THE
AQUACULTURE ROUNDTABLESERIES® 2019

A shared vision for aquaculture in Asia

August 14-15, 2019 • Bali, Indonesia

AQUAFEEDS: FIT FOR FUTURE

TARS 2019 MEETING REPORT

Contents

TARS 2019
Aquafeeds: Fit For Future

The Aquaculture Roundtable Series (TARS) 2019, held from August 14-15 in Bali, Indonesia was attended by 247 participants from 26 countries. The series returned to focus on Asia's aquafeed sector, the third time in its nine-year old history. Previously, the aquafeed industry was covered in 2015 (Hanoi, Vietnam) and in 2011 (Singapore, its inaugural year). Focusing on developing "Aquafeeds: Fit for Future", plenary speakers discussed the state of the aquafeed industry in four major producing countries, nutrient requirements for fish and shrimp, new ingredients for fish meal and oil replacement, disease control and health management, and how the industry can be fit for the future via technology and sustainability.

Organisers, Aqua Culture Asia Pacific and Corporate Media Services, Singapore invited three C-suite executives from the aquafeed industry in Denmark, India and Philippines for the Hard Talk. The breakout session had participants networking and discussing the next steps in marine shrimp, marine fish and freshwater feed production. Industry sponsors at TARS 2019 were: Inve Aquaculture, DSM, Corbion, Biomin, BASF, Adisseo, BioMar, Calysta, Jefo Nutrition, Veramaris, Phibro Aqua and Skretting.

The aquafeed industry in Asia has always played a supporting role in the development of aquaculture. A prerequisite is that the aquafeed industry moves in tandem with aquaculture - catalysing and incentivising aquaculture.

TARS 2019 was supported by the Ministry of Marine Affairs and Fisheries, Indonesia (MMAF). The aquafeed segment has a supporting role and as such, feed producers need to keep up with developments," said Mimid Abdul Hamid, Director of Feeds and Drugs at the Directorate General of Aquaculture (DGA), MMAF, in his welcome address. "Currently, our farmed fish production, from tilapia to the Asian seabass totalled more than 6.8 million tonnes. Indonesians consume a lot of fish and demand for fish is increasing as the population expands and as incomes rise.

"Small scale farmers are the back-bone of our aquaculture industry and the government is frequently faced with calls to reduce the costs of feeding the catfish and other freshwater fish. Therefore, to solve this problem, DGA initiated a feed self-sufficiency movement or simply abbreviated to GERPARI (Gerakan Pakan Mandiri), a program which aims to produce affordable feeds by using local raw materials," added Mimid.

TARS 2019 started with state of industry presentations on four major aquafeed producing countries in Southeast Asia-Indonesia, India, Thailand and Vietnam. Common to these countries is stable and upward demand for various freshwater fish feeds although that for shrimp feeds fluctuates as farms face disease outbreaks. Feed producers continue to play a large supporting role throughout the production cycle.

SESSION 1: STATE OF INDUSTRY AND CHALLENGES

Aquafeeds in Indonesia: Different strokes for different species in Indonesia

The aquafeed demand comes from the farming of various aquatic species with different characteristics. In 2015, Indonesia produced 947,000 tonnes of tilapia, 575,000 tonnes of milkfish and 1.4 million tonnes of carps, *Clarias* catfish and pangasius (Phillips et al., 2015). However, feed producers focus on the production of shrimp and tilapia feeds.

"The GPMT aquafeed division, comprising 10 members, have been trying to develop marine fish feeds but the progress is slow compared to that for various freshwater fish," said **Haris Muhtadi,** current chairman, Aquafeed Division of the Indonesian Feedmills Association (GPMT) and Associate Director at PT CJ Feed and Livestock Indonesia.

In the Indonesian shrimp feed sector, demand is mainly for vannamei shrimp feeds, similar to that in countries like Thailand and Vietnam. As most monodon shrimp farmers have converted to farming the vannamei shrimp, almost 90% of the farmers in Indonesia are culturing the latter. Most GPMT members produce only shrimp feed, while the others produce both shrimp and fish feeds.

The marine fish feed market is still very small as Indonesia only produces groupers and seabass in some parts of the country, namely Bali, Lampung, north of Jakarta and around Medan in Sumatra. The government has drastically changed the regulation on selling live grouper to well-boats for Hong Kong and mainland China markets. This affected production.

Challenges in Indonesia

GPMT data on aquafeed production varied with official government figures. Total aquafeed production in 2018 reached almost 1.7 million tonnes, comprising 1.4 million tonnes of fish feeds and 321,000 tonnes of shrimp feeds.

Mimid Abdul Hamid (third left) with Indonesian feedmillers and stakeholders, from left: Anwar Hasan, Biomin; Haris Muhtadi; Rizky Darmawan, PT Delta Marine Indonesia; Fauzan Bahri, Skretting Indonesia and Rudy Purwono, PT Matahari Sakti.

The Indonesian aquafeed industry has been facing many challenges such as feed pricing, purchasing capacity of farmers and requests for lower feed prices from the farmers. The main challenge is on producing high-quality yet cost-effective feeds. Haris noted, "The competitive landscape is changing with the entry of new foreign companies with lower prices and longer credit terms. We expect disruption in industry causing the oversupply of fish and shrimp feeds, when these companies launch new products into the Indonesian market next year."

Acceptable prices

From the perspective of feed millers, the challenge is to meet market demand on acceptable prices. Haris also listed some innovations required in the feed supply chain such as pre-treatment of raw materials, application of feed additives, dietary essential amino acids, mill efficiency and raw material quality management, efficient milling process to increase bioavailability of nutrients and improving farm and health management.

Internal factors

Internally, the challenges are in tandem with the global trend of sustainable aquaculture, with regards to sources of raw materials and responsible use of resources. At the same time, the industry need to meet the minimum standard for feeds, be profitable and to ensure food safety. At the farm level, it is to ensure good feed conversion ratios (FCR), high survival rates and high average daily growth (ADG). In addition, lowering waste from feed production and feed application, while ensuring the safety of employees and customers by using non-hazardous chemicals and antibiotics are important. Lastly, it is providing workers with a safe working environment.

In feed production, challenges include reining in the costs of energy, labour costs and other costs such as certification. The feed industry depends on imported raw materials, calculated at 80-85% in the production of fish and shrimp feeds. GPMT members face the problem with local production of fish meal and fish oil in some parts of Indonesia. There is an abundance of by-products from fisheries, but post-harvest processing is a big challenge. The centre for fish meal production is in Banyuwangi, but in terms of supply consistency and quality, there is still a long way to go.

External factors

Some government policies have been difficult for the industry such as feed standards based on crude protein levels. But recently, the government adjusted regulations on feed standards and on registration to fit the needs of industry. To fulfill the nutrient requirements of different species, feed producers can also apply composition of amino acid and minerals to register feeds. Recently, GPMT met with the government to change the feed standard on the minimum crude protein level for milkfish and for some freshwater and brackish water fish species, from 18% to 15%. This will be profitable for the feed industry and will help farmers farming milkfish in semi-intensive and traditional systems. Previously, 15% crude protein feeds were banned for distribution in the Indonesian market.

At the first Q&A session, from left: Orapint Jintasataporn, Jarin Sawanboonchun, Haris Muhtadi, Ravikumar Bangarusamy, Brett Glencross and Marc Campet.

Future in shrimp feeds

The size of the current shrimp feed market is small with an estimated 500,000 tonnes per year (tpy). Competition is tough and feed companies are pushed to extend credit terms, as well as reduce selling prices. Most aquafeed plants are concentrated in the eastern and western parts of Java Island. The logistics and distribution to other parts of this large country (e.g Sumatra, Sulawesi) and maintaining feed quality are major challenges.

In shrimp feed production, only 51% of the existing capacity of 620,000 tpy is utilised while the market growth is only 8.5% a year. By 2020, three new investments will add another 140,000 tpy, which is equivalent to 22.6% of current capacity, while the overall utilisation rate of future capacity will decrease to 44%.

Future: Some possible scenarios

Haris gave some scenarios. With a crowded market, a price war will soon be looming. Usually feed price is related to quality and with the pending price war, there is a possibility where aquafeed producers will adjust the feed quality, to sell the feed at an 'acceptable price'. Aside from reduced shrimp or fish performance, the negative effects are that fish and shrimp will be more susceptible to disease outbreaks. He predicted more bad debts with crop losses.

Haris concluded, "Despite its current state and the many challenges presented to the Indonesian aquafeed industry, there will always be a demand for cost effective feeds to fulfill supply needs of protein for a burgeoning population. In order to produce cost-effective and high-quality feeds, the industry needs to reduce its reliance on imported raw materials by improving the quality of local raw materials.

From left, Adnan Kharisma and Andri Budi Santosa, Alltech Indonesia; Dr Erwin Suwendi, PT Suri Tani Pemuka and Erik Harjadi Lisnan, Japfa Comfeed Indonesia.

Growing pains and technology changes in India

Ravikumar Bangarusamy, Technical General Manager, Growel Feeds Pvt Ltd, India discussed the state of the aquafeed industry in India and the recent threats from the farming sector.

India's aquafeed industry has 68 aquafeed mills with almost 68% located in Andhra Pradesh state. There 18 dedicated shrimp feed mills, 16 for fish feed production and 12 feed mills producing both shrimp and fish feeds. Fifteen feed mills have large capacities (>100,000 tonnes per year (tpy). In 2018, installed aquafeed capacity totalled 4.8 million tpy but the utilisation rate was only 50%.

For India's aquafeed producers, the advantage is that most feed ingredients are available locally, particularly for fish feed production. There are restrictions on the imports of animal origin ingredients, GMO crops and soybean meal which limit the industry's competitiveness. Spiralling prices of ingredients against stagnant or declining prices of fish and shrimp, have forced feed manufacturers not to increase feed prices.

Shrimp feed demand and supply

Ravikumar indicated that since late 2018, in 80% of areas, farmers have started to reduce stocking density. Today, average stocking density is only 30 post larvae (PL)/m^2 instead of the previous 40 to 60 PL/m^2. Clearly, farmers are challenged by disease outbreaks and low prices. The microsporidian *Enterocytozoon hepatopanaei* (EHP) is a major problem in India. In addition, there has been extreme high temperatures particularly in Tamil Nadu and Andhra Pradesh, intermittent rains in Orissa and West Bengal and floods in Gujarat. Late arrival and absence of monsoons is another factor.

"Generally, in well managed ponds and good shrimp growth performance, FCR, can be between 1.2-1.3. In EHP affected farms, FCR will be very poor. At the end, the crop will either be at breakeven or a loss. Premature harvest due to disease outbreaks impacted all support industries including feeds."

In 2018, 46% of installed capacity for shrimp feeds (2.8 million tpy) was utilised with 1.3 million tonnes of shrimp

feed sold. Data on the monthly consumption pattern for shrimp feed collected over three years (2016-2018) showed feed consumption peaked at 72% of installed capacity during May-June and was lowest at 22% in December.

