

The system can be controlled remotely to feed instructions to the smart box that controls equipment and save electricity costs by 30 to 50%. The model powered by solar cells, can periodically send data to the cloud via Wifi or LoRa. "We programmed a new AI (artificial intelligence) algorithm for risk control integrated with cloud infrastructure. That way farmers can be warned two days in advance." *www.quadlink-tech.com*

Quadlink Technology Inc.'s president Otto Tsai (right) and colleagues with his smart equipment monitoring system integrating QIoT technology.

Hai-Yu Enterprise Co., Ltd.'s five-decade-old roots are based in the manufacturing of shrimp feed, specifically hatchery feed. After conquering a full spectrum of aquaculture feed products, Hai-Yu is expanding horizontally. They now cover high density polyethylene (HDPE) ponds and cage equipment to IoT monitoring systems.

Hai-Yu's general manager Jeffrey Liu elaborated on the Intelligence Aquaculture IoT (IA IoT) system to predict disease outbreak in shrimp and other aquatic animals at least a week or two before it happens. "It includes pH, water level, and turbidity sensors with an option to use 6, 9 or 12 sensors. The ammonia and nitrite sensors are especially important to predict good or bad water quality."

The technology also allows for remote monitoring and control of equipment such as DO enhancers and probiotic tanks. In addition to these, Liu introduced their novel negative ion nozzle system (NINS). The device produces micro bubbles that supply oxygen and negative ions to create an environment for stable growth and reduce aquatic animal stress. "Negative ions are also needed for metabolism and to neutralise free radicals. NINS micro or nano bubbles last longer when compared to traditional methods like biofloc, which creates coarser bubbles that dissipate faster." *www.hai-yu.com*

Hai-Yu Enterprise Co., Ltd. general manager Jeffrey Liu (right) and colleagues.

Fu-Chen Auto Technology Corporation follows the same line, developing software for automated control technology with a smart integrated system, iFish 4.0. However, its origins lie in an interesting story of Fu-Chen's managing director Auto Hsu. Growing up in a farming family that stretched back to his great grandfather, Hsu knew of the difficulties of a farmer's life. He created the system with a view to increase the quality of life and work efficiency of farmers in the agriculture and aquaculture industry. As such the system comprises features to monitor, collect data and control equipment remotely from different countries using handheld devices. "Different sensors are installed in the water or greenhouse to monitor it in real-time," said Hsu. "In the future we are planning to work with the weather bureau for up-to-date weather forecasts in order to prevent typhoon crisis. iFish4.0 is a humanised design to complement what people need. So, it can be expanded without additional costs as it uses only one control system that relies on Wifi connection," clarified Hsu. *www.Fuchen-Auto.com*

Fu-Chen Auto Technology Corporation sales manager Joan Ho with a miniature mock-up of the i.Fish 4.0 that can be controlled with mobile devices.

From functional feeds to probiotics

A long-standing aquaculture feed manufacturing company, **Grobest Group** was founded in Taiwan in 1974. By 1980 the enterprise designed an antibiotic-free feed formula, and by 2006 it formulated functional feeds using biotechnology. The enterprise prides itself on feed innovation through research and development for sustainability as well as consistency. Grobest's head of animal health, Jennifer Kuo noted that aquaculture will become increasingly important in food production in the future.

"We have developed projects to manage the fluctuating price of raw materials. We also explore opportunities for suppliers and customers with new product launches for shrimp and other high-value marine and freshwater fish," she said. Moving forward, an investment by the global investment firm Permira will see Grobest casting a wider net. "As a leading brand of functional feed producers and farming solution providers, we are now based in Asian countries but are looking to explore beyond Asia and go global." *www.grobest.com*

Jennifer Kuo, Grobest Group

Glac Biotech Co., Ltd. concentrates on developing functional probiotics in healthcare, food and aquaculture applications. According to glac Group's International Business Development Department manager Michael Hsiao, the company's competitive advantage lies in a patented micro encapsulation technology that ensures the stability of live bacteria. "Our sales largely come from China, around 80% and we are looking to expand globally," he said of the company founded in 2008. Their most notable product is the MegaProbiotide, which contains multiple probiotics, antimicrobial peptides, organic acids, minerals, small peptides and amino acids. The product's efficacy was tested with a field trial as a feed additive for vannamei shrimp. "The trial showed a 10% increase in harvest rates and shrimp length, and more than 80% survival rate compared with the control group. *www.glac.com.tw*

glac Group's International Business Development Department manager Michael Hsiao (right) and colleagues.

Environmental conscience

A firm grasp on the importance of ocean sustainability, **Awareocean Technology Co., Ltd.**, like its namesake seeks to create ecologically sound solutions with underwater instruments. Founded by Dr Hsiang-Chih Chan in 2015 as a marine equipment manufacturer, the company focuses on developing technology as an answer to monitoring and maintaining underwater ecosystems. An example of this is the passive acoustic monitoring (PAM) system that measures underwater noise up to 2,000m deep. Another is the mini remote operational vehicle (ROV) Scorpion that can be installed with a camera and sensors, such as sonar, to reach a maximum depth of 150m for underwater investigations.

Awareocean has also branched out with a Marine Investigator Training Centre, opened in October 2018 which assists fishermen seeking a job transition. "The centre provides lessons on understanding safety, the use of equipment and the requirements of deploying equipment at offshore wind-farms. Our next step will be to approach the Taiwanese government and offshore wind farmers for grants," he said, adding that the centre will begin accepting students in 2019. *www.awareocean.com*

Awareocean Technology Co., Ltd president with the Scorpion Mini ROV.

