ISBN 1793 -0561

JULY/AUGUST2016

Volume 12 Number 4

AQUA CULTURE

Asia Pacific

Shrimp farming: Control for success

IPA technology expands in China

Marketing micro feeds in Asia

Marine ingredient standardisation

Pangasius in India and Indonesia

MCI (P) 037/10/2015 PPS1699/08/2013(022974)

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Photo courtesy of B. Laxmappa

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AQUA Culture Asia Pacific is published bimonthly by

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Printed in Singapore by
Man Cheong Printing Pte Ltd
996 Bendemeer Road, #03-02,
Singapore 339944

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Industrialisation & Smart Aquaculture

Zuridah Merican

China is leading Asia's aquaculture again. It is moving towards the transformation of its aquaculture in its 13th Five Year Plan. The focus is on freshwater fish farming and coastal aquaculture. Controlling production parameters is also very relevant for China's fish and shrimp farming. During the Asia Pacific Aquaculture Expo in Xiamen City, I learnt that eel farming in recirculation systems began 25 years ago under controlled conditions! Again, we see that China is pointing to the fact that we cannot be dependent on whatever water and natural resources which may not be readily available in future. This also includes the common belief that most of Asia is viewed as 'kitchen to the world' with its 'cheap' labour resources.

In this editorial, I would like readers to ponder on ways to bring aquaculture to the next level as an industrialised activity. Often, aquaculture is mentioned as the means to increase fish supply to meet the growing global population and that this production will be from Asia. This is the task for aquaculture in Asia. Amidst Asia's limited water and land resources, productivity must increase from a smaller footprint. This means moving away from backyard farming to industrialised enterprises. To achieve this, farmers and other stakeholders will need to grasp the science of their farming and develop SOPs that can be followed to achieve consistently successful crops. The days of owner operators knowing the 'savoir faire' and the staff dependent on 'instructions' are over. Even in China, Dr Cui He (CAPPMA) says that a shift away from 'mom and pop' business will be inevitable for the organic growth of aquaculture. He added that the modernisation of aquaculture is inevitable.

The success of Norway's salmon is the role model for aquaculture be it shrimp, freshwater or marine fish. One, the industry there stopped using antibiotics in 1994 and continues to grow. Two, it is well supported by R&D from various research organisations, public and private for salmon genetics, disease control and feeds. Three, as the industry automates and innovates, it is very efficient with unimaginable (at least in Asia) productivity of 300 tonnes/year/person. In comparison, we can report on examples of shrimp productivity at 10 tonnes/year/person or fish production of 50 tonnes/year/person. If we do our calculations right, are Asian producers competitive then? Will automation help with labour intensive jobs such as feeding, grading and harvesting? Many governments recognise that aquaculture provides job avenues for rural communities but neither should aquaculture be so labour-intensive that recruitment of labour from other countries becomes necessary, as in the case of Malaysia and Thailand.

Segmentation is also another option for industry to advance. Segmentation is common in many manufacturing and capital intensive industries. Integration is sought after by aquaculture in Asia as large companies like to have absolute control of the upstream and downstream components of a business. However, segmentation should be looked at as an option by leaving the experts to handle segments such as hatchery and feed production. Another example is outsourcing harvesting rather than having an in-house harvesting team. In many cases, the efficiency improves as it is operated as a stand-alone profit centre.

In the case of the Norwegian salmon industry, both the private sector and government work together to innovate. Similarly, here in Asia, we seek more involvement from government research institutes to innovate for some of the tasks which the industry needs, such continuous and real-time monitoring of water parameters.

Many aquaculture producers in Asia are emerging economies that are stuck in the 'middle income trap'. They have lost their competitive edge in the export of goods because their wages are on a rising trend. However, they are unable to keep up with economically more developed economies in the high-value-added market. In aquaculture, this is a critical hurdle to cross in order to move into the next phase of development.

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China's transformation in aquaculture

Industry and business leaders shared their views on the way forward for a transformation in aquaculture to meet current and future environmental and business challenges at the Global Aquaculture Summit.

China is the world's aquaculture 'powerhouse' accounting for 61% of global aquaculture production at 45.5 million tonnes in 2014 (FAO, 2016). Any change in its production will affect the rest of the world. To maintain stable growth of high quality species to meet the demand of premium markets both locally and overseas, industry in China agrees that it will need to move towards industrialisation and adopt advanced technologies. The days of production at low cost are limited.

"Aquaculture contributes 73% to the national production of aquatic products. There is no doubt that the future supply will be from aquaculture to help alleviate pressure on limited capture fisheries resources. However, the industry is facing a crucial phase in its development. We are confronted with adverse economic situations globally and we face various challenges posed by an economic slowdown in China. We need to seek appropriate development models. To do this, we need close cooperation among stakeholders. At this summit, we have industry leaders who will share their insights on new technologies that will lead to a healthy and sustainable development of the industry," said **Dr Cui He**, Executive Vice Chairman, China Aquatic Product Processing and Marketing Alliance (CAPPMA), organiser of Global Aquaculture Summit and Asian Pacific Aquaculture Expo in Xiamen in May 2016.

China's aquaculture has been growing in the past 30 years. In 2014, freshwater fish farming contributed 27.2 million tonnes and marine fish farming, 1.3 million tonnes to fish supply. **Jiansan Jia**, Deputy Director, Fishery and Aquaculture Division, FAO, listed some future directions which China's aquaculture stakeholders could consider. These include: production from more intensified and diversified systems; production of premium species due to scarce land and water resources; offshore farming; and more stringent quality control on food safety.

Jia also identified some global issues shared by industry in China such as the conflict and competition on land use with other users, contingency strategies to mitigate disease outbreaks, credit, capital and insurance, climate change and lower purchasing power in contrast to increasing costs of production due to higher costs for energy, feeds and labour. The way forward, which several speakers at the summit elaborated, will need private sector and government support for sustainable development, innovation and technological breakthroughs.

In his discussion on marine fish farming in China, **Xiaowei Zhou**, Fishery Statistician at FAO, said that out of 130 countries with marine aquaculture, 113 do not have significantly high production. Not all countries are fully utilising their resources. China is the second largest finfish producer after Norway. Zhou showed some interesting recent developments such as the progress in seaweed production. In 2014, Norway increased farming licences for seaweed from 54 in 2014 to 164 in 2015. Shrimp farming in land based recirculation aquaculture systems and biofloc are trendy but to date has not contributed significantly to increase production. Another development is farming of the Atlantic salmon in North Korea with eyed eggs from Norway. A more ecological farming model is integrated multi-trophic aquaculture (IMTA) and the US and Canada are interested in integrating seaweed with salmon farming.

"The moot point for stakeholders is whether to move from freshwater fish farming and coastal farms to offshore farming. However, when we move offshore, it is no longer possible for it to be a 'mom and pop' business. The shift should be from family owned business to small and medium enterprise. Governments in other countries have moved from farming in reservoirs and rivers. Here in China, we need to look at organic growth. Modernisation is the direction for us to challenge competitors," said Cui He.

In his presentation on the status and future strategy of freshwater aquaculture in China, **Professor Ge Xianping**, Secretary General of the Freshwater Fisheries Research Centre committee, said this is an important sector, not only in its contribution to fish supply, but also in its contribution to the economy and job creation. Freshwater fish, in particular contribute 31% in comparison to 45% by meat products to national protein consumption. The farming area has increased by over 7.17 million mu (478,000 ha) for an increase in production of 5.29 million tonnes for the period from 2008 to 2013. The annual consumption of water was 151 million m^3 which is 5.4% of China's water resources. There is also excessive discharge of nitrogen and phosphorus, which according to a survey by the Ministry of Agriculture would be

Dr Cui He (right) with summit participants

Jiangsu Shi (right) and Xinglong Jiang

Professor Wang Zhi-Yong, Fisheries College, Jimei University (left) with Professor Zhou Enhua

Gary Allee (centre) with the large group of participants from DBN. DBN was a sponsor of the Global Aquaculture Summit.

382,700 tonnes of nitrogen and 31,900 tonnes of phosphorus per year. Ge added that serious water pollution has adverse effects on production and on food safety. The economic loss caused by aquaculture diseases is over CNY 6 billion (USD 902 million) annually. A transformation which involves renovation of ponds, breeding technologies, development of vaccines to prevent drug use, increase processing and the development of a quality inspection, system is required.

Innovations for a modern aquaculture

In freshwater fish farming, **Professor Zhou Enhua**, US Soybean Export Council (USSEC) described a new era with pond raceway aquaculture (see article on pages 24-26). The main problem in pond aquaculture is the discharge which goes directly into the environment causing eutrophication. At the same time, in intensive farming, water quality is often compromised. **Professor Xinglong Jiang**, Jimei University, invented the biofilm low carbon aquaculture in ponds in 2009. His justification was, "Once cyanobacteria species (*Microcystis* sp, *Anabaena* sp etc) become dominant in ponds, it will inhibit growth of beneficial plankton, resulting in a single dominant species. Fish hypoxia occurs when cyanobacteria dies, consuming oxygen."

The biofilm filter grid works by forming a large amount of biofilm about 6-10 times the area of the pond. This would then absorb large amounts of residual feeds and organic wastes; the biofilm also reacts with bacteria, protozoa and algae attached on it, forming a floc. Jiang has tried the technique in ponds culturing the Japanese and European eel, vannamei shrimp, common carp and tilapia. The technique also works against acute hepatopancreatic necrosis (AHPND) as it removes toxic algae.

"The biofilm incurs a low investment cost, does not require maintenance and it will last 3 years. Our studies showed more than 60% savings on water use. In treatment groups, the average *Vibrio* concentration was reduced by 54% and morbidity of shrimp was remarkably lower than in the control group. No *Vibrio* was found in the treatment group," said Jiang.

In controlling AHPND and more recently, *Enterocytozoon hepatopenaei* (EHP), **Jiangsu Shi**, Sales Director, China, India and Southeast Asia for Kona Bay Marine Resources, USA gave examples of how farms in India minimise organic loads in vannamei shrimp ponds with a shrimp toilet, and farms in Vietnam culture shrimp with tilapia. In China, the high-level ponds allow for easy draining of sludge. Shi also discussed a case study with early mortality syndrome (EMS) management in the Blue Archipelago farm in Malaysia which also stocks post larvae from EMS/WSSV (white spot syndrome virus) resistant broodstock.

Offshore farming

In the search for consistently better quality water, offshore farming is the way forward. **Bjørn Karlsen**, Director of Sales, AKVA, said that based on experiences in Norway, technology is critical for success but competence is the key. In his presentation on 'automation in cage operations and new designs' Karlsen said

The trade show was a joint Asian Pacific Aquaculture and Xiamen Fisheries and Seafood Exhibition. It was held from 26 to 28 May at the Xiamen International Convention and Exhibition Centre, Xiamen City, Fujian Province. The Global Aquaculture Summit and associated conferences were held on 25 to 27 May.

A new and improved PCR detection method for EHP

Hepatopancreatic microsporidiosis (HPM) caused by *Enterocytozoon hepatopenaei* (EHP) is a newly emerging disease of cultivated shrimp in Asia. Current evidence indicates that it can be associated with severe growth retardation that may not be clearly evident until the second month of culture and that it may even cause low continuous mortality in the case of very severe infections.

The research team from Centex Shrimp, Thailand now presents a new and improved PCR detection method for *Enterocytozoon hepatopenaei* (EHP) based on a gene encoding a spore wall protein. This information is available on the website of the Network of Aquaculture Centres in Asia (NACA, www.enaca.org).

The report added that this new method has superior specificity to the first generation SSU-PCR developed in 2009 when the genetic information of EHP was still limited. Due to the urgency in stemming losses to HPM, the team of Itsathitphaisarn, O., Jaroenlak, P., Sanguanrut, P., Salachan, P.V., Wiredu-Boakye, D., Williams, B.A.P, Stantiford, G.D., Flegel, T.W. and Sritunyalucksana, K. have decided to release this method for free, non-commercial use to the global shrimp farming community.

The second generation EHP detection method presented is based on a gene encoding a spore wall protein (SWP) of EHP (SWP-PCR). Results from laboratory work revealed, in contrast to SSU-PCR, that the SWP-PCR method did not give cross reactions with DNA from crabs infected with *H. eriocheir* and *E. canceri*. From these results, the team recommend that the new SWP-PCR method replace the first generation SSU-PCR method. The sequences of the primers for the SWP-PCR method (nested PCR) are given below and can be used freely for non-commercial applications to detect EHP.

Please contact Centex Shrimp (ornchuma.its@mahidol.ac.th) to obtain a free positive control plasmid (pGEM-EHPSWP). The method can be download from this link: http://www.enaca.org/modules/library/publication.php?publication_id=1177&title=improved-pcr-detection-of-ehp

continued from p5.

that the salmon farming industry in Norway has progressed to an average of 4,000 tonnes of fish/year/farm of eight cages. The average cost of production is USD 3.40/kg. Industry has a gross margin of 20% with sale prices at USD 4.50/kg. Productivity is 300 tonnes/year/person. Some important lessons learnt by Norwegian farms are that economy of scale is crucial, investment in suitable equipment is of utmost importance and that farmers should focus on their core competence which is farming and contract out other activities. At this stage in their development, the trend is to focus less on automation but more on innovation.

Bio-economic modelling for tilapia farming

At FAO, **Junning Cai** and his collaborators have developed bio-economic models for tilapia farming to help farmers improve technical and economic performance. Cai presented some models developed with data provided by farms in Hainan Province. Subject to the assumption of stocking 1,200 fish/mu, Cai showed the cost structure and that harvesting after 21 weeks at 707 g fish would give the best profit per week. He also described impacts of water temperature on feeding ration, time of stocking, number of crops per year, density and 2-phase farming, on profitability.

"These models demonstrate how increase in feed price, increase in mortality and decrease in fish price would significantly reduce profitability and reduce optimal harvesting size. A smaller impact on profitability is obvious with increase in price or cost of inputs. Given no price discrepancy against small fish, we show that harvesting 300 g fish in 2-year-5 crop-arrangement could increase the overall profit by up to 50% compared to harvesting above 500 g fish in 1-year-2-crop arrangement. Overall, we show the potential benefits of bio-economic modelling as a tool to facilitate science based aquaculture," said Cai.

An internet and business epoch

Da Bei Nong group has developed an aquaculture program (DBN Aqua) by integrating aquaculture in China via the internet and its associated services. DBN is a hi-tech agricultural enterprise and is a national livestock industry leader specialising in feed, genetics, pig breeding, and livestock insurance. **Gary L Allee** said that the group sees fantastic opportunities in aquaculture. It has invested CNY 40 million (USD 6 million) to set up DBN Aqua and to create three platforms (financial services, e-commerce and comprehensive services) for its aquaculture business. He added that times have changed and aquaculture should be in an era of innovation. DBN wants to be a global leader in aquaculture nutrition, health solutions and production technology. It wants to position itself as a leader in internet based aquaculture.

Dr Smith Thummachua, Consul Agriculture, Royal Thai Consulate-General, Guangzhou, China (right) and Maggie Xu, China Manager, IFFO. Xu presented on the IFFO Global Standard for Responsible Supply (IFFO RS).

The DBN group implements the strategy of driving corporate development through scientific and technological innovation. The company has already set up national laboratories and scholarships for students, similar to its approach in the livestock industry where to date it has set more than 60 production bases, 80 subsidiaries and 2,000 service centres across the country. DBN is also the leading premix supplier in China in the last 5 years.

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New era in shrimp farming

The innovative recirculation system in Brazil has zero sludge discharge into the environment, keeps parameters extremely stable and raises productivity.

Camanor Produtos Marinhos Ltda was set up in 1983 and today has two farms in the north and south of Brazil's Rio Grande do Norte state. During Lallemand's Aquaculture Meeting in Chennai, India in March, CEO, Werner Jost recounted the journey of the farm from an annual production of only 50 tonnes of shrimp until 1991 to 500 tonnes annually. In 2013, the farm began to use AquaScience, an innovative recirculation system, developed by a partner Luiz Henrique S Peregrino which pushed productivity in the farm in the south to 48 tonnes/ha whereas the traditional ponds continue to produce 1.5 tonnes/year.

"We are a dynamic team of three partners and we can quickly change decisions. For ten years, we had a production of 50 tonnes of shrimp annually. This was our lost decade without post larvae supply, feed or knowledge. Then we started a vannamei shrimp hatchery called Aquatec, now with 4 billion post larvae/year, the first commercial hatchery in Brazil. Our big break was when the Brazilian real was devalued and we could export to France's shrimp market. Production expanded to 5,000 tonnes in 2011. This came from three farms, the largest with 580 ha," said Jost.

"In 2008, the real appreciated which made it impossible to sell into Europe. We had to restructure for the local market. We were also hit by the white spot syndrome virus (WSSV) in 2011 with mortality from 90-95%. Years before we had been studying the Asian concept of small lined ponds stocking 100 PL/m^2 but we lost the crops at 15 to 45 days of culture. Despite changing designs and protocols, we lost 10 cycles over two years. We then moved to this AquaScience model."

Werner Jost, CEO (right) with Luiz Henrique Peregrino, Technical Superintendent (left) and Marisa Sonehara, Operations Superintendent (centre). In the third week of June, the farm managed to reach a new productivity record of 49.4 tonnes/ha.

"The important aspect of AquaScience is zero sludge discharge. It is important that we do not discharge waste into the environment.." - Jost

View of Camanor with AquaScience's covered ponds in the background

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An AquaScience pond has shading to control pond water temperature

AquaScience

In this model, production ponds are 3,000-4,000 m² and HDPE lined, with a central drain for water recirculation. The water recycles for 100-120 days and is then pumped out into a reservoir after each harvest and channelled back after pond cleaning. The farm is in its 7th cycle of reusing the water.

"The important aspect of AquaScience is zero sludge discharge. It is important that we do not discharge waste into the environment. Today we have 25 ha of productive ponds following this model and in a second phase, we will add another 25 ha of ponds. Soon we will have 50 ha of production ponds and 30 ha of channels, tilapia ponds and recirculation area.

Jost emphasised that the system is special in that the water parameters are extremely stable. "Fluctuations of dissolved oxygen at only 0.5 mg/L and 0.3 for pH over 24 hours keep away pathogens. Pond water temperature is controlled at 27-28°C with shading. Pathogens are present as the system is not totally closed and WSSV although present, does not kill shrimp. Solid waste goes to ponds holding tilapia, which feeds on the biofloc and clean water is recycled back to the shrimp ponds.

Harvesting

"With our first successful cycle in 2013, we were able to produce 10 tonnes/ha of 12 g shrimp at 90% survival at a stocking density of 100 PL/m². In February 2015, we increased this to 48.5 tonnes/ha/cycle of 22 g shrimp. Stocking density was 230 PL/m² and survival was 95%. We target 55-60 tonnes/ha/cycle in 2016. In terms of costs and revenues, our breakeven size is 8 g. This means AquaScience needs to produce 20 g size to get 50% gross margins. We have to keep to this size as the market cannot absorb large quantities of larger shrimp," added Jost.

"AquaScience is not only about technology; it is also an organisation for the maintenance of equipment and to effectively manage risks. It cannot be without electricity for more than 15 minutes. We need to design the right systems with four layers: electricity from the grid, local generators, central power station and finally a mobile generator.

"In the next three years, the target is 1,900 tonnes in 2016, 5,000 tonnes in 2017 and 9,000 tonnes by 2019. With a nursery system, we can increase to 4 cycles per year and by working on genetically improved shrimp for faster growth from the current 1.5 to 2 g/week, we can increase to 5 cycles per year. Ultimately, the production target is 450 tonnes/ha at a production cost of USD 2/kg for 20 g shrimp by lowering fixed costs. This is a threshold for a new era in shrimp farming."

Is regular sludge removal the answer to successful cycles in shrimp farming?

By Zuridah Merican

In East Java, two farms attest that the right SOPs in ponds with central discharge systems are critical for successful cycles.

During the Asian Pacific Aquaculture (APA 2016) post conference tour to two farms in Pasuran and Kabupaten Probolinggo in East Java, participants observed first hand farm practices unique to shrimp farming in Indonesia. Both farms are operated by PT Central Proteina Prima or CP Prima, the leading shrimp farming and aqua feed company in Indonesia. Shrimp Improvement Systems (SIS), the global leader in vannamei shrimp genetics and broodstock supplies is also part of CP Prima.

The Andalas farm and PT Windu Empang Mas farm, located next to each other and around 100 km from Surabaya (where APA 2016 was held) are customers of CP Prima which supplies feed, post larvae and probiotics to the farms. CP Prima has stationed technical staff to run operations at the farms. The Andalas farm covers an area of 2.7 ha with 10 culture ponds in production. The average water depth in these ponds is 1.25 m. There are four reservoir ponds; two treatment and two settling ponds.

PT Windu Empang Mas (WEM) farm covers an area of 3.4 ha and has 12 ponds including three reservoir ponds together with one treatment and two settling ponds. Water depth is 1.5 m and ponds and dykes are cemented. The farm was built in the 1990s and as its name implies, it started with farming the monodon shrimp. It now farms the vannamei shrimp and CP Prima started technical services at the farm in 2012.

In an introduction to the farms, Sri Basuki Bambang Harmiyanto, Technical Partner Manager at CP Prima, Surabaya, said, "Both farms show how farming can be successful with good management, even though these two farms are located in a disease outbreak area. Year after year, they demonstrate success

Sri Basuki Bambang Harmiyanto (second left) and the CP Prima Technical Partner team, pictured at the WEM farm. From left, Suhartatok, Eko Purnomo and Dio Maliki Hakim.

Tour participants checked out the central discharge system used to drain away sludge by gravity. This is an infrastructure common in ponds in both farms.

Sample of size 80/kg shrimp at 70 days of culture from a 1,900 m² pond at the Andalas farm. Stocking density was 111PL/m².

and show shrimp farming can be sustainable. The ponds in these farms have central discharge systems, which has become part of the infrastructure for shrimp ponds in Indonesia today.

"The keys to the success are the use of sedimentation and treatment reservoirs, paddlewheels to move and aerate water, feeds and right feeding management, probiotics to manage the feed and pond wastes and sludge removal. Another contributor to success is a good partial harvesting program."

In both farms, operating procedures are standardised. Post larvae certified from specific pathogen free (SPF) broodstock come from a CP Prima hatchery in Situbondo, about 60 km or 2 hours by road away from the farm. During the period from February 2014 to December 2015, production at the Andalas farm has been consistent with the total harvest of the 9-10 ponds in operation ranging from 17 to 19 tonnes/ha. Over the period from January 2014 to November 2015, the production at the 12 ponds in WEM ranged from 15-21 tonnes/ha.

Andalas farm

Water is drawn from the sea and is kept in the reservoir ponds prior to use for production in the all-concrete ponds. Pond sizes average 2,700 m²; the size of the largest pond is 4,900 m² and the smallest 1,800 m². Dio Maliki Hakim, Supervisor Technical Partner, CP Prima, explained that water exchange is about 3% daily at days of culture (DOC) 20-30 and later at DOC 60, the exchange is 6% daily. Seawater salinity ranges from 28-32 ppt but salinity in pond water is maintained at 12-15 ppt by mixing seawater with underground water.

"Usually, there are four programmed partial harvests and then a final harvest. In the December 2015 cycle, the first harvest started at DOC 69 and the average size was 82/kg (12 g/shrimp). But for the cycle in May 2015, it was earlier at DOC 62 when the average shrimp size was 91/kg (10 g/shrimp). The biomass left for the final harvest is usually 10 tonnes/ha. In December 2015, the final harvest was at DOC 125 and shrimp size was 33/kg.

"Usually the first partial harvest will take out 10-15% of the biomass. There are special circumstances when with signs of white faeces disease (WFD), the first partial harvest is increased to 20% of the stock. We then restored pond conditions back to normal by improving pond management. A potential outbreak of infectious myonecrosis virus (IMNV) is still imminent but is not such a worry as in previous years.

"Post larvae (PL 9-11) are stocked into the ponds. Survival rate ranged from 85 to 96% in the 4 cycles in 2014 and 2015. As a rule, management allows us to stock at a range of 100-120 PL/m². For example in the two ponds of 2,500 m² and 1,900 m², production was 5.4 tonnes/pond and 3.3 tonnes/pond, respectively. The stocking density was 112 PL/m². The tolerance is below 12% variation and as such we also stocked as low as 94 PL/m² in a cycle in February 2014.

With regard to water quality parameters, Nurkholis, Station Technical staff, CP Prima added, "Oxygen levels are maintained at 5-6 mg/L in the morning and 4-5 mg/L at night. Oxygen is checked at the deepest part of the pond. We use one 1 HP paddlewheel for each 250 m² area. In a 1,900 m² pond, we use 8 aerators."