Auto feeders and functional feeds

Ravikumar emphasised that the feed industry can offer shrimp health solutions, but these cannot substitute good farm management. Today, some of corporate farms use sensor-based auto feeders which are highly recommended to reduce organic loads of ponds. Part of his role in Growel is to conduct R&D and advise farmers on pond management including using functional feeds.

Data from his R&D work comparing pelleted feeds versus extruded functional feeds in about 1,000 ponds across India for the past 3 years at various locations, at different salinities and over winter and summer, showed better survival rates by 24%, better average daily growth rate (ADG) by 30% and improved FCR by 21% with extruded functional feeds.

Shrimp feed: growing pains

These range from ingredients to impact along the supply chain. “Less fish meal is available while there is a decline in quality of local fish meal. There is also a lack of good quality animal proteins. We depend on local soybean as there are restrictions on the import of soybeans. As most of the feed mills are in Andhra Pradesh, feed prices can increase by as much as 6% for farmers in West Bengal,” said Ravikumar.

With shrimp growing slowly, premature harvests, repeated crop failures and reduced stocking density by 50%, farmers have cash flow problems which will filter to poor repayment to the input suppliers. Ravikumar continued, “Dealers have high risks with slow or poor recovery of credit. In turn, dealers expect more discounts from feed companies to compensate for the extended credit period to farmers.

“With such uncertainty, feed companies have difficulty in forecasting feed demand and producing feed at competitive prices, limited scope to increase prices and face unhealthy competition.”

Ravikumar added, “The growth of the shrimp feed segment will depend largely on farmers overcoming disease challenges and introduction of disease tolerant stocks, especially for WSSV and EHP. It can benefit if domestic shrimp consumption can reach 20 to 30%. We can expect some consolidation; merger and acquisition of independent feed mills by multinationals.”

Fish farming: The big change

There has been a steady increase in demand for fish feeds. In 2018, utilisation of installed capacity for fish feed production (2 million tpy) was 47.5% at 950,000 tpy. However, for such low cost fish feeds, the transport cost of supplying to distant markets is prohibitively high by as much as 9%, since most fish feed mills are in Andhra Pradesh. “Compared to shrimp feed, demand is stable throughout the year; the highest is 74% in October/ November and 40% of installed capacity in May,” said Ravikumar.

“The big change is that farmers use extruded and pelleted feeds. In the beginning it was only for 2 species and now, 4 species. The farmed fish market is also improving; more diversified with improved pond productivity and post-harvest handling. But prices drop with an oversupply and we can stabilise prices with species diversification which will also increase feed usage.” Some corporate farms have started to farm tilapia and murrel (snakehead) is being farmed in cages in reservoirs.

To increase feed performance, some feed mills have been conducting trials on post pellet application of enzymes. They are however limited in the selection of application methods in terms of cost and efficiency. However, there is a cost increase. Changing farmers’ mindset is an issue, especially if fish prices continue to drop. Such a technology may be more suitable for high value species. Another change is the introduction of high fat feeds for marine species such as 16% fat in seabass feeds.

Ravikumar concluded, “India’s aquaculture and aquafeed sectors are expanding and have long-term growth potential. Both are undergoing various challenges but we are positive that eventually we will overcome them and continue to grow and meet our production targets.”

Raising questions on moisture content to stability of vitamins in feeds, From left, Md Akteruzzaman, Jefo Nutrition, Bangladesh; Hendi, PT Leong Hup Jayaindo, Indonesia and Steven Goh, Delstasia Sdn Bhd, Malaysia

Challenges in Thailand: A view from the next generation

Dr Jarin Sawanboonchun, aquaculture nutrition and feed specialist said that the commercial aquafeed industry began around 1988; now 30 years later, it is the next generation that is taking over.

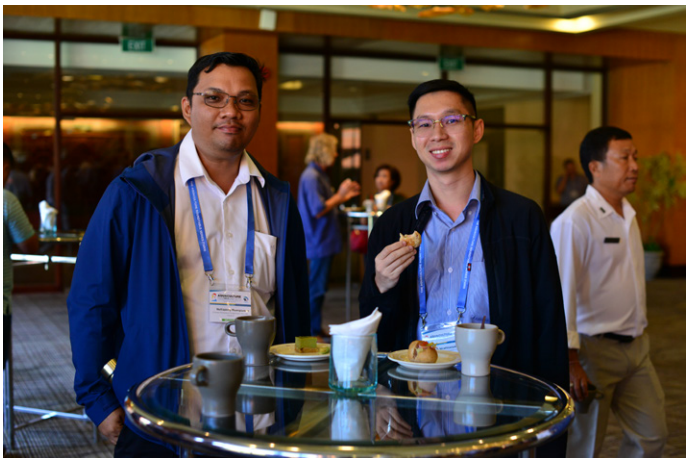
Today, Thai feed mills operate in a highly competitive market where the demand is for the production of the best performance feeds at the lowest cost possible. To do this, feed mills need good nutritional knowledge, technology (software and production), quality raw materials available at low costs and R&D facilities to trial changes in formulation. A good technical team is also needed to provide advice and services to farmers. The emerging social media has been useful for industry to follow aqua production trends and understand real time monitoring of emerging issues. Jarin discussed the direct challenges faced by aquafeed producers and indirect ones affecting the aquafeed industry.

Fish meal supply and demand

This is a problem quite unique to Thailand as in 2015, it was issued the "yellow card" for IUU (illegal unregulated and unreported) fishing. This was removed in early 2019. "For a long time, Thai feed producers prefer to use local fish meal. While the government was settling the IUU issue, fish meal production went down, but more importantly, a lack of certified fish meal which is desperately in need by feed producers with certification," said Jarin, adding that this pushed for R&D to find alternatives to fish meal in aquafeeds.

Disease outbreaks and lower prices

While disease outbreaks brought down shrimp production by 12%, the drop in global shrimp prices discouraged farmers from investing. The impact was not only low demand for feed, but also farmers losing confidence. Most shrimp feed millers reduced prices to help farmers. A cost analysis showed feed costs ranging from 40-70% of production costs. On whether feed mills can produce cost-effective feeds just to help farmers lower costs, Jarin answered, "Yes, in Thailand, the industry is constantly working on this; cheaper feeds with lower crude protein and has developed functional feeds. However, it is efficient feeding practices together with good farm management that can reduce feed cost."



Nuttapong Muangsuwan, Charoen Pokphand (left) and Pakpoom Nirattisaiyakul, Zinpro Animal Nutrition, Thailand.

Therefore, there are recommendations to use automatic feeders to improve feed intake while reducing labour costs. The Department of Fisheries (DOF) has also created a mobile phone feed application for farmers to use. The aim is to lower cost of production with DOF recommending not to over feed and improve FCR with prudent management, such as not rushing to increase feed for the next day even if shrimp has eaten all.

Standards, certification and traceability

Today, good manufacturing practices (GMP) is a minimum requirement for industry. Thailand has 12 Best Aquaculture Practices (BAP) certified feed mills and they need to keep up with certification standards such as control of feed formulations to reduce fish meal inclusion rates and traceability of ingredients along the supply chain. Traceability is a priority for export to most countries. The latest BAP feed mill standard requires use of responsible soybean meal by 2022; use of at least 50% certified soybean meal. These add costs for aquafeed producers. Certified fish meal is 5% more expensive than the standard fish meal. At the same time, the industry has to catch up and invest in R&D to remove fish meal and fish oil from feed formulations.

Alternative protein sources

Over the years, the inclusion rate of fish meal dropped in feeds for every species. In shrimp feeds, less than 10% fish meal is used in feed formulations. For freshwater species, at least 1% fish meal is used. Feed producers do this by using software that develop formulations based on the amino acids composition of ingredients.

R&D and innovation

As the industry is on track to move from low fish meal to zero fish meal, R&D is critical. At the same time, the industry is seeking suitable protein replacement ingredients and additives for its functional feeds or when formulations have low fish meal. The latter is new in Thailand and requires more R&D. "The challenge is to prove that the functional feeds work. While farmers do not know what to expect, feed producers are also concerned that these functional feeds might not be the correct solution for the farmer."

In red tilapia, Thai farmers prefer the dark red colour and thicker body, more than the pale colour variety. Catfish farmers prefer the yellow colour instead of a darker colour. The constraint is that prices of red tilapia and catfish are very low. "An additive might not work and so we may seek raw materials containing for example high levels of carotenoids instead. R&D in feeds also have to catch up with genetic improvements in the vannamei shrimp. The current feed requirements for the vannamei shrimp is between 20% to 45% crude protein; should there be nutrient dense diets for the fast-growing strains which in turn may pollute ponds?"

Industry constraints

While industry is undertaking R&D to help farmers with cheaper feeds and innovate to produce sustainable feeds, it is limited on how it can change feed composition. Feed standards regulate that the protein in shrimp feeds must start from 32%. "In terms of replacement of fish meal with insect meals, this is not allowed at the moment. Microbial proteins are now available in the market. The first consideration on whether to use insect meal or microbial proteins, will be price, relative to fish meal. Next is quality and supply. A third would be nutritional and toxicology aspects as well as consumer acceptance," said Jarin.

R&D remains core to industry's progress from the current low fish meal to zero fish meal in feeds. In the future, more feed types are expected in the market such as functional feeds. As farmers are also trying their best to improve farm and feed management and using more and better technology, Thailand's feed industry will keep moving forward.

The aquafeed industry is just part of the production cycle. Together with the farming segment, it needs environment, disease and farm management. To address these challenges, the private sector, universities and government need to work together.

Sawasporn Jaklerdchai, SPF Diana, Thailand (right) and Ngo Xuan Tuyen, Pilmico Vietnam JSC.

Gede Suwarthama Sumiarsa, Institute for Mariculture Research and Fisheries Extension (IMRAFE), Indonesia and Dennis Leong, Calysta, USA.

Aquafeeds in Vietnam: What's next?

Vietnam is a major player in Southeast Asian aquaculture and it is also a leading seafood exporter, mainly for the pangasius and shrimp. Aquafeed volumes are large at 3.9 million tonnes, with home-made feeds accounting for 25%. **Marc Campet,** ADM Animal Nutrition, Vietnam looked at recent developments and presented his views on what is next for the country's aquafeed sector.

Pangasius and shrimp feed production dominate the aquafeed sector in Vietnam. Today, there is strong international participation in aquafeed production in Vietnam. However, the industry is probably reaching the over-capacity stage for the past 3 years, new investments coming into Vietnam is a worrying trend.

"We tend to see Vietnam as a leader in terms of aquafeed quality. But among the players, there is strong competition driven by pricing rather than quality. The tendency in Southeast Asia with over-capacity in feed production is also the scenario in Vietnam. There is a wide range of species being farmed, and this is really driving a constant evolution, which is leading to a high demand for new formulations", added Marc.

An emerging nursery shrimp feed segment

Vannamei shrimp farming ranges from low density (<30 PL/m^2), to the recently hyper-intensive (>200 PL/m^2) and indoor production systems. In 2019, the drop in shrimp selling prices has been very challenging for all stakeholders, in addition to diseases. With partial harvesting, the farm structure is significantly moving from large outdoor ponds to much smaller ponds which sometimes are indoors.