Going green

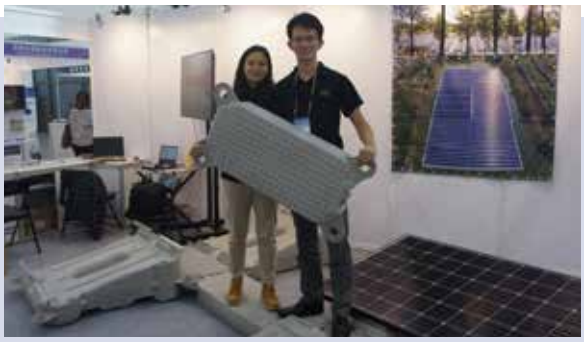
Green technology has long been a positive way to take charge of the enviroment and cost efficiency. This is where solar panels play a significant role, especially in the aquaculture industry.

Sun Rise E&T Corporation has done well by combining cages for aquatic farms with floating solar panels. "It's a policy in Taiwan to put solar floating systems above fish ponds to generate power for the farm and sell the rest to the government," said Sun Rise sales specialist Eric Tung. "What makes our cages different is that we use the injection mould technique while other companies mostly use the rotomould technique."

Tung explained that the panels and cages factors in Taiwan's biggest weather challenge of typhoons. "Sun Rise started in 1995 and our product came out in 1999. Since then, we've not had any cases of broken cages. Our biggest market is Norway, Japan, Europe and the Philippines. We are the only HDPE cage manufacturing company outside of Norway to sell to the Norwegian market," he said. *www.srise.com.tw*

Sun Rise E & T Corporation specialist Eric Tung with the floating HDPE-cage with solar panels.

Another industry expert, **Ciel et Terre Taiwan Limited** specialises solely in floating solar panels. According to Ciel et Terre's sales representative Luc Hong, these panels have been used on reservoirs and dams but can also be fitted on the water surfaces of fishponds. "The company started in 2011 and has installed Hydrelio floating solar panels in over 23 countries. It is made from 100% recyclable material and can minimise water evaporation as well as reduce algal bloom," he said, adding that the floating system has a higher Feed-in-Tarif (FIT) for renewable energy generation that can be sold back to the government. "In Taiwan, only 40% of fishpond surfaces can be covered, so it does not affect fish production." *www.cieletterre.tw*



Ciel et Terre Taiwan Limited, from left, project manager Jasmine Lin and sales representative Luc Hong with a demo of the Hydrelio floating solar panel.

Yvonne T Nathan is a contributing writer based in Malaysia.

Increasing shrimp immunity with IgY technology

Marine shrimp farmers are constantly fighting off various diseases to achieve consistent production. To assist them, South Korea-based **Adbiotech Co. Ltd** has developed Ig-Guard (Shrimp) using egg yolk antibody (IgY) technology or immunoglobulin in egg yolk technology. Ig Guard (Shrimp) increases immunity as well as acts as a growth promoter.

Ahn Hyeong-chul, general manager in the international sales team of Adbiotech, said, "Based on antibody production technology (IgY) using the egg yolk, we have shown that Ig-Guard (Shrimp) promotes shrimp immunity and resist bacterial and viral diseases in shrimp. We have shown that the product also reduces mortality rates, improves feed conversion ratios and growth rate. Aside from the shrimp, using the same technology, on request, we can develop antibody products as for the salmon, shrimp, yellowtail and eel on request. These can replace vaccines and antibiotics."

Presented as a powder, Ig Guard Shrimp is a natural feed additive to control disease. Specifically, it has shown effects against *Vibrio* and white spot virus infections (WSSV) in the Pacific white shrimp *Penaeus vannamei*. Its principle ingredient is immunoglobulin from egg yolk and the recommended dosage is 0.1 to 0.5% i.e. added at 1 to 5kg/tonne of feed.

In a series of trials carried out Vietnam, Thailand, China, Ig Guard Shrimp was fed to the shrimp. In the treatment diet, the additive was added in various concentrations via in feed or mixed with feed and then was challenged either with *Vibrio parahaemolyticus*, the strain causing early mortality syndrome/acute hepatopancreatic necrosis disease (EMS/AHPND) or WSSV for 4 days.

Growth performance, survival and immune parameters were then evaluated. They found that shrimp fed the diets containing Ig Guard shrimp at 0.2% and 0.5% increased body weight, survival and immunity. Post-challenged with VP_{AHPND}, survival improved to 66.6%, up from 33.3% in the negative control (Figure 1) and when challenged with WSSV, survival improved to 62.5% versus 25.5% in the negative control (Figure 2). Post challenge with EMS, haemocytes increased to $3.51x10^7$/mL against $1.8x10^7$/mL in the negative control. After 45 days of feeding with the additive, feed conversion ratio improved to 1.23:1 from 1.42:1.