WEM farm

At this farm, which utilises both semi biofloc and plankton technologies, pond preparation covers a total of 28 days. This starts with the treatment of incoming water with chlorine and copper sulphate and Nuvaq as a crustacide. Water depth at this farm starts at 1.2 m and increases to 1.5 m. Plankton preparation takes 14 days and the CP Prima probiotic is used at this stage. Fermentation uses rice bran, mollasses and yeast. During the rainy season, fertilisers are used to develop pond plankton. Fry are stocked once the water transparency reaches 60-65 cm. The onsite laboratory constantly checks on nitrate, calcium, magnesium, bacteria density and composition, and total plankton populations in the water. Pond water salinity is maintained at a maximum 25 ppt. Similar to the Andalas farm, incoming seawater is diluted from 34 ppt.

A 1,900m² pond at the Andalas farm.

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"The trend in production showed how we have improved production from only 15 tonnes/ha in January 2014 to 21 tonnes/ha in November 2015. Stocking density ranged from 100 to 110 PL/m^2. We had only three partial harvests and a final harvest. In the last cycle in November 2015, we started partial harvesting at DOC 64 when the shrimp size was 93/kg (10 g/shrimp). Growth was faster in the earlier cycle in April 2015 when the shrimp reached size 93/kg at DOC 57. Overall, the average growth has been quite consistent from a high of 0.23 g/day to a low of 0.21 g/day. An exception was the cycle in January 2014, when the average growth was only 0.16 g/day."

Siphoning away pond sludge

Ponds in both farms are fully equipped with a central discharge system to drain away sludge at regular frequency. Dio said that after DOC 20, the sludge removal is carried out 2-3 times/week and this continues for 30-45 minutes each time. "Sludge removal is through siphoning by gravity. Paddlewheels move the sludge to the central area where the water depth is 1.30 m deep in the Andalas farm. The positioning of the paddlewheels is important. Sludge is removed via a 6-8" pipe. When we detect dead shrimp in the pond, we will remove sludge on a daily basis. Sometimes, we also send a diver to vacuum out the sludge."

PT Windu Empang Mas farm

In addition, the ponds at the WEM farm also have a waste disposal unit for the removal of plankton directly into the waste outlet.

Feeding and feed management

The Andalas farm uses the CP Prima's Irawan vannamei feeds with 30% crude protein. Feeding at the ponds here is four times/day at 7 am, 11 am, 3 pm and 6 pm. A worker broadcasts feeds from a feed boat as he moves along the outer perimeter of the pond. There are four feed trays for the sampling of feed consumption after 0.5 to 2 hours after feeding. "Depending on weight, we allocate feed at 0.6-1.2% of body weight. One percent of the feed allocated for each feeding is placed in the feeding tray. We also practise blind feeding until DOC 30," said Dio.

Some examples of feed conversion ratios (FCR) obtained at the various cycles included 1.21 at 85% survival and shrimp size was 45/kg at the Andalas farm. In another cycle, FCR was high at 1.5 at 93% survival and final size was 50/kg. In the WEM farm, the best FCR (1.26) was recorded for size 52/kg and survival at 92%. FCR was 1.62 when the harvest size was 66/kg and survival was 90%.

In general, the feed costs account for 50% of production cost which is around IDR 43,000 (USD 3.3/kg) for size 50/kg. The other major costs inputs are electricity at 18% and labour at 14%.

Adapting to a new reality: Shrimp nurseries as the new normal

By Jesper Hedegaard Clausen, Olivier Decamp, Saran Kayankarnnavee and Nongluk Thaisilp

There is a need to increase biosecurity measures in the shrimp aquaculture industry as part of the 'new normal'.

It is not a secret that the shrimp industry in many countries has suffered considerable economic losses due to a number of different shrimp diseases including the acute hepatopancreatic necrosis disease (AHPND). According to OIE, AHPND has been officially reported in China (2010), Vietnam (2010), Malaysia (2011), Thailand (2012), Mexico (2013) and the Philippines (2015) (NACA's quarterly aquatic animal disease report, 2015 and OIE, 2013). The economic losses in the shrimp industry in Thailand alone is estimated to have cost the industry more than USD 5.01 billion to date (Shinn et al. 2016). There is no 'silver bullet' to address this disease or any future diseases. However, a combination of increased focus on biosecurity, adoption of better management practices and a focus on high quality nutrition and health products is showing promising results to get shrimp production back on track. This article summarises and discusses some of the initial results from introducing a shrimp nursery segment before the grow-out in Southeast Asia.

AHPND

Shrimp diseases have caused serious economic losses to the shrimp industry globally. The initial weeks of shrimp production have always been of high importance, as getting the nutrition and health of the shrimp right at the early stages, will translate into a more robust animal later in the production. AHPND infects shrimp often during these critical first 30 days of production, thus hitting the shrimp industry hard.

AHPND is caused by a bacterium that colonises the shrimp gastrointestinal tract and produces a toxin that causes tissue destruction and dysfunction of the hepatopancreas, the shrimp digestive organ. The culprit is the bacterium *Vibrio parahaemolyticus*, as well as *Vibrio harveyi*, both common bacteria in brackish water. It affects the main species of cultured shrimp including the giant tiger shrimp *Penaeus monodon*, whiteleg shrimp *Litopenaeus vannamei* and also Chinese white shrimp *Penaeus chinensis*. With mortalities of infected shrimp stock often exceeding 70% this is a serious 'game changer' for the industry (OIE, 2016).

Farmers have tried to deal with the disease in different ways. Some of the approaches include lower stocking densities, change in water treatment, polyculture with tilapia and increased usage of antibiotics. Some of these changes in management procedures, especially the reintroduction of antibiotics in production, have led to problems further up the value chain. There is a clear correlation between outbreaks of AHPND and the number of detentions and rejections from shrimp importing countries (EU portal RASFF, 2016).

Figure 1. Examples of different levels of shrimp nurseries. Clockwise from top left: fibre glass tanks in a semi closed system with high level of aeration and water exchange, cement tanks in a semi closed system with high level of aeration and water exchange, and fully covered high level of aeration and water exchange.

Another approach is to introduce an additional production stage prior to stocking shrimp in grow-out ponds, namely the shrimp nursery phase. This is a practical management solution to deal with the disease. In the early days of shrimp farming in Southeast Asia, the use of nurseries was common practice, but the nurseries were phased out and direct stocking from hatchery to grow-out became the standard. In Latin America, the use of shrimp nurseries continued and developed further. This was done more as a management tool to increase growth of the shrimp and shorten the production cycle. In contrast, the recent reintroduction of shrimp nurseries in South-east Asia is more a measure of increased biosecurity, to protect against diseases in particular against AHPND.

Shrimp nurseries

The construction of nurseries can vary according to the level of production needed; knowledge and experience of the farmer as well as the level of investment the farmer has at his or her disposal. In Figure 1, we show some examples of shrimp nurseries; tanks in a semi closed system to high technology-high investment involving fully closed systems. One of the critical points is the transfer of the post larvae from nursery to grow-out. It is very important that this transfer is done as gentle as possible to minimise stress of the animals. Also at this stage e.g. 5 days before and 5 days after the transfer of the post larvae a high quality health booster additive or immune booster is given to help the post larvae with the transition.

The number of days the farmers keep the post larvae (PL10) in the nursery varies between 20-30 days. The additional days with better husbandry, higher quality diet and feed supplements in the nurseries are considered good protection against infections, especially with AHPND. This phase also increases the robustness of the shrimp towards other diseases.

Focus on high quality diet and feed supplements

The approach used in shrimp hatcheries to focus on higher quality products in the early stages of the life cycle should be carried over into the shrimp nurseries. The opportunity to culture the shrimp in more controlled conditions also gives an opportunity for the farmers to take better care of the shrimp and to produce a more robust animal. This is very important and will ensure economic benefit at harvest.

Table 1. Key performance indicators from shrimp farms in Thailand, using normal feeding protocols developed for nursery conditions, compared to high quality nutrition and health additive protocol developed for nurseries. Post larvae were stocked in the nursery as PL10 and again transferred to the grow-out pond after 24 days in the nursery (PL34).

	Normal feeding protocol	High quality feeding and additive protocol
PL density	5-10 PL/L	30-50 PL/L
Survival rate	85-90%	85-90%
Size	50% faster growth than direct stocking	85% faster growth than direct stocking
Grow-out stocking density	100,000/rai (62.5/m^2)	300,000/rai (187.5 PL/m^2)
Total bacteria count	$3.61X10^5$	$1.64X10^5$
Bacteria count (Yellow/Green)	8.88	7.98
Note: one rai equals 1,600 m^2		

In Table 1 the results from a commercial trial done in Thailand showed the difference between traditional feeding protocols for hatcheries compared to a high quality feeding protocol with high quality feed and addition of carefully selected marine protein sources and amino acid supplementation.

The numbers above indicate that there is a significant advantage from feeding post larvae at the nursery stage with high quality feed and health products with elevated doses of nutraceuticals and specific immunostimulants. The inclusion of these products ensure a diet with high levels of vitamins, lipids and nucleotides to support osmoregulation, growth and other vital processes during normal as well as stressful conditions. This all adds up into a stronger animal with a faster growth and improved survival.

It is also important to note that stocking densities can be a lot higher if a high quality diet and additives are used. This makes it easier for the farmer to manage his water quality, water usage and also lower the initial investment needed as it saves space and infrastructure. The normal stocking densities in Latin America varies, but is often not more than 10-12 post larvae (PL)/L and with survival rates about 75-85%. In the trials done in Thailand the survival rates were 85-90% with stocking densities at 35-40 PL/L and some farmers are now experimenting with stocking densities at around 50 PL/L.

Increased biosecurity

The increased levels of biosecurity that can be applied in a smaller water volume held in a tank or smaller pond, often in a building or under a roof are beneficial to the farmers as well (see Figure 1).

As an additional benefit the introduction of the nursery stage provides an extra point of quality control of the post larvae before stocking into the grow-out pond (Figure 2). This provides the farmers with opportunities to get their post larvae sampled and analysed for diseases before stocking to the grow-out pond. This can save the farmers a lot of work and potential economic losses.

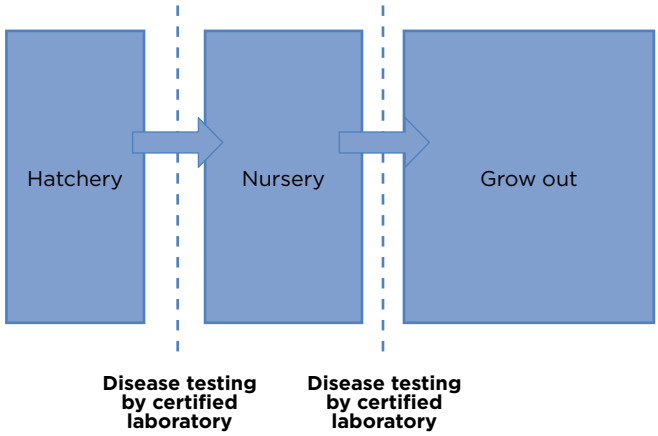

Figure 2. A schematic diagram showing the additional disease testing opportunity to reduce the risk of introducing shrimp with disease in the grow-out pond.

Throughout the shrimp farming industry, there seems to be several areas to increase levels of biosecurity. Looking at livestock industries (poultry and pig production), where quarantine for visitors, disinfection procedures and movement of animals are a lot stricter than in any aquaculture industry. In aquaculture, there is still room for considerable improvements on biosecurity. As part of the new normal, the shrimp industry should learn from other industries in this aspect and increase levels of biosecurity at all production steps including hatcheries, nurseries and grow-out ponds.

Conclusion

The reintroduction of shrimp nurseries in many South-east Asian countries is an important step in managing the new normal for the shrimp industry. The emergence of new diseases will not stop and the industry has to adapt to current and future diseases through adapting management practices and focusing on quality feed and feed supplements to ensure robust animals. Shrimp nurseries are already being implemented on a commercial scale by farmers in Thailand, Vietnam and Indonesia. Not only industry but also governments in some countries see the importance in the introduction of nurseries. The government in Vietnam through the Directorate of Fisheries, sees the benefit for small-scale farmers using nurseries to increase production without increasing land use.

Farmers setting up shrimp nurseries should focus on using high quality diet and feed supplements that are specially designed to be used at this stage of shrimp production. There is an increased cost associated with this, but an increase in volume at harvest will more than recover the initial extra cost for using nurseries. Keep in mind that many farmers today do not make it past 30 days of culture due to disease.

Biosecurity is of crucial importance for the industry, both to deal with current diseases, and also to be ready for new and emerging diseases. We cannot predict what new diseases will be, but many of the critical control points and biosecurity measures are likely to target transmission routes of new diseases as well. In order to deal with the 'new normal' in shrimp farming, of which shrimp diseases will definitely be a part of, the industry needs to adopt biosecurity measures at farm level and to apply management practices that include a focus on quality feed and supplements.

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Sustainable maturation protocol for shrimp using pellets as the main feed

By Aedrian Ortiz Johnson

Trials in Mexico and Brazil demonstrate the viability of cold-extruded semi-soft pellets for vannamei broodstock in achieving successful maturation and nauplii production numbers comparable to broodstock fed fresh feeds.

Traditionally, maturation departments within shrimp hatcheries all over the world have fed their *Penaeus vannamei* broodstock between 25-30% fresh feeds in order to get them to mate and spawn nauplii on a commercial scale. Feeding broodstock with squid, polychaete/bloodworm, clams, oysters and Artemia biomass typically allows for the following production numbers:

- 15%-20% mating per day
- 150,000-200,000 nauplii per female
- 60%-90% hatching rate
- Less than 3% female mortality rate

Disease is one of the biggest challenges in shrimp culture, with white spot syndrome (WSSV), Taura syndrome (TSV), infectious hypodermal and haematopoietic necrosis (IHHNV), baculoviral midgut gland necrosis (BMN), *Vibrio harveyi* and *V. parahaemolyticus* representing the most serious challenges. Most of these diseases are transmissible through fresh seafood such as polychaete/bloodworm, Artemia biomass, mussels, oysters and squid, etc. Traditional maturation diets are given in Table 1.

Traditional diets are associated with a number of challenges, mainly:

- Sourcing of all marine-based feed ingredients. As human consumption of these species increases, the availability of the best quality for use in maturation departments becomes more expensive and more challenging to source.
- Polychaete/bloodworm is especially difficult to source in some countries as stocks have been depleted by overharvesting.
- Disease represents the main risk for the broodstock used in maturation as well as their offspring (nauplius). Most of these food sources are wild, which makes them a possible vector of shrimp diseases such as WSSV, *V. harveyi* and *V. parahaemolyticus*. Even when sourced from non-shrimp farming countries, the risk of introducing new pathogens is significant.
- When using fresh feeds, it is often reported that shrimp broodstock refuse to eat or show little interest in formulated diets.

Replacing with formulated feeds

Vitalis 2.5 is a cold-extruded semi-soft pellet. It is formulated and produced at the Skretting's centre of excellence for hatchery diets in France. The formula is based on a high level of marine protein components, algae, omega-3 fatty acids (DHA/EPA), vitamins and minerals. The diet is formulated with a high protein content to support high fecundity and spawning frequency and is 2.5 mm in diameter and approximately 5mm in length.

Commercial trials feeding maturation broodstock with the dry pellet Vitalis 2.5 as the main food source of nutrition, plus 5% squid or 5% bloodworm, demonstrated that it is possible to obtain the same production parameters compared to traditional maturation feeds. These trials have been conducted in several countries. This article describes the methodology and results for trials conducted at commercial hatcheries in Mexico and Brazil.

The Vitalis 2.5 test diets consisted of:

- 3% body weight pellet, Vitalis 2.5 + 5% body weight squid, and
- 3% body weight pellet, Vitalis 2.5 + 5% body weight polychaete/bloodworm.

Mexico

Maricultura Del Pacifico S.A. de C.V. is one of the largest shrimp hatcheries in Mexico supplying the Mexican shrimp industry with post larvae, since 1992 and located in Mazatlán, Sinaloa. Since its beginnings, it has enjoyed a privileged location giving it access to markets, good weather and water quality, with a production capacity of 500 million post larvae/month. At present, it runs a genetic nucleus and a hatchery which consists of maturation, larvae culture, nurseries as well as an intensive grow out farm and a diagnostic laboratory.

The trial was divided into a control population of maturation tanks fed with the traditional maturation diet and a trial population fed with the test diet: 3% Vitalis 2.5 + 5% polychaete (Table 2).

Table 1. Types and sources of traditional maturation diets in Asia and the Americas.

Feed	% wet body weight	Sourced from:
Polychaete/ bloodworm	5-10	Locally, China, US, The Netherlands and UK
Squid	5-10	Locally, California
Mussels	3-8	Locally, New Zealand
Artemia biomass	3-8	Locally, USA, Russia, China
Dry pellet	1-3	Many brands

Table 2. Feeds and feeding rate, Mexico trial.

Groups/ Feeds	Squid	Mussels	Oysters	Polychaete	Pellet Feed	Total bodyweight /day
Control	+	+	+	+	-	25%
Vitalis 2.5	-	-	-	5%	3%	8%

The maturation tanks consisted of eight broodstock/m^2 with a 1:1 male to female ratio, 200% daily water exchange, average water temperature of 28 °C and average salinity of 35 ppt. Control females were 40.0 g versus 32.8 g for trial females. Feeding was divided into five daily rations.

The trial showed no significant difference between both diets. The trial diet Vitalis 2.5 + polychaete had a 4% higher production

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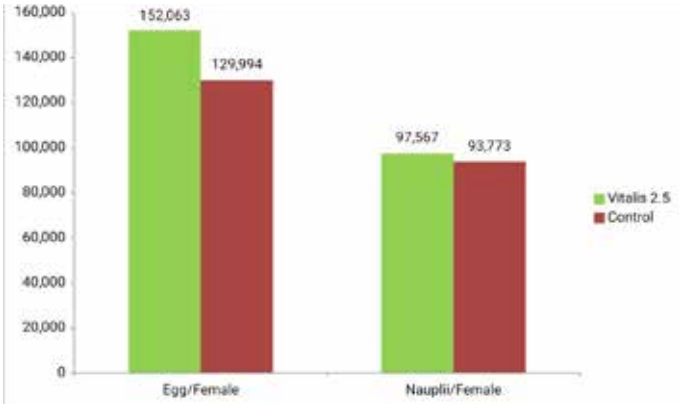
of nauplii per female (Table 3, Figure 1). The trial also showed that broodstock animals freely switched between fresh and formulated feeds without any bias.

Table 3. Comparison of spawning parameters for broodstock fed with pellets and control feed, Mexico trial.

Indicators	Vitalis 2.5	Control
Eggs/female	152,063	129,994
Nauplii/female	97,567	93,773
% hatching rate	64.8%	71.0%
% mating	13.6%	13.2%
Weight female (g)	32.8	40.0
Female number	300	500
Note: The egg and nauplii numbers were calculated based on biomass ratio.		



Note: The egg and nauplii numbers were calculated based on biomass ratio.

Figure 1. Eggs/female and nauplii/female from broodstock fed pellets and control feed, Mexico trial.

Brazil

The trial took place in one of the largest hatcheries and market leaders in Brazil, based in Rio Grande do Norte. It has shrimp farms and a shrimp hatchery with a production capacity of 250 million post larvae/month.

The trial was divided into a control population of maturation tanks fed with the traditional maturation diet and a trial population fed with the test diet: 3% Vitalis 2.5 + 5% squid (Table 4).

Table 4. Feeds and feeding rate, Brazil trial.

Groups/ Feeds	Squid	Mussels	Chicken liver	Artemia Biomass	Pellet Feed	Total BW/day
Control	12%	3%	3%	5%	1%	24%
Vitalis 2.5	5%	-	-	-	3%	8%

The maturation tanks consisted of 8 broodstock/m^2, with 1:1 male to female ratio, 250% daily water exchange, average water temperature 28°C and average salinity 35 ppt. Control females were 53.5 g versus 51.2 g for trial females. Feeding was divided into five daily rations.

The trial showed no significant difference between either diet. The trial diet Vitalis 2.5 + squid had 10% less number of nauplii per female (Table 5). The water quality in the maturation tanks was drastically improved and this result was reflected in a reduction of female mortality.

Table 5. Comparison of spawning parameters for broodstock fed pellets and control feed in the trial in Brazil.

Indicators	Vitalis 2.5	Control
Eggs/female	242,684	258,307
Nauplii/female	146,473	161,345
Hatching rate	61%	63%
% Mating	20%	20%
Survival/female	94%	87%
Weight female (g)	51.2	53.5
Female number	187	301
Water quality	+++	++

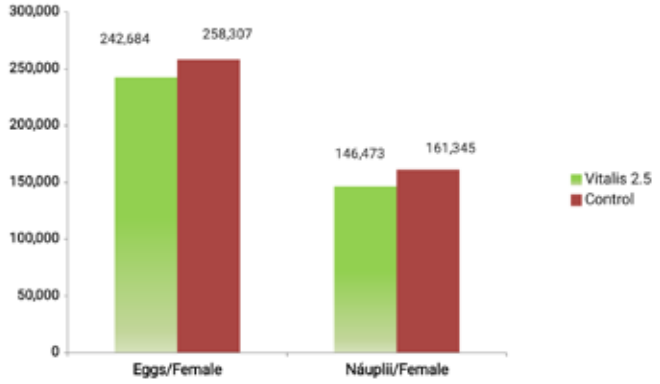


Figure 2. Plot of eggs/female and nauplii/female from broodstock fed pellets and control feed, Brazil trial.

Discussion

After several commercial trials, we observed that the pellet feed can be used as the main feed ingredient and still achieve successful maturation production numbers. Therefore, we no longer need to rely on fresh diets which represent a health hazard in this first stage of shrimp farming.

Both combinations: Vitalis 2.5 + squid and Vitalis 2.5 + polychaete produced the same results, in Mexico and Brazil. Although following different feeding schedules and ingredients, the results were statistically the same. Number of nauplii per female and % mating were not significantly different.

Commercial use of the pelleted feed is ongoing in both countries, using 3% Vitalis 2.5 pellet + 5% squid with the same results. Further research is needed to challenge other paradigms such as amount of water usage, eye ablation, etc.

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Smart fish feeder start up

An internet of things for the aquaculture industry in Indonesia and promoting a digital future.

The new generation of farmers in shrimp and fish farming in Asia needs technology to bring industry to the next level. Smart fish feeder start up eFishery is facilitating this transformation with digital innovations, initially for Indonesian farmers. At the Asian Pacific Aquaculture (APA 2016), the eFishery team shared their journey as the first start-up for aquaculture in Indonesia.

eFishery's CEO, Gibran Huzaifah was farming catfish in Bandung when a couple of fish farmer friends mentioned how at times feeding fish and shrimp is time consuming and is too problematic. To them feeding is the biggest challenge. They asked Gibran, a biology graduate, whether technology can solve their problems.

"I can sympathise with farmers as it is difficult to make good profits. When I was in college, my aquaculture professor inspired me to start a farm. However, I had two loss making cycles until I value-added my fish harvests and sold cooked nuggets at a stall near my college. I noticed that fish feeding was run inefficiently by labourers and farmers do not have the technology and knowledge to optimise feeding operations. This is very important as feed costs can reach as high as 80% of operating costs for some farms. At eFishery, we believe technology can make fish farming easier, efficient and profitable.

"We started by developing an automatic fish feeder and then realised that such feeders merely replaced human labour which is not really an issue in Indonesia. What if we can make a smart feeder that can allow the owners of farms to have more control in their business?"

eFishery developed a prototype demand fish feeder but took this further. Chrisna Aditya W, Chief Innovation Officer said, "As an internet of things, we developed automatic smart feeders that can connect to the internet and use sensors to measure fish appetite. Our technology calculates the right amount of feed to dispense. We can then automatically feed the fish. Farmers do not only operate the feeders but can ask for solutions to some problems and then use the social media platform to market the fish. We also connect farmers to the rest of industry (feedmills, health and aquaculture solutions providers and buyers).

"Since we started a year ago, we have gone through five different prototypes and we are still improving the designs such as to reduce energy consumption. Adding a solar panel is one way. The feeders are designed for both small and large scale operations and can deliver real time reports of fish consumption to the farmers' smartphones."

The eFishery team, from left, Rully Setya P, Chief Operating Officer, Gibran Huzaifah, Chrisna Aditya W and Ivan Nashara, VP of Digital. Rully Setya came from the marine fish farming industry.

Gibran said that as a new company, their focus is the market in Indonesia. eFishery's smart feeder is being used by government institutions and leading aquaculture companies such as PT Suri Tani Pemuka and other farms in Java and Sumatra. "We develop according to market demands. We also have small capacity smart feeders which are more affordable, for example for catfish farmers, and can be moved around easily. The feeding device is located on the pond dykes and have 90 degrees and up to 10 m spread for 1-5 mm pellets. However, we need to develop smart feeders with the species in mind and also for larger feed sizes. We need to install fish algorithm in the device to cope with feeding fish for different species and different feed sizes."