The nursery phase which can be 2 weeks to 1 month, is a

K.Venkata Raju, Avanti Feeds Ltd, India (left) and Preecha Bangnokkhwaek, Thai Union Feedmill, Thailand

relatively new feature and a key phase for the farmer. “In the nursery, stocking density is from 1-10 PL/L, with 10PL/L considered as quite a high stocking density. There is an emerging nursery feed market for PL10 to 1-2g juveniles in Vietnam, which is met by micro-pellet feeds starting anywhere at 500µ up to 1mm. Additionally, the trend is towards functional feeds and feeds with high digestibility in order to reduce ammonia and nitrogen levels in tanks. The average protein level of nursery feeds can be 40 to 45%.”

At the farm level, there is a strong focus on controlling production cost leading to a feed evolution towards lower protein feeds. In Vietnam, we start at 40% protein which is still very high for the vannamei shrimp. So, there is a need to examine that, especially if we want to have more cost-effective production. There are also some interest among farmers on probiotic feeds, mainly to regulate gut microbiota.”

Fish feeds

At less than a million tonnes of fish per year, pangasius farming itself has not significantly changed for the past 10 years, but small-scale, grow-out farmers are disappearing.

“If we look at pangasius feed, it is strongly credit-driven and is mainly produced by local players. The protein level is around 30%. FCR is between 1.3 to 1.5 and survival rate is around 70%. R&D on feed development has been very limited since 2000,” said Marc.

In marine fish farming, while artisanal farms mainly use trash fish, industrial farms have moved to intensive farming using complete fish feeds. “A feature of the marine fish feed segment is the multispecies possibility which is changing the focus to R&D on feed development. Marine fish feeds comprise high-density nutrients. The average starter level of protein is around 50%. Slow-sinking extruded feeds are used for cage farming, and for ponds, floating feeds are used. The small and specific feed market for industrial farms in Vietnam is limiting the number of players as well as competition,” said Marc.

“There is an increasing demand for international certification, mainly from the industrial grow-out operations. If we look at the feed profile, over the past 5 years, there is a very significant drop in fish-in-fish-out (FIFO) ratio with 10 to 15% fish meal inclusion and use of co-product fish meal which is now taken into the FIFO calculation.”

Diversification fuels feed evolution

For the past 7 to 8 years, the snakehead is an alternative for pangasius farmers. This high value fish is sold in local markets. Feed protein levels are high at 40% which is basically a mix of grain protein and fish meal. Trout and sturgeon are farmed in north Vietnam. These are high-value species with a small feed market. Snail production is booming in central Vietnam as an alternative for shrimp farmers. Currently, snails are fed on trash fish, but for a more sustainable production, the trend is moving towards complete feeds to replace trash fish.

“In Vietnam, a drawback is the lack of communication between public R&D institutions and private stakeholders. There are a few feed mills investing in R&D capacity in order to be able to develop their own formulations and feeds for new species such as the snakehead.”

Marc summarised, “We can drive aquafeed production by species’ needs and/or by system specificity. Feed performance and technical support are becoming more and more in demand as well as functional feed for gut microbiota control. I believe that vaccination can be a really strong drive for the industry in Vietnam, especially if we can find an option to include vaccines in feeds.”

Prakarn Chiarahkhongman (left), Advance Pharma Co., Ltd, Thailand and Pradeep PJ, Leiber Gmbh, India

From left, Suhartono, PT Novus International Indonesia; Guruh Arifianto, PT Sinta Prima, Indonesia; Thapanee Temrangsri, Athene Consulting, Thailand, Dachni Riantika, PT Novus International Indonesia; Candra Yanuartin, PT Sinta Prima, Indonesia; Marilyn Sim, Diamond V, Malaysia; Stefani Harianja, ADM Animal Nutrition, Indonesia; Suaedi Sunanto, Nutricell Pacific, Indonesia and Helentina Mariance Manullang, PT Malindo Aquafeed, Indonesia, Hendro Cahyono, PT Novus International Indonesia and Prapatantio Pringgodigdoyo, PT DSM Indonesia..

SESSION 2: NUTRIENT REQUIREMENT BASED DIETS

Creating value for aquafeeds

Aside from creating value for aquafeeds, Associate Professor **Orapint Jintasataporn,** Faculty of Fisheries, Kasetsart University, Thailand also discussed improvement of feed quality. "When we talk about feed quality, we refer to the nutrient requirement which relates to raw material inclusion. Different raw materials have different digestibility and when we look at plant materials, they contain antinutritional factors (ANFs) that will affect the digestibility, gut health, and immunity of the animal."

Change in nutrient requirements

The inclusion of marine proteins in salmon feeds have decreased to 18.3% in 2013 from 65.4% in 1990 (Nofima, 2014). Marine proteins in shrimp feeds have seen a reduction by 30% to 7-10% and in freshwater fish feeds, it is present at 0-5%. However, in salmon feed, there was an increase in micro ingredients from 1.0% in 1990 to 3.7% in 2013. "When we change the inclusion rates of raw materials, we usually try to balance the nutrient requirement by adding amino acids, fatty acids, vitamins and minerals. But it is more than just these micro ingredients, identified growth factors like the emulsifying properties of fish meal and active ingredients not identified yet, are the reasons for the high nutritive value of fish meal. Today, we term these micro ingredients, functional ingredients," said Orapint listing a range of additives in current shrimp feed formulation included at 0-5%.

In nutrition, among the three focus points is digestibility. When work on requirements was started some 20 years ago, high-quality fish meal with a digestibility of 90 to 95% was used. This is because fish/shrimp get almost everything it needs from fish meal: nutrients, amino acids, fatty acids, vitamins, and minerals. In comparison, plant protein digestibility was only 80 to 85%. "Today, it may seem that the commonly used nutrients are not enough, or the nutrient requirement has changed. Actually, it is the quality of the raw material that has decreased. Sometimes with plant proteins, we have some contaminations such as mycotoxins or high ANFs which decrease digestibility and affect gut health and immunity.

"In summary, we need to focus on digestibility, control ANFs and effects on the immunity to have the same feed quality as we had with high inclusions of fish meal. There are options: increase digestibility and control ANFs with additives, increase inclusion of protein or increase the nutrient concentration. Therefore, in the market today, we have premium feed with high concentration of nutrients or feed additives."

n-6: n-3 ratios

In an example from the livestock industry, Orapint showed what happens with the replacement of fish oil with soy oil. "Dietary n-6: n-3 ratios of 1:1 or 5:1 suppress cytokines. But a ratio of 10:1, especially from arachidonic acid (ARA 20:4n6), induces a synthesis of pro-inflammatory prostaglandins. Eicosapentaenoic acid (EPA 20:5n-3) also induces synthesis of prostaglandins but is an anti-inflammatory molecule. This is the reason why by increasing the levels of n-3 you can reduce the inflammation which induces chronic stress in the animal's body."

Nutrients for gut health

High levels of pathogens in the environment and poor water quality reduce feed intake and affect gut health. Under stressful conditions, activating the NF-kB induces synthesis of pro-inflammatory substances in the body and also increases lysozyme and destroys cells, leading to cell death. In normal conditions, mucus on the villi surface area is where the probiotics and pathogens inhabit. "Probiotics are the useful bacteria. But in a stressful condition, this layer decreases when mucus is less. So, the probiotics and the pathogens are really close to the villi's surface. The pathogens invade the epithelial cell and cause blood infection," explained Orapint.

Many herb extracts in the feed market such as extract of *Macleaya cordata* (sanguinarine) can inhibit the inactive NF-kB from being the active NF-kB. Zinc can also inhibit the inactive NF-kB and can prevent viral infections; when added continuously in feed, and zinc can accumulate at optimum to high levels. "Zinc is a trace mineral and cannot be added in large concentrations. On the other hand, by using the organic minerals, it is possible to include more organic trace minerals such as zinc, copper, manganese amino acid complex, selenomethionine and selenium yeast. Interestingly, extract of artichoke can promote muscle yield in the tilapia by up to 4%, depending on the concentration and it can also decrease cholesterol and triglycerides."

The shrimp also has the NF-kB pathway and organic minerals like mineral amino acid complex, copper glycinate and zinc glycinate in the feed can promote immunity and control pathogen infections in the blood. Marine sulphate polysaccharides from brown, red and green seaweed have anti-inflammatory properties too and can control pathogens. The mode of action is by increasing the mucus on the villi surface and control the mycotoxin from entering blood circulation amongst others. "Many researchers found that the inclusion of marine sulphate polysaccharides, improves the survival rate, especially for shrimp post-larvae or fish fry," said Orapint.

Antibiotic-free production

Creating value of the fish feed also means using alternatives to antibiotics to overcome infections. The challenge is the requirement of high concentrations of these alternatives. The efficacy of antibiotics to control for example *E. coli* is very low at less than 10ppm but for commercial antimicrobial peptides, it is around 100 to 200ppm and commercial essential oils, around 1,000 to 5,000ppm. Antimicrobial peptides are found in fish meal and they can control pathogens and improve growth. Fish and shrimp also produce antimicrobial peptides at very low concentrations and dietary sources are required to control pathogens, promote growth performance and immunity.

Shrimp Feeds: Fit for new genetics and new culture systems?

In his presentation discussing shrimp nutrition fit for genetics and culture systems, Professor **Brett Glencross,** University of Stirling, Scotland looked at what nutritional parameters can genetics and culture systems affect respectively.

The way genetics interacts with nutrition is due to four components; intake, requirements for maintenance, efficiency of utilisation and the overall growth potential. There is little data on these interactions in shrimp but available data suggest multiple points of interaction.

Nutrition and genetics

On the nutrition-genetics interaction, Brett described one study which used a standard shrimp grower diet fed to an 8th generation selectively bred strain and the wild type (Glencross et al., 2013). Results showed a lower maintenance and lower basal energy demands. "The same animals under the same conditions now fed a high nutrient density diet with 50% protein, 7% lipid compared to 40% protein, 6% lipid showed that shrimp with a higher-performing potential needed more nutrient-dense diets and had the capacity to eat more to meet those requirements. However, not all studies have shown clear differences in terms of nutritional responses to genetics."

In 2012 an American study (Gong et al., 2012) looked at different breeding lines from the same founder population, both fast-growing but selected for different traits like disease resistance or high growth, under super-intensive culture conditions. In that study there were no differences to the responses of the animals to different protein levels.

Epigenetic responses

These are responses on top of the changes that are inheritable by DNA changes in terms of the way an animal can adapt to its environment. A recent study (Lage et al., 2018) included young larval shrimp, starved for 3 days and then fed for an extended period of time. Starved or not starved larvae were then exposed to different levels of protein in their diet. After the starvation period, no differences in survival or growth were observed. But once larvae were fed the low, medium or high protein diets after starvation, larvae that had been starved suddenly responded, later in life, to high nutrients and grew better at those on high nutrient supply. "So, clearly something allows an animal an adaptive response at an epigenetic level to allow it to adapt to changing dietary circumstances," said Brett.