In November 2018, at the 11th World Chinese Symposium on Crustacean Aquaculture, Shantou University, China, Dr Wang Lei, said that based on these test results, Ig-Guard A could contribute to good shrimp farm management and improve productivity. www.adbiotech.com

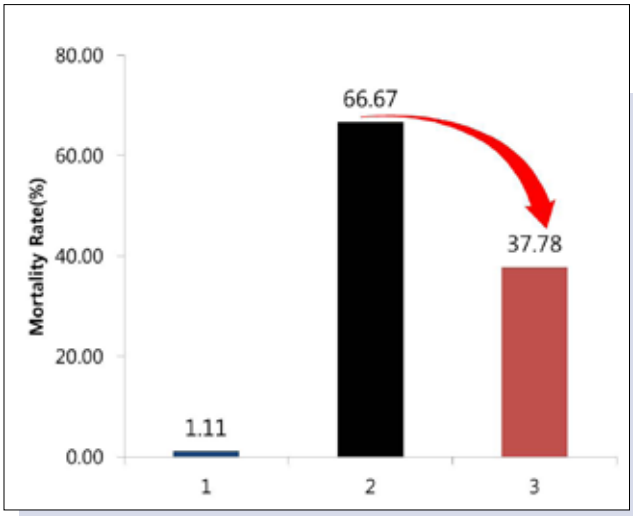


Figure 1: Mortality rate after 4 days of EMS challenge conducted at Kasetsart University, Thailand. (1 Positive control, 2 Negative Control (challenge), 3 Ig-Guard A)

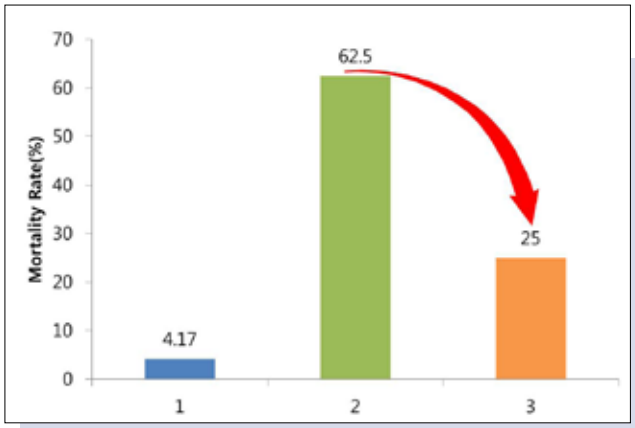


Figure 2: Mortality rate after 4 days of WSSV challenge conducted at Can Tho University, Vietnam. (1 Positive control, 2 Negative Control (challenge), 3 Ig-Guard A)

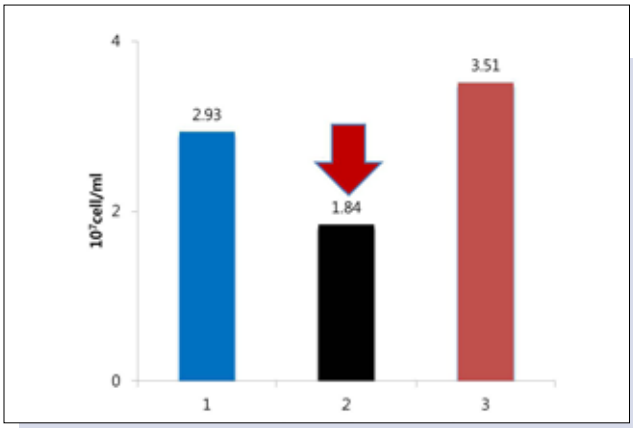


Figure 3: Total haemocytes cells after 4 days of EMS challenge conducted at Kasetsart University, Thailand. (1 Positive control, 2 Negative Control (challenge), 3 Ig-Guard A)

Kemin AquaScience introduces leadership team

The team, from the right, Nicola Tallarico, Ning Widjaja, M. Rajalekshmi, KP Philip, Chinnadurai Sugumar and Leo Xie-Lei

Kemin Industries, the Iowa-based global nutritional ingredient company has announced the selection of its leadership team for its newest business unit, Kemin AquaScience™, formerly known as AquaKulture.

In April 2018, Kemin had announced it would be dedicating a global team to the aquaculture market in 2019 with a newly formed business unit. "Kemin AquaScience transfers our knowledge and expertise in animal nutrition and health to the aquaculture industry, while maintaining our strong customer experience," said Dr Chris Nelson, President and CEO, Kemin Industries. "By having strong leadership around the world in the regions where we operate, we can better provide for the global market. We can offer our superior service and our years of experience in innovative solutions to help improve sustainable fishing and shrimp farming."

KP Philip, who has led Kemin AquaScience through its creation, will continue to serve as President. He has been with Kemin for more than 20 years, developing the Kemin Animal Nutrition and Health business unit in India. In 2001, he relocated to Singapore to lead the Animal Nutrition and Health business unit in Asia Pacific and China. Four years later KP became President of the global, newly demerged Kemin Food Technologies, based in Belgium. He returned to India in 2010 to manage the business unit he launched. In 2016, he moved back to Belgium to lead Kemin Animal Nutrition and Health in Europe, the Middle East and North Africa (EMENA).

Leo Xie-Lei recently joined Kemin as Chief Commercial Officer for the business unit and Regional Director of its China market, based in Shanghai. For the past decade Xie-Lei has held business leadership positions in the nutrition and food industries, most recently as President, Asia Pacific for the enzymes, cultures and yeast extract business of Royal DSM NV. Prior to that he was Vice President of Greater China for DSM's Human Nutrition and Health Business.