In the November/December 2015 issue, AAP carried news on eFishery funding. It secured pre-series A funding led by Aqua-Spark, a Netherlands based aquaculture investment fund. Indonesian venture capital firm Ideosource also participated in this round of funding.

eFishery's business model includes subscription fees for the mobile software to monitor feed usage. It will use the funds to scale up its distribution network, engage local partners, and expand its market share aggressively in Indonesia. After Indonesia, the team aims to sell to customers in the region.

Gibran said, "Our technology can attract funding from both conventional and tech venture capital. We are very positive in terms of funding. We are looking at being successful, sustainable and profitable."

In-Pond raceway aquaculture (IPA) technology expands in China

By Zhou Enhua

Laying the foundation in the transformation of China's freshwater fish farming with this closed system technology; moving from uncontrolled traditional pond culture to ecological and measurable culture for quality and safe products.

In 2015, the total aquaculture production in China was 49.4 million tonnes, in which freshwater aquaculture was 30.6 million tonnes, accounting for 62% of the total production in China. Freshwater aquaculture contributed 27.2 million tonnes of food fish in 2014. It is an important sector in China's rural economy and the industrialisation of freshwater fish farming has elevated farmer's incomes by 23 times to an annual CNY 14,000/person which is higher than those working in the agriculture sector. The supply in 2014 was sufficient to meet the demand for the 47.24 kg per capita of fish consumption. It also provides a steady fish supply to the majority of Chinese consumers, a business enterprise for farmers and downstream players involved in processing, marketing and trade in freshwater fishes (Xianping, Ge, 2016).

The importance of freshwater fishes to the national food consumption sector is evident as it comprises a third of the commodities in the price index food basket. China's 13th Five-year Plan (2016-2020) targets a production of 70 million tonnes of aquatic products and aquaculture is projected to contribute from 73% in 2015 to 75% of the total aquatic production in 2020. The target is not only additional volumes, but also a supply of safe aquatic products.

The total area used for freshwater aquaculture was 6.08 million ha in 2014. Ponds accounted for 2.66 million ha or 43.7%. In recent years, concerns on the environmental effects of intensive farming have increased, especially when some water bodies are also important tourist sites. Traditional fish farming methods in China cause serious pollution of water such as in the Yangtze River and Pearl River Deltas. Declines in productivity have led to higher costs of production and decreased economic efficiency. Consumers question the safety of fish products because of the excessive use of chemicals for disease treatments.

According to the Ministry of Environmental Protection, some 60% of water resources fall into the low and middle quality range. The Ministry is promoting efforts on water quality improvements such as implementing a triple purification system which will remove 74% of total nitrogen and up to 69% total phosphorus from contaminated water sources. For our entrepreneurs, we need to find ways to further develop aquaculture industry during the 13th Five-year Plan.

IPA, an innovation in pond raceway systems

As early as 2007, the US Soybean Export Council (USSEC) started a technical collaboration with Auburn University in the USA working on the development of the in-pond raceway aquaculture technology (IPA). This system integrates the traditional pond aquaculture system and raceway system. The IPA technology was first developed in the United States as a means to improve the inventory harvests in big and undrainable earthen ponds. Moreover, the IPA technology also increases fish production in conventional pond units by culturing in a confined raceway with aeration, flowing water and removing fish and feed wastes. The IPA technology was first transferred to China by USSEC/China through a cooperative project funded by the Iowa Soybean Association and tested at the Pingwang Fish Farm of the Wujiang Municipal Aquaculture Co. Ltd., Suzhou City, Jiangsu Province in 2013.

The USSEC IPA Demonstration Farm in Songjiang, Shanghai

At the farm, three concrete in-pond raceway cells were constructed in a 32 mu (2.1 ha) pond. The raceway cells are 110 m^2 in area i.e. 22 m X 5m (LXW). A 13 m x 3 m channel was constructed at the downstream end of the three cells for collection of fish and feed wastes. Grass carp was the first species to be tested in the IPA system. The first USSEC IPA demonstration results are shown as follows:

Table 1. Harvest results of the first USSEC IPA demonstration in Pingwang, Jiangsu Province in 2013

	Cell No 1	Cell No 2
Fish species	Grass carp	Grass carp
Initial stocking size (g)	750	300
No of days	168	168
Harvest size (g)	2,614	1,660
Fish production (kg/m^3)	130.7	86.2
Total fish production (kg/tank)	21,568	14,223
FCR	2.0	1.8
ROI (%)	20	18

In 2014, the USSEC IPA technology was transferred and adopted in four different cities and provinces, such as Shanghai, Jiangsu, Anhui and Shanxi Provinces, with a total cell area of 26,190 m^2. By 2015, the area under this technology totalled 62,697 m^2 in eight

cities and provinces including Jiangsu, Anhui, Shanxi, Zhejiang, Fujian, Shanghai, Beijing and Chongqing. The largest IPA system with 52 cells is now operating in Jianhu County, Jiangsu Province. The IPA technology is also the answer to China's problem of limited water resources with its zero water discharge. Per capita, China has only a quarter of the world's average water resources and is one of the 13 countries with a shortage of water supply. By 2030, it will have only 1,600 m^3/capita of water resources because of the population increase. China faces not only limited water resources but also good quality water for aquaculture. We estimate that water available for freshwater fish farming will decline in the future. Nationwide we have been upgrading pond farming technology but we find it difficult to alleviate the water pollution factor. It is important to address this challenge.

In the IPA system, each in-pond raceway or cell has been installed with air-lift white water units for aeration and moving water at the upstream end. Each cell can be stocked with different fed fish species and outside these areas for the purification of the water where non-fed species such as the filter feeders bighead carp, paddle fish, silver carp and pearl clam are cultured. Fed fish species include grass carp, black carp, tilapia channel catfish, wuchang carp, crucian carp and largemouth bass. Water in raceway cells move towards one end and waste and faecal matter are collected at the quiescent zone and is then vacuumed out. This prevents eutrophication and pollution of the whole water body in pond (Figure 1). With this system, we do not have to reduce stocking density which is a common solution to poor water quality in traditional ponds. Instead of cement, we can also use PVC sheets and some soft materials to create the raceway cells.

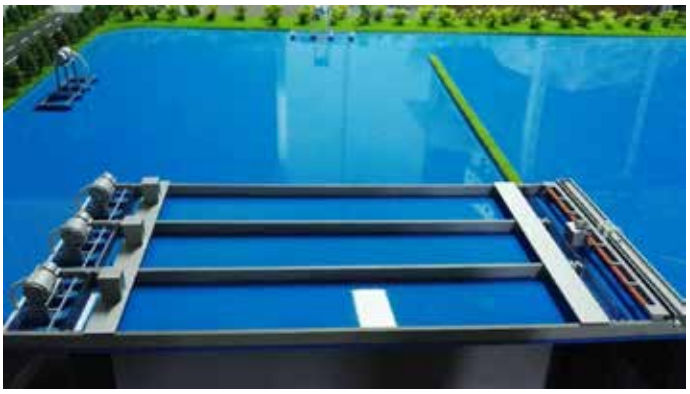

Figure 1. Model of the USSEC In-pond Raceway Aquaculture Technology

Technical superiority

The technology takes advantage of multi species culture. An interesting observation is that an increase in biomass by as much as 200% is possible and no extra water and farming area is required. Better water quality leads to less disease problems. The fast water flow and higher dissolved oxygen raise the survival rates to >95% and less chemicals are used for culture in comparison to traditional pond culture. Feed digestibility also improves. In a survey conducted, the USSEC IPA demonstration results showed that the use of chemicals was reduced by 90-95%. In some instances, no drugs were used. This means that we can assure the food safety of fish harvested.

With rising costs of labour in China, this technology is a model for industrialisation and automation of aquaculture in China. Auto feeders are positioned at one end of the rectangular culture areas. In general, labour costs can be reduced by 50%, for instance,

The USSEC IPA Demonstration Farm with 52 cells in Jianhu County, Jiangsu Province

USSEC Aquaculture Consultant Jesse Chappell, Auburn University, USA (centre), Technical Manager (left) and IPA Co-operator (right) at the USSEC IPA Demonstration farm in Shanghai

only 4-5 workers are required for managing 52-cell IPA farm. To further reduce labour, the USSEC team is researching into more automation where the waste collection can be done at the touch of a button. Harvesting can be improved by transferring fish into hapas and by using cranes. A next step is the automation in fish grading by placing graders across the tanks, allowing smaller fish to pass through. All in all, we are laying the foundation in the modernisation of China's freshwater fish farming with this closed ecosystem technology which will also allow for more precise data collection.

Intensification

This technology is also a model for super intensive culture of various freshwater fish in an outdoor pond. The farm can change species without affecting profitability. Based on the USSEC IPA demonstration results of grass carp in the previous years, the biomass recommended is 25,000 -30,000 kg in one cell of 110 m^2. In Shanghai, we demonstrated how IPA technology increases the productivity of aquaculture in existing pond units. The removal of solid wastes allows for a threefold or greater increase in fish production over traditional pond culture technologies. For example, in the IPA system farming with grass carp the return on investment (ROI) improved to 34.1% in the demonstration site in Shanghai. There was less mortality and better feed conversion ratio (FCR) (Table 2).

The USSEC IPA demonstration results with grass carp showed 20-34 tonnes/cell and 23.4-36 tones/cell in Lu'an City, Anhui Province and Jianhu County, Jiangsu Province, respectively (Table 3 and 4).

Table 2. Harvest results of the USSEC IPA demonstration in Shanghai in 2015

	Cell No 1	Cell No 2
Fish species	Snakehead	Grass carp
Initial stocking size (g)	250	188
No of days	230	230
Harvest size (g)	650	1,435
Fish production (kg/m^3)	31.6	75.9
Total fish production (kg/cell)	6,318	15,180
FCR	1.46	1.63
Survival (%)	97.1	84.4
ROI (%)	0.76	34.1

Table 3. Harvest results of the USSEC IPA demonstration in Luan, Anhui Province in 2015

	Cell No 1	Cell No 2
Fish species	Grass carp	Grass carp
Initial stocking size (g)	750	100
No of days	230	230
Harvest size (g)	2880	1,400
Fish production (kg/m^3)	156	95
Total fish production (kg/cell)	34298	20864
FCR	1.52	1.49
Survival (%)	99	99
ROI (%)	40.3	11.2

Table 4. Harvest results of the USSEC 52-cell IPA demonstration in Jianhu, Jiangsu Province in 2015

	Cell No 1	Cell No 2
Fish species	Grass carp	Grass carp
Initial stocking size (g)	350	700
No of days	205	205
Harvest size (g)	3,100	4,000
Fish production (kg/m^3)	164	106
Total fish production (kg/cell)	36,053	23,460
FCR	1.39	1.42
Survival (%)	99.8	99.6
ROI (%)	33.7	42.0

This is a step towards the intelligent and smart aquaculture road map given to us.

Professor Zhou Enhua has been working with the U.S. Soybean Export Council (USSEC) for 17 years. He is a Technical Manager for freshwater aquaculture programs in China. He pioneered the transfer of IPA technology from the US by conducting the first IPA demonstration in China in 2013. Previously, he was with the National Freshwater Fisheries Research Center (FFRC) of the Chinese Academy for Fishery Sciences for about 15 years. Email: ehzhou@ussec.org

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City University of Hong Kong's School of Veterinary Medicine working jointly with the Institute of Aquaculture, University of Stirling, Scotland, is introducing an **MSc course in AQUATIC PRODUCTION AND VETERINARY HEALTH** in **SEPTEMBER 2016**. A team of experienced staff of aquatic veterinary medicine and higher education from Hong Kong and Scotland has created this MSc programme.

The programme covers professional subject areas such as:

- Aquatic Animal Biology and Health
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- Bacterial, Viral, and Parasitic Diseases
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Multiple functions of *Lactobacillus* spp. fermented soybean meal in aquafeed

By Winton Cheng and Yu-Hung Lin

Substituting fish meal with soybean meal in aquafeeds raises the issue of high levels of antinutritional factors and consequent effects on growth and health. A series of studies show how substituting for fish meal with *Lactobacillus* spp. fermented soybean meal alleviates some of these concerns in the grouper and white shrimp.

The major protein ingredient in aquafeeds largely comprises fish meal. Whilst there is no doubt on the high nutritional value of good quality fish meal, the best quality is expensive. According to some projections, their availability is expected to decline with increases in price. Therefore, there is a need to identify and utilise less expensive and more sustainable protein sources for aquafeed production. Soybean meals are the most widely used plant ingredient for aquafeeds. However, the use of soybean meal is limited because of its deficiency in methionine and lysine and the presence of antinutritional factors (ANF) such as trypsin inhibitors, haemagglutinin, phytic acid, saponins, phytoestrogens and anti-vitamins.

In Asia, traditionally, the quality of soybean meal can be improved by fermentation with microorganisms, including *Lactobacillus* spp., *Bacillus* spp. and *Aspergillus* spp. Fermented soybean meal commonly shows less antinutritional factors, smaller protein molecular weight, more metabolites and small peptides than in untreated soybean meal (Zhuo et al., 2014). It is worth mentioning the additional functions of these metabolites and small peptides in fermented soybean meal products.

The disease challenge

The occurrence and spread of fish and shrimp diseases have constrained the global expansion of farming and its productivity. Often farmers tend to use antibiotics excessively as prophylactics in an attempt to mitigate these disease challenges. In recent years, antibiotics usage has been met with increasing opposition due to concerns over the long term impacts on the environment as well as potential harm to human consumers. Moreover, research has shown that the long term use of antibiotics can actually become less effective due to the emergence of resistant bacterial strains in aquatic animals (Rebouças et al., 2011) while excessive levels can adversely affect growth and overall animal condition (Bray et al., 2006).

Consequently, identifying suitable antibiotic alternatives is receiving increasing attention. One such preventive measure is the development of various nutritional strategies that can enhance the immunity and resistance to diseases for cultured animals. Fish and shrimp are infected by pathogens, such as *Vibrio* spp. mostly through their food or rearing water. Thus, the intestinal health of aquatic animals would play a key role in preventing foodborne or waterborne diseases. This article introduces our recent studies on *Lactobacillus* spp. fermented soybean meal used as protein sources in aquafeeds. In these studies, we show that fermented ingredients are not only high quality protein sources but also act as immunostimulants and intestinal health enhancers.

A high quality protein source

A formulated diet may appear, from its chemical composition, to be an excellent source of nutrients for fish and shrimp growth; however, it will be of little value unless it can be digested and absorbed. An effective protein source should show good digestibility in aquafeed. The apparent digestibility coefficients (ADC) of dry matter and protein of fish meal, soybean meal and *Lactobacillus* spp. fermented soybean meal in diets for orange-spotted grouper (*Epinephelus coioides*) and white shrimp (*Litopenaeus vannamei*), were determined by using 0.5% Cr_2O_3 as an inert indicator.

The *Lactobacillus* spp. fermented soybean meal used in the two studies was supplied by DaBomb Protein Corporation, Taiwan. In the grouper, the ADC of dry matter was highest in fish meal, followed by *Lactobacillus* spp. fermented soybean meal and lowest in soybean meal (Figure 1). The ADC of protein was higher in fish meal and fermented soybean meal than in soybean meal. These results suggested that for grouper, the digestibility of soybean protein can be improved through *Lactobacillus* fermentation of soybean meal (Zhuo et al., 2016).

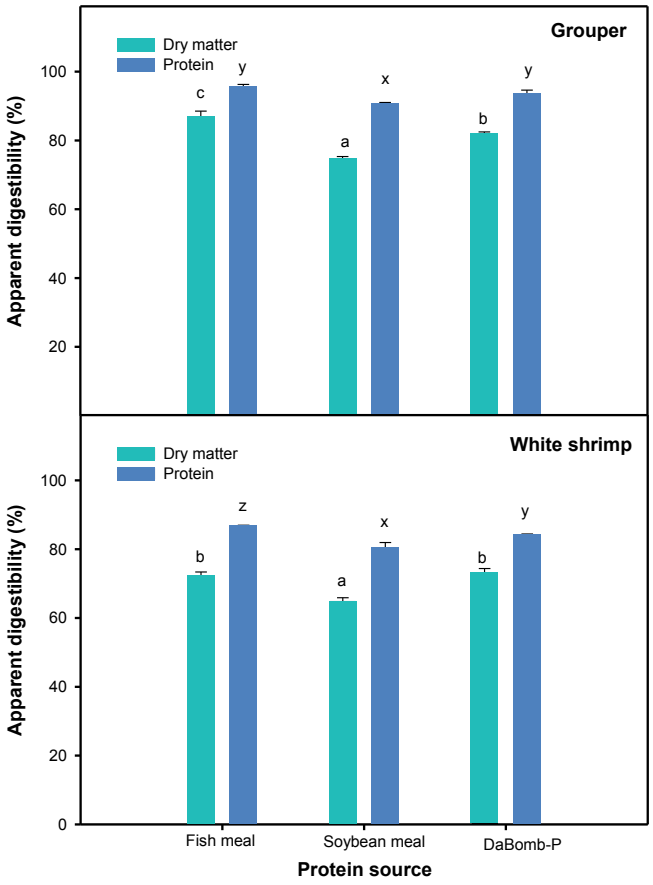

Figure 1. Apparent digestibility of dry matter and protein of fish meal, soybean meal and *Lactobacillus* spp. fermented soybean meal (DaBomb-P) in grouper and Pacific white shrimp. (Data used in the figure were obtained from Zhuo et al. (2014, 2016).

A similar trend was found in the white shrimp which showed enhanced digestibility of fermented soybean meal (Zhuo et al., 2014). Our results agreed with some previous studies. Fermented soybean meal showed higher protein digestibility (94.0%) than soybean meal (83.2%) in diets of Chinese sucker *Beaufortia kweichowensis* (Yuan et al., 2010). Yan et al. (2012) reported that nitrogen digestibility of *Lactobacillus* spp. fermented soybean meal was better than that of *Aspergillus oryzae* fermented soybean meal in diets for pigs. The authors explained that this is because the protein hydrolysis ability is greater in *Lactobacillus* spp. than that in *A. oryzae*.

We also measured the molecular weight of soluble protein fractions in soybean meal and fermented soybean meal by high performance liquid chromatography (HPLC). The molecular weight of soybean meal and fermented soybean meal were mainly distributed at 30-70 kDa (66.7%) and ≤ 30 kDa (75.39%), respectively (Figure 2). This clearly indicated that the molecular weight of soybean meal protein was degraded by *Lactobacillus* spp. fermentation. Moreover, we also found that the small peptides (molecular weight < 10 kDa), critical quality indicators for fermented soybean meal, comprised 16.35% of total soluble peptides in the fermented soybean meal. Hence, higher digestibility of fermented soybean meal as compared to that for soybean meal for white shrimp was to be expected.

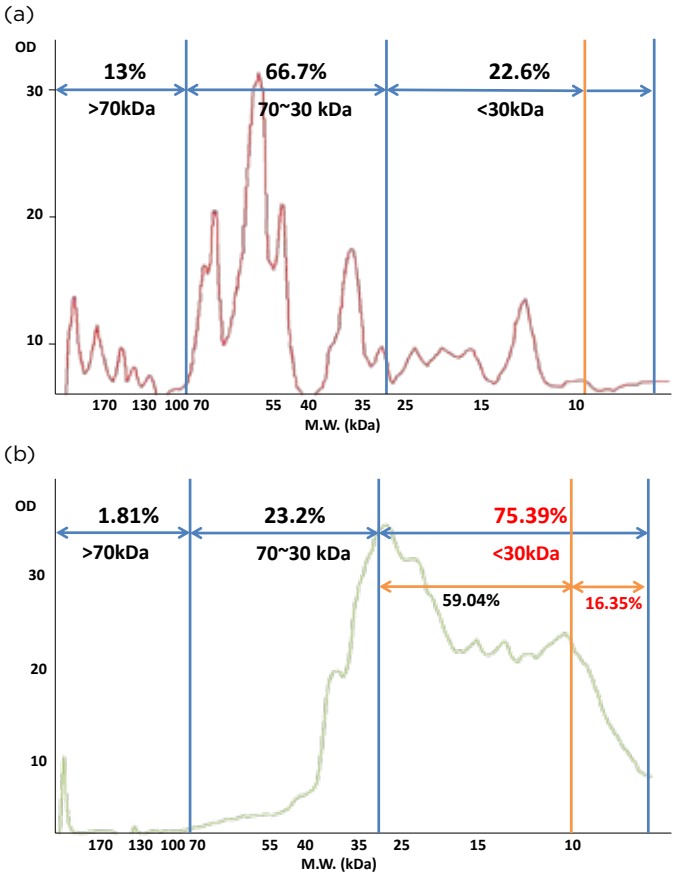

Figure 2. The distribution of molecular weight of protein. (a) soybean meal; (b) hydrolysed soy protein. The protein molecular weight distribution was measured by high performance liquid chromatography (HPLC).

Water quality also plays an important role in successful aquaculture industry. Approximately 90% ammonia in water are produced from the protein metabolism of aquatic animals. High concentration of ammonia is harmful to aquatic organisms

and affects their physiological and immunological responses. In addition, organic compounds also play a part. Our previous study found an interesting phenomenon in that shrimp fed diets with 10-20% fermented soybean meal showed less nitrite-N excretion compared with the shrimp fed all fish meal diet (Figure 3). Besides growth performance, fermented soybean meal inclusion in diets also showed beneficial effects on the immunity and intestinal health in fish.

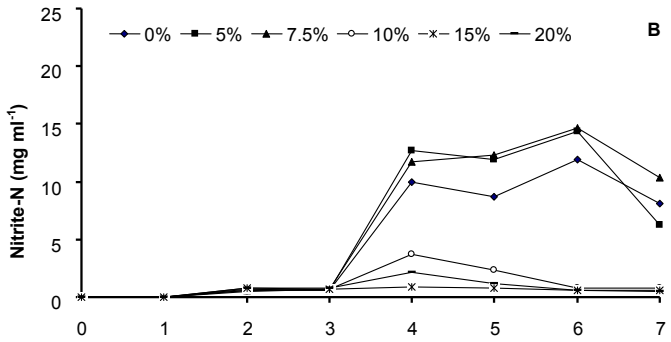

Figure 3. The changes of nitrite-N concentration in the rearing water of *Litopenaeus vannamei* fed different diets for 7 weeks.

Effects of partial replacement of fish meal by *Lactobacillus* spp. fermented soybean meal on the growth performance of aquatic animals have been evaluated previously. The results indicated that the fermented soybean meal can replace fish meal protein at 30%, 20% and 40% for orange-spotted grouper, white shrimp and Asian sea bass, respectively but with no growth-promoting effect. The beneficial effect of this ingredient is for immunity or intestinal health. Overall, we summarised from these performance parameters that undoubtedly, fermented soybean meal is superior as an alternative to fish meal relative to soybean meal.

Immuno-modulatory effects

The immune system can be influenced by a wide range of factors, including disease, pollutants, hormones and diet. Recent evidence suggests that nutritional and immune status are tightly linked (Lygren and Waagbø, 1999). Dietary immunomodulation has the potential to greatly aid aquaculture production through prevention of disease and/or improvement of disease resistance. However, information on the influence of feedstuff on fish health, including immune response and disease resistance, is limited.

In our previous replacement study, fish meal protein was replaced by *Lactobacillus* spp. fermented soybean meal (DaBomb Protein Corp., Taiwan) at 0, 5, 7.5, 10, 15 and 20% in white shrimp diet. After an 8-week feeding trial, non-specific immune responses and challenge test of *Vibrio alginolyticus* were measured for white shrimp. Total haemocyte count (THC), superoxide dismutase (SOD) activity and survival to *V. alginolyticus* challenge showed higher responses at 7.5-15% replacement level compared to the control diet (Figure 4). Our study with the grouper showed a similar trend with higher macrophage respiratory burst activity and survival to *Photobacterium damsela* observed in the fish fed diets with 30-40% fermented soybean meal (substituting for fish meal) in comparison with fish fed an all fish meal control diet.