Nutrition and culture systems

Different culture systems are emerging with various levels of intensity, from super hyper-intensive systems to laboratory and biofloc systems. How do these systems affect the nutrition? Brett described an experiment conducted by Dr Albert Tacon using an indoor flow-through laboratory clear water system and an outdoor zero-exchange culture green water tank system. "Fed the same diets, there was an overwhelming effect that system was far more dominant than the feed type (Tacon 2002). This begs the question, if the pond is so important to the nutrition of the animal, what is the contribution of green water or pond systems?"

This is not the pelleted feed but the natural productivity within the system. The contribution varies from as little as 7% to almost 90% to shrimp nutrition (Gamboa-Delgado, 2014). The average is about 52%. In a semi-intensive system, the response in terms of growth peaked at around 30 to 33% of the dietary protein whereas in a super-intensive system, it went as high as 37% or maybe even higher (Jatoba et al., 2104).

"However, not all responses are the same," said Brett as he compared results from several studies. A Chinese study (Xu and Pan, 2014) looked at the level of protein in a super high intensive biofloc system. Growth was not better beyond 30% protein. An Australian study (Glencross et al., 2014) compared the clear water laboratory system versus the green water tank system. In the green water system, the endogenous nutrient production was clearly contributing additional nutrition, masking differences seen between diets in the clear water system, but surprisingly those animals grew less than in the clear water system.

"When we increase the intensity of the farming system, we are relying more on the exogenous feed inputs and less on natural productivity. It is time to move towards precision nutrition. This is becoming increasingly important in the way we manage these animals."

Scorecard on nutrient requirements

"During TARS 2014, I did a scorecard for shrimp nutrient requirements. The availability of quantitative data for each of the 45 different nutrients, minerals, and vitamins was 40/45. Today the score is 45/46 and additionally in the last 5 years, we have discovered other nutrients influencing the growth of shrimp. At the same time, we may have to relook at some of the older empirical studies as today what we know has grown considerably from the earlier experience," said Brett.

A classic case can be seen from a Chinese study published about 10 years ago which gave a nice linear curve for various levels of lipid or protein plotted against gain rate (g/kg). "Today, when we re-integrate that data and look at the protein-energy balanced approach, we get a much clearer picture of the response to the supply of protein with respect to energy intake," said Brett. "This is similar to the pig and poultry nutrition approach based on protein and energy supply which have been integrated for decades. It is also fundamental to understand quantitative essential amino acid requirements for growth and the protein: energy ratio." said Brett.

Speakers at the afternoon Q&A session, from left: Martin Guerin, Dr Olivier Decamp, Dr Ester Santigosa, Allan LeBlanc, Dr Stephane Ralite, Dr Benedict Standen and Dr Fuci Guo

Revisiting Requirements

Classical dose/response experiments have looked at using amino acid deficient diets, supplemented with graded levels of essential amino acids. Different performance metrics like growth, protein synthesis and food conversion ratio are measured. A classic example of the dose/response version was by Joe Fox et al. in the mid 90's which looked at the requirements for lysine and two different levels of protein in the diets.

Using a broken-line response, it reported that the lysine requirement was about 4.7% of the protein but with a factorial response, it could be argued that the optimal level of lysine was actually between 5.5% up to about 6.2% of the protein. The factorial approach depends on looking at the growth potential of an animal and the composition of that growth, and what it needs in terms of utilisation in nutrients, protein, and energy for supplying growth and also maintenance requirements.

By modelling protein, energy and amino acid demands, Brett showed that a 10g shrimp growing at a certain temperature with an average daily growth (ADG) of around 0.33g/day, needs about 1,494 J/day, equivalent to 55mg/day of protein of which lysine is about 3.7mg. Concurrent to their growth demands, the animals need about 2,000J/day just to stay alive, which is 45mg of protein to maintain its body of which lysine is 3.0mg. "When we take this approach, we estimate the lysine requirements for that animal is about 6.7% of protein, a bit higher than previously thought."

Is it time to revisit the requirements?

Brett said, "Maybe not, but rather it is time to rethink our approach. Repeating nutrient requirement studies with new genotypes and new culture systems is too slow and too costly. Maybe a modelling approach is quicker and cheaper and can be optimised for ideal growth as well as adapted to the culture system's potential and inputs or even different environmental regimes.

Henry Wong, Alltech and Chee Wei Ling Dindings Soya & Multifeeds, Malaysia.

Roundtable on marine fish feeds with Dr Zhang Song.

SESSION 3: NEW PROTEIN MEALS AND OILS FOR FISH MEAL/ FISH OIL REPLACEMENT

Fish meal replacement strategies: Just a question of protein?

Since the history of modern fish nutrition, fish meal has been the golden standard ingredient for aquaculture feeds, said **Martin Guerin,** Regional Technical Manager Aquaculture, APAC/ISC, Adisseo Asia Pacific.

"It is a great raw material, delivering the right nutrients; it is very high in protein and essential amino acids as well as lipids of all types, including polyunsaturated and omega-3 fatty acids. It contains phospholipids which are very important for juvenile and larval nutrition and cholesterol which is important for shrimp nutrition. When processed and produced properly, it has very high digestibility. It is a very good source of minerals, fat-soluble vitamins and functional protein molecules such as attractants like free amino acids and peptides." However, price, production supply, sustainability, certification and social responsibility are pushing industry to replace or partially replace fish meal.

In addition, Martin said that the amino acid taurine is growing in importance over the past few years. "Today, nobody wants to formulate marine fish feed without taurine. Finally, there are all the peptides with antimicrobial, immuno-modulation, and antioxidant properties that contribute to immunity when you formulate with fish meal. So, what should we look for in terms of fish meal replacements? There is a gap in amino acids levels which needs to be compensated especially for two key essential amino acids: methionine (usually the first limiting amino acid in aquafeeds high in soybean meal) and lysine but also occasionally threonine, tryptophan and arginine," added Martin.

Protein sources from poultry meal, insect meals to microbial proteins supply fat but they are very poor in omega-3 fatty acids, phospholipids and cholesterol. Plant proteins contain antinutritional factors, antigenic proteins and mycotoxins causing inflammation in the gut.

Compensating nutrient gaps

As the industry is not able to find a one-solution ingredient to replace fish meal, additives can help to compensate those nutrient gaps. "Today, there is supplementation with methionine, lysine, threonine and tryptophan. But to replace fish meal fat, in addition to adding fish oil (with its own supply and sustainability issues) or omega-3 rich algae (high priced and still limited availability), a strategy is to better utilise existing sources with emulsifiers like lysophospholipids or bile salts which can help to improve fat digestion, absorption and fat utilisation and thereby get a sparing effect on those levels of essential lipids and energy.

"Lysophospholipids have a higher hydrophilic-lipophilic balance (HLB) value than lecithin which makes them better emulsifiers to emulsify oil into water. This is needed in the gut of fish and shrimp." Martin showed that the European sea bass fed a low-fish-meal diet supplemented with lysophospholipids had a reduction in FCR over 75 days. This came with a better utilisation of energy from lipids, which also helps growth and protein efficiency ratio.

Bile salts are very powerful emulsifiers with HLB value of 25, working almost like a detergent. They are good co-factors of lipase and help lipase access the fatty acids of triglycerides through the lipid membrane of micelles and hydrolyse triglycerides into mono- di-glycerides or free fatty acids. Working with a pangasius integrator, a trial showed that after 124 days, there was a reduction in FCR when bile salts was added at 170ppm. This was through better energy utilisation, improved growth and protein utilisation by about 4%. The integrator also observed reduced deposition of viscera fat.

Bile salts are absent in the shrimp, but dietary bile salts work in shrimp to improve digestion of lipids and to replace cholesterol, a precursor of moulting hormone. This results in improved growth of shrimp. At least 0.2% of cholesterol in the diet is required and a deficit reduces growth. High plant protein diets require supplementation of cholesterol. Adding 0.15% bile salts to a high-plant diet with only 0.1% natural cholesterol improved growth to the same level as adding 0.15% cholesterol.

"Plant proteins lack the attractants found in fish meal which leads to slow feed consumption and high leaching of essential nutrients. This results in higher FCR and slower growth. Formulated marine hydrolysates consisting of short-chain marine peptides added to low fish meal diet at 2% inclusion improve feed intake and reduce nutrient loss by leaching. One-hour faster consumption with their use, allows shrimp to consume 10% more dry matter otherwise lost to leaching during such time. This helps saving on 10 to 15% of formulation cost, as the leaching concerns mostly high-value nutrients like amino acids and water-soluble vitamins and additives." explained Martin.

"Selenium is much higher in fish meal compared to plant proteins. Vannamei shrimp, fed low or high fish meal diets supplemented with a very stable and pure form of organic selenium showed a very nice improvement in growth as well as higher antioxidant activity." Growth of the low fish meal diet supplemented with 0.3ppm organic selenium was similar or better that the control high fish meal diet.

Ning Widjaja, Indonesia (left) and Natalia Jorge Trevilla, ITPSA, Thailand

Roundtable on shrimp feeds

Martin discussed the negative effect on anti-nutrients from plant proteins such as phytate and non-starch-polysaccharides, how enzymes (phytase, carbohydrases such as xylanases and arabinofuranosidases) boost performance of 0% fish meal tilapia diets. Addition of such enzymes helped improved growth, FCR and protein efficiency ratio (PER) of such non fish meal diets.

Alternatives to omega-3 PUFAs in aquafeeds: Addressing rising demand and critical animal health needs

Highly unsaturated omega 3s are essential fatty acids for development and growth of fish and shrimp. Common sources of eicosapentaenoic acid (EPA, 20:5 n-3) and docosahexaenoic acid (DHA,22:6 n-3) are marine algae and phyto- and zooplankton. The requirement varies with species, whether freshwater or marine, said **Dr Fuci Guo,** Business Development Director Aquaculture, Corbion Biotec, Inc.

"The European sea bass which is quite close to our Asian sea bass requires 1%. In monodon shrimp, the literature says 0.9% of DHA; for vannamei, it is 0.5% of EPA and DHA. These data are mostly coming from aquarium trials, so in a real commercial setting, it could be different," said Fuci.

For the past 15 years, European feed producers have reduced the omega-3 level in Atlantic salmon feeds by reducing fish meal from 50% and fish oil from 30% in 1990 to less than 10%, and replacing the fish meal and fish oil with plant proteins and plant oils, respectively. The FCR remained constant, 1.1-1.2, but the fish-in fish-out (FIFO) ratio has been reduced from 8 down to less than 1.

Omega-3 PUFAs in algae

For fish oil, aquaculture is directly competing with human consumption. New sources of omega-3 PUFAs are definitely needed for a responsible aquaculture industry. There are options such as GM (genetically modified) canola oil which is not easily acceptable in many countries. "The alternative is microalgae growing in the dark through fermentation where there is better control of all the parameters but the challenge is cost; making a product comparable to fish oil prices today. However, using sugarcane as an renewable energy source allows for a large scale production in a factory in Brazil. This lowers production costs and is sustainable with a low carbon, water and land footprint."