Kemin also named three other regional directors will be located in aquaculture markets across the globe to best serve customers:

Chinnadurai Sugumar will be the Regional Director for the South Asia market. He joined Kemin in 2007 as a product manager for Animal Nutrition and Health – India, before moving to the company's Singapore office in 2010, where he was later promoted to platform manager for Animal Nutrition and Health – Asia Pacific. Sugumar has 14 years of experience with feed formulation, as well as feed mill and farm operations in both the aquaculture and animal feed industries.

Nicola Tallarico will serve as Regional Director for the EMENA market. In 2010, he became a technical service manager for Kemin Animal Nutrition and Health – EMENA, following the acquisition of Eurhema, where he had worked for several years. Tallarico then moved into the role of product manager for Kemin's SAFE platform, the company's program designed to guarantee safety of feed by controlling microorganisms, mycotoxins and oxidation challenges.

Ning Widjaja will be the Regional Director for the Asia Pacific market. She served as the region's aqua business manager for Kemin Animal Nutrition and Health prior to the demerger of Kemin AquaScience. Widjaja has worked for more than a decade in the aquaculture industry, covering many aspects of the value chain across multiple countries including Indonesia, Vietnam, Thailand, India and China.

Dr M. Rajalekshmi, R&D Director, will handle global research and development for Kemin AquaScience. For the past 12 years, she has led Kemin research groups on diverse projects catering to animal nutrition and health. Rajalekshmi has numerous publications and patents associated with new products and processes in aquaculture and animal nutrition. She received her bachelor's degree from Kerala University of Fisheries and Ocean Sciences and holds a Ph.D. in post-harvest technology from the Central Institute of Fisheries Education, Indian Council of Agricultural Research, Mumbai, India. www.kemin.com/aquascience

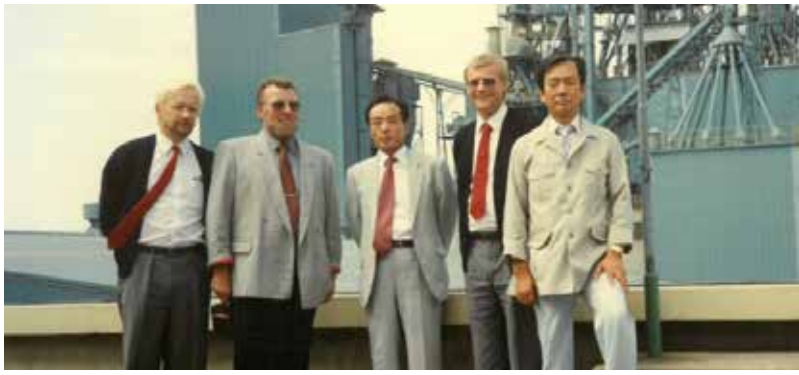
BioMar icon Niels Alsted retires after 45 years in aquaculture

Niels Alsted, Executive Vice President of Business Relations in BioMar, nicknamed 'Mr Aquaculture' by his colleagues has retired after 45 years of service in the aquaculture industry.

"Niels has been one of the most important people forming not only BioMar but also the industry. His dedication to developing a sustainable and professional aquaculture has led to industry standards and the high-end feed ranges we see in the market. Furthermore, he has been one of the most important people forming the culture in BioMar: A culture built upon trust, relationships, professionalism and a desire to pioneer the future of the industry", said Carlos Diaz, CEO BioMar Group.

There are not many in the aquaculture industry who can claim 45 years of service. Niels' career started in 1974 on a small trout farm in Denmark before beginning his studies in aquaculture research at the University of Tromsoe, Institute of Fisheries in 1977 in Norway. He stayed in academic research for several years and was an associate professor at Aalborg University when he accepted to undertake his commercial PhD with BioMar in 1987.

Over the last 32 years Niels has held various positions in BioMar from R&D, sourcing, food safety and business relations and has been part of the executive management team in BioMar Group where he contributed to opening new markets like Chile and China. Niels is valued for his broad and deep technical knowledge and while at BioMar has published several papers on nutrition and sustainability. He was instrumental in the creation of the first ever environmentally friendly aquaculture feed product, Ecoline and is known for his scholar approach to feed product development.



Niels Alsted (left) and delegation at Dae-Han feed factory in South Korean 1989

"I am very grateful to BioMar, I have seen most of the world meeting fantastic people and really enjoying my work in the aquaculture industry. I simply could not ask for more", concluded Niels who now looks forward to spending more time with the family, but has not closed the door on potentially doing more aquaculture related projects. www.biomar.com

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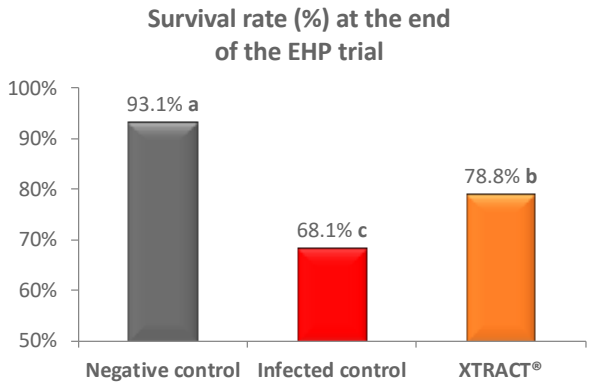
Bioactive product shows consistent efficacy in new EHP trial in shrimp

Keen on providing natural solutions to support aquaculture efficiency and sustainability, Swiss feed additive manufacturer Pancosma has been addressing this issue over the last years.