In Asia, the most recent disease to hit the global shrimp industry is the acute hepatopancreatic necrosis disease (AHPND) or more commonly known as early mortality syndrome (EMS) where shrimp mortalities can be 100% when infected with certain strains of *V. parahaemolyticus* (Tran et al., 2013). In an *in vitro* antibacterial study, we found the solution of *Lactobacillus* spp. fermented soybean meal showed significant depression (32%) of bacteria count of *V. parahemolyticus*. It encouraged us to evaluate

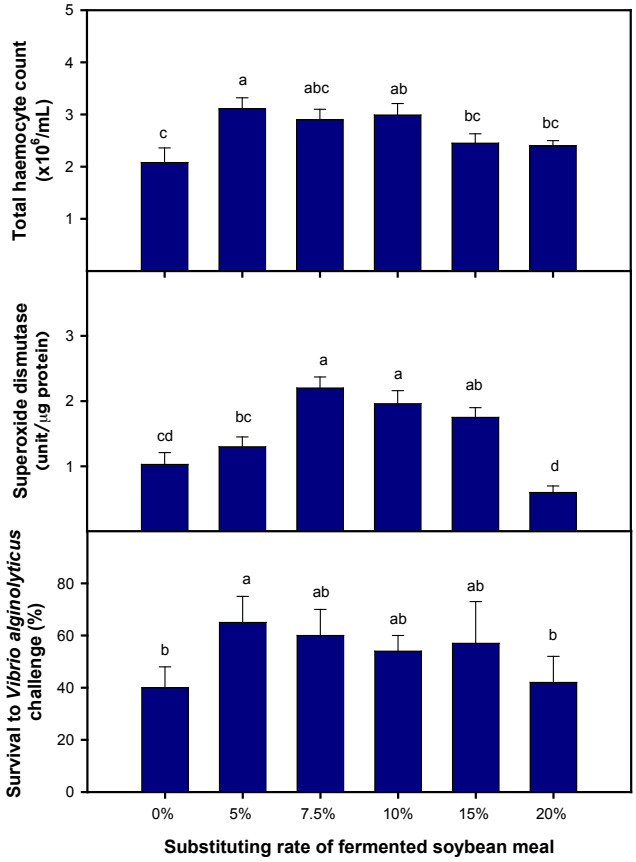

Figure 4. The immune responses of white shrimp fed diets with different substituting rate of fermented soybean meal for 8 weeks.

the fermented soybean meal as a feed additive against pathogen infection. The white shrimp were fed all fish meal control diet and control diet supplemented with 2.5% *Lactobacillus* spp. fermented soybean meal (DaBomb Protein Corp.) in a feeding trial. The immune gene expression, including clotting protein, transglutaminase and lysozyme, were significantly improved in shrimp fed with 2.5% fermented soybean meal (Table 1). Other non-specific immune parameters, such as total haemocyte count, hyaline cells, granular cells, phenol oxidase activity and total protein concentration were also enhanced. We also challenged the shrimp with two strains of *Vibrio* spp., *V. parahemolyticus* and *V. alginolyticus*. The survival rates of shrimp infected by *V. parahaemolyticus* and *V. alginolyticus* were higher in shrimp fed diets with 2.5% fermented soybean meal compared with the control group.

The suppression of the immune responses of shrimp fed with soybean meal might be due to the imbalanced nutritional status of shrimp due to the antinutritional factors in the soybean meal or the imbalanced nutritional composition of soybean meal. Our studies demonstrated that *Lactobacillus* spp. fermented soybean meal can be used as an immunostimulant for grouper and white shrimp. Fermentation by *Lactobacillus* spp. can degrade most of the antinutritional factors in soybean meal. In addition, the soybean proteins are hydrolysed to peptides which can be well digested and absorbed by fish and shrimp. The overall enhancement of nutritional values of soybean will enhance the immunity of aquatic animals. Moreover, bioactive peptides derived from soybean have been well demonstrated in human research (Singh et al., 2014). The beneficial health effects of bioactive peptides may be due to several compunds that are antihypertensive, antioxidative, antiobesity, immunomodulatory, antidiabetic, hypocholesterolemic and anticancer. High concentrations of small peptides levels in *Lactobacillus* spp. fermented soybean meal can also explain the immunostimulation ability in this ingredient.

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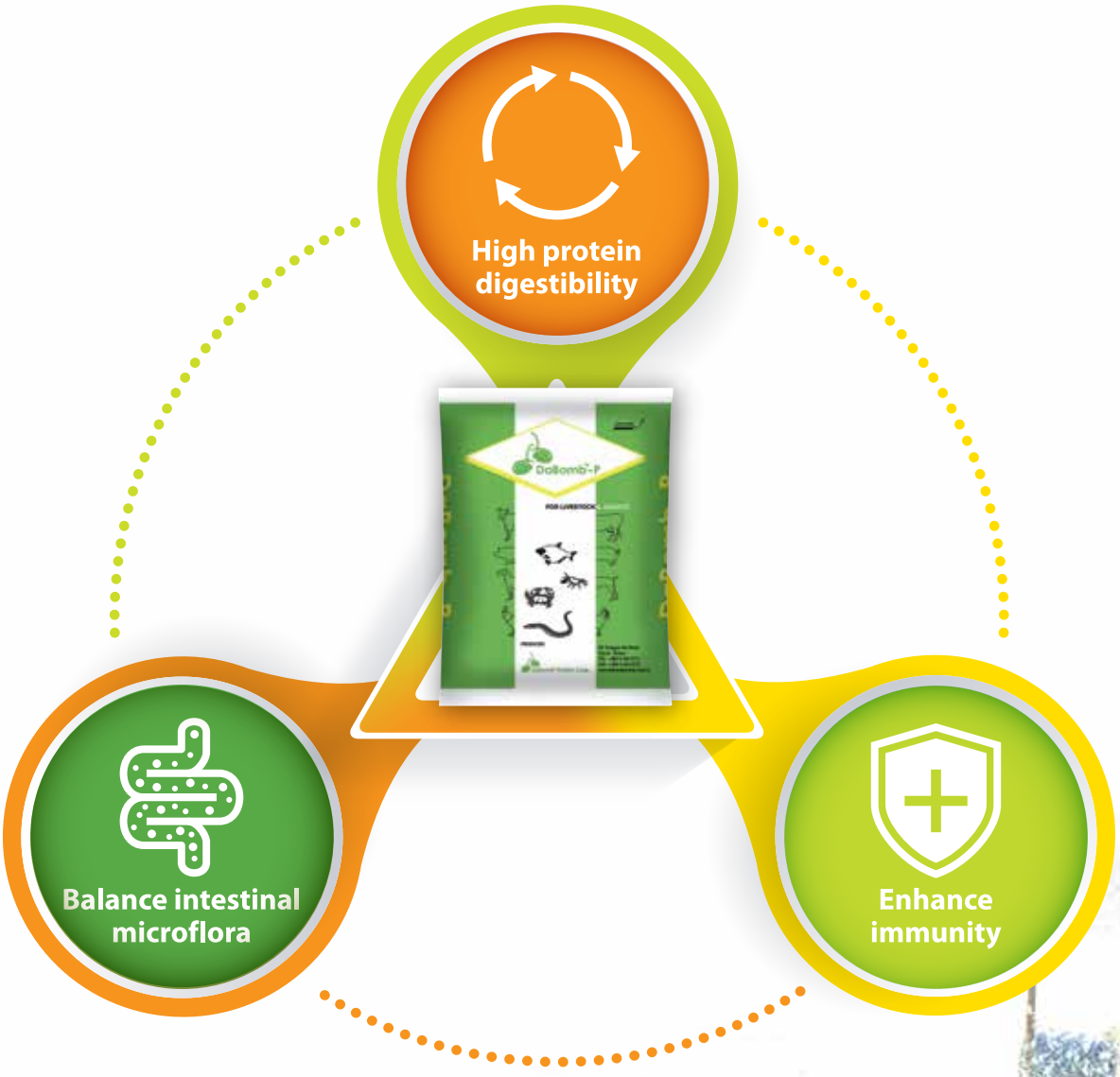

DaBomb inside

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Table 1. Immune gene expression, non-specific immune responses and shrimp survival to pathogens when fed diet containing 2.5% *Lactobacillus* spp. fermented soybean meal.

	Control	Control +2.5% fermented soybean meal	% change vs control
Immune gene expression			
Clotting protein (fold)	1	1.26	25.80
Transglutaminase (fold)	1	3.78	277.70
Lysozyme (fold)	1	1.12	12.40
Immune responses			
Total haemocyte count (x10^4/mL)	3.68	4.55	23.64
hyaline cells (x10^4/mL)	1.88	2.54	35.11
granular cells (x10^4/mL)	0.57	0.81	42.11
phenol oxidase (O.D. 490 nm)	1.49	4.62	210.07
Total protein (mg/mL)	55.86	86.56	54.96
Survival to pathogen			
Vibrio parahaemolyticus (%)	1.8	26.20	1,355.56
Vibrio alginolyticus(%)	36.7	56.70	54.50

Intestinal function enhancer

It is important to pay attention to the amount of antinutritional factors found in soybean meal. This will cause poor performance of the culture species when fed diets with high levels of soybean meal. Microorganism bioprocess is an ideal way to remove almost all antinutritional factors. Glycinin and β-conglycinin derived from soybean meal have been demonstrated to be the main antigenic components that cause allergic reaction in animals (Xu et al., 2010). Figure 5 showed that the glycinin and β-conglycinin in soybean meal were completely degraded through the *Lactobacillus* spp. fermentation. Thus, it means that the animal fed with *Lactobacillus* spp. fermented soybean meal can improve the enteritis condition and inflammation of villi caused by antinutritional factors compared with animals fed with un-processed soybean meal.

In our previous grouper study, we also found that when 20% fish meal was replaced by soybean meal in the diet, there was some damage to the villi of the orange-spotted grouper compared to fish fed all fish meal diets. For example, cell infiltration of the submucosa and lamina propria increased, and extended lamina propria in this group was also observed (Figure 6). Interestingly, when fish meal protein was replaced by *Lactobacillus* spp. fermented soybean meal, there was a significant reduction in the negative effects found in fish fed soybean meal. Soybean meal-induced enteritis is commonly found in carnivorous fish (Krogdahl et al., 2003). It is considered as an inflammatory disease caused by antinutritional factors derived from soybean meal. Our results clearly indicate the fermentation of *Lactobacillus* spp. in soybean meal can reduce antinutritional factors levels and improve intestinal health.

The organic acid (lactic acid) concentration in fermented soybean meal used in our study was about 6%. It has been reported that dietary lactic acid supplementation enhanced the nutrient utilisation by rainbow trout (Pandey and Satoh, 2008). Short chain organic acids (C1-C6), including lactic, formic, citric and propionic acids have been shown to inhibit various *Vibrio* spp. strains *in vitro* (da Silva et al., 2013). This is often attributed to enhanced nutrient availability due to a reduction or alteration of gastrointestinal bacteria as well as the acidifying effects to the diet and gut, which can chelate or solubilise minerals and/or to the stomach that may improve digestive enzyme activity. According to these literature, the high digestibility and normal intestinal morphology of grouper may be also attributed to the lactic acid content in *Lacotobacillus* spp. fermented soybean meal.

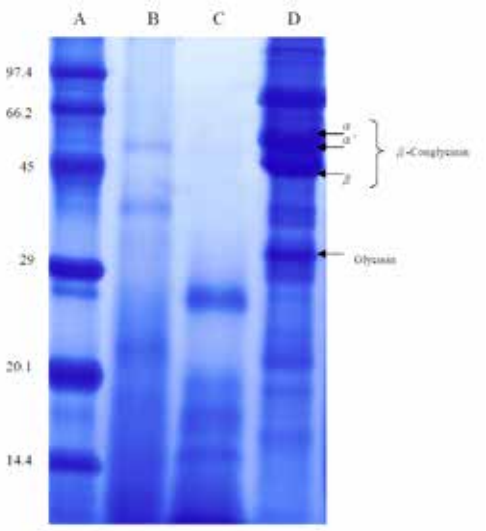

Figure 5. SDS-PAGE analysis of antigenic protein. A: marker; B: competitor soy product; C: DaBomb-P; D: soybean meal.

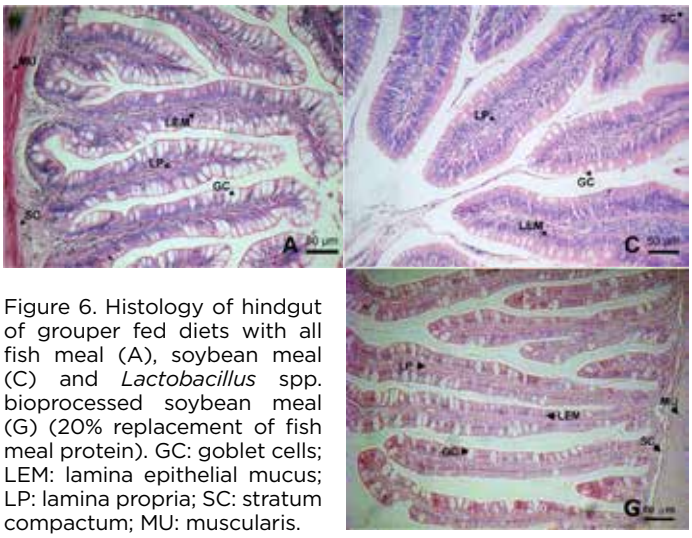

Figure 6. Histology of hindgut of grouper fed diets with all fish meal (A), soybean meal (C) and *Lactobacillus* spp. bioprocessed soybean meal (G) (20% replacement of fish meal protein). GC: goblet cells; LEM: lamina epithelial mucus; LP: lamina propria; SC: stratum compactum; MU: muscularis.

Summary

Here our recent studies demonstrate that *Lactobacillus* spp. fermented soybean meal has a high digestibility, acts as an immunostimulant and improves intestinal health for fish and shrimp. Consequently, we suggest that *Lactobacillus* spp. fermented soybean meal will be an ideal ingredient to overcome some of the issues related to aquatic farming.

References are available on request

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DL-Methionyl-DL-Methionine

By Alexandros Samartzis and Girish Channarayapatna

A novel methionine source for crustacean which can also help to reduce the fish meal level in vannamei shrimp feeds while balancing the amino acid profile.

The growth in aquaculture during the last decades has been remarkable, raising the hope that the potential of this industry can be realised. Shrimp is among the cultured species with the highest production volume (4.5 million tonnes globally in 2014) accompanied with an average increase in the production rate of 10.4% between 2000 and 2014 according to the latest FAO statistics. The specialisation and innovation in feed additives have also kept pace with the increase in aquaculture production. The latest novel product, AQUAVI®Met-Met, to address the challenges in shrimp aquaculture was officially launched during the Asian-Pacific Aquaculture (APA 2016) in Surabaya. (See Aqua Culture Asia Pacific, May/June 2016, p38-39).

AQUAVI® Met-Met is the dipeptide DL-Methionyl-DL-Methionine consisting of four different Met stereoisomers: L-Methionyl-L-Methionine, D-Methionyl-L-Methionine, L-Methionyl-D-Methionine and D-Methionyl-D-Methionine (Figure 1). The three distinct features of the dipeptide are:

- the significantly reduced water solubility compared to the other available methionine sources,
- the four different stereoisomers and
- the optimised particle size for aquatic organisms such as the shrimp.

Hence, the major challenges with traditional sources of methionine which are known to lead to both poor growth and eutrophication of the water, can be effectively addressed. The slow feeding behaviour of shrimp results in a long residence time of feed in the water and leaching of nutrients in particular soluble amino acids. The primitive digestive system of the animal might also limit the efficiency with which nutrients, especially free amino acids are being absorbed and consequently utilised.

Water solubility tests showed that the dipeptide was 5-10 times less water soluble compared to other commercial methionine sources. Pellet leaching tests revealed significantly lower leaching of methionine at both 30 and 60 minutes compared to the second less soluble methionine source.

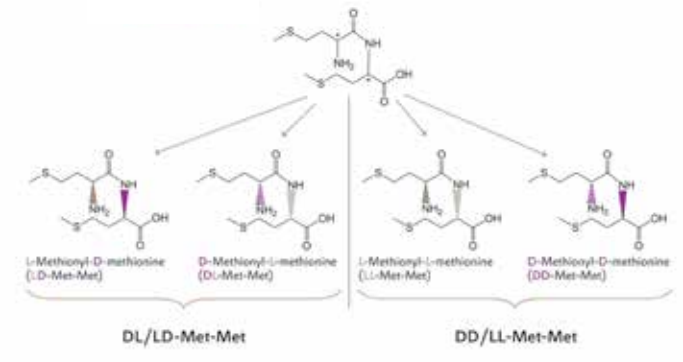

Figure 1. Illustration of AQUAVI® Met-Met's chemical structure consisting of the four different stereoisomers.

Regarding the digestion of the dipeptide, *in vitro* experiments also revealed that the digestive system of crustaceans (as well as fish) can effectively cleave and digest the dipeptide molecule. At the same time the four stereoisomers are gradually released, providing a more sustained overall digestion as the D form has to be converted to L form in order to be used by the animal with the sequence listed in Figure 2.

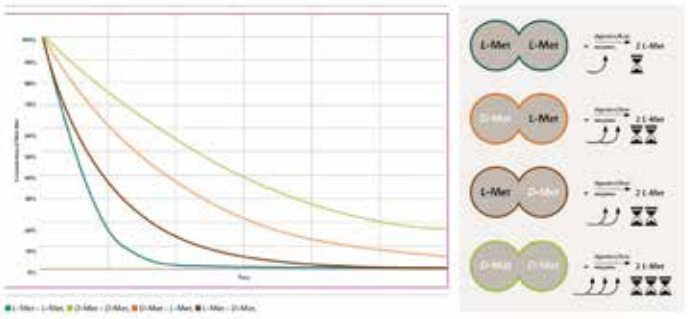

Figure 2. The combination of four stereoisomers providing a more sustain digestion in the crustacean's gut, starting with L-Met L-Met and ending with D-Met D-Met.

Finally, the average particle size of the dipeptide ranges from 63-300 μm fraction with 90% of the particles smaller than 300 μm. This provides a uniform distribution of the supplemental Met during the mixing process and homogeneity of the feeds.

The overall benefits of the dipeptide is not only limited to a more sustainable feed and production but also to a significantly higher bioefficacy (BE) of the first limiting amino acid in shrimp feeds. A series of studies and validation experiments conducted in research institutions and under commercial conditions across the globe both in clean (aquariums) and green (ponds/cages) water systems support the fact that the dipeptide is about twice (200%) more efficient in promoting the growth of shrimp than the most widely used supplemental methionine source, DL-Methionine for Aquaculture (Evonik, Germany). As a result, the supplementation of AQUAVI® Met-Met in shrimp diets can further help to reduce the dependence on the unsustainable and expensive fish meal.

Experiment with reduced fish meal diets and supplementation

A 56-day study conducted in the South China Sea Fisheries Research Institute, China with 3.1 g juveniles *Litopenaeus vannamei* fed six experimental diets confirmed the above claim. The diets consisted of a high fish meal (26%) as positive control and a low fish meal (10%) as negative control diet, both without any methionine supplementation. Treatment diets were three diets similar to the negative control but with gradually increasing levels of supplemental DL-Methionine for Aquaculture at 1 kg, 1.9 kg and 2.8 kg/tonne of feed. The negative control diet was supplemented with 0.9 kg AQUAVI® Met-Met per tonne of feed. The white shrimp were fed three times per day on the 1.8 mm pellets, at a rate of about 7% of their body weight, which was adjusted fortnightly. There were four replicates for each treatment

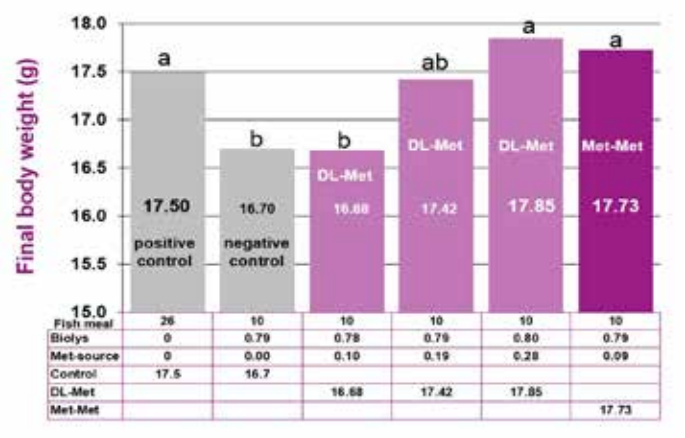

Figure 3. The final body weight of *Litopenaeus vannamei* fed the six experimental diets.

and control diet with 30 shrimp in each 500 L fibreglass tank, with temperatures ranging from 25-30°C, dissolved oxygen level >5 mg/L and salinity between 30-32 ppt.

The analysis of the samples showed that the specific growth rate and final body weight Figure 3) were significantly higher in shrimp fed the diet supplemented with the dipeptide compared to the negative control and the diet with the lowest inclusion level of DL-Methionine for Aquaculture. The same trend was observed with feed conversion ratios but with no significant differences between treatment groups.

The results of this study provide two main conclusions. First, fish meal can be successfully reduced from 26% to 10% when balancing the amino acid profile by supplementing the limiting methionine. Second, the inclusion of AQUAVI® Met-Met at 0.9 kg/tonne of feed resulted in the same performance as the positive control (26% fish meal). The two low fish meal (10% fish meal) diets with the supplementation of 1.9 kg/tonne and 2.8 kg/tonne of DL-Methionine for Aquaculture also demonstrated results equivalent to the positive controls.

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Dietary protease improves growth and economic performance of Pacific white shrimp in Ecuadorian farm conditions

By Herve Lucien-Brun, Emilio Missale, Jimmy Wonsang and M A Kabir Chowdhury

The economics of adding a protease enzyme in diets with marine and plant protein combinations was demonstrated in trials at a typical Latin American semi-intensive commercial shrimp farm

A balanced feed is the main source of nutrients necessary to maintain life and growth of farmed shrimp. It is for this reason that crude protein content is usually the main discussion between manufacturers and farmers, especially to justify the price of the feed. Nevertheless, the crude protein content is not the most important criterion. The most important is digestible protein composition and amino acid profile. Indigestible proteins contribute to unnecessary additional costs and contaminate pond water.

Both plant and animal proteins are currently being used in shrimp feed formulations. Among animal proteins, fishmeal is usually used as well a limited amount of other terrestrial animal proteins. Some of these animal proteins are highly digestible. However, the use of these quality raw materials is confined by their limited availability and volatility in price.

Plant proteins such as soybean meal are extensively used as protein source in shrimp feed. In addition, rapeseed, lupin, pea and rice polish meals are also used; they are usually poorly digested because of their imbalanced amino acid profiles, presence of antinutritional factors (ANF) and high fibre content.

Providing a nutritionally balanced diet is essential to ensure better health and optimum growth of farmed animals and in turn, this gives rise to a higher economic return on investment. Feed cost has been a major impeding factor for farmers, often exceeding 60% of the total operational costs. Besides, scarcity and high cost of quality raw materials are forcing feed manufacturers to use alternative protein sources, which are often inferior in quality and poor in digestibility resulting in lower performance of targeted animals. The increasing use of poor quality raw materials is making it challenging for nutritionists, formulators and manufacturers worldwide to provide a cost-effective but nutritionally adequate feed.

The use of protease in feed has been considered as a key solution to improve the quality of these raw materials and can serve two equally important purposes: one is to improve production performance and the other is to reduce formulation costs while maintaining the performance.

The main objective of this study was to assess the effect of a dietary protease on the production performance of the Pacific white shrimp *Litopenaeus vannamei* reared with four different diets with or without a protease enzyme.

Experimental protocol

The trial was conducted for 90 days in earthen ponds at the experimental farm of the CENAIM in the Santa Helena Peninsula, Ecuador. A total of four experimental diets were formulated, where each diet was tested in triplicates and randomly assigned to 12 ponds. A local commercial hatchery supplied 48,000 post larvae (PL) from the same batch. Post larvae (4,000 per pond at 10 PL/m^2) were equally distributed into 12 ponds of 400 m^2 each. The average weight of the post larvae was 0.003 g with an initial biomass of 12.5 g per pond. Post larvae were acclimatised to their respective pond for a week before commencing the feeding trial. During the acclimatisation period, they were provided a commercial feed.

The water was pumped directly from the sea and through a 700 µ mesh screen. During the trial, salinity of the water ranged between 37-40 ppt. Water depth was maintained at 40cm during the first 3 weeks and subsequently, the level was increased at a rate of 20 cm per week for the next three weeks. Then the water depth was maintained at 1 m for the rest of the trial duration.

Dissolved oxygen (mg/L) and surface water temperature were measured twice a day. The first water exchange was conducted 45 days after stocking and is repeated depending on the pond conditions. Emergency water exchange was performed if the level of the dissolved oxygen concentration was less than 3 mg/L. The mean water quality parameters are provided in Table 1.

The first sampling of 20 to 25 animals caught with a cast net for the determination of the average body weight was done at the third week and subsequently weekly. Three samplings of population biomass were performed to estimate the survival in each pond and to adjust feed amount with respect to the existing biomass in each pond. The same management protocol was followed for all the experimental ponds.