Responsibly restoring DHA

"In March this year, through BioMar, more than 350,000 tonnes of salmon feed have been incorporated with the non-GM algae *Schizochytrium* called AlgaPrime DHA. It has consistently high DHA levels at 28-30%," said Fuci. "In shrimp, a paper was published in 2018 which used cod liver oil as a source of fish oil and treatments of 25%, 50%, 75%, and 100% replacement. With a 100% replacement, growth is very similar to the control. Weekly growth showed the same scenario with partial replacement having better average daily growth (ADG) and feed conversion ratio compared to the control."

Feeding tilapia with algae-derived DHA can increase the tissue DHA level. In a trial with 7 diet groups with 1%, 3%, and 5% fish oil, fish oil was replaced with 1.75%, 5%, and 8% of algae meal containing 27% DHA. With 1-3 % fish oil, DHA in the fillet ranged from 260 mg to 330 mg. This was compared to 1700 mg to 2500 mg in salmon fillet.

"Interestingly, a group of Taiwanese scientists was looking at the inclusion of algae derived DHA for the grouper. With the inclusion levels of 2%, 4%, and 6%, they observed that the 2% inclusion rate showed a mortality of less than 5% over two weeks, compared to the control with 15% mortality due to cannibalism. Why should the grouper behave less aggressively when fed the DHA diet? They measured a few parameters; one of them is cortisol, the fish with high algae DHA was calmer and less stressed. Another parameter they measured was the brain 5-HT (hydroxytryptamine), an indicator to see how calm or aggressive an animal is. There was an increase which explained the lower level of aggression.

"In summary, we see that microalgae is a sustainable, scalable option and how the barriers of high costs and low volume have been addressed," concluded Fuci.

Benchmarking protein meal alternatives for fish meal replacement in shrimp feed

Fish meal has a supply range between 4.5- 5.2 million tonnes and with the warm *El-Nino* current off the South American Pacific coast, supply can be down by 0.5 million tonnes. "Combine this large growing demand with a static and volatile supply chain, you get extremely volatile prices. Prices range from USD1,500-USD2,500/tonne but at prices over USD2,000/tonne, aquafeed producers will try to squeeze as much of it out of their formulations. Whereas at USD1,500/tonne, it is still attractive to use," said **Allan LeBlanc,** Vice President and FeedKind® Product Manager Calysta.

In benchmarking essential amino acid levels in fish meal against alternative ingredients, it would be preferable to use digestible amino acid levels for all of these ingredients, but the literature shows huge variations from one study to another. Fish meal is high in lysine and sulphur amino acids and the next series of limiting amino acids generally threonine, histidine and tryptophan are all present in varying quantities.

Benchmarking with lysine

Allan briefly reviewed available protein meal alternatives for fish meal replacements in shrimp feeds, comparing them with 75% CP (crude protein) fish meal as the gold standard which has 7% lysine as % of CP. "Within the methanotroph single cell proteins, Calysta's 71% CP protein's amino acid profile tracks quite closely to fish meal. Lysine is almost comparable and then tryptophan is actually available and in excess as are methionine and cystine. From the essential amino acid profile, this is a great fit."

With the black soldier fly insect meal, the lysine level is close to that in 75% CP fish meal, but methionine and cystine levels are lower but still comparable. Depending on the source, one could see a significantly lower crude protein level. Many companies, including AgriProtein, are looking at further concentrating their protein ingredients. With fish meal analogues, the reference is a poultry by-product, blended with vegetable proteins and supplemented with methionine. It is, however, significantly short on lysine and leucine. With corn-based ingredients, there is purified corn gluten with high nutrient density and a high-protein product, but consistent across all the corn ingredients, we see really low lysine levels. A significant amount of lysine and tryptophan supplementation is needed to formulate a complete feed.

"Soy protein concentrate (SPC, 67% CP), like soybean meal is a success because it really does have high lysine levels (6.7%). However, the sulphur amino acids are deficient, requiring supplementation. The antinutritional factors are more prominent with soybean meal than soy protein concentrate, but they are definitely still present," said Allan.

Fermented soy protein concentrates via solid-state fermentation degrade the indigestible phosphorus and saponins. While it produces short-chain organic acids, supplements can be added to stimulate the immune system, to help with fighting microbial infections in the gut and promote a healthy gut. But while soybean meal or the soy protein concentrate contains 7% lysine, after fermentation, it comes down to 3%. An interesting decision for any formulator to say - well, do I want to take that hit on the lysine and methionine and the cystine, but get some extras for it? And are those additives that you are effectively blending into a protein carrier worth the reduced protein value in the lower amino acid levels?" commented Allan.

Poultry by-product meals (PBM) are available containing 50% to 65% CP and with varying levels of ash. For the pet food and aquaculture sector, PBMs are high quality 65% CP meals but the amino acid profile is unbalanced and requires significant supplementation.

The message was, "The industry should not focus on replacing fish meal but focus on the essential amino acid requirements for the species. If we look at the NRC data for monodon shrimp, the methionine and cystine are suitably met by the content in fish meal, but levels of lysine, tryptophan, and threonine are all significantly in excess. Is there an opportunity to formulate with lower levels of those essential amino acids at a lower cost and deliver the same growth and the same performance that we are looking for?"

Prapatantio Pringgodigdoyo, DSM, Indonesia; Kadi Mey Ismail, De Heus Animal Nutrition, Indonesia; Henrik Aarestrup, BioMar Group A/S, Denmark and Tran Ngoc Thien Kim, Deheus Aqua Co, Vietnam.

The next generation aquafeeds: EPA and DHA from marine algae to support sustainable aquaculture

"In human nutrition, health institutes recommend a daily intake of 250 mg of EPA and DHA per diet. Both EPA and DHA are related to different functions in human health," said **Dr Ester Santigosa,** Senior Aquaculture Scientist, DSM Nutritional Products, France.

"A study in Scottish Atlantic salmon showed that between 2006 and 2015, the EPA and DHA in the fillet have decreased by 50%. A similar figure exists for barramundi between 2002 and 2013. There is also a 16% decrease in the content of omega-3 in Indian shrimp feeds between 2014 and 2016", said Ester.

"With the stagnation in fish oil production and the increasing demand from aquaculture, we are proposing a sustainable marine oil free from contaminants obtained from a non-GMO *Schizochytrium* where EPA and DHA concentration is more than 50%. The benefit in terms of marine resources is that we can decrease the forage fish dependency ratio (FFDR) by 80%."

Requirements of EPA+DHA

In feed formulation, the focus is on minimum dietary requirement for health and growth. Using salmon as the model, a deficiency comes with increased levels in intestinal and visceral fat, hyper-vacuolisation and the deposition of pro-inflammatory fatty acids. EPA and DHA at 1.7% of the diet is the minimum requirement for optimal growth and health under normal conditions. This equals to around 7% of EPA and DHA of the fatty acids of the diet. Higher levels are required for challenging environments.

"With shrimp, data is lacking but there are some insights for the monodon and vannamei and separate requirement for EPA and DHA from the total fatty acids of the diet. Requirements range from 0.5 to 2% EPA and DHA in the diet of marine fish species" said Ester.

From pellet quality to final product quality

In terms of R&D targets in assessing the marine oil, firstly, it was to ensure there was no pellet quality or palatability issues. The second step was to ensure digestibility and then finally that there was no quality difference in the final product.

In salmonid trials, the reference diet contained 10% of fish oil and for treatment diets, the same level of EPA and DHA provided by a combination of fish oil and algae oil and a 3% of algae oil diet. Results showed there were no differences in the quality of the feed and when fed for 8 weeks, there were no differences in terms of feed intake. The feeding trial had 4 treatments; fish oil control diet, 3% inclusion maintaining the same EPA and DHA levels as in the control diet and higher levels of 4.6% and 6% to ensure no negative effects in terms of health of the fish. After 3 months of feeding, there were no differences in the final body weight. There were no negative effects on the health parameters as assessed by external veterinarians.

For the digestibility trial, diets included a 10% fish oil control diet and treatment diets formulated with only vegetable oils and 3 inclusion levels of algae oil. With fish oil or the microalgae oil, digestibility was 99%. Deposition in fish flesh after a 5-week trial showed EPA+DHA in the fillet reflected the levels in the diet. "The more EPA+DHA included in the diet, the more we are finding in the fillet, indicating that fatty acids from microalgae oil were not used for energy, but is deposited in the muscle, even if provided at a higher level than the control 10% fish oil diet." added Ester.

Mohd Zaidy Abdul Rahman, Zaiyadal Aquaculture Sdn Bhd, Malaysia; Lelia Lim, Lim-Loges & Masters, Singapore; Nobumitsu Sato, Nagase Sanbio Co., Ltd, Japan; Ian Carr, Veramaris, Netherlands.

SESSION 4: DISEASE AND HEALTH MANAGEMENT

Diseases and health management continue to take centre stage in Asia's aquaculture industry as it strives to improve productivity, predictability and determine some degree of consistency in production. This session was dedicated to ways to improve nutrition and health of fish and shrimp; from looking at gut microbiota to feeding strategies and maximising benefits of feed additives.

Different strategies towards quality feeding

In 2018, according to the annual GOAL survey, the concerns of the industry evolved by including international price and feed cost to the ever important disease management. **Dr Olivier Decamp,** INVE Aquaculture, Thailand, said, "The worry is on production cost, market price and how to reduce costs. Unfortunately, this also means a reduction in investments covering biosecurity and production costs, by, for example, procuring cheaper post larvae and lowering feed cost. Feed producers try to meet customer demands for cheaper feed, but the increasing prices of raw materials put pressure on them to optimally formulate performing feeds."

Improvement of production efficiency

This starts from genetics. Selected animals, with the potential for growth or robustness, need to express their potential. Therefore, it is critical when working with quality animals, throughout the production cycle, from broodstock maturation all the way to the hatchery, nursery and grow-out, to really exploit that potential. Good production comes from strong and healthy post larvae which will grow faster and handle challenges better.

Heat shock proteins to strengthen post larvae

To strengthen post larvae and onwards from the hatchery to the nursery or grow-out, Olivier introduced the mechanism of heat-shock proteins (HSP), which animals use to cope with stress. HSP can be produced by exposing the post larvae to a higher temperature (non-lethal heat shock). "We have been working with a natural plant extract that we know can really work on the robustness of the animals. More specifically, this plant extract can stimulate the production of HSP. In a disease challenge situation, studies at Ghent University show that animals treated by the HSP were able to handle a *Vibrio* challenge more efficiently."

Nursery phase

A nursery phase reduces risks by extending the rearing duration that can be carried out under controlled conditions, i.e. with limited contact with pathogens. There are two main approaches in nursery management: focus on a larger biomass and the largest number of post larvae or focus on biosecurity and consistency. The former is a gambling approach, risky with consequences on biosecurity and on cost, but is the fastest way to stock ponds. The latter is practised by integrators who are more focused on planning in the hatchery, nursery and farm, and are more concerned with managing risks.