Two months after confirming XTRACT® ability to support shrimp performance against white faeces syndrome, a new trial has highlighted its efficacy to limit detrimental impact of *Enterocytozoon hepatopenaei* (EHP) in shrimp. This infectious trial was performed in Ho Chi Minh City, Vietnam and shrimp infected and receiving feed supplemented with XTRACT® showed a significant higher survival rate in comparison to the infected control.

With this new experience, Pancosma is expanding its knowledge and position as a worldwide leader in the use of bioactive compounds. Indeed, in the current global context of expansion and among the challenges facing shrimp production, animal health and immunity have become major concerns. Its bioactive products respond to these challenges by being at the forefront of the scientific trials performed.

Pancosma innovates with this XTRACT®, a micro-encapsulated additive based on an active ingredient inspired by garlic.



This compound is well known in shrimp production but its standardization and stabilisation is a technical feat. It is precisely by taking up this challenge that Pancosma distinguishes itself from the manufacturing of products composed of allicin, traditionally found on the international market. www.pancosma.ch

Permira invests in Grobest Group

In November, Global investment firm Permira and Ye Cherng Industrial Products Co., Ltd ("Grobest"), one of the largest independent and most advanced producers of aquatic feed in Asia, announced that a company backed by the Permira funds, will acquire 50% of the shares of Grobest, through a new joint venture company that will become the sole corporate shareholder of Grobest after closing. A shareholder group led by Grobest CEO Ko Chi-Kang and Chairman Chen Chun-Ping, will also retain a 50% stake in Grobest.

Grobest with its headquarters in Taiwan was founded in 1974. It has operations in Taiwan, Vietnam, Thailand, China, India, Indonesia, Philippines, and Malaysia. Grobest is also a pioneer and technological leader in an array of innovative and differentiated functional feed products, focused on preventing and combating diseases as well as increasing yields. The company provides a full range of services and technical assistance to farmers throughout Asia, including pond maintenance, water treatment, and soil and disease testing.

The Permira funds identify long-term macro trends to back market-leading businesses and management teams with strong growth potential to become global leaders. Aquaculture is the fastest growing source of protein to feed a growing population and is dependent on the advancement of sophisticated products and services as the sector continues to industrialise. The investment in Grobest is the result of Permira's continued thematic focus, since 2007, on the food value chain and specifically on aquaculture.

This is the fund's third investment in aquaculture, with Pharmaq, a world-leading aquatic health company, and Provimi, a leading animal feed company across species including aquaculture, and its sixth investment in the food value chain (Arysta LifeSciences, Netafim and CABB).

Grobest was identified by Permira as a highly attractive investment opportunity based on its strong technical capabilities and R&D leadership across warm water species, wide regional presence, and its vision for expanding the business further across Asia and globally. The founding families, represented by Ko and Chen, will continue to play an important role in the development of Grobest. www.permira.com

Four enter "fish-free" fish oil race

Four contestants have officially joined the race to replace the "fish" in fish oil. The competitors include China-based Guangdong Evergreen Feed Industry Co. Ltd., China-based Shen Zhen Alpha Feed Co. Ltd., Netherlands-based Veramaris and the UK/U.S.-based team Aquaculture Innovation/Qualitas Health. A combined total of 77,535 kg of F3 oil was sold by the contestants during the first sales period, which ran from October 1 to December 31, 2018. Veramaris is currently in the lead with the most oil sold.

"We are excited by the global reach of the contestants in the F3 fish oil race," said Kevin Fitzsimmons, F3 Challenge judge and professor at the University of Arizona. "These top-notch competitors will help move the industry toward more sustainable ingredients in fish feed."

The F3 Fish Oil Challenge is an incentive prize designed to help accelerate commercial-scale ingredients for aquaculture feed that meet the nutritional requirements of fish to produce healthy seafood for consumers without utilizing wild-caught fish. The global competitor who sells the most "fish-free" fish oil for aquaculture that meets the challenge criteria by August 31, 2019 will win the USD100,000 grand prize.

The University of Arizona, University of Massachusetts Boston, Synbiobeta, Anthropocene Institute, Dawson Family Fund, Sustainable Ocean Alliance, The Nature Conservancy, The Campbell Foundation, Tides Foundation and The National Renderers Association are sponsors of the crowdfunded prize. www.f3challenge.org/

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New LT hydrolysed feather meal

Prossential, part of the Tessenderlo Group has embarked on rebranding strategy with its products. Sophie Grégoire, communication manager said, "We want to be in the high value market with innovative processing of poultry by-products-feather meal, poultry meal and poultry blood meal.These are manufactured in France by Soleval, also part of Tessenderlo Group and well-known for a broad range of category 3 animal fats, dehydrated animal proteins and hydrolysed proteins. The origin of by products are guaranteed from France. "For the aquaculture segment, we only promote by-products from poultry."

The new product marketed at the booth during Aqua 2018 is a LT-hydrolysed feather meal as an economical replacement for fish meal. Produced with a low temperature (LT) vacuum processing, it is already available in Asia, Europe and South America. "Trials have confirmed that this feather meal can replace fish meal in sea bream diets. In future, we will conduct trials with salmon and shrimp," added Mélanie Guédon, market and product manager Aquaculture.