Table 1. Water quality parameters

Parameters	Min	Max	Average
Temperature	30.0 °C	35.6 °C	32.9 °C
Afternoon (4:00PM)			±1.1 °C
Temperature	25.0 °C	31.0 °C	28.2 °C
Night (00.00AM)			30.9 °C
Dissolved oxygen	4.2 mg/L	11.6 mg/L	8.4 mg/L
Afternoon (4.00 PM)			±0.9 mg/L
Dissolved oxygen	2.3 mg/L	6.0 mg/L	3.4 mg/L
Night (00.00AM)			±0.5 mg/L
Salinity	38 ‰	40 ‰	

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Table 2. Specifications of the experimental diets

Diets	Diet A	Diet B	Diet C	Diet D
Crude Protein	35.5%	35.5%	35.5%	29.4%
Digestible Protein	32.7%	32.7%	32.4%	26.9%
Marine Protein	27.7%	27.7%	22.7%	20.8%
Plant Protein	67.7%	67.7%	72.0%	74.6%
JEFO Protease	0 ppm	175 ppm	175 ppm	175 ppm
Cost/ tonne (USD)	919.44	922.71	886.16	830.13

Experimental diets

All diets were extruded mainly because the batches were too small for pelleting. The JEFO protease, AG175, was mixed with the feed ingredients before passing through the extruder. Table 2 details the main specifications for the four experimental diets. A description of the diets is given below:

- Diet A is a typical Ecuadorian formula with 35.5 % crude protein (CP), of which 28% was from marine animals and 68% was from terrestrial plant sources. The formulation cost was USD 919/ tonne.
- Diet B has the same formulation as Diet A except that AG175 was incorporated at a rate of 175 mg/kg. The formulation cost was USD 923/tonne.
- Diet C was isoproteic like in Diet A but had a lower animal protein content (23% from marine animals and 72% from terrestrial plant sources) and with AG175 incorporated at a rate of 175 mg/kg. The formulation cost was USD 886/tonne.
- Diet D had a lower crude protein level (29.4% CP) obtained by reducing the proportion of fishmeal to 21% and obtaining 75% of the crude protein from terrestrial plant sources, plus the incorporation of AG175 (175 mg/kg). The formulation cost was USD 830/tonne.

> **“.. the best profit per tonne of shrimp was obtained with the Diet D containing 29.4% CP followed by the Diet B with 35.5% CP, both containing the protease..”**

Growth and economic performance

Data on growth performance after the 90-day trial are shown in Table 3. Weight gain was significantly higher (90% confidence limit) in shrimp fed with Diet B, which is a high marine protein diet with protease (Diet B, 10.37 g) than Diet A, without the protease (Diet A, 6.75 g). This was confirmed with calculations on feed conversion ratio (FCR) for the four treatment diets.

As expected, a significantly higher protein efficiency ratio (PER) was observed in shrimp fed the low protein diet with protease Diet D (2.4) than those fed Diets A, B or C (1.7, 1.9 and 1.9, respectively).

An economic analysis of the results was done to determine the gross profit farm-gate sale minus the cost of the feed. The farm-gate sales were estimated from the average prices paid to shrimp farmers by five of the major packing plants in the country during the trial period. This analysis showed a significantly better profit (USD 58, 33 and 70 for Diets B, C and D respectively compared to Diet A). The gross profit (farm-gate sale – cost of feed) was calculated based on the growth performances of shrimps fed all the three diets containing protease compared to Diet A. Best profit per tonne of shrimp was obtained with Diet D containing 29.4% CP followed by Diet B with 35.5% CP, both containing protease. (Table 4).

Discussion

These results showed the efficacy of the protease in improving growth and economic performance of shrimp reared in commercial farm conditions. The analysis of the results also supports the conclusion that protease can be used with two different strategies to obtain better result:

An example of the economic impact of the incorporation of the JEFO protease, AG175, in a typical Latin American semi-intensive commercial shrimp farm is shown in Table 5.

In a 500 ha shrimp farm producing 1 tonne/ha/crop, the harvest is a total of 500 tonnes per crop. With 2.5 crops/year, the annual production would be 1,250 tonnes. With a FCR of 1.5:1, it will need 1,875 tonnes of feed or 46,875 bags of feed of 40 kg each. In these conditions the annual savings on feed cost for the shrimp farmer using a 28% crude protein plus AG175 protease versus a classical 35% crude protein feed would be USD 359,531.

Table 3. Zootechnical results

Treatments*		Average body Weight (g)	Survival (%)	Biomass (kg)	FCR	Yield (kg/ha)
Diet A	35% CP	6.75 ± 0.43a	70.8 ± 7.4 a	19.1 ± 1.6 a	1.64 ± 0.13 a	477 ± 39.4 a
Diet B	35% CP+AG175	10.37 ± 1.25a	52.1 ± 3.0 a	21.5 ± 1.4 a	1.45 ± 0.10 a	538 ± 34.7 a
Diet C	35% CP+AG175	8.74 ± 2.32 a	61.4 ± 11.7 a	20.8 ± 2.2 a	1.52 ± 0.17 a	519 ± 56.0 a
Diet D	29% CP+AG 175	9.52 ± 0.49 a	58.7 ± 8.3 a	22.3 ± 2.1 a	1.41 ± 0.14 a	557 ± 52.1 a

* refer to table 2 for protein sources

Table 4. Comparison of the value of the shrimp and of the feed

Diets	Farm-gate sales		Feed prices USD/ tonne	Cost of feed		Gross profit (USD)
	kg	USD	USD	kg	USD	
Diet A	92.59	205.56	919.44	152.16	139.90	65.65
Diet B	104.35	263.91	922.71	151.66	139.94	123.97
Diet C	100.68	233.87	886.16	152.69	135.31	98.56
Diet D	108.03	262.07	830.13	152.32	126.44	135.63

Table 5. Annual cost saving in a 500 ha farm using feed with protease

Type of Diet	Cost per bag of 40 kg of feed (USD/bag)	Annual cost for feed (USD)
35% crude protein	36.33	1,702,969
28+% crude protein + JEFO Protease	28.66	1,343,438

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Asia is the new focus for a leading supplier of micro feeds in the Americas

US based Zeigler Feeds strives to know the needs of its Asian customers better as it continues to grow in the region.

In 2015, Zeigler Bros., Inc. celebrated 80 years in the production of livestock and aqua feeds. Zeigler was founded by brothers Leroy and Ty Zeigler as a local producer of livestock and poultry feeds in Pennsylvania, USA. In 1955, it began production of aqua feeds and 12 years later, Dr Thomas R Zeigler (son of Leroy) assumed leadership as president and changed the strategic direction from commodity feeds to focus on research and development of specialty animal and aquatic diets.

Today, as Zeigler embarks on its third generation of family leadership, the company continues to develop new and innovative technologies for specialty markets. It is active in four areas: aquaculture, specialty pet, health and research, and feed mill franchising. For 30 years the franchise program has offered turnkey solutions for local production of aqua and specialty feeds in conjunction with R&D collaboration to provide advancements and technologies needed to meet ever-changing market conditions. The company has two manufacturing facilities located in South-Central Pennsylvania, two franchises located in Mexico and a third franchise in Ecuador.

In 1983, Zeigler was first to develop the technology for water stable shrimp feeds. Five years later it helped create and commercialise Stay C, a stable form of Vitamin C. In the 1990s Zeigler went on to introduce shrimp hatchery diets, including microencapsulated larval feeds and bio-secure maturation diets thus marketing a complete line of feed for shrimp hatchery and farming. As part of its ongoing mission to minimise biosecurity risks and inconsistencies associated with live feeds, the company developed EZ Artemia, and in 2009, it first achieved 100% Artemia replacement with this product. In 2016, the Zeigler Research Centre was set up to provide a platform to evaluate feed performance (see Aqua Culture Asia Pacific, issue March/April 2016).

Advancing into Asia

Asia is the company's new focus with a concentration on the shrimp hatchery and franchise markets. Today, Zeigler hatchery products are present in India, Vietnam, Indonesia, Bangladesh, Philippines, Malaysia and the Middle East. It has also just begun entering the market in Thailand and China.

During the World Aquaculture 2016 trade show in Las Vegas in February, Dr Thomas R Zeigler, Senior Technical Advisor, past President and Chairman of Zeigler gave an exclusive interview on how he is bringing Zeigler's aqua feeds to Asia and the strategy and challenges for this new business. Chris Stock, Sales Manager – Eastern Hemisphere, joined him.

AAP: What are Zeigler's strengths which helped the company start up and lead in Central America

TZ: Basically, it was a case of, "We had the feed, and there was a need." Our strengths came with the fact that we were there first when the shrimp farming industry in Latin America needed

Dr Tom Zeigler (right) joined Zeigler Bros in 1961 as director of nutrition. He co-founded Vitamin Technologies Inc, a company which created the new patented stable form of ascorbic acid (Vitamin C) and sold the company in 1991. During his tenure at Zeigler, he pioneered the development of 70 unique nutritional technologies and products. Chris Stock (left) joined Zeigler in 2006 and currently leads Zeigler's business development in Asia.

commercial feeds. Also, our products worked for them. Being in the US, we were very close to the farms. We also speak the language. It also helped that in those days, farm managers in large farms such as Belize Aquaculture were Americans! As a young man, I was travelling there often and developed many personal contacts. In my visits to the farms, I asked what they needed and made recommendations. With this feedback, we made improvements in products, and all the time we tried to provide the best value.

In the 1980s and 1990s, in Central America, feed was relatively primitive because there was no structured feed ingredient industry that could produce feed ingredients of aqua feed quality. Whereas, in the US, we already had had suppliers of such raw materials. Therefore, our products performed well and, because of this, we established our brand reputation.

AAP: What will Zeigler bring to the shrimp farming industry in Asia?

TZ: We are approaching Asia in the same way. We want to understand the markets and walk in their shoes and work to expose industry to methods and products which are effective. We are very serious about the Asian market. We feel that the technology from the US and from Zeigler can make a significant difference in the region. Innovative products that bring value is key.

Our core strength has always been in the hatchery and raceway segment of the industry. We have niche products for this segment; precision milled and specialised ingredients, which use more sophisticated technologies. These are the products which we will be bringing to Asia; products which we can afford the freight costs all the way from the US and which we know will be cost effective. Our business is a people business. We focus on people.

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AAP: What are the current and anticipated challenges for Zeigler in Asia?

TZ: Unfortunately, our biggest challenge is in the registration of products. Many of the rules, we feel, are not logical. Although Zeigler itself can overcome these, personally I feel that the local industry is suffering because they do not have access to products they need to make improvements to their farming practices. This is just unfortunate. Countries in Asia need to find ways to cooperate for the benefit of each other. We may have to wait for trade agreements, but, on the other hand, many trade agreements are mega trade agreements and a small company like Zeigler will just have focus on what we can do best.

> **"This means that we really need to learn how to 'walk in their shoes' to know what the industry in Asia really needs. I believe that success is always for good people doing things together. Our business is a relationship business. Being able to put a product in place promptly is important." - Tom Zeigler**

Then there is the difference in culture and production methodology between Asia and the Americas. For example, operators in Asia still love to feed live Artemia and feed four or more times a day. It works but we know from the work over here that we can totally replace live Artemia in shrimp hatchery production. Our EZ Artemia product is semi buoyant and goes to the bottom in a couple of hours and thus the hatchery operator will need to feed more frequently to really get benefit out of it. This is an example of cultural differences we need to study. This means that we really need to learn how to 'walk in their shoes' to know what the industry in Asia really needs. I believe that success is always for good people doing things together. Our business is a relationship business. Being able to put a product in place promptly is important.

AAP: What will be Zeigler's strategy in Asia?

CS: The marketing strategy is to work through distributors and develop strategic relationships. In Central America, our success was through building trust and we are taking the same approach in Asia, creating trust by supporting distributors and clients directly. This takes time and we know we cannot capture the market's trust overnight.

AAP: What do you think will be your advantages compared with the existing feed players in Asia?

TZ: Our strength is with products manufactured in the US which are of high quality. We entered the Central American market with a strong reputation and performance track record. We do not measure competition in terms of price but in terms of being able to add greater value. The customer has to be profitable first.

We consider ourselves a technologically sound company. What we do is to bring innovation and customisation. If we have to make a special order, we will do this. Our advantage in being a

Tanks at the Zeigler Research Centre (Z-ARC), set up together with Florida Atlantic University's Harbor Branch Oceanographic Institute in Fort Pierce, Florida. This R&D centre significantly extends the scientific capability of Z-ARC for applied research on new feeds, feed performance of different species, health management and the impacts of feeds and nutrition on production.

small business is that we are more flexible in comparison to large companies, which have many levels of decision makers. This has always been one of our competitive edges.

CS: We challenge the status quo too when we see opportunities and take things we learn in other markets and transfer the knowledge and production practices to other places. We will also challenge practices when we know that there are opportunities to help clients improve their business.

AAP: Following the entry into Asia, what are your expectations and targets in this market?

CS: First, we have to build the reputation of our company as a leader in terms of quality products and innovation in Asia. We are trying to show ourselves as delivering value, not just with products, but also with concepts and practices. We are not in Asia to promote products only, but to see our clients succeed.

Relative to many of our competitors, we are a small company; thus, we need to be sharper in our approach to visiting clients and markets. We continuously face the challenge of a price-oriented market. We will continue to deliver products designed for the best returns and convey the concept that feed is an investment.

AAP: In five years, where would you like to position Zeigler in the Asian region?

TZ: We want to be recognised as one of the primary producers of quality feed products. We want to continue to innovate for this market. I hope that in the near future, we will have one or two production sites in Asia. This is the investment we are making for markets in Asia. Absolutely, we are in Asia for the long term.

Marine ingredient standardisation for feed standardisation

By Philippe Sourd and Vincent Fournier

While fish meal proximal analyses may show little variations, analyses at the peptide level show higher variation among fish meal sources as compared to hydrolysates. Such variation impacts feed standardisation and, ultimately, the goal of consistent feed performance.

Tens, if not hundreds of macro-ingredients are now computed into the system of any feed mill today. Modern fish and shrimp feed formulae may contain over 10 macro-ingredients or more that can be selected according to many parameters, ranging from price and availability, to customer's expectations of price or performance, to farming conditions.

The list of raw materials available to feed manufacturers is extremely large. Increased knowledge on the nutritional profiles of ingredients and fish and shrimp nutritional requirements allow talented formulators, helped by sophisticated formulation software, to come up with efficient and flexible solutions to formulate high-performing and cost effective recipes.

Multiple origins and diverse manufacturing processes applied to vegetable, marine and land animal raw materials lead to an immense variety of ingredient profiles. Marine ingredients and, in particular, marine proteins are considered a landmark in the formulation of diets for many species. Yet such ingredients prove to be extremely diverse in their composition, value and, most importantly, consistency.

Very few processes allow for the manufacturing of extremely consistent marine ingredients. Indeed, most do not allow replicating, i.e. producing the very same product characteristics batch after batch. While the content of marine proteins in modern fish and shrimp feed recipes decrease, more attention must be paid to their quality and consistency.

Processing marine raw materials

The processes applied in fishmeal and fish soluble production as well as to silage production often lead to some inconsistency between batches in the end product when compared to batch hydrolysation process (Chart 1). Even if the end quality is not compromised and proximate specifications are within a small range, ultimate feed performance can be affected by those fine changes affecting mainly protein quality and characteristics.

Quality Controls (QC) in place in feed mills help in anticipating those changes, but this comes at a cost. Proximate and freshness parameters can be easily checked for each batch, while fewer in depth investigations are actually undertaken on a routine basis.

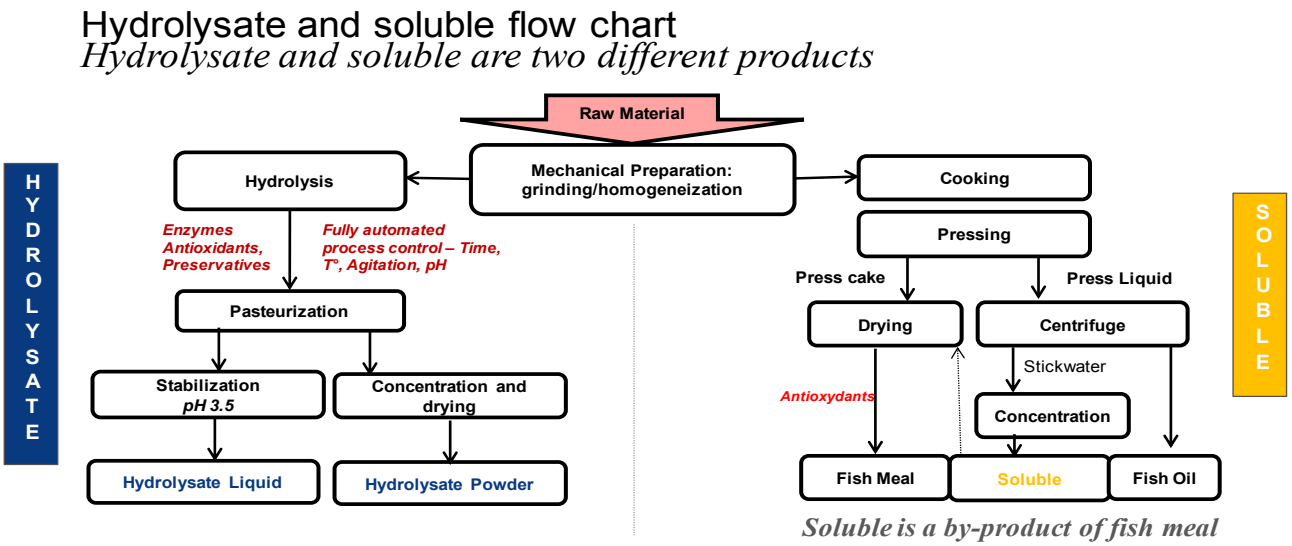
Marine ingredients survey

As part of our activity, we regularly sample and analyse marine raw materials of various origins that are, or may be used by different aquafeed producers. While we gather data, interesting features appear and eventually help to build up robust support for the characterisation of sources for marine ingredients.

Proximate analyses

Here we explain some results of analyses of 11 batches of a single super prime fish meal type (anchovy fish meal) from one specific origin. Figure 1 indicates that the crude protein (CP) content is very consistent and thus the product in compliance with a premium grade. Other parameters (TVN, histamine) not shown here were also very consistent.

However Figure 2 shows that two out of eleven batches are below 4% dry matter. Excessive drying can affect digestibility. This may not be accounted for in the formulation and shows that even the best fish meals are not fully standardised. The proximate analysis of a liquid hydrolysate (Figure 3) reveals that the process truly yields the very same consistency batch after batch for all proximal features throughout the year.



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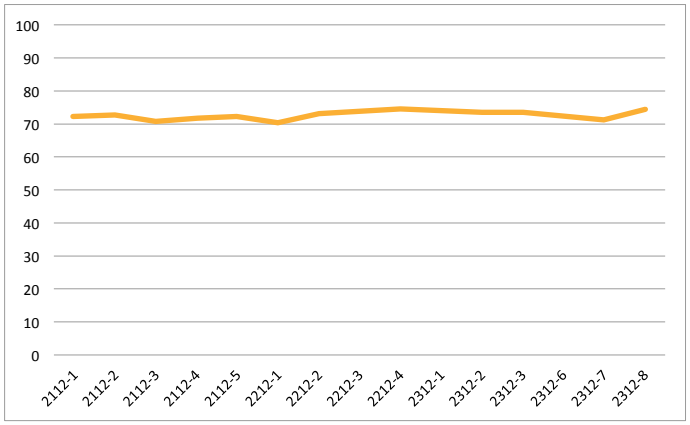

Figure 1. Crude protein (% of product) of an anchovy super prime fish meal (n=11).

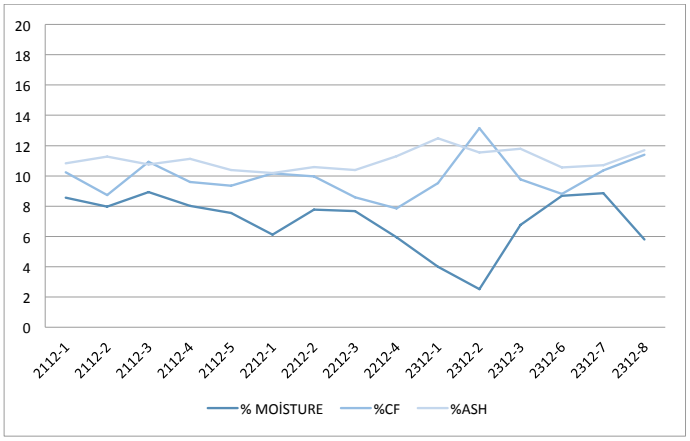

Figure 2. Moisture, ash and fat content (% of product) of an anchovy super prime fish meal (n=11).

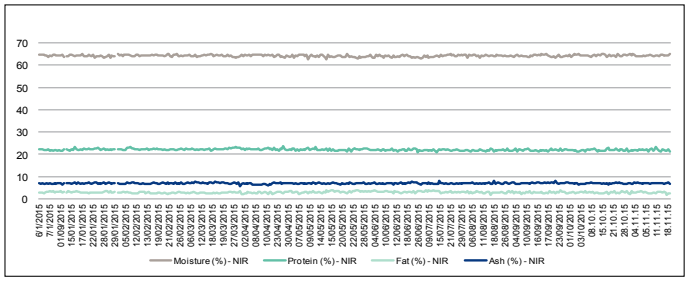

Figure 3. Protein, moisture, ash and fat content of a liquid hydroysate (n=41).

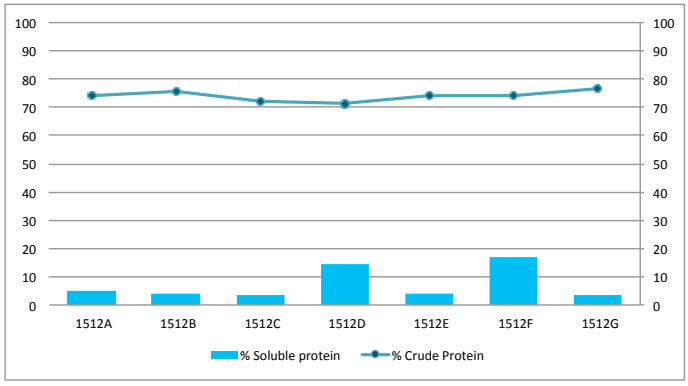

Figure 4. Protein content and soluble protein content of 8 batches of super prime anchovy fish meal

Soluble proteins

As we go deeper in the protein profile we can see that the protein content and amino acid profile proved very consistent in the products. Nevertheless, soluble protein content varied from 3% to 17% of the product and appeared to change from batch to batch, and most importantly, between suppliers as shown in Figure 4.

Further analyses of the soluble protein content will reveal the stickwater content of the fish meal. This datum is also a good indicator of the product's performance and standardisation. Stickwater contains a lot of essential and functional nutrients such as free amino acids and derivatives, nucleotides and other low molecular weight compounds, and will largely impact the fish meal functionalities (palatability, digestibility and bioactivity). However, during the fish meal manufacturing process, stickwater is often discarded (or sold as fish solubles) and not added back to the fish meal. This is either because of the process technology or because they tend to concentrate biogenic amines.

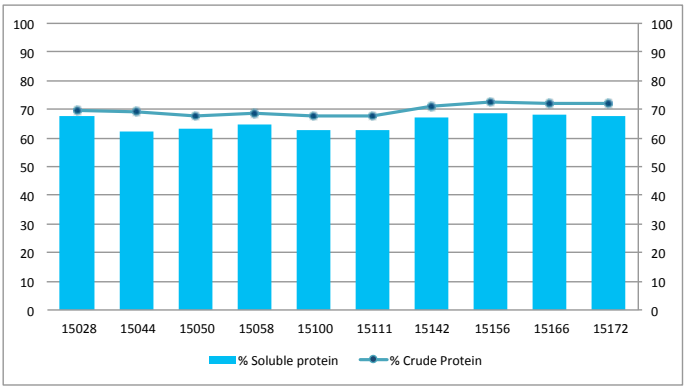

Figure 5. Protein content and soluble protein content of 10 batches of hydrolysate powder.

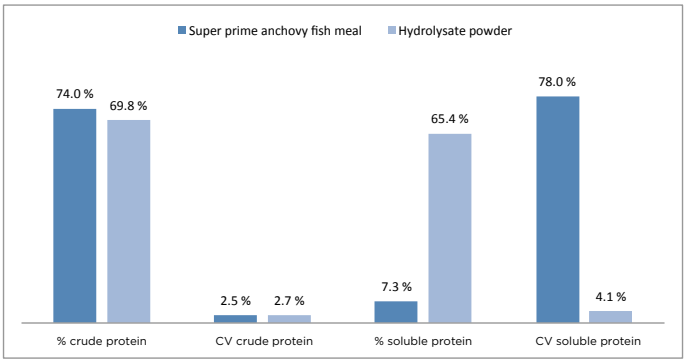

Figure 6. Average crude protein and soluble protein content of super prime anchovy fish meal compared to hydrolysate powder and corresponding coefficients of variation in the samples studied.