In Vietnam, by reducing water exchange with stocking density of 2PL/L, over 24 days and with over 20 cycles, there was consistent growth. Investments in water treatment, energy and labour were reduced with increased investments in quality feed.

In another example in Thailand, the protocol included a combination of high-quality nutrition and high-quality health booster, with the inclusion of immunostimulants and natural plant extract. This partially replaced bulk feed. A 15% replacement of the bulk feed by a health booster gave 38% more biomass, better growth and stronger animals. In Vietnam, post larvae fed a partial replacement with this health booster diet could cope in an early mortality syndrome (EMS) challenge test.

Higher quality feed within the nursery

The use of high-quality feeds was demonstrated in Mexico where diets included higher grade ingredients, which were more typical of a hatchery feed and were micro-extruded. The feed cost was higher. Olivier explained, "We were able to have better growth, FCR and, more importantly, an improved cost benefit against both crumbled or extruded feed. Obviously, the approach has to be adapted to the production conditions."

In seabream production in Europe, improved larval rearing protocols resulted in fewer opercular deformities. The stronger larvae, after being fed high-quality nursery diets, performed better in cages. This shows the value of integrating the different steps in the production.

Gut composition of healthy *vs* diseased shrimp

Xiong et al. (2018) analysed the gut composition of shrimp that were either healthy or diseased. In diseased shrimp, there were more cyanobacteria or dinoflagellates, a direct consequence of poor pond soil management, emphasising the importance of the right pond management in disease control. Chen et al. (2017) looked at microbiome dynamics in a shrimp grow-out pond with possible acute hepatopancreatic necrosis disease (AHPND) and showed that if there was diversity in the pond microflora, and therefore in the gut, there was a stronger chance of avoiding a *Vibrio* outbreak.

In Ghent University and Universidade Federal do Rio Grande, Barbara Hostins compared the gut microflora in shrimp that were reared in clear water and biofloc systems. Under both culture methods, the addition of *Bacillus* led to a change in the composition of the gut microflora, with an increased abundance of *Bacillus* and a clearly reduced presence of *Vibrio*. "Under different rearing conditions, we can manipulate gut composition by applying probiotics and then see how the animals cope with the challenge." said Olivier.

The application of probiotics in the feed is carried out at the farm by top dressing or by feed mills. In Australia, a different way of delivering the feed probiotics to shrimp is by using a carrier and without involving feed mills. This led to improved FCR and yield.

Olivier concluded, "To cope with feed cost, the focus should be on production efficiency and predictability, at every step in the production process. At the same time, it is imperative to have the right biosecurity and feeding approaches."

Overcoming constraints and maximising benefits with feed additives

Dr Benedict Standen, BIOMIN Holding GmbH, Austria said that diseases such as the early mortality syndrome/ acute hepatopancreatic disease (EMS/AHPND) in shrimp resulted in USD 45 billion losses in the last decade. Managing diseases is a bottleneck to industry growth from diagnostics, treatment, time, labour, to loss in consumer confidence. Probiotics, organic acids, phytogenics, toxin binders and enzymes are some feed additives to improve performance and health of fish and shrimp.

From a disease perspective, probiotics act in three main ways: exclude pathogens by competitive exclusion, produce inhibitory substances or interact with the immune system by attaching to the epithelia. "But not all probiotics are created equal. Lactic acid bacteria, in general, are very effective at attaching to the gut for gut health and also for competitive exclusion. Not all *Bacillus* is created equal and to maximise the benefits, choosing the right strain is key, not the genera or the species.

A study demonstrated how adjusting the feeding regime can maximise the benefits of a multi-species probiotic. Vannamei shrimp were fed diets supplemented with the probiotic at four feeding regimes: over 12 weeks, continuous feeding, or combinations of pulse feeding (weeks supplemented with probiotic feed: control feed at 1:1 or 2:2 or 2:1). Growth was not affected by the feeding regimes but after the challenge with *Vibrio parahaemolyticus*, the best survival, was observed in the continuous supplementation. "Again, the benefits depend on the objective; if it is performance, you can look at a pulse regime. For disease resistance and survival, a continuous supplementation may be best."

Organic acids have antibacterial effect and can reduce gut pH. The pKa value is the pH at which 50% of the acid is in its undissociated form. The higher the pKa value, the stronger the microbial effect. Reducing the pH in the gut is very difficult to achieve because there is a huge buffering capacity in the gut. Therefore, it is better to choose organic acids with high antibacterial activity.

Phytogenics can modulate gut microbiota; improve feed conversion and digestibility; and improve flesh quality, taste and colour. The essential oils can have anti-inflammatory properties. Replacing fish meal is not just a nutritional challenge but a challenge from an immunological perspective. In a trial with the European seabass fed high fish meal and low fish meal diets with or without a phytogenic feed additive, it was shown that when seabass was fed the low fish meal diet, the feed conversion goes up and protein efficiency ratio (PER) is reduced. "The phytogenic supplemented feed additive can bridge this performance gap, improve the feed conversion and PER. With low fish meal diets, the microvilli become shorter and the fish is less able to absorb nutrients. A phytogenic feed additive can alleviate this negative effect. With an anti-inflammatory effect, phytogenics improve the surface area of the gut for better nutrient uptake."

There are four main factors when assessing the efficiency of toxin binders. Binding is also depended on the pH. Nearly every binder can bind aflatoxin at pH2, but according to the EFSA guidelines, you have to be able to bind a specific amount of aflatoxin at pH5. Benedict emphasised the criterion that the binder should bind mycotoxins, endotoxins but not the vitamins and minerals.

Heat stability issues

The three main challenges in the industry today are heat stability of heat-sensitive components, the cost, and the confusion with many different products available in the market and their many different modes of action. Enzymes are also heat sensitive feed additives but with enzyme engineering, the amino acid sequence can be modified, such as in one example where the melting point was increased to 66°C.

"With heat sensitive additives, encapsulation allows for slow release of the active component, such as in the tilapia, which has a long intestine. Encapsulation ensures that all of the heat-sensitive components of the additive is protected from high temperatures during pelleting and extrusion. It also allows for controlled and targeted release as well as to combine multiple products. Liquid additives can be encapsulated. Encapsulation masks unpleasant odours which is very important for some essential oils and acids."

At the feedmill, post pellet application of heat-sensitive components with a top or vacuum coater has the advantage of ready-to-use functional feeds. Post pellet application at the farm can provide a fast reaction to a disease outbreak. "But the disadvantages are costs of time/labour as well as leaching requiring higher doses to compensate for this. A negative effect is that pellets may become quite sticky making it difficult to use with automatic feeders," added Benedict.

The costs of adding a feed additive may be higher but this has to be considered in terms of improving survival, digestibility and performance, to achieve a more efficient production. An expensive protein such as fish meal can be substituted with a cheaper protein and if the additive can improve digestibility, feed costs may be the same without compromising on growth performance.

Benedict said, "Cost and value are two completely different things; you increase your cost by using an additive, but you also create value in your feeds. We also need to manage expectations of additives; there is no silver bullet in aquaculture. We just need to use different technologies together with synergistic effects and additives are part of the solution."

His message was, "In terms of cost, there is no running away from the fact that an additive will probably increase the feed cost. But a feed that can improve survival, will raise sales potential for the feed miller. Reducing costs is very different from improving cost-effectiveness. For the farmer, even if there is a small increase in cost in the feed, cost per unit biomass can be reduced because production becomes more efficient and cost-effective. And in a competitive market, you must be able to differentiate and feed additives offer a good way of differentiating your product from your competitors."

Towards bespoke microbiota management along the life cycle to improve nutrition and health of fish and shrimp

The microbial community in the gut is one factor determining the health status of fish and shrimp as well as its potential for growth. In this presentation, **Stéphane Ralite,** Lallemand Animal Nutrition, France, improved our understanding of the microbial community in the gut of fish and shrimp and how it is possible to manipulate and tailor-make the microbial community to suit a situation.

Aligning with the aquafeed focus at TARS 2019, the discussion was on the impact of the composition of the gut microbial on the animal's health, growth, FCR and overall performance. Gut microbial composition also changes along the lifecycle, between a young and older animal, and is also determined by the environment in which the animal is farmed. In recent years, in aquaculture, there has been tremendous new scientific publications and awareness on the importance of gut microbiota.

Impact of feed on gut microbiota

Butt et al. (2019) gave two main factors influencing gut microbial composition: intrinsic factors such as age of the animal, genetics, immunity and nutritional status, and external factors. In the latter, diet has a major impact on the microbial community. Stéphane elaborated on some links to nutrition. "The gut microbiota can have an impact on fish feed intake. The colonisation of gut microbiota can promote lipid absorption and metabolism. Modulation of microbiota impacts enzymatic activity inside the gut and on mineral absorption and metabolism."

In general, more is known on the shrimp gut microbial composition and management. Proteobacteria, Bacteroidetes and Actinobacteria are dominant in shrimp gut microbiota. The microbial diversity in the hepatopancreas is lower than that in the intestine. Gut microbial composition is closer to that in the sediment rather than that in the water, due to the influence of feed and feeding behaviour. Shrimp gut microbial community changes with shrimp age and pathogens, such as the vibrios dominating during the later growing stages, according to Huang (2014).

"There are publications showing some links between the larval gut microbiota composition and the broodstock or the egg bacterial colonisation. In shrimp, although the first colonisation happens at the opening of the anal pore at the fifth nauplius stage, the real gut microbial colonisation starts with the mouth opening at the zoea stage. This stage happens to be often a period with high levels of vibrios in the water, if you don't control it. In *Litopenaeus vannamei*, gut microbiota is much more homogeneous at the early stage as compared to the later stages. Similarly, in fish, the bacterial community starts with the mouth opening and the diet has a major impact on shaping the gut microbial community."

Referring to Gatesoupe (2012), Stéphane said, "It does seem that fish can maintain a core microbial community which is only partially influenced by the water microbial diversity. Feed is one of the major external factors. There are clear differences in microbial composition in the gut of seabass fed feeds with fish meal compared with feed with plant meals or feed treated with an antibiotic." He stated that after 18 months post treatment, "This study is one example of the impact of an antibiotic treatment on microbial composition in the gut. You can have some efficacy, but the impact of the antibiotic treatment on the gut microbial community remains for a long time after stopping the treatment."

Linking health and gut microbial composition

While gut microbial composition depends on age, at a particular age, the gut microbial structure differs between the healthy shrimp and shrimp with different diseases. But the question is, "Is it because the microbial composition is different that you have diseased shrimp or is it because you have diseased shrimp that you have microbial composition differences?"

AHPND, WSSV and microbial composition

The link between animal health and microbiota composition was demonstrated in samples of pond water, healthy and diseased shrimp. "There are clear differences between the microbial composition of pond water and of the gut, and between the microbiota composition of the healthy shrimp and of the shrimp with symptoms of acute hepatopancreatic necrosis disease (AHPND).