With the sea bream, the trials were conducted at the Malta based Aqua BioTech Group facility over two stages of growth; 10 weeks for 60g-170g fish and then a second period from 290g to 570g fish. Three diets were tested. A control diet with 30% fish meal and two treatment diets with 15% replacement of fish meal with a LT hydrolysed feather meal and standard feather meal, respectively. "Specific growth rate (SGR) and feed conversion ratio (FCR) during the 1st period showed that fish fed diet LT grew better than those fed only fish meal and had the same FCR at 1.26. In the second period, there was no difference in SGR and FCR," added Guedon. "From this trial, we concluded that for the replacement of fish meal at high inclusion rates, this LT feather meal is the choice and if the required replacement level is lower, the option is the standard feather meal. At the end, the replacement with LT feather meal is economically the most efficient solution."

Guédon announced, "The future launch will be a premium poultry blood meal, i.e. a 100% pure poultry blood meal, spray dried quality produced through a new technology developed in-house, giving it a very high digestibility. It has also been scientifically established that poultry blood meal has a more balanced amino-acid than porcine haemoglobin meal. This poultry blood meal is rich in the key amino acids such as lysine, making it an ideal replacement for fishmeal."

Sophie Grégoire (right) and Mélanie Guédon at their booth during Aqua 2018.

Guédon listed other attributes of blood meal for aquafeeds, such as better binding properties in the pellet and increased faeces stability. "The low phosphorous content leads to a reduction of the environment load and we see excellent digestibility due to our in-house spray drying technology."

Prossential will be at VIV Asia 2019 at Hall 103 Booth 2027 (Aquatic Pavilion)

BioMar to build new line for extruded shrimp feed in Ecuador

BioMar Group has announced further investments in the factory in Ecuador. A new extrusion line will add approximately 40,000 tonnes capacity and is expected to enter operation in Q1 2020, just one year after the latest capacity expansion, which is due in Q1 2019.

"We have experienced a strong growth in Ecuador since the acquisition of Alimentsa in 2017 and we currently operate at our capacity limit. For our customers the new line will mean increased flexibility and increased choice, as it will significantly expand our capacity for extruded and value-added feed solutions," said Henrik Aarestrup, Vice President Emerging Markets in the BioMar Group.

Shrimp production in Ecuador has been growing with double digits in 2018 placing Ecuador as the third largest shrimp producing nation in the world. "The Ecuadorian shrimp sector will continue to grow in the coming years, however at a somewhat slower pace than in 2018, where we have seen an exceptionally high growth. Ecuador has a competitive edge when it comes to producing shrimp in a responsible manner with high focus on both sustainability and product quality. Recent initiatives like the launch of the Sustainable Shrimp Partnership will further enhance this position", says Aarestrup.

The investment is part of BioMar's strategic plan for the shrimp business, which also includes a recently inaugurated research and trial unit in connection with the plant in Ecuador.

Apart from the shrimp feed business in Ecuador, BioMar currently produces extruded shrimp feed in Asia and Central America plus some support production for Central America and Ecuador coming from BioMar's factories in Chile. Larval diets for shrimp are distributed worldwide under the LARVIVA brand from BioMar's French production site. www.biomar.com

VIV Asia 2019 starts the sign-up

VIV Asia is back on March 13-15 as Asia's outstanding international feed-to-food event covering all species and sectors of the animal protein value chain. It is already guaranteed to fill the whole BITEC exhibition centre in Bangkok, Thailand, with more than 1,250 exhibitors.

A truly international and upbeat show

VIV Asia is held biennially, meaning its most recent appearance was in 2017. That edition took the show into a new league of global platforms in terms of event size and reach. Its certified final figures confirmed a new record total of 45,952 visits from 127 countries, revealing a nearly 20% rise in attendance compared with 2015.

"We expect more than 50,000 visits in March 2019," said event manager Zhenja Antochin. "Past editions have achieved the highest approval ratings from visitors and exhibitors of any event organised by VIV worldwide. We are determined that the March 2019 show will confirm a degree of value and satisfaction for everyone concerned and the key role we play in serving industry leaders from all parts of Asia and beyond. Our job is to make sure that the event has excellent and specific features to suit all visitors and that everyone in the feed-to-food chain is aware of the value of visiting.

"The pre-show promotion campaigns for VIV Asia 2019 are targeting a number of key countries in the wider Asia-Pacific region, including China, India, Pakistan, Bangladesh, Japan and of course Thailand. We are organising important delegations from each of these countries and others as well, representing their most forward-thinking businesses active in the sectors of meat, eggs, milk and aquaculture."

Multi-species appeal

"The fact that VIV Asia is truly a multi-species show is seen from the long list of companies who will be there in March," said Panadda Kongma, the Thailand-based project manager of VIV Asia. "Farm production and the enhanced focus on food engineering involve more exhibitors this time. At the last edition up to 20% of companies exhibited on farm production themes. The proportion is higher in 2019 mainly because there will be a larger selection of suppliers dedicated to pork production. And whereas the processing section of 2017 contained around 6% of all exhibitors, the new Food Engineering feature is set to contain 10% of companies and occupy double the former space.

"Of all the sections of the show, those relating to feed and animal health products are most typical of the multi-species approach, with products and services of high interest for every species. These sections held 60% of exhibiting companies at VIV Asia 2017 and are ready to do at least the same in 2019. In fact, the demand for stands in those areas has out-stripped the space available.

"The overall data from 2017 underlined the multi-species profile of VIV Asia when they referred to the animal protein sectors in which visitors were mainly involved. Given the importance of pork, milk and aquaculture in the Asian market, we see clear opportunities for increasing the attendance from each of those industries."