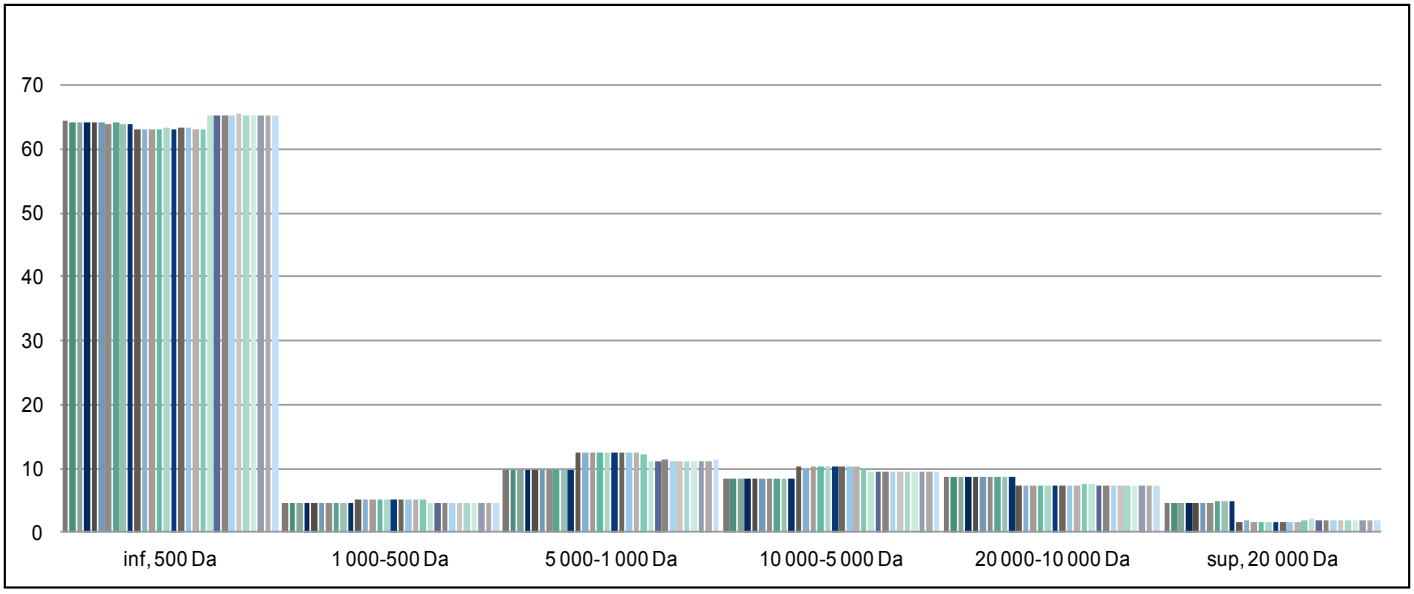

Figure 7. Peptide profile of 30 batches of a liquid hydrolysate – Percentage of peptide per sizes (Dalton)

Conversely, the analysis of a hydrolysate powder (Figure 5) shows that this process yields a highly soluble protein content (62% to 69% of product) and more importantly, the same consistency of soluble protein content.

In fact, when comparing the average soluble protein content of both ingredients, we can see the high coefficient of variation for fish meal as compared to that for the hydrolysate. (Figure 6)

Peptide profiles

Finally, when going even deeper into protein characterisation, we can also show how peptide profiles change immensely according to fish meal types and origin. Peptide content and feed ingredient profiles are influenced by the manufacturing process and the freshness of the raw material. Such analyses help in the assessments of feed performance and standardisation levels.

The examination of the portfolio of fish meals used by several feed companies allows us to see the obvious differences of peptide profiles among these fish meals. Fish meals and silages peptide profiles vary widely, whilst the controlled batch hydrolysis process yield a very consistent peptide profile (Figure 7).

More detailed results on peptide profiles of fish meal together with complete data on soluble peptides and fish silages will be presented at The Aquaculture Roundtable Series (TARS 2016) in August in Thailand.

Conclusion

Several common indicators such as crude protein, ash content, TVN or histamine are often used in trading marine ingredients. These parameters are too limited in the assessment on the true value of the ingredients.

More evidence, not shown in this article, reveal that there is more than just protein content to qualify and to grade the value of marine proteins. Indeed, marine protein performance is intimately linked to its peptide profile. Any change in the profile leads to a change of product performance, either in terms of digestibility, bioactivity or palatability. This can clearly be demonstrated by *in vivo* performance tests.

Marine ingredients require more focus than what is provided by proximal profiles alone. Deeper characterisation is required but may be complex to use on a routine basis.

As formulators seek maximum performance with a vast array of ingredients, finding items such as hydrolysates can be landmark developments in improving the base formula towards more flexible and consistent of dietary performances.

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Can krill meal replace fish meal in shrimp diets?

Q&A on how krill meal and oil provide dietary cholesterol and help vannamei shrimp grow faster and osmoregulate in high salinity culture.

Dr Alberto J.P. Nunes

Nils Einar Aas

It is rare to find feed ingredients that are attractants, drive efficiency, accelerate growth and at the same time are cost efficient. In this interview Dr. Alberto J.P. Nunes, associate professor at LABOMAR aquaculture facilities in Brazil, and Nils Einar Aas, vice president at Aker BioMarine, share how krill meal can improve white shrimp diets.

The Antarctic krill, *Euphausia superba* has a nutritional composition that improves the shrimp's survival and growth rates. Krill meal is one of the few naturally available marine proteins with high levels of long-chain polyunsaturated fatty acids, cholesterol and phospholipids. Typically, krill meal has 65% crude protein, 22% lipids, 13% phospholipids, 5% chitin and 0.6 mg/kg cholesterol. Krill meal is also rich in omega-3 highly polyunsaturated fatty acids (PUFAs). DHA (docosahexanenoic acid) and EPA (eicosapentanenoic acid) make up 5.5% of krill meal. Recent research shows that replacing shrimp feed ingredients like fish meal, soybean lecithin, cholesterol or fish oil, with small quantities of krill meal, can increase feed intake and accelerate shrimp growth.

At Asia-Pacific Aquaculture 2016 conference, you spoke on your research on the benefits of krill meal. With your background in aquaculture and crustacean nutrition and your recent research, what findings stand out?

Nunes: We have been researching the application of krill meal in shrimp feeds for almost 10 years now. What happens when you replace today's frequently used feed ingredients with krill meal is as interesting as whether or not it is possible.

Compared to other sources of protein namely soybean meal, soy protein concentrate, poultry by-product meal, meat and bone meal, feather meal, blood meal, tilapia meal and salmon meal, krill meal has promoted the highest growth rate and final body weight in shrimp. Our studies show:

First, krill meal in shrimp feed increases both the attractability and palatability of the feed. The increased feed consumption compared to feed containing alternative attractants is one of the reasons why krill meal in shrimp feed increases shrimp growth.
Second, krill meal in shrimp feed helps accelerate the growth of shrimp. The unique combination of the krill meal properties improves the feed conversion ratio. Third, krill oil in the feed helps white shrimp, *Litopenaeus vannamei*, resist high salinity. White shrimp farmed in high salinity water use energy from protein to osmoregulate their salinity levels, instead of using the protein to grow. When we added krill oil to their feed, they used the energy from lipids in krill oil to process the extra salinity, not from the protein. Including as little as 3% krill oil in the feed increases growth rates by more than 10% in high-salinity conditions.

So let me summarise. Krill in shrimp feed makes shrimp grow faster by attracting them to their food, making them eat more and helping them convert their feed into body mass. It also helps shrimp to cope with high salinity so that the protein is used for growth, not on handling the external environment. You only need a dietary inclusion of between 2-3% krill meal to see these benefits.

What does this mean for the aquaculture industry?

Aas: Today there is insufficient availability of high quality marine proteins. The aquaculture industry is growing so fast that we can only expect the price of such ingredients to increase further. You can replace, for example, fish meal with other sources of protein such as soybean, but this may negatively impact feed performance.

Nunes: In plant-based protein diets, we added 2% krill meal and achieved the same growth rates as with 12% fish meal.

What features of the krill meal create these benefits?

Nunes: The benefits are seen in the nutrients the shrimp needs. Krill meal is also unique because of its lipids content. In comparison, regular fish meal has 10-12% lipids, whereas krill meal contains 25%. A large amount of the lipids is composed of phospholipids with omega-3 polyunsaturated fatty acids. These are nutrients required by shrimp which they cannot produce themselves.

Which growing environments have krill meal been tested in?

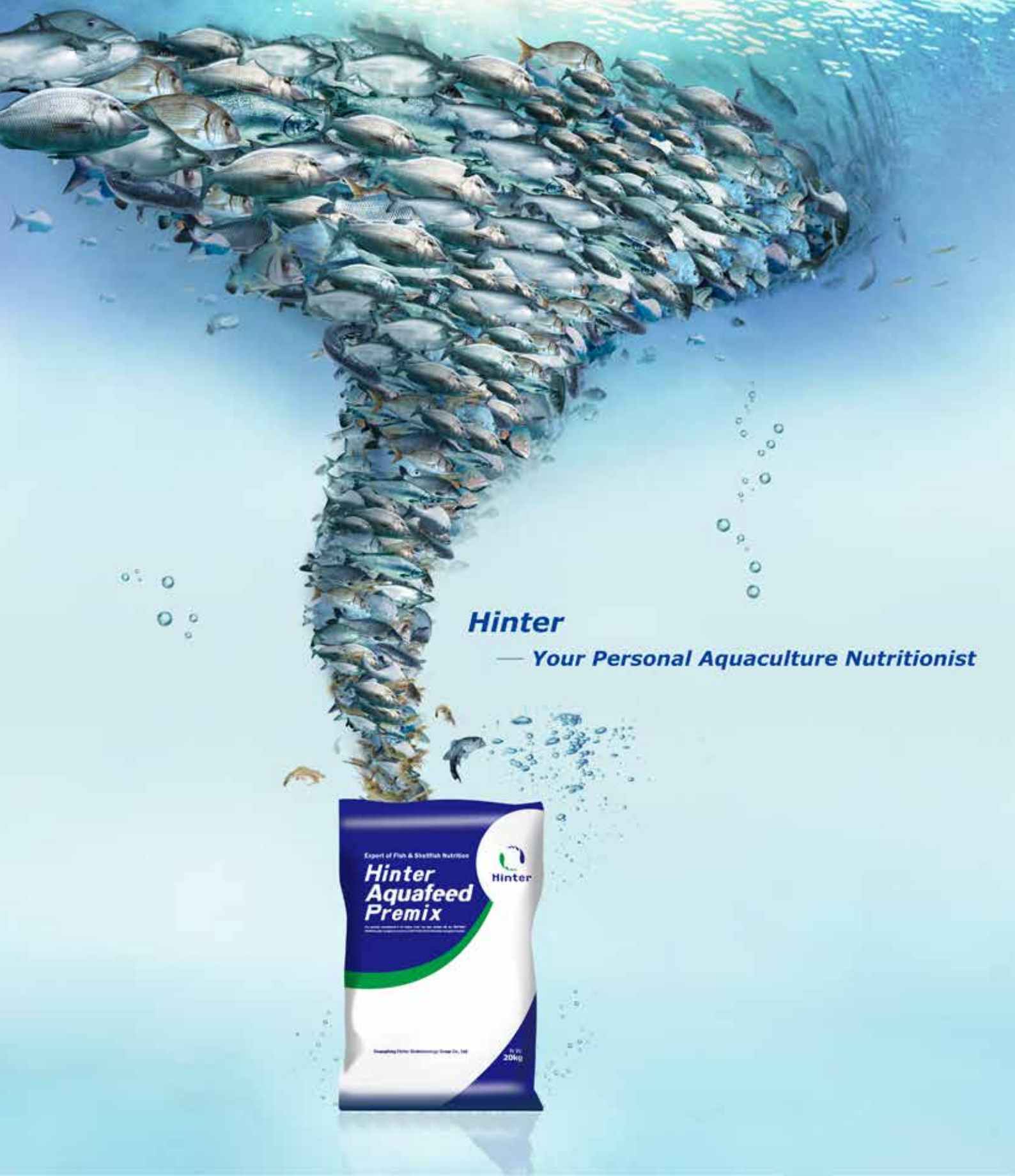
Nunes: We have tested krill meal in clear water and in green water. Microalgae in green water reduces visibility. In green water, shrimp also feed on other organisms that grow in the water. Adding krill meal to the feed still has the same positive effects.

Krill has also been said to be able to replace cholesterol in feed. Why is this? How much krill meal is required in order to do this?

Nunes: Cholesterol in shrimp feed acts as a component of cell membranes and as a metabolic precursor of steroid and molting hormones. Cholesterol requirements range from 0.1-1%.

Cholesterol is available in very small amounts in ingredients produced from terrestrial animal by-products and marine protein sources. Cholesterol is extracted and purified from wool grease from farmed sheep, primarily from New Zealand. Limited cholesterol suppliers worldwide lead to fluctuating prices depending on wool demand. In recent years, the price of cholesterol from extracted wool grease has increased dramatically.

We know there is an interaction between dietary cholesterol and phospholipids in diets for shrimp. Cholesterol requirements in the diets for shrimp decline with higher levels of supplemental phospholipids.



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We have found that by adding 2% krill meal to the shrimp diet, it is enough to completely replace cholesterol in diets. When one kilo of cholesterol can cost over USD100, replacing cholesterol with krill meal can help feed manufacturers and shrimp farmers save significantly on the feed cost.

Will consumers notice that shrimp have been fed krill?

Aas: We have seen that consumers actually prefer the color and flavor of shrimp fed with krill oil instead of fish oil and soybean oil. Adding krill oil to the feed also increases the amount of omega-3 in shrimp flesh, making them healthier to consume as well.

How does krill meal compare to other alternatives?

Nunes: We can find equally effective attractants in by-products from food production such as squid or crustacean meal. However, these by-products do not have consistent nutrient quality or proportions. The aquaculture industry needs feed with a set percentage of lipids and protein. This they can get from feed with krill.

Aas: Other available attractants may also carry an additional risk of pathogens. Krill on the other hand are fished in pristine Antarctic waters, which makes the pathogen risk lower.

Krill is an important part of the food chain. Are you worried that the benefits of krill will lead to overfishing?

Nunes: The reason I moved from fisheries to aquaculture is that I did not want to work in an industry that was overexploiting natural resources. Many fisheries are not sustainable.

Aas: In recent years, a major concern has been obtaining additional research data on the Antarctic ecosystem, and especially its krill biomass. To this end, Aker BioMarine continually evaluates new ways to secure healthy krill biomass levels by undertaking new research. In 2015, we partnered with the Antarctic and Southern Ocean Coalition (ASOC) and WWF-Norway to establish a new research fund. The purpose of the Antarctic Wildlife Research Fund (AWR) is to facilitate and promote Antarctic marine ecosystem research.

In pursuit of our sustainability commitment, we also initiated establishment of an industry-wide Association of Responsible Krill Harvesting Companies (ARK). The organisation's goal is to make sure that accountability is shared among all participants operating in Antarctic waters.

Last year, Aker BioMarine was recognised several times for its sustainability achievements. Our company was featured in a report by the Sustainable Fisheries Partnership (SFP) that called the krill fishery in Antarctic waters one of the most sustainably managed reduction fisheries worldwide. Harvesting is restricted to a specific region of the Southern Ocean, Area 48. The annual quota for Antarctic Krill is set at 1% total biomass, which amounts to 620,000 tonnes, whereas the recognised precautionary level for other fisheries is 10% total biomass. The actual Antarctic krill catch is less than 300,000 tonnes per year, or 0.5% total biomass. Today's rate of krill harvesting is not a threat to the Antarctic ecosystem.

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A view on the holistic approach to sustainable aquaculture

By Rui A. Gonçalves and Anwar Hasan

By adopting a range of different strategies, the use of feed additives can help farmers achieve better aquaculture practices.

Global demographic trends show us that the world population is growing, and will continue to grow. Currently, it is approximately seven billion, and by 2050 it will reach nine billion; two billion more mouths to feed. Additionally, it is expected that in developing countries more people will come out of poverty and demand protein rich diets. In developed countries, there is also a trend towards a higher demand for seafood products, due to its healthy image. To supply this demand, aquaculture will definitely have an important role, especially in view of the stagnation of capture fisheries output. According to FAO projections, it is estimated that global aquaculture production will need to reach 80 million tonnes by 2050. Nevertheless, doubling aquaculture production needs to be done in a sustainable manner, whilst simultaneously ensuring the profitability of the industry.

Challenges in aquaculture

The aquaculture industry faces several, and often contradictory, constraints. Reliance upon scarce and costly raw materials, such as fish meal, and the optimal use of alternative ingredients constitute major challenges in aquaculture. Consumer awareness about environmental impacts also encourages producers to improve the production performance through sustainable aquaculture practices. However, the use of less costly protein feed raw materials and low-nutrient dense diets can lead to lower protein digestibility, higher amino acid imbalance and higher carbohydrate and fiber content in feeds. This can lead to inefficient nutrient use, resulting in increased feed usage, greater susceptibility to disease and higher waste outputs—raising production costs and increasing the ecological footprint.

Sustainability on the rise

In recent years, several certification schemes have been implemented to assess sustainable aquaculture practices and certify aquaculture products. Consumer demands relating to environmental impacts of production have driven the industry to increasingly embrace certification. The most widely used certification programmes are typically based on seven main categories; three of these relate to feed efficiency, waste management and disease control. Within these topics, certification bodies have established specific targets in terms of feed conversion ratio (FCR), waste discharge and water pollution, and the use of medicines.

The holistic approach

Sustainability requires a holistic approach to considering resource needs and profitable industry growth. By adopting a range of different strategies, the use of feed additives can help farmers achieve better aquaculture practices. This will enhance growth, survival and feed conversion rates, and increase tolerance to diseases, as well as improve environmental conditions. Ultimately, feed additives can support a more sustainable and profitable farming.

Feed management

Improving nutrient utilisation

Phytogenics are known to stimulate digestive secretions, increase the abundance and length of mucosal folds and increase mucus production by increasing goblet cell populations. As a result, phytogenics could be used to improve feed digestibility. By improving the nutrient utilisation, FCR is improved. By reducing FCR, farmers can achieve one of the most important requirements for the certification programme—'nutrient utilisation efficiency". This improvement also has positive effects directly on feed cost, water quality and nitrogen discharge. Through improved protein utilisation, phytogenic feed additives can decrease ammonia production and organic matter discharge and reduce the amount of nutrients available for pathogen growth.

Mycotoxins: preventing inefficiency and disease susceptibility

Ingested mycotoxins may lead to an overall decline in performance which may ultimately result in economic losses. It is difficult to directly observe the negative effects of mycotoxins in aquaculture species, as most of the symptoms of mycotoxicosis are subclinical and hard to detect. Several studies have highlighted the negative effects of mycotoxin-contaminated feeds in aquaculture. Some of these effects are reduced growth, increased production costs, overall negative effects on the pond eco-system, immune suppression and decreased disease resistance. Symptoms of mycotoxicosis in aquatic species can pass unnoticed and economic losses are then usually associated with disease outbreaks rather than mycotoxins. The incorporation of Mycofix® product line (Biomin GmbH) in aquafeeds can help mitigate the negative effects of mycotoxins, mainly tissue damage, that can lead to a poor growth performance and disease susceptibility.

Health medicines and chemicals management

Tools for improved gut health

Preventing diseases is surely more cost effective than treating ill animals. Probiotics are able to modify the intestinal microbiota, secrete antibacterial substances (bacteriocins and organic acids) and compete with pathogens for attachment sites, preventing their adhesion, and subsequent infection, in the intestine. Probiotics also compete with pathogens for the nutrients necessary for pathogen survival, for example iron. The use of AquaStar® Hatchery/ Growout (Biomin GmbH) can improve the health status of aquatic animals by reducing disease outbreaks and the need for veterinary medicines.

Reducing the use of medicines

Acidifiers are known to inhibit the growth of gram-negative pathogens through the dissociation of acids and production of anions in the bacterial cells. Biotronic® Top3 (Biomin GmbH) is a commercial acid-based product that contains a phytochemical component which prevents bacterial pathogens from dividing, and also has a quorum quenching effect by disrupting bacterial communication. In order to improve the mode of action of the previous components, Biotronic® Top3 also includes a unique permeabilizing complex which weakens the cell wall of gram-negative pathogens by breaking down the lipopolysaccharide layer. Several aquaculture trials performed with the Biotronic® product line, show that these products can act as natural growth promoters, and help to eliminate the use of antibiotic growth promoters. This fulfils one of the most important criteria for certification without any loss in growth performance. In addition, the decreased uptake of harmful biological organisms through feed will improve the health status of cultured fish, reducing disease outbreaks without any need for veterinary medicines.

Water pollution and waste management

Pond management

Intensive farming produces large amounts of organic waste which accumulate in the pond bottom and cannot be utilised by the phytoplankton. Oxidation of these organic waste compounds depletes the dissolved oxygen deep in pond bottom soils, leading to the formation of toxic metabolites. This contributes greatly to deteriorating water quality and disease occurrences. A useful and sustainable tool for managing the pond environment is the application of AquaStar® Pond/PondZyme (Biomin GmbH).

This type of bioremediation uses selected strains that focus on reducing pathogenic bacteria, enhancing the mineralization or degradation of organic matter, and removing undesirable waste compounds. Although these are not considered as therapeutic agents, the beneficial bacteria can directly or indirectly alter microbial communities in the rearing environment, and consequently in the fish gut, improving animal health and performance.

Integrated solutions

The projected growth in aquaculture and a greater emphasis on sustainable production practices all highlight the need for effective, natural solutions for aquaculture producers. Feed additives contribute to sustainable aquaculture by supporting feed management, health medicines and chemicals management and water pollution and waste management. Many of the factors involved are intertwined. For example, better nutrient digestibility leads to improved feed efficiency, lower feed costs and reduced environmental discharges. Phytogenic feed additives, probiotics, acidifiers and mycotoxin risk management solutions each have a role in profitable and sustainable aquaculture.

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Pangasius in Indian reservoirs

By B. Laxmappa, Ravinder Rao Bhakshi, B.Sreenivas Reddy and Ranga Ram Mohan

Recent success is paving the way for cage culture as the preferred farming method to expand pangasius production.

India is the second largest producer of the pangasius, *Pangasianodon hypophthalmus* after Vietnam. In 2015, total production in India was estimated at 425,000 tonnes. Due to its remarkable growth rate, the fish is a popular species for farming in ponds in many states particularly in West Bengal, Kerala, Orissa, Andhra Pradesh and Telangana. It is also popular as an alternative to farming the Indian major carps in cages in reservoirs.

Pond farmers culture pangasius using improved pond preparation protocols, such as adding fertilisers for plankton development and using both extruded and pelleted feeds along with local farm made feeds. Probiotics are used after 15-20 days of culture depending on pond water conditions and water exchange. Feeding frequency is twice/day in the morning and evening. Feeding rations vary with age and size of fish.

Cage farming is preferred because fish can be stocked at higher density and fish can grow faster. Recently, pangasius culture in cages was initiated in some of the selected reservoirs particularly in the states of West Bengal, Madhya Pradesh, Uttar Pradesh and Jharkhand. In this Telangana state the government also initiated pangasius culture in floating cages in five selected reservoirs on an experimental basis in mid 2015. The culture was successful and now the government is planning to extend this to other suitable reservoirs by providing financial and technical support to the fisher folk in the state.

Potential for reservoirs

Reservoirs or man-made lakes are huge water bodies, created primarily for irrigation, power generation and other water resource development purposes. India has 19,370 reservoirs spread over 19 states and this is expected to increase due to various water projects in the country. The reservoirs of India have a combined surface area of 3.25 million ha, mostly in the tropical zone, which makes them the country's most important inland water resource. Now cage fish farming has started in the reservoirs in Tamil Nadu, Jharkhand, Himachal Pradesh, Kerala, Odessa, Karnataka, West Bengal, Chhattisgarh, Assam, Tripura, Manipur, Bihar, Srinagar (J&K), Uttar Pradesh, Andhra Pradesh and Telangana.

Culture in cages

In India, the stocking of pangasius fry in cages varies and depends on the carrying capacity of the water body, water exchange, quantity and quality of feed inputs. In each cage (6 m x 4 m x 4 m) 7,500 healthy fingerlings of 4-6 g size are stocked and are cultured for 45-60 days in the nursery phase. After this phase, the fingerlings of size 20-25 g are transferred to other cages at a stocking density of 5,000 fingerlings in each cage (96 m^3) for grow-out for 6–8 months. Best management practices such as regular cleaning of cages to prevent algae from clogging the net and to allow free water exchange. Monthly cleaning of the inner net in the cages to remove settled organic matter is carried out. Fortnightly observation of fish health and growth in each cage is also important. Application of water sanitisers during the culture period when the water turns an abnormal colour must also be carried out. Feed additives and tonics consisting of yeast and vitamins are given for 4-5 days in a month for optimal feed consumption and healthy growth of fish. Each battery (group of cages) has a minimum of 12 cages. This may vary from reservoir to reservoir and from state to state.