"In one example (Wei Yu Chen, 2017), we have two groups, both positive for Vibrio parahaemolyticus, but some shrimp showed signs of disease, while some did not. This was explained by the specific event of heavy rain and appearance of AHPND symptoms. This was an impact resulting from external factors, which stressed the shrimp, leading to microbial gut composition changes which induced the appearance of the pathology."

A clear impact of white spot syndrome virus (WSSV) infestation on the microbiota composition compared to the control was also shown by Wang (2019). In WSSV infected shrimp, there was an increase of Proteobacterium and Fusobacteria but a decrease in Bacteroidetes and Tenericutes.

Modulation of gut microbial composition

One of the compounds specifically aiming at modulating gut microbial composition are probiotics–live beneficial microorganisms active in the gut. In terms of efficacy, there is a specific widely documented strain, *Pediococcus acidilactici* MA 18/5M. "To demonstrate the mode of action of a probiotic, first we have to demonstrate that it is present live in the digestive tract and that it is associated with the intestinal mucosa of the animal. This will have a direct impact on the animal as well as a major impact on the gut microflora composition. The probiotic, the associated changes in the gut microflora composition and in turn the cell-to-cell interaction between the animal's mucosa and its microbiota, will impact on the immune and antioxidant status of the animal. As an example, the specific strain *Pediococcus acidilactici* MA 18/5M promotes higher enzymatic activity and supports energy uptake with increased amylase specific activity and higher carbohydrate utilisation. As the glycogen content of the hepatopancreas increases, growth of the shrimp increases for each ration size tested.

In a recent publication, Ashouri et al. (2018) compared growth of barramundi *Lates calcarifer* fed three treatment diets: classical feed with the probiotic, Bactocell, a prebiotic, and their combination as symbiotic. The researcher showed some significant improvement In terms of specific growth rate and immune parameters, with the probiotic treatment.

"In carnivorous fish, you can often have some problems of mineralisation and it has been demonstrated that with the use of the specific strain *Pediococcus acidilactici* MA 18/5M at a very young stage, it is possible to improve the ossification in seabass, trout, salmon, eel and sturgeon (patented application). The mode of action is linked to mineral absorption and metabolism as well as to a decrease in inflammation at the very early stages which help ossification.

Allen Wu, Adisseo, Taiwan (left) and Ezhil Subbian, String Bio Pvt Ltd, India

In Asia, there are different *Vibrio* spp from different origins –*Vibrio harveyi, V. alginolyticus*, *V. splendidus, V. anguillarum and V. parahaemolyticus*. A very specific heat stable mixture of yeast strain and fraction which can undergo the extrusion process for feeds has the ability to bind these *Vibrios* compared to a standard yeast. In a challenge test, shrimp with white faeces syndrome (WFS) were fed a multi-strain yeast fraction incorporated in a basal diet, which subsequently changed and reduced the impact of WFS in the affected shrimp. Analysing the microbiota composition, there was a clear impact 48 hours after the challenge on the microbiota composition in the hepatopancreas. The reduction was at the *Vibrio* family level. Looking at the score on hepatopancreatic health, Stéphane said, "The loss of growth due to WFS was reduced by 50% in the group fed the multi-strain yeast mixture. With much better conditions, we see better survival by 17%, better growth compared to the challenge control, and 14% better economical FCR. This is just one example of the study we did on microbiota composition and how you can change this microbiota to enhance the overall performance of the shrimp."

From left, Dr Anuj Tyagi, and Alluri Venkat Sanjeev Avanti Feeds Ltd; Pravin Patil, DSM Nutritional Products India; A V Subramanium, Deepak NexGen; Mahesh Nekkanti, Devi Sea Foods Ltd; Seshu Akkina, Deepak NexGen; Korupu Venkata Raju, Avanti Feeds and Kumuda Chandra Patra, Biomin, India.

SESSION 5: TECHNOLOGY & SUSTAINABILITY: FIT FOR FUTURE

Quality research: A pre-requisite fit for future feed

Dr Kabir Chowdhury, Global Technical Manager – Aquaculture & Sales Director – South Asia, Jefo Nutrition Inc., Canada says that for future sustainable aquaculture development, good quality research is key. In his presentation, Kabir walked the audience through steps in aqua nutrition research discussing some mistakes to avoid.

Critical points are: designing; preparing diets, feed and feeding management; faecal collection methods; sampling, sample collection and chemical analysis; and statistical analysis and interpretation.

"When we think about experimental designs, we need to think of the expected outcomes from the experiment; we need also to consider data analysis, the statistical design, and required parameters to achieve those outcomes," said Kabir.

He cited an example of a 2004 trial on bioefficacy of protected micro-encapsulated lysine compared to free biolysine, which was the control. The organic product is spray dried blood meal (SDBM) as a lysine source. The encapsulated biolysine, had three indicator parameters: weight gain, thermal-unit growth coefficient (TGC, which measures growth rate) and feed efficiency. "When we look at the weight gain, the bioefficiency of encapsulated lysine was 110%, with TGC it was 108%, but when you look at feed efficiency, it shot up to 143%.

"The question was which parameters should we use to compare treatments? Sometimes, companies choose best ones which show the best results, which may not be true. In the above example, which parameters are most important to choose to prove the efficiency of that lysine source? It is the deposition of lysine in the body which we should be choosing. Therefore, choosing the parameters as indicator parameters can change the results and outcome," said Kabir.

Data collection and analysis

It is common to be wary of qualitative research because of costs, especially among small, medium-sized feed mills. But a simple growth trial, requires only small 100L aquarium tanks. Trials with 24 of 100L aquarium tanks can be in one small controlled room. "Simple systems can deliver good results as well," said Kabir adding, "When we do a controlled trial it is also very critical to do a field trial. A field trial is on a larger scale to understand the variations and other external factors. A controlled trial is on a smaller scale, to understand dynamics of this specific product prior to field trial application."

Before and during trials

Kabir listed some mistakes and gave some advice in conducting trials. In a 2011 trial, in one treatment, oil was not sprayed on the treatment feed and the lipid level was 6% less. Data for the whole trial was useless and money wasted. In another trial, there was 50% dust and in another, there was no 100% intake of the feed. Another critical point is that if the initial body weight is 10g, there should be a minimum of 300% increase in the final body weight for a justifiable experiment.

Digestibility trials

There are several methods. The direct method is collection of all the faeces from force-fed fish which is very difficult. The indirect method uses an indigestible marker. The movement of different markers in the gut differs and sometimes, the markers will not move along with the digestas. The most commonly used markers in aquaculture today are chromium oxide and yttrium oxide.

An active indirect method is stripping, dissecting and collecting digesta from the hindgut, or using a vacuum to remove the digesta. The passive indirect method is screening and filtering, and indirectly collecting without disturbing the faeces via siphoning, netting or settling.

"However, the problem with the active method is that the physiological materials can come out. These are the advantages and disadvantages. It is critical to compare data; once a method is chosen, keep using the same method and not switch methods," said Kabir."

Feeding trial (dose-response)

In a three-level dose-response study, often it may be difficult to find a linear response. "A 1942 paper showed that for a linear response with three data points, the highest data point should be less than 80% of the requirement to achieve the linear response. This is very interesting as the best FCR (not necessarily economically viable) we can get when we feed the animal is between 70% and 80% of the requirement," said Kabir.

Statistical design and interpretation

Kabir recommended going beyond convention in statistical data interpretation. We can move away from growth, FCR and protein efficiency ratio. In an example, he discussed how a 2018 study on nutrient retention efficiency did not show any difference in growth performance but instead showed differences in nutrient deposition, nutrient retention, and enzyme activity in the hepatopancreas. "To interpret the data, a principal component analysis (PCA) was carried out which showed the enzyme was linearly increasing the hepatopancreatic enzyme activity as well as lipid nutrition efficiency."

Lastly, Kabir said, "Human factor is very critical. Properly trained staff are critical to minimise errors. We need to ensure that the feed we put in the tank is completely eaten by the animal. Wasted feed will skew results."

Growing the aquafeed business

The aquafeed sector is highly dependent on the aquaculture industry. In turn, the latter needs the former to grow. Throughout Asia, the aquafeed sector is highly competitive with many players and overall feed supply is greater than demand. In his presentation on growing the aquafeed business, **Dr Zhang Song,** Vice President, Nutriera Group, Guangdong, China, discussed current and future trends for aquaculture in China and its effects on the aquafeed sector and vice versa.

Two key technologies continue to push aquaculture forward: hatchery production and commercial feed development. From producing feeds for carps, feed mills in China have been successful with floating and sinking feeds used for feeding the high value mandarin fish (farm gate price of USD14/kg) which were previously fed live fish. With this development, annual fish production is expected to increase from the current 300,000 tonnes with feed demand at 400,000 tonnes.

Aquafeed and seafood consumption

In China, seafood consumption is increasing with the rise in disposable income of the urban population. Retail seafood for the young generation is fast developing in China spearheaded by e-commerce. Besides these new trends in food distribution and demand, there are new requirements on seafood.

"The Chinese prefer to eat more seafood and place great importance on issues pertaining to health, nutrition and convenience. They also follow seafood trends. Pangasius (local and imported from Vietnam) is popular for the hotpot dishes. Other popular seafood are the grass carp, frogs and crayfish. China continues to import seafood and in the next few years, I think the trend will not change." Pangasius is also imported from Myanmar and future imports will likely also come from Bangladesh and India. Zhang also touched on the current situation on the Asian swine fever affecting the Chinese swine industry. With a shortage of domestic pork, consumers will turn to seafood, creating demand for imports from various countries.

However, there is the "transformation and upgrading of aquaculture and aquafeeds." China has targeted antibiotic-free aquaculture by 2020 and this is expected to change how the aquaculture and aquafeed sectors operate. The strict environmental scrutiny and protection of the environment will push feed mills to upgrade feed formulation and production technology and push farmers to improve management and farming protocols.

The market for aquatic farm-care products in China is growing with the market size of more than USD 7 billion/year. Zhang expects this to grow, creating a potential business for aquafeed producers. More local feed mills have started to produce and market their own farm-care products.

"Farm care products can increase farm productivity, aquafeed volume and farming profit. In the farming of the grass carp, production is 22 tonnes/ha, but with farm care products, production can reach 28 tonnes/ha. In terms of feed volumes, without these products, it is only 33 tonnes/ha but with farm-care products, it can reach to about 40 tonnes/ha. With farm care products, moulting in Chinese mitten crabs can increase to 6-7 times from 4-5 times to reach a much bigger size, with a higher market price, in a shorter time."

Suitable feeds are also required for better farm productivity. Feeds for recirculation aquaculture systems will differ from the ones for pond or cage farming systems, due mainly to differences in feed nutrients, water stability and pellet physical characteristics. "In China, with product upgrades we improved FCR for tilapia farming from 3:1 in 1992 to 1.2:1 in 2018. For several feed types, we have moved from sinking to floating feed, and lately to functional feed. This has been done for various species," said Zhang. "Farming creates a demand for quality feed, and efficient feed pushes up growth in production."