Aquatic Pavilion

The international line-up of companies, all fully dedicated to aquaculture, reveals an emphasis on feed and health supplies for the industrial production of fish and shrimp. The Aquatic Pavilion will host a selected few exhibitors in the following areas. However, note that at VIV Asia, there will be several exhibitors involved in aquafeeds and aquaculture. Fifteen companies have reserved their places to exhibit in the Aquatic Pavilion, some new and some returning exhibitors:

Shrimp health management and Breeding-Blue Aqua Int, Singapore.
Breeding - IMV Technologies, France
Diagnostics and health: Genereach, Taiwan
Feed ingredients and additives: Aker BioMarine, Norway; Atacama, Chile; Empyreal, USA; Kemin, USA; Prossential, Belgium; Aliphos, Belgium; Liptosa/Lipto Aqua, Spain; Hebei Yuwei, China; Proteus, USA and Jolink Biotech, China.

Visit Aquaculture Asia Pacific at *Hall 103 Booth No 2036, (Aquatic Pavilion)*

Aker BioMarine, Norway is a biotech innovator and Antarctic krill-harvesting company. The core business consists of harvesting, production, sales and marketing of krill-based ingredients through a 100% traceable and sustainable supply chain. Aker BioMarine has QRILL Aqua, derived from Antarctic krill giving many benefits in aquaculture feeds for salmonids, marine fish and shrimp. It is a protein rich product, high in phospholipid-bound omega-3 fatty acids, astaxanthin, and minerals to increased feed uptake and enhanced growth. It is proven to improve health and stress tolerance.

Hall 103 Booth 2045 (Aquatic Pavilion)

Alltech will showcase their latest innovations and solutions in animal health. At the booth, visitors can talk to an Alltech representative about ONE: The Alltech Ideas Conference (ONE19), where everyday heroes from various industries across the globe dare to dream bigger and explore solutions to improve their businesses and the world around them. This is one of agriculture's most ground-breaking conference. Alltech is also delighted to welcome visitors to two Happy Hours, on March 13 and 14, both from 3–5 p.m.

Hall 102 Booth 2100 (by the gate)

Atacama Bio Natural Products S.A. is a private biotechnology corporation that cultures algae to extract the healthy ingredients. Its name comes after the surrounding Atacama Desert, away from any agricultural or populated areas which strongly guarantees secure algae cultivation with no environmental pollution. A 250 (101ha) acres facility in a high light intensity region with pure water from the Andes mountains makes Atacama Bio a prime producer that can greatly expand its production capacity to meet demand.

Founded in 2003 and after a 13-year R&D project to scale up from the laboratory the production of microalgae *Haematococcus pluvialis*, the company now has a robust proprietary low energy culture technology, made up of closed and open photobioreactors. The product is functional in terms of antioxidant capacity, growth performance, reproduction, colour and immunity. (related article pages 20-23).

Hall 103 Booth 2039 (Aquatic Pavilion)

BCF Life Sciences, France produces natural mixes of free-L form amino acids, extracted from a food grade protein source, poultry keratin. Established in 1986, BCF LS has a range of highly soluble and highly bioavailable free amino acid mixes with very low molecular weights for industrial applications in human, animal and plant nutrition, produced through a proprietary keratin hydrolysis process technology. This ensures very stable and standardised products with a dedicated range, Kera-Aqua®, which is conceived for aquafeed formulations and positioned on both attraction and nutrition.

Hall 104 Booth 1663

Blue Aqua International is promoting the continuous development of knowledge and technology for the implementation of sustainable production in aquaculture. It strives to be at the forefront of intensification technology for the improvement of food security globally and has cutting-edge solutions in two main areas quintessential to farming and aquaculture: the controlled management of the culture environment and the optimisation of animal nutrition. Blue Aqua will be launching a campaign to prevent and treat white faeces disease in shrimp at the VIV Asia 2019. (related article pages 14).

Hall 103 Booth 1944 (Aquatic Pavilion)

Diana Aqua, part of Symrise Group, the worldwide leader of functional hydrolysates for aquafeed will organise a half-day seminar titled "PEPTI'DAY 2019" where various topics about feed in aquaculture will be presented to prominent Asian aquaculture feed manufacturers, researchers and students. It will be held the day before VIV starts, March 12.

Hall 105 Booth 827

LIPTOSA is a Spanish company specialised in manufacturing phytobiotics and nutraceuticals for animal feed. LIPTOAQUA is the aquaculture division, with a tailor-made portfolio of prebiotics focused on gut health for preventive use controlling bacteria, parasites and fungi diseases on fish and shrimp. Prebiotics improve zootechnical parameters along the culture helping the farmer to obtain more survival when AHPND/EMS or other diseases appears. Products as natural growth promoters or anti-parasites against gill and skin fish parasites will be presented at the booth.

Hall 103 stand 2010 (Aquatic Pavilion)

ICC Brazil combines research and biotechnology, carrying out studies that prove the benefits of yeast-based additives for several animal species. Its aim is to improve the scientific understanding of yeast properties and components. One of its products is Immunowall®, a prebiotic derived from the *Saccharomyces cerevisiae* yeast cell wall, a rich source of mannan oligosaccharides and ß-glucans. The immune stimulating action leads to better growth performance, strengthening your animals to fight against pathogens.