Pangasius cage culture in Chandil reservoir of Jharkhand.

According to the decision of the farmer, separate cages are used for pangasius culture while others for tilapia culture. Pangasius are fed extruded floating feed. The feed sizes are starter, grower and finisher with varying crude protein levels (Table 1). Feed costs are more than 60% of the total production costs and are rising. Feeding is twice a day i.e. morning and evening at 3-6% of body weight per day. Feed adjustment is carried out every 15-20 days. At the end of the culture period, which can be 8-10 months, 3-5 tonnes of pangasius are produced from each 96 m^3 cage. Although production volumes have been increasing in recent years, there are still doubts on its economic and environmental sustainability.

Table 1. Composition and cost for commonly used extruded floating fish feed (Growel Feeds Private Limited)

Pellet size (mm)	Crude protein min. (%)	Crude fat min. (%)	Crude fiber max. (%)	Moisture max. (%)	Price per kg (ex-factory)
1.2	32	5	5.5	11	INR 45.5 (USD 0.67)
1.8	32	5	5.5	11	INR 43.5 (USD 0.66)
2.5	28	4	7.5	11	INR 34.5 (USD 0.52)
4	24	3	8.0	11	INR 29.0 (USD 0.44)

Harvesting and marketing

Harvesting is very easy in cages as the fish is contained in a confined area/compartment in the cage. A critical issue is low profit margins as ex-farm prices fluctuate regularly. Now, farm gate prices ranged from INR 60-80/kg (USD 0.9-1.2/kg). The highest price in Jharkhand state was INR 90-100/kg (USD 1.4-1.5/kg). Daily harvesting of pangasius fish is done from the cages at the end of the culture period. This occurs after 8-10 months of culture. With proper cage management, fish reach about 1 kg in size in 8-10 months. Total production varies according to stocking density, survival, types of feed used and level of management.

Pangasius are fed twice a day at 3-6% of body weight per day.

Marketing is the major problem in pangasius culture; output for pond culture fish is higher than demand and the prices fluctuate every year due to various reasons. For pangasius fish cultured in cages, harvested fish are sold fresh daily in local markets in almost all the states. In a few states, it is also sold live at higher prices.

A roaring success

Chandil is one of the largest reservoirs in Jharkhand state. The Department of Fisheries, Government of Jharkhand has installed more than 250 cages with the help of fishermen's cooperatives. From each cage about 4 tonnes of fish are produced. This helps the rural unemployed and those displaced to sustain their livelihood. Several villages with tribal population dependent on fishing in the reservoirs have significant income from cage culture of the pangasius, *Pangasius sutchi*, in addition to fishing from the reservoir.

Technical guidance, skill development and step-by-step training of community members on cage construction and management have led to the adoption of the cage culture system in Jharkhand. The success story of Chandil Reservoir's fish cage farming is the model for replication across the country.

Daily harvesting of pangasius fish is done after 8-10 months of culture.

Extruded floating fish feed

Pangasius farmed in cages are sold fresh daily in local markets or live at higher prices.

Promoting cage culture

The National Fisheries Development Board (NFDB) supported several initiatives in cage culture in reservoirs, first in Jharkhand (Chandil Reservoir), later in Chhattisgarh (Kabirdham) and Assam (Samuguri Beel). NFDB is also providing financial assistance to Fisheries Research and Training Institutes for capacity building to fisher folk and fishery officials on cage fish farming system in reservoirs in the country.

Conclusion

The adoption of any innovation or new technology lies in its economic performance. The rate of return per rupee invested is the economic indicator that guides the investor to choose a particular enterprise or practice. It is essential that cage culture in inland open waters is economically viable for augmenting fish production. Stocking with the right fish species, using fry of appropriate size and stocking at the right time are essential to optimise fish yield in cages. The success demonstrated in different locations in the country has paved the way for cage culture to enhance fish production and livelihood of communities adjacent to the reservoirs.

References are available on request

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Increasing profit margins with farm-made feeds for the pangasius

By Ediwarman and T Luqman

A reduction in cost of production by 30-40% in comparison to using commercial feeds but feed production is subject to raw material availability and price fluctuations.

The farming of the pangasius catfish *Pangasianodon hypophthalmus* in Sumatra is undergoing rapid development, especially in ponds located in marginal areas. In 2015, production in Sumatra South was 250,000 tonnes, making it the largest producer of this fish in the country (bisnis.liputan6.com, 2015). The national production of the pangasius (including the local species *P. djambal*) in 2015 was 393,000 tonnes (MMAF, 2015).

High cost of production

At the national level, the business opportunity in farming the pangasius as a commodity is bright. This is supported by the high demand for pangasius products in both the local and export markets. The Ministry of Marine Affairs and Fisheries (MMAF) continues to encourage its farming. The target for pangasius production was 604,000 tonnes in 2015.

One constraint in this development is the low ex-farm prices for the fish in comparison to the cost of production. Commercial extruded feeds are available in the market but farmers contend that their margins are too low when they use such feeds. Farmers currently receive a net profit of around IDR 2,000/kg (USD 0.15/kg) of fish produced. Calculated production costs range from IDR 10,000 - 11,000/kg (USD 0.75-0.82/kg) and the selling price range is IDR 12,000-13,000/kg (USD 0.90-0.98/kg). The said profit will not materialise when prices drop. According to MMAF, ideally ex-farm prices should be IDR 15,000/kg (USD 1.14/kg). High feed price is seen as the main cause of farmers not being able to lower the cost of production. Currently the price of commercial feed for catfish ranges from IDR 6,500-7,000/kg (USD 0.49-0.52/kg, bibitikan.net, 2016).

Farm-made feeds

There is now a national strategy to reduce the cost of feeds for the pangasius. Since 2014, the research team at the Freshwater Aquaculture Centre (BPBAT) in Sungai Gelam, Sumatra has been developing farm-made feeds with 28% crude protein (CP) at a lower cost of IDR 6,000/kg (USD 0.45/kg) in comparison with 28% CP commercial feeds which costs IDR8,000/kg (USD 0.62/kg).

Our work started with a search on a wide variety of potential raw materials. We had the following criteria; feed ingredients from agriculture such as copra, palm oil and rice; by products from the processing industry; good nutrient content; do not compete with human needs and do not contain toxins. However, these should be available at competitive prices. From selected raw materials, we developed feed formulations according to the nutrient requirements of the pangasius.

This production of farm-made feeds using local ingredients has helped pangasius farmers in Muaro Jambi Regency to make the feed themselves. This was supported by MMAF's program on farm-made feeds called GERPARI. By 2015, this program has succeeded in mobilising farmers to return to farming the fish. Prior to this, almost 40-50% of ponds were unutilised. Through the GERPARI program, large numbers of feed processing equipment are available for use, in comparison with only 70% previously. Now the numbers have increased to 85%. However, there remains the problem of farmers hard-pressed in getting raw materials at affordable prices and seasonal price fluctuations.

The raw materials used include rice bran (Table 1). There is a large variation in the ingredients used and this depends on the individual farmer as well as the availability of raw materials. Usually the raw materials are mixed manually prior to pelleting. These are either fed directly to the fish or dried prior to feeding fish. The quality of the feeds produced by farmers varied, with protein levels ranging from 16% to 26% and feed production costs from IDR 3,500-4,000/kg (USD 0.26-0.30/kg)

Field trials in co-operation with pangasius farmers in Desa Pudak and Tangkit Baru showed that fish fed these feeds grew well. Within 5-6 months, they harvested fish sizes of 2/kg (500 g each). As the feed conversion ratio (FCR) ranged between1.8-2, cost of feed could reach IDR 7,200- 8,000/kg fish (USD 0.54-0.60/kg). Based on prevailing ex-farm prices, farmers can profit up to IDR 5,000/kg (USD 0.38/kg). If fish prices plummet, margins will decline but the farmers will still make a profit. The use of farm-made feeds will reduce the cost of production by up to 30-40% in comparison to using commercial feeds.

Table 1. Formulation and cost of production for grow-out feed with 28% CP.

Feed ingredients	Formulation (%)	Volume (kg)	Contribution of protein (%)	Price/ kg (IDR)	Total cost/kg of feed (IDR)
Fish meal	20.00	20.00	9.39	7,000	140,000
Copra	25.00	25.00	5.63	3,000	75,000
Rice bran	33.00	33.00	4.40	3,500	115,500
Tapioca	1.00	1.00	0.0012	8,000	8,000
Soybean meal	20.00	20.00	9.08	7,000	140,000
Fish oil	0.40	0.40	0	25,000	10,000
Phytase	0.20	0.20	0	56,000	11,200
Premix	0.40	0.40	0	25,000	10,000
Total	100.00	100.00	28.50		509,700
Note: The energy cost per kg of feed was IDR42. The total production cost was IDR 5,510/kg and the selling price was IDR 6,000/kg.					

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Products and services at APA 2016 trade show

Asian Pacific Aquaculture 2016 (APA 2016) Conference and Exposition, held during April 26 to 29, 2016 in Surabaya Indonesia was co-located with two Indonesian aquaculture meetings, INDOAQUA and FITA 2016 as well as the International Symposium on Tilapia in Aquaculture (ISTA). Co-organisers, the World Aquaculture Society-Asian Pacific Chapter (WAS-APC), said that the three events were attended by approximately 6,000 participants from 51 countries.

The trade show was one of the most spectacular yet held with many multi-storey booths, with elaborate designs featuring numerous displays of live fish and aquaculture products. The aisles between booths were constantly crowded and exhibitors hardly had time for a break! The trade show had 241 booths from 22 countries. Several global and regional companies took this opportunity to participate, particularly as Indonesia has a very strong aquaculture industry and aquaculture in the rest of Asia is expanding rapidly.

Rabobank Indonesia, the subsidiary of the Rabobank group of the Netherlands intends to increase its aquaculture portfolio. The business is not limited to food and agribusiness but to the entire supply chain from farm to fork. To date, it has funded medium scale enterprise in tilapia, shrimp and goldfish culture. For aquaculture, understanding and mitigating risks are major challenges for the industry in Indonesia. The bank helps with an internal education sales team to inform industry on mitigating risks. (www.rabobank.co.id)

Korea's **CJ Cheiljedang** launched Aqua-Tide 65, a 65% fermented crude protein concentrate (soybean and corn gluten meal) for partial replacement of fish meal in aqua feeds. The target market is for shrimp feed in Asia. At their booth, CJ's team, Jun Young Bae and Jehoon Ryu, Technical Manager, Feed Ingredients R&D Centre said that the product is the best sustainable protein ingredient for aqua feeds. The advanced bioprocessing technology gives the product higher bioavailability. Antinutritional factors are minimised after *Bacillus subtilis* fermentation. In white shrimp, the apparent digestibility coefficient (ADC) for Aqua-Tide is comparable to fish meal (FM 65%) but in the rainbow trout, the ADC is higher than fish meal. These were results from research at Pukyong University, Korea. Ongoing replacement studies are carried out with the yellow tail at Tokyo University, Japan. (www.cj.co.kr)

Super Artemia Sdn Bhd's team, from left, LL Wong and Fan Lai Fong.

The Malaysian company **Super Artemia Sdn Bhd** markets several brands of Artemia cysts in Asia Pacific. To cater for the demand for high end Artemia, the company markets Golden Dolphin Artemia Premium Plus. According to the company, it is ideal for both tropical aquariums and hatcheries due to the high hatch rate and nutritional value. (www.superartemia.com)

Indonesia's **PT Stargold Internusa Jaya** is a leading manufacturer of cage systems. The latest product from the company is round cages for offshore finfish farming. These cages are 20 m or more in diameter, and are suitable for farming seabass or barramundi *Lates calcarifer* as well as tuna. It is also possible to combine them with other Stargold cages. The company is also promoting the use of its 'KJA Bulat Stargold Tipe Indukan' for holding broodstock. Based on its study on efficiency of egg production, the Research Centre in Batam (BBL Batam) attested that there was improvement in reproduction of the barramundi and pompano *Trachinotus blochii*. Other products are 3-6 m diameter cages for small scale farming of groupers and pompano. The larger 8-15 m diameter cages are also suitable for farming barramundi, pompano, carp and tilapia. (www.stargold.co.id)

At the Inve Aquaculture seminar, Herry Samudra, Indonesia (left) with Rudi Bijnens (middle) and Manuel Poulain.

Dr Kathy Tang and Simon Chung, GeneReach Biotechnoloy Corp, Taiwan

Strong presence

The large presence of Indonesian aquaculturists, including farmers, government officials and researchers was an opportunity for **Nutriad International** to promote products and services. This year Nutriad selected APA16 as its platform for organising a number of technical seminars for its aqua distributors and customers. "These seminars provide an excellent opportunity to our central and regional aqua team as well as our partners and customers in Asia Pacific to learn about current market developments and new findings regarding the application of our functional feed additives for fish and shrimp," said Dr Peter Coutteau, Nutriad Business Unit Director Aquaculture in opening the seminar. He added that there are challenges facing the industry. In fish meal, it is not only its replacement but also recently, the illegal, unreported and unregulated (IUU) fishing issue with Thailand's fish meal supply. Nutriad's role is resolving bottlenecks. The Belgium based company delivers products and services to over 80 countries through a network of Nutriad sales offices and distributors.

"Indonesia's aquaculture grew nearly 20% in the last 5 years in terms of hectares. Production volume increased more than 50% over the last 10 years. Attendees from all over Southeast Asia learned how the Indonesian aquaculture industry realised this amazing growth and the conference was very well attended," said Allen Wu, Nutriad's Regional Manager Aquaculture Asia Pacific and Board Director, WAS-APC.

The invitation-only event for customers featured product and trial updates presented by Nutriad's product managers on aquaculture health and nutrition. Invited speaker Dr Kathy Tang from the Aquaculture Pathology Laboratory, University of Arizona, USA gave an update on emerging shrimp diseases in Asia including acute hepatopancreatic necrosis disease (AHPND), *Enterocytozoon hepatopenaei* (EHP) and white faeces syndrome (WFS).

The Nutriad aqua team, from left, Ho Gim Chong, Technical and Commerical Manager, Malaysia, Alexander van Halteren, Peter Coutteau, Chew Boon Kee, Asia Pacific Director, Allen Wu, Maria Mercè Isern Subich, and Glenn Ferriol, Area Manager, Philippines

At the scientific WAS conference, Nutriad gave two presentations. Alexander van Halteren, Business Development Manager Aquaculture Nutrition, talked on "Cost efficient replacement of essential lipids (cholesterol, n-3 HUFA and phospholipids) in practical grow-out diets for white shrimp *Penaeus vannamei* using different sources of purified bile salts." Maria Mercè Isern Subich DVM, Business Development Manager Aquaculture Health, presented on "The effect of a gut health modulator on productivity and profitability of Nile Tilapia *Oreochromis niloticus* in cage farming."

Some of the researchers from Centex Shrimp, Faculty of Science, Mahidol University and Biotec, National Science and Technology Development Agency, Thailand working on the isolation of PIR toxins from Vibrio parahaemolyticus causing AHPND. From left, Ha T. Dong, Saengchan Senapin, Walaiporn Charoensapsri and Pakkakul Sangsuriya

Holistic management in shrimp farming

The overall objective of the **INVE Aquaculture** seminar "Care for Growth-A Holistic Product and Management Approach" was to present to farmers up-to-date information on its holistic approach in shrimp farming. This included nutrition, health and management issues in the production chain, from hatchery, nursery to grow-out farms. Prior to presentations by the team in Thailand, Rudi Bijnens, Asia Pacific Sales Director, introduced the company's Care for Growth Program where good nutrition, biosecurity and management 'must be there'.

Erik Van Ballaer, Technical Support Manager, Asia-Shrimp discussed problems with water quality along the production chain. He discussed how biofilms in the hatchery can be eliminated using effective doses of disinfectants and a virucide. He also presented nutritional and feed protocols at the hatchery and nursery level. Ballaer showed the costs structure to produce 15 g shrimp and added that larval nutrition is very important for quality post larvae, and should not be compromised by attempting to reduce costs such as that for quality feeds in the hatchery.

Jesper H Clausen, Senior Assistant Product Manager, Farm and Feedmill, spoke on the developments in shrimp nurseries in Asia and Latin America. His message was, using Inve's nursery protocols will bring down total bacterial counts and transfers will require immunostimulants and probiotics (see article on pages 15-18). Manuel Poulain, Technical Sales Support Manager presented some points on super intensive shrimp farming in zero water exchange conditions. He discussed the application of products for microbial and environmental control in nurseries in Vietnam. Dr Olivier Decamp, Product Manager, Farm and Feedmill listed the factors causing white faeces disease (Vibrio and EHP) and linked these to poor water quality, unstable phytoplankton bloom, poor aeration and poor pond condition. The important role of disinfectants, virucides and probiotics was discussed.

Aqua feed additives

During the 3-day trade show, **Trouw Nutrition Asia Pacific** promoted a full package of Selko solutions and several related services to some 300 customers and visitors to its booth. Customers were introduced to solutions for optimal nutritional value, mould and mycotoxin control, osmoregulation and organic trace mineral nutrition.

Prior to the conference and trade show, it also organised a forum titled 'Blending Knowledge with Performance for Trusted Aqua Feed Additives' attended by 60 customers. Attila Honfi, Business Development Aquaculture Selko Feed Additives, opened this with Nutreco's vision on how nutrition for fish and shrimp can contribute to the group mission of Feeding the Future. In his presentation on functional feeds, Dr Alex Obach, Managing Director, Skretting, Aquaculture Research Centre said that long term solutions to resolve health issues include functional feeds and for recirculation systems, faeces binders. He added that fish meal free diets for certain species are already possible and gradually, it will be possible to have such diets with other species. Replacing fish oil is possible with EPA and DHA (eicosapentaenoic and docosahexaenoic acids) from algae, but for the moment, cost is the bottleneck.

On early nutrition in fish and shrimp farming, Dr Eamonn O'Brien, Product Manager, Skretting emphasised its importance, since many species have very delicate digestive systems and the use of high quality fish feed is therefore crucial to support young fry. He said that Skretting is equipped to ease the problems of farmers by taking early nutrition to a whole new level. The final presentation by Dr Kai-J. Kühlmann, Technical Manager, Trouw Nutrition Asia-Pacific, looked at effective strategies to control moulds and mycotoxins which include both monitoring and product application.

The CJ team at APA 2016, Jehoon Ryu (left) and Jun Young Bae.

Launch of global strategy - Shaping the Future

Carlos Diaz

Jan Sverre Røsstad

Ole Christensen

Henrik Aarestrup

In June, the BioMar Group launched a new global strategy 'Shaping the Future'. The strategy will reinforce BioMar's position as a locally responsive, agile, and specialized aquaculture feed provider.

Earlier this year BioMar launched a renewed purpose statement 'We are innovators dedicated to an efficient and sustainable global aquaculture' and a new corporate theme 'Let's Innovate Aquaculture'. Now follows a new corporate strategy.

"It has been important for us to create a strategy built on our corporate DNA and in particular on the four pillars supporting our purpose statement: Innovation, Performance, Sustainability, and Cooperation", explains CEO Carlos Diaz. Diaz underlines that it is the perfect time for launching a new strategy: "We have seen strong financial results in the last couple of years; we have achieved many of our strategic goals; and both we and our owners Schouw & Co. are willing and capable to invest further to continue the success."

The new strategy targets a 6% EBIT level combined with a 50 % increase in BioMar volumes over the next five years coming from both organic growth and acquisitions.

The development of the new strategy has to a large extent involved stakeholders from within and outside BioMar: "We have in particular listened carefully to our customers. It has been crucial for us to both address their present areas of concern and create a strategy which fits with their future plans. Closeness and cooperation with our customers is fundamental for our and their success. One of our new initiatives is that we want to exploit and develop our agility and flexibility further to the benefit of our customers."

A first step in the strategy is strengthening some of the core functions in BioMar. "We have a very lean, agile, and locally responsive organisation. However, in order to secure future growth we want to further enhance our global innovation capability, some of our corporate support functions, and in general our capacity to enter new markets and feed more species", explains Diaz.

As one of the first initiatives BioMar will adjust the operating model and establish three market divisions; Salmon, Emerging Markets and EMEA.

"Our new Salmon Division will comprise all current salmon markets. We target to improve efficiency and integration between these markets and not least to reinforce our R&D efforts in a specie, which accounts for the major share of our turnover, and which at the same time is extremely important for the development of new solutions for the whole aquaculture industry."

Initially, the new Emerging Markets Division will be small, in terms of turnover, but Diaz sees this new division as one of the most important initiatives to secure growth for BioMar: "We are currently building a plant in China and we see great opportunities in China, in other Asian markets and in Latin America. To really tap into these opportunities we need to have a stronger coordination and link between business units and more implementation power."

The third market division will be the EMEA Division, covering Continental Europe, the Middle East, and Africa. "Production has started in our new plant in Turkey, we have seen major improvements in the situation in Greece and the region has in general performed well. With the new steps, we want to consolidate and strengthen our market position in this important area," added Diaz. (More information: cdiaz@biomar.com (Carlos Diaz).

New executive structure

The BioMar Group announced a new Executive Committee comprising Carlos Diaz, Mogens Stentebjerg, CFO and three Vice Presidents: Jan Sverre Røsstad, Ole Christensen and Henrik Aarestrup.

Diaz will during an interim period personally take the lead of the Salmon Division, however Røsstad, BioMar's current Vice President for the North Sea region will immediately become more involved in the company's Chilean operations in order to start creating a stronger link between the company's two largest market areas in Chile and around the North Sea.

Christensen will head the new EMEA Division, which will succeed the company's current Continental Europe region where he was also at the helm. Prior to this, Christensen headed R&D for BioMar Continental Europe. He has extensive experience covering all aspects of the feed business from sourcing to product development to commercial management.

Henrik Aarestrup will move from the position of Global Marketing Director to Vice President of the company's Emerging Markets Division. Besides his position of head of marketing, Henrik Aarestrup has been deeply involved in the development of business plans and strategies for several BioMar companies around the world. With a strong knowledge of the entire organisation combined with extensive experience in international management, his role will be to link the emerging markets to the rest of the organisation and create the necessary push to succeed in these markets. More information: www.biomar.com

Acquisition of innovative aquatic feed and nutrition company

Anno Galema (right), with Dr Pearse Lyons, celebrating Alltech's completed acquisition of Coppens International.

Alltech has acquired Coppens International, a leading international aquatic feed solutions company in the Netherlands. Coppens International is now part of the Alltech family of companies, which includes 14 other companies that Alltech has acquired globally since 2011.

For almost 24 years, Coppens International has earned a strong reputation for being an innovative, high-quality aquatic feed producer. The company's specialties include temperate and tropical marine and freshwater diets for a variety of juvenile and adult species. The company also produces top-quality ornamental, specialty and bait feeds. The company's latest acquisition enhances the Coppens International product range by integrating Alltech's microalgae and protein platforms, thereby providing customers with cutting-edge sustainable technologies pertinent to success in today's demanding aquaculture industry.

"Coppens International has many qualities we admire in a fish nutrition business: a robust, quality production system, dynamic routes to market and a pioneering spirit for research and development, which, all combined, present us with numerous synergies," said Dr Pearse Lyons, Founder and President of Alltech. "With a combination of Alltech's primacy in science and Coppens International's strong distribution network, we have a winning formula for moving aquatic nutrition forward to greater feed efficiency."

"With an average growth rate of 10% per annum, this is a truly exciting time to be in the aquaculture sector," said Anno Galema, Managing Director of Coppens International. "By joining Coppens International with Alltech, we now capitalise on this growth and bring together the best aquatic nutrition solutions to aquatic producers around the world.

Coppens International will continue to be headquartered in Helmond, the Netherlands, and led by Galema, who will report to Patrick Charlton, Vice President at Alltech and newly appointed CEO of Coppens International.

"Today's aquaculture sector requires focus, dedication and an aggressive approach to continuous improvement of nutritional technology," said Charlton. "Moving forward together with Coppens International provides a wealth of opportunity and growth, which will benefit aquatic producers across the globe." More information: www.alltech.com/news or www.coppens.com

New, strain-specific fish vaccines available internationally

Kennebec River Biosciences is now fully approved by the US Department of Agriculture's Centre for Veterinary Biologics to produce autogenous vaccines for fish. This approval greatly expands KRB's ability to design and provide custom, strain-specific health solutions both to the aquaculture sector and to resource agencies worldwide.

Unlike others, KRB Custom™ vaccines target the specific strains of bacteria and/or virus found at the client's farm or facility. KRB's veterinarians have made fish vaccines in this way for years, but only for clients in states where they were individually licensed. Now, KRB Custom™ autogenous fish vaccines are available in all states, as well as internationally.