Hall 104 Booth 1426

Enhanced on Food Engineering

In the press release, Zhenja Antochin takes up the story about Food Engineering by explaining that the section will present the products and services of more than 100 global suppliers, for the complete post-farm chain from slaughtering and processing to logistics, refrigeration, food ingredients and packaging. Food Engineering is a multi-species concept including poultry meat, egg processing and handling, red meat, fish, shrimp and dairy products.

GFFC by IFIF precedes VIV Asia 2019

This time VIV Asia brings in also a new collaboration with the International Feed Industry Federation. As Ruwan Berculo, director VIV worldwide announced: "The 6th Global Feed & Food Congress will be held in Bangkok, Thailand, on March 11-13, 2019 under the theme 'The future of Feed & Food – are we ready?'. It will bring together leaders from the global feed and food chain and will offer in synergy with VIV Asia an outstanding combination of contents to all the professional visitors heading to Bangkok this coming March."

Food manufacturers along with primary producers and processors of animal proteins are invited to register to attend VIV Asia 2019. The English language pre-show registration has opened on the website www.viv.net since November. Online pre-registration in Thai and Chinese are also available now.

Registering in advance to VIV Asia 2019 saves time on arrival at the show. Visitors who pre-register at www.viv.net can print out a bar-code form or have it on their smartphone, enabling their entry badge to be generated in less than two minutes when they arrive. Additional merits of pre-registration include being kept fully informed about the forthcoming show's attractions and having all the logistical information at hand to prepare a fruitful visit.

Aqua Culture Asia Pacific in *2019*

Volume 15 2019					
Number	2 – March/April	3 – May/June	4 – July/August	5 – September/ October	6 – November/ December
Issue focus *Trending issues and challenges for the next step*	Health & Disease Management	Hatchery	Sustainable & Responsible Aquaculture	Genetics & Genomics	Integration and supply chain
Industry Review *Developments, outlook, demand & supply*	Marine Fish	Aqua Feed Production	Tilapia	Functional Feeds	Catfish & Freshwater Fish
Feeds & Processing Technology *Technical contributions from feed industry*	Feed Additives Omega 3 oils	Health/Safety/ Environment in feedmills	Lipids & Minerals Nutrition	Extrusion & Processing	Larval & Nursery Feeds
Production Technology *Technical information and ideas*	Offshore and Industrialisation	Innovations	SPF/SPR/SPT shrimp	Post-Harvest Technology/ Processing	Organic Aquaculture
Market and product developments, market access, certifications, branding, food safety etc)	EU	Tilapia	China	USA	Marine Fish
Aqua business *Feature articles*	Experiences from industry and opinion article covering role models, benchmarking, health management, SOPs, social investments, CSR, ancillary services, self-regulation etc				
Company/Product news	News from industry including local and regional trade shows				
Technical articles	**January 18**	**March 15**	**May 17**	**July 12**	**September 13**
Advert booking	**January 25**	**March 22**	**May 24**	**July 19**	**September 20**
Show Issue & Distribution at these events as well as local and regional meetings ****Show preview***	**Seafood Expo Global 2019** May 7-9 Brussels, Belgium **12th Asian Fisheries & Aquaculture Forum (12AFAF)** April 8-12, Iloilo City, Philippines	***Asian Pacific Aquaculture 2019** June 19-22, Chennai, India **Aquaculture Philippines 2019** June 26-28 Pasay City, Metro Manila	***The Aquaculture RoundTable Series, (TARS 2019) Aquafeeds** August 14-15, Bali, Indonesia **Vietfish 2019** August 29-31 Ho Chi Minh City, Vietnam	**Aquaculture Europe 2019** October 8-10 Berlin, Germany	

2019

Details on the events below are available online at **http://www.aquaasiapac.com/news.php**
To have your event included in this section, email details to **zuridah@aquaasiapac.com**

January 23-25
Brackishwater Aquaculture (BRAQCON 2019)
Chennai, India
http://braqcon.org

February 3-8
Practical Short Course on Feeds & Pet Food Extrusion
Texas A&M, USA
https://perdc.tamu.edu/; https://perdc.tamu.edu/extrusion/

March 7-11
Aquaculture 2019
New Orleans, Louisiana USA
www.was.org

March 13-15
VIV Asia 2019
Bangkok, Thailand
www.vivasia.nl

March 12-14
Annual Seminar on Marine Science and Aquaculture (ICOMSA2019)
Kota Kinabalu, Sabah, Malaysia
www.ums.edu.my/ipmbv2/icomsa/

April 8-12
12th Asian Fisheries & Aquaculture Forum (12AFAF)
Iloilo City, Philippines
www.asianfisheriessociety.org

May 7-9
Seafood Expo Global 2019
Brussels, Belgium
www.seafoodexpo.com

June 19-22
Asian-Pacific Aquaculture 2019
Chennai, India
www.was.org

June 26-28
Aquaculture Philippines 2019
Pasay City, Metro Manila
www.livestockphilippines.com

August 14-15
TARS 2019: Aquafeeds
Bali, Indonesia
www.tarsaquaculture.com

August 29-31
Vietfish 2019
Ho Chi Minh City
http://vietfish.com.vn

August 28-30
14th Shanghai International Fisheries and Seafood Exhibition
https://www.worldseafoodshanghai.com

September 3-5
Seafood Expo Asia
Wanchai, Hong Kong
www.seafoodexpo.com/asia/

October 7-10
Aquaculture Europe
Berlin, Germany
www.aquaeas.eu

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