"Accurate detection and diagnosis is a core competency for us," says Dr Cem Giray, COO and Laboratory Manager. "By sampling on a regular basis and by producing our vaccines from recent, farm-specific isolates, we provide our clients with a precisely targeted solution."

To produce their vaccines, scientists at Kennebec River Biosciences use the pathogens most recently isolated from fish at individual farms or hatcheries. After identification, characterisation and subsequent growth under optimized culture conditions, candidate organisms are inactivated and included in a vaccine. Each vaccine serial is rigorously tested to ensure its quality as well as its safety in fish.

KRB can produce either immersion or injectable custom vaccines. Immersion vaccines are administered to fish through the gills and the gut by exposing fish to specific dilutions of the vaccine in hatchery water for a specific period of time. According to Dr Peter Merrill, a KRB veterinarian and Director of Regulatory Affairs, "the use of immersion vaccines in fish as small as 5 g can be an important factor in an integrated fish health management program."

Effective vaccines can not only reduce disease in vaccinated fish, but also reduce or eliminate costly antibiotic treatments. As many pathogens are capable of changes in their antigenicity, autogenous vaccines (generally developed from more recent isolations) can potentially provide a critical advantage as fish encounter live pathogens and need to mount an immune response.

"Pathogens evolve," says President and CEO Bill Keleher. "Our goal is to help clients evolve faster, to reduce mortality rates and improve profitability." More information: www. kennebecbio.com

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Final program at www. tarsaquaculture.com/2016-program/

The State of the Shrimp Aquaculture Industry in Asia

"We are now learning to deal with a primary bacterial killer (APHND) and a fungus (EHP). These are diseases that our systems were not designed for.. Today there are conflicts in the shrimp industry – some say we should go back to lower density shrimp culture, using specific pathogen resistant (SPR) shrimp, while others say we must go forward with higher production, with higher efficiencies using improved disease-free shrimp.."

Robins McIntosh, *Charoen Pokphand Foods, Thailand*

The Tsunami of Vannamei Shrimp in India: Challenges to Future Growth

"White spot syndrome virus (WSSV) is still the major cause for these crop losses. Apart from WSSV, we also have *Enterocytozoon hepatopenaei* (EHP), white faeces and running mortality syndromes contributing to the losses.. Small farms dominate making it difficult for adequate biosecurity measures.."

Ravikumar Yellanki, *Vaisakhi Bio-Resources (P) Ltd, India*

Indonesian Shrimp Farming: Lessons from IMNV

"Infectious myonecrosis virus (IMNV) came to Indonesia in 2006. A decade later, what is the current shrimp farming condition in Indonesia? How are farmers culturing their shrimp, and what are the lessons learnt?"

Anwar Hasan, *Biomin, Singapore*

Sustainable Shrimp Farming in Latin America with Performance Feeds

"A combination of severe disease incidence/ prevalence ratio, limited resources for aqua feeds, and specific market demands has driven industry stakeholders to rise as active players to propose fundamental solutions for the local, regional and global shrimp culture industry.."

Camilo Pohlenz, *Biomar Americas, Costa Rica*

Genetics and Sanitary Status: SPF vs SPR/SPT

"SPR/SPT may, in some cases, have the drawback of lower performance when compared to other stocks. While resistance, tolerance, susceptibility or higher productivity is a choice based on the biosecurity risk of the farm that will use them, the sanitary status should not be a choice. Why would anyone want to stock (invest) in infected animals?"

Victoria Alday-Sanz, *National Aquaculture Group, Saudi Arabia*

Adapting to a New Reality: Shrimp Nurseries

"There is no 'silver bullet' to address acute hepatopancreatic necrosis disease (AHPND) or any future diseases for that matter. However, increased focus on bio-security, better management practices, and a focus on high quality nutrition and health products are showing promising results to get shrimp production back on track.."

Jesper H Clausen, *INVE Aquaculture, Thailand*

Supply Chain and Ingredient Excellence: Foundations of a Stable Shrimp Industry

"The aquaculture value chain starts with feed raw materials and ingredients. They represent the most determining factor to yield standardized and sustainable performances in farming. However, with current challenges in the farmed shrimp industry, farmers' expectations of feed performances have become very high.."

Vincent Percier & **Philippe Sourd**, *SPF-Diana Aquativ, France*

The Lost Billions in Asia's Shrimp Aquaculture Industry

"White spot syndrome virus remains one of the most serious pathogens – infections are rapid and typically result in an 80-100% loss of stock. AHPND has had devastating economic impacts for Asian shrimp while EHP, the causative agent of hepatopancreatic microsporidiosis (HPM) has caused severe growth retardation.."

Andy Shinn, *Fish Vet Group Asia Ltd, Thailand*

Living with Current Shrimp Disease Threats in Asia

"Several shrimp diseases are new or newly emerging in Asia..CMD is caused by covert mortality nodavirus (CMNV).. There is a new type of shrimp pathology of unknown cause - characterized by the transformation and sloughing of microvilli of hepatopancreatic tubule epithelial cells. This leads to accumulation of vermiform bodies comprising aggregated, transformed microvilli (ATM) in the tubule lumens. Massive production of ATM leads to gross signs of disease called white faeces syndrome (WFS) that results in decreased shrimp growth and survival.."

Kallaya Sritunyalucksana, *National Center for Genetic Engineering & Biotechnology, NSTDA, Thailand*

Health Management for Profitable and Safe Aquaculture Production

"Health management, aimed at disease prevention and avoiding the costs of disease and corrective measures is becoming a must for the shrimp industry to maintain sustainable and profitable growth...Appropriate legislation and enforcement are essential for effective health management.."

Maria Mercè Isern i Subich, *Nutriad International NV, Belgium*

Dealing with Deadly Diseases: Reviewing Nutritional Solutions Available to the Shrimp Industry

"Every few years, the global shrimp farming industry faces major outbreak of a new disease while still suffering from the old ones. Every time an outbreak occurs, the industry suffers billions of dollars in loss productivity and income, and as well as a significant loss in employment opportunities...In the absence of adaptive immune functions, crustacean relies on nonspecific immune mechanism to prevent entry and spread of pathogens.."

M A Kabir Chowdhury, *Jefo Nutrition Inc., Canada*

Disease Mitigation via Feeds and Feeding: Feed Industry Perspectives

"Given the important relationship between nutrition and infectious disease, poor nutrition and poor feeding practices may lead to a reduced immune system response and lower the ability of shrimp to resist disease.. The manipulation of nutrition and feeding will help farmers to prevent and take control of disease outbreaks.."

Daranee Sookying, *DSM Nutritional Products Ltd, Thailand*

The Complete Story of AHPND: Possible Control of the Disease

"We now have evidence that some of the genes are very easily passed from *V. parahaemolyticus* to *V. alginolyticus* with the result of other Vibrio species becoming 'weaponised'..We strongly believe that this can be a practical way of resolving AHPND once we have the appropriate legal and commercial framework.."

Ung Eng Huan, *Biovalence, Malaysia*

Managing EHP and Production Planning to Maximize Output

"Infection is shown in several severity grades that are linked to shrimp growth performance. In addition to the severity, the average body weight (ABW), average daily growth (ADG) and feed conversion (FCR) have to be monitored to come up with decisions related to the subsequent management of affected ponds and timing for harvest. Production planning based on the above variables will be part of the new normal in shrimp farming.."

Celia R Lavilla-Pitogo, *iAqua Malaysia*

Penaeus monodon in MRAS: A Cost Effective Model For Controlled Production in China

"The discussion will include the various phases of the culture cycle with a focus on stocking densities, husbandry techniques and water quality management..Despite relatively low yields, the commercial trial demonstrated that there is enough future potential for further investigation of this species commercially in MRAS in China.."

Robby Mort, *RADAQUA, Australia*

Proactive Management to Keep Disease Away 2.0: An Overview of Current Shrimp Farming Practices

"Today, farmers continue to pay attention to microbial and pond water management to mitigate or overcome disease. Many have innovated and adopted proven techniques to battle diseases, such as expansion of reservoir pond areas for water quality management, changing feeding regimes and developing a nursery phase.. Thai farmers are better managing disease and changing their practices to achieve successful harvest.."

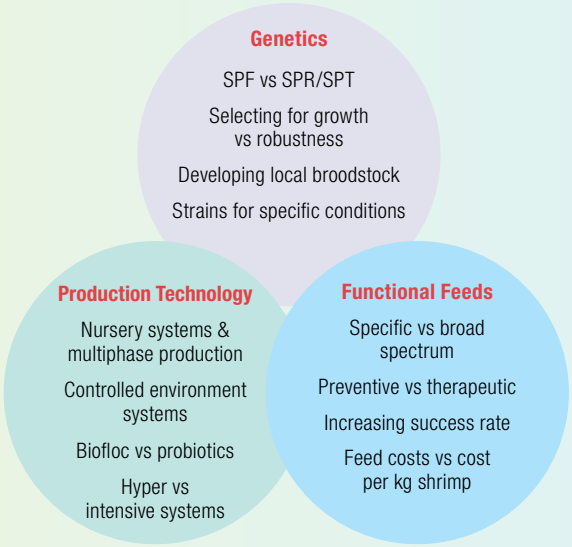
Soraphat Panakorn, *Novozymes Biologicals, Thailand*

INTERACTIVE BREAKOUT GROUP SESSIONS

"Pathways to Disease Mitigation"

The plenary presentations will set the tone for the interactive breakout group sessions aimed at bringing the industry to a New Normal in light of ongoing and emerging diseases. Participants will break into groups to discuss challenges and opportunities; debate on the pros and cons of critical strategies and identify recommendations for disease mitigation.

The three breakout groups will discuss Disease Mitigation via:



Supported by: Organised by: Sponsors:

REGISTRATION IS LIMITED TO 200 PARTICIPANTS. Walk-ins are not encouraged. For more information and updates, please go to www.tarsaquaculture.com • Email: conference@tarsaquaculture.com

New bio-surfactant

In May, Kemin launched LYSOFORTE® Liquid, a bio-surfactant, which revolutionises the application process by directly dosing the bio-surfactant into the oil and fat application line. It is one of the most cost-effective bio-surfactants on the market. The product was launched in Europe, Middle East, India and in a number of markets in Asia.

This naturally derived liquid bio-surfactant is added directly into the oil or fat line during feed production. Mixing the bio-surfactant with the oil and fats early enhances its efficacy and helps standardize the energy value of the oil, in combination with the well-known effects on nutrient digestion and absorption.

"This is a situation where we took something that was working well and made it even better," explained Dr Monika Bieber, Lead Global Platform Manager. "Traditionally bio-surfactants are added as a dry product to the mixer with other feed raw materials. Their benefits to improve various steps in lipid digestion, such as emulsification, hydrolysis and nutrient absorption are well known. Consequently, the addition of a bio-surfactant leads to a better utilisation of the energy from feed raw materials, resulting in improved feed conversion ratios, lower production costs and improved profitability."

Lipids come from a wide variety of sources and are prone to large variations in their nutritional value. Recently, Kemin laboratories have been analysing numerous oil and fat samples using the Lipid Evaluation Test to determine accurate lipid profiles, and characterise apparent metabolisable energy (AME) values and oxidative status. Kemin scientists have reported up to 30% variation in AME values for a single oil type. Trials have demonstrated that applying the liquid bio-surfactant reduces the natural variability of oils and fats. As proven through the Lipid Evaluation Test, Lysoforte® Liquid increases feed formulation accuracy and, in turn, increases feed cost savings.

A state-of-the-art application system is available to assist customers with the application of Lysoforte® Liquid directly into the oil and fat line at the feed mill. (www.Kemin.com)

What to look forward to in Aqua Culture Asia Pacific in 2017

In 2017, we will cover what is trending and technologies for the next step in aquaculture in Asia Pacific. Our topics are most relevant to the industry to help companies reach marketing targets.

Volume 13 2017						
Number	**1 – January/ February**	**2 – March/April**	**3 – May/June**	**4 – July/August**	**5 – September/ October**	**6 – November/ December**
Issue focus *Recent developments and challenges for the next step*	Microbial Management	Hatchery & Nursery Technology	Sustainable & Responsible Aquaculture	Revisiting Shrimp Nutrition	Biosecurity & Disease Management	E-aquaculture & commerce
Industry Review *Trends and outlook, demand & supply*	Marine Shrimp	Marine Fish	Aqua Feed Production	Tilapia	Catfish	Genetics
Feeds & Processing Technology *Technical contributions from feed industry*	Fish Meal & Marine Protein Replacements Feed Enzymes	Novel Ingredients Micro Feeds Feed Additives	Lipids & Minerals Performance Feeds for Intensification	Extrusion & Processing Feed Additives	Sustainable Feeds Feed Safety and Hygiene	Functional Feeds for Health
Production Technology *Technical information and ideas*	SPF/SPR/SPT shrimp	Cage Culture Automation	Controlled systems/RAS	Disease Mitigation	Finfish Industrialisation	Aeration Technology & Waste Treatment
Aqua business Feature articles	Experiences from industry and opinion article covering role models, benchmarking, health management, SOPs, social investments, CSR, ancillary services etc					
Markets	Developments in markets (live fish, product development, market access, certifications, branding, food safety etc)					
Company/Product news	News from industry including local and regional trade shows					
Deadlines for Technical articles	**November 16, 2016**	**January 16**	**March 13**	**May 15**	**July 17**	**September 18**
Deadlines Advert bookings	**November 23, 2016**	**January 23**	**March 20**	**May 22**	**July 24**	**September 25**
Show Issue & Distribution at these events as well as local and regional meetings ****Show preview***	**VIV ASIA 2017** March 15-17 Bangkok, Thailand	**Giant Prawn 2017** March 20-24 Bangkok, Thailand **Seafood Global Expo** April 25-27 Brussels, Belgium	***World Aquaculture 2017** June 26-30 Cape Town, South Africa	***Asian Pacific Aquaculture 2017** July 24-27 Kuala Lumpur, Malaysia **The Aquaculture RoundTable Series, (TARS 2017)** TBA **Vietfish 2017** TBA Ho Chi Minh City, Vietnam		

World Aquaculture 2017

Sustainable Aquaculture
New Frontiers for Economic Growth
Spotlight on Africa

June 26-30, 2017

Cape Town International Convention Centre
Cape Town, South Africa

The Annual International Conference & Exposition of World Aquaculture Society

Hosted by

Aquaculture Association of Southern Africa

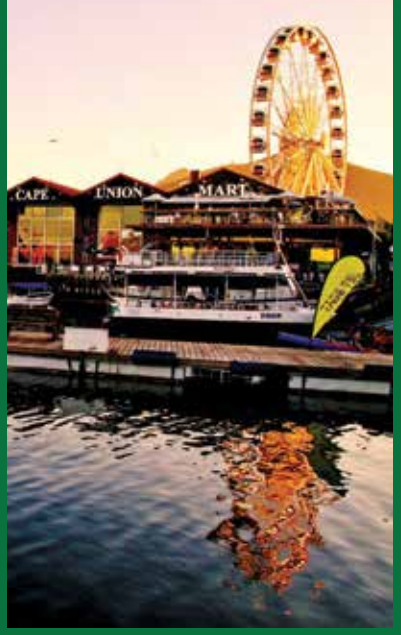
Department of Agriculture, Forestry and Fisheries, Republic of South Africa

Associate Sponsors

Aquaculture Engineering Society

International Association of Aquaculture Economics & Management

WorldFish



For More Information Contact:

Conference Manager

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

Tel: +1.760.751.5005 | Fax: +1.760.751.5003

Email: worldaqua@aol.com | www.was.org

23rd Annual Practical Short Course

Aquaculture Feed Extrusion, Nutrition and Feed Management

August 21-26, 2016

A one-week practical short course on Aquaculture Feed Extrusion, Nutrition and Feed Management will be presented on August 21-26, 2016 at Texas A&M University by staff, industry representatives and consultants. This program will cover information on designing new feed mills and selecting conveying, drying, grinding, conditioning and feed mixing equipment. Current practices for preparing full-fat soy meal processing; recycling fisheries by-products, raw animal products, and secondary resources; raw material, extrusion of floating, sinking and high fat feeds; spraying and coating fats, digests and preservatives; use of encapsulated ingredients and preparation of premixes, nutritional requirements of warm water fish and shrimp, feed managements and least cost formulation are reviewed.

Practical demonstration of sinking, floating and high fat aqua feed, are demonstrated on four major types of extruders - (dry, interrupted flights, single and twin screw), using various shaping dies. Other demonstrations include: vacuum coating and lab analysis of the raw material for extrusion. Reservations are accepted on a first-come basis.

More information: Dr. Mian N. Riaz, 2476 TAMU; Food Protein R&D Center, Texas A&M University, USA. Email: mnriaz@tamu.edu; Website: http://foodprotein.tamu.edu/extrusion

2016

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**

July 20-21
AQUATECH Philippines 2016
Tagaytay City, Philippines
Email: aquatech.ph@gmail.com
Web: https://www.facebook.com/AquatechPhils

August 3-5
Vietfish 2016
Ho Chi Minh City, Vietnam
Web: www.en.vietfish.com.vn

August 3-7
11th Asian Fisheries and Aquaculture Forum 2016
Bangkok, Thailand
Web: www.afsconferences.net

August 4-6
Asean Fisheries and Aquaculture Conference and Exposition 2016
Bangkok, Thailand
Web: www.aseanfishexpo2016.com

August 8-9
Aqua Fisheries Cambodia
Email: sabrina.hoang@veas.com.vn
Web: www.veas.com.vn

August 17-18
The Aquaculture RoundTable Series (TARS 2016) - Shrimp Aquaculture & The New Normal
Phuket, Thailand
Email: conference@tarsaquaculture.com
Web: www.tarsaquaculture.com

September 6-8
Seafood Expo Asia
Wanchai, Hong Kong
Web: www.seafoodexpo.com/asia

September 20-23
Aquaculture Europe 2016
Edinburgh, Scotland
Web:www.easonline.org

September 23-25
India International Seafood Show 2016
Visakhapatnam, Andhra Pradesh
Web:http://internationalfair.in/

September 26-30
Certificate in Aqua Nutrition
26-30 September 2016,
Bangkok, Thailand
Email: agrischools@progressus.asia
Web: www.progressus.asia

September 28-30
Aqua Fisheries Myanmar
Yangon, Burma
Email: sabrina.hoang@veas.com.vn
Web: www.veas.com.vn

October 19-21
AquaSG 16
Singapore
Email: info@aquasg.com
Web: www.aquasg.com

October 27-29
6th International Conference of Aquaculture Indonesia (ICAI) 2016
Kuta-Bali
Email: icai.aquaculture@gmail.com
Web: www.icai.aquaculture-mai.org

October 31-November 2
International Fisheries Symposium (IFS2016)
Phu Quoc Island, Vietnam
Email: ifs2016@ctu.edu.vn
Web: http://ifs2016.ctu.edu.vn/

November 2-4
China Fisheries and Seafood Expo (CFSE)
Qingdao
Email: seafoodchina@seafare.com
Web: http://chinaseafoodexpo.com

November 9-11
Taiwan International Fisheries and Seafood Show
Kaohsiung
Email: taiwanfishery@taitra.org.tw / stenly_yonardi@myexhibition.com.tw
Web:www.taiwanfishery.com

November 21-25
Certificate in Aqua Feed Milling
Bangkok, Thailand
Email: agrischools@progressus.asia
Web: www.progressus.asia

November 28-December 1
LAQUA 2016
Latin American & Caribbean Aquaculture 2016
Lima, Peru
Web:www.was.org/www.marevent.com (for exhibition)

2017

March 15-17
VIV Asia 2017
Bangkok, Thailand
Web:www.vivasia.nl

March 20-24
Giant Prawn 2017
Bangkok, Thailand
Email: salinkr@ait.asia/new.macrobrachium@yahoo.co.uk

April 4-6
International seminar on Advances in Fish Health
Putrajaya, Malaysia
Email: isafe@upm.edu.my
Web: www.isafe.my

Food for thought

The annual meeting of the
European Aquaculture Society

aquaculture europe 16

Edinburgh

September 20-23

Scotland

eas 40 years
european aquaculture society

www.easonline.org

BioMar

marinescotland

All info on:
www.easonline.org

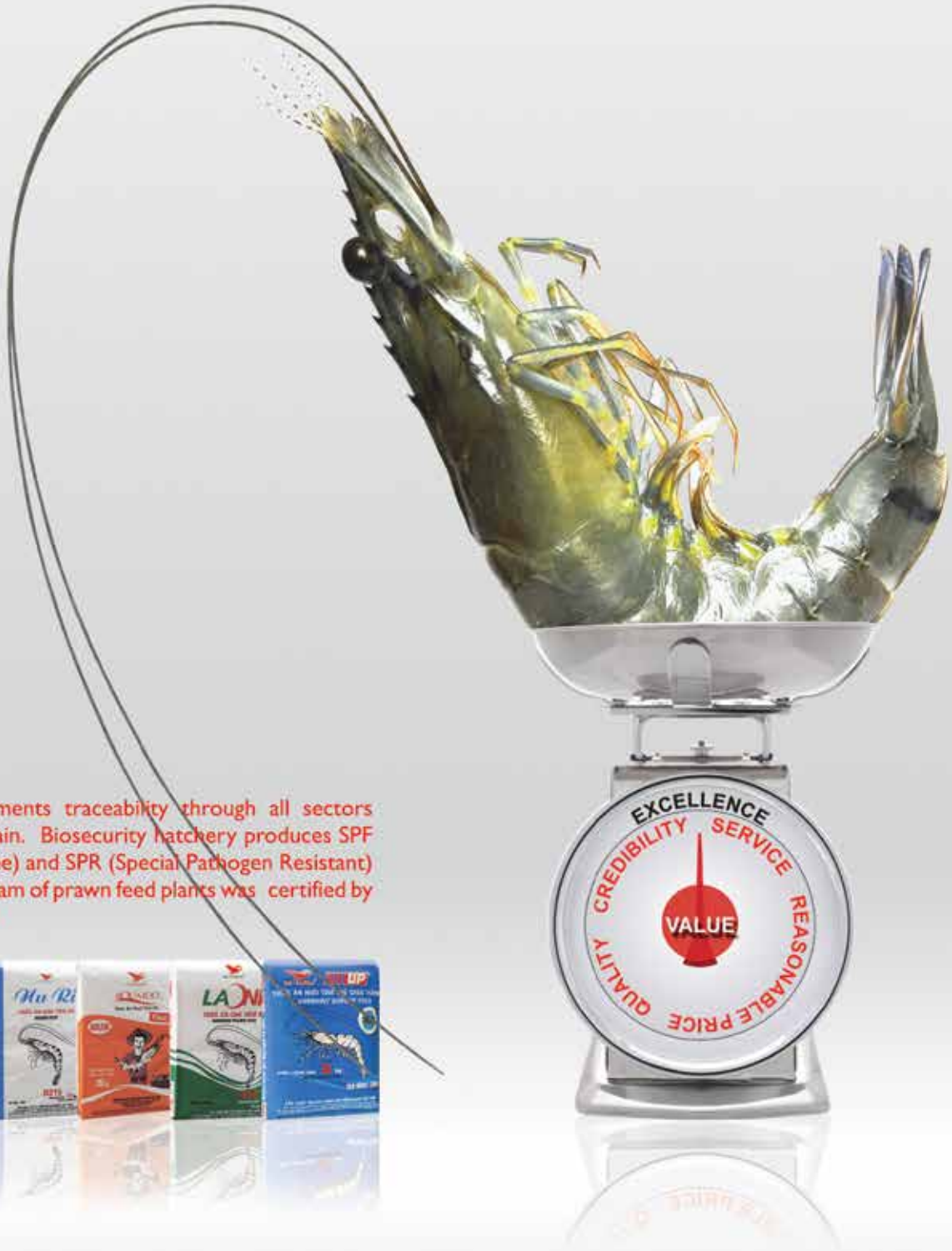
The Scottish Government
Riaghaltas na h-Alba

Marine Alliance Science Technology Scotland

Organised by the European Aquaculture Society with the cooperation and support of Marine Scotland, part of the Scottish Government and The Marine Alliance for Science and Technology for Scotland

Uni-President®

CREATES THE VALUE OF PRAWN



Uni-President implements traceability through all sectors along with supply chain. Biosecurity hatchery produces SPF (Special Pathogen Free) and SPR (Special Pathogen Resistant) larvae. Quality program of prawn feed plants was certified by ISO 22000 & HACCP.

- No.16-18-20, DT743 Road, Song Than II Industrial Zone, Di An Ward, Di An Town, Binh Duong Province, Vietnam
- Tel: +84-650-3737626 - Fax: +84-650-3790819
- Email: aquafeed@upvn.com.vn

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UNI-PRESIDENT VIETNAM CO., LTD.

Establishing a Healthy and Happy Tomorrow