Functional feeds

"Functional aquafeed for better farming performance is the direction to go," said Zhang. "Nowadays in China, local feed mills have started to expand their product range. There are several functional additives: health care for liver and gut health with anti-stress properties; prevention against viral and bacterial pathogens; fast growth: low FCR; high density culture, hot season crop or high salinity culture; fillet quality; colour and flavour. For example, we have demonstrated how a functional feed used in combination with probiotics and a premix had effectively solved the pangasius yellow fillet problem."

His takeaway message was, "Feeding is the most important stage in the farming of aquatic animals. Together we need to adapt and update farming technology to ensure the production of safe and high-quality seafood."

Marlito Uy, (centre) and Cliff Ryan Chua (right) from Marcela Farms Inc and Elvin A Arriesgado, Novus International Pte Ltd, Philippines.

Feed for thought: Shrimp Feeds

The PT Delta Marine Indonesia's farm on Sumbawa Island, comprising 2,500m² to 5,000m² ponds, concentrates only on the grow-out of *Litopenaeus vannamei* at stocking densities ranging from 100 to 180 PL/m². It is a typical farm in Indonesia. In a newer part, 2,500m² ponds are HDPE-lined while older ponds are concrete ponds. Feeding is done manually, 5 times/day, or over 24 hours using auto feeders.

Rizky Darmawan, Director, PT Delta Marine Indonesia shared data on costs of production, calculated from previous cycles. Feed is a large part of production cost (55%) and feed trays are used to monitor feed usage. He manages feed inputs with a feed index of ±0.6, which helps the farm attain optimal feed utilisation, and avoid overfeeding and underfeeding. "We do not depend solely on FCR anymore as with auto feeders, we can bypass the conventional feeding rates."

"Occasionally there is top dressing of feeds to counter disease or improve feed digestibility. We still use feed trays in our farm. We always want high quality feed and do not want any decrease in feed quality in our farm. We use a minimum of two brands of feeds for benchmarking. When there is a drop in performance of a particular feed brand, we will reduce the proportion of this feed used in the farm. As with every farmer, we want to reach our target average daily growth (ADG), look for competitive feed prices and technical support.

On KPIs, the farm strives for the following: 5g shrimp at days of culture (DOC) 40; growth in every sampling; ADG which correlates to the feed index indicating good feed performance; ADG 0.3g and FCR 3 1.2. The most recent strategy is the use of lower protein feed. "The reasons are that we can get the same growth than using higher protein feed as most of us in Indonesia ferment the feed which make them more digestible. Lower protein feeds are cheaper and contain less nitrogen, helping us with pond water quality."

On his wish list are: early stage feed suitable to be used with autofeeders; functional feeds to help mitigate diseases; feeds which give good ADG, robustness in shrimp and no annual increase in feed prices. "Currently starter feeds are crumbles which pollute autofeeders and mess up the mechanism. Yearly with the increase in feed prices, and current low shrimp prices, profit margins are declining."

In summary, Rizky would like to see cheaper feeds in the market. "We want to see in the future that the shrimp farming industry is as mature as the salmon industry; right now, we can get FCR 1.2, but hopefully, in the future, we can get FCR 1."

From left, Thayada Phlyhirun, TRF Feedmill, Thailand; Dr Nguyen Duy Hoa, Cargill Vietnam; Marcel Boaventura, BernAqua, Belgium and P Maheswari, The Waterbase Limited, India.

Marine fish feeds in Indonesia: A farmer's perspective

Phillips Foods Indonesia operates an Asian seabass *Lates calcarifer* or barramundi farm in north Bali. **Troy Keast,** Director of Aquaculture and Sustainability is in charge of all operations, from egg to plate. The farm is integrated with broodstock, hatchery, nursery and grow-out. It also has processing facilities and its own restaurants.

"Our nursery stage is actually offshore; it is the most challenging stage but nutrition has been the easiest way to meet this challenge. Historically when we had problems at the farm, when all else fails, we hit it with nutrition."

Troy focused on vendor tiers in the supply of marine finfish feeds in Indonesia and commented, "The multinationals are poorly represented in Indonesia as marine finfish culture lacks the footprint to justify investment. As I see it, one uncertainty is regarding regulations which continue to handicap the industry and scare away investors," said Troy.

"A top tier vendor is able to produce those feeds in Indonesia that my competitors are able to access overseas. The middle tier vendor is willing and capable to re-calibrate/ formulate those feeds produced in country or import to meet customer requirements and the bottom tier vendor is in a race to the bottom to produce the cheapest feed possible.

"I am a firm believer that basically, you get what you pay for. In the nursery, we address problems with high nutrition and very expensive feed. We use mortality rate, rather than survival as our performance indicator."

The ideal vendor

Troy believes that an ideal vendor facilitates progress and has the vision to weigh up their potential customer, know where they want to go and know what this will require. Customers without a classical education needs to depend heavily on technical support, in the form of a technical manager supplied by the vendor, as in the case of Phillips Seafood. "Together we work through trials which are not bound by science or the analytical mind.

An alternate angle on sustainability

"For me, the basis for a sustainable relationship is trust, honesty, integrity and authenticity." His message to growers is, "Once you have established a relationship with an individual (these relationships can transcend corporations) or a vendor , the benefits are compounding- they get better and better as the years go by. You don't jeopardise these relationships with flippant speculation. You remain loyal and when you come across a problem, you solve it together."

Finally, Troy said, "We should also be doing whatever we can to press down on the phenomenum of decreasing protein prices, it is totally counter-intuitive and detracts from the goal of equitable value chains"

From left, M A Kabir Chowdhury and Md Akteruzzaman, AKM Ruhul Amin Sarker, DSM and Himangshu Bhowmik, Agata Feeds, Bangladesh

The interactive breakout session

Hard Talk with C-Suite Executives of Aquafeed Companies

C-suite aquafeed executives, from left, Christopher Co, Palanisamy Ravi and Henrik Aarestrup. The moderator was Ronnie Tan.

TARS 2019 featured a Hard Talk with three C-suite executives of aquafeed companies from Denmark, India and the Philippines. The aim was to identify successful business models and to see what opportunities and threats they could foresee in the near future. They gave some directions in line with the "Fit for Future" theme of TARS 2019.

Henrik Aarestrup, Vice President, Emerging Markets Division, BioMar Group, Denmark, is responsible for driving the group's expansion into new market areas in both Latin America and Asia. His achievements include the company's successful entry into the shrimp feed segment and the establishment of two joint venture factories in China. Global sustainability initiatives under the BioSustain umbrella.

BioMar, founded in 1962 is one of the leading companies in the production of high-performance feeds for the global aquaculture industry. The group supplies feed to around 80 countries and to 45 aquaculture species from 14 feed factories.

Palanisamy Ravi, Senior Vice President of Operations at The Waterbase Limited (TWL), India. He was part of the initial project team tasked with the founding of TWL in 1992.

TWL, India's first integrated aquaculture company, established in 1993 has two feed mills in Ananthapuram and Bogole in Nellore, Andhra Pradesh. TWL produces starter to grow-out pelleted shrimp feeds for the marine shrimp, and freshwater prawn. It has shrimp processing and hatchery operations and 12.1 ha (30 acres) of shrimp farms and a R&D centre.

Christopher Co, Vice President Marketing of Oversea Feeds Corporation, an integrated aquafeed producer based in Cebu, Philippines, has considerable experience in the growing and breeding of different species: monodon and vannamei shrimp, grouper, snapper, pompano, crab and tilapia.

Oversea Feeds Corporation started with fish farming in 1987, and subsequently went into feed milling in 1988 and the hatchery business in 1989. There are several company-owned and joint venture grow-out farms for vannamei shrimp and milkfish fingerling production to supply offshore fish cages and pens. Species wise, the focus is on vannamei and monodon shrimp and milkfish.

On business models contributing to success and challenges faced in the immediate future..

Henrik: We are fully focused on aquafeeds and that is also the base for being successful in China. Sales in China are related to long term relationships and giving a lot of credit can run very high risks.

In China, our Tongwei-BioMar JV gives us access to the right customers via Tongwei and to technology via BioMar. The success needs both investment and willingness, and both partners are in it for the long term.

Palanisamy: In the 1990s, TWL went straight into an integrated strategy for a commercial aquaculture business, comprising hatchery, farm, feed and processing for export. This extended to franchisee farmers.

The boom with the vannamei shrimp began after 2009, but at this time, TWL had shutdown most of its supply chain, to only producing feed, thus leaving the integrated approach. We now have returned to our original approach.

Apart from feed performance, we now look at sustainability with the mantra of 'making our farmers profitable'. A company providing an integrated solution is better at addressing farmers' problems and there are only two listed companies including TWL doing this today.

Christopher: We have to look at the Philippines as a country within a country and one business model cannot be applied to all the regions. Shrimp culture varies from island to island. With competition, I believe integration into farming and hatchery helps keep control over many aspects. It is necessary to form alliances with other players. It is actually cheaper to import than to produce feed locally and this is due to the high cost of electricity.

On species focus..

Henrik: Shrimp has taken a big role and is expected to be the third leg. Shrimp feed only comprises 9%. Building on shrimp feed in Central America, we can now introduce shrimp feeds in China. The target is not to be number one in shrimp feeds but focus on customers who value innovation and sustainable solutions.

Palanisamy: TWL focused on vannamei which grew at a double digit CAGR since 2009 in India. It is true that the risk is huge but we do not have any other choice. The freshwater fish business is not our focus as it is for the domestic market.

Christopher: Oversea Feeds actually started in shrimp grow-out in the heyday of the monodon shrimp. After this shrimp failed, we shifted to vannamei shrimp but there is also the local fish, milkfish and tilapia and marine fish.

Is integration the future or will it be just focusing on the core business of feed?

Henrik: We understand the benefits of integration; with transparency in the value chain we hope to reap the benefits along this chain. We have chosen to be the best at feed and using this best practice around the world. This allows for opportunities with partners in various geographies and countries across the world.

Christopher: It is possible to rely only on one segment of the value chain but how can we relate to the farmers if we ourselves have no grow-out experience? How does one control the stocking without our own hatchery? This applies to other species of fish where we do not have a hatchery. Oversea is not integrated into processing as it requires a full-time operation and can be a stand-alone business.

On strategies for geographical expansion in Asia..

Henrik: In our case, entry into China was about timing. There are much stricter environmental regulations implemented now which easily compare to regulations introduced in Europe 20-30 years ago. Northern Europe had to overcome this with innovative products, specialised systems, high performance and low impact feeds. Today the Chinese market is mature enough to accept these exact same products and systems. It's about applying new technology at the right time when there is market pull.

Palanisamy: The are opportunities for expansion within India. The east coast from Tamil Nadu to Odisha has aquaculture activities which has grown over the past 15 years. As transport cost is expensive in India and can amount to 5% of feed costs, it will impact as we are more than 400km away from our customers in Gujarat, so we have been looking at sites for a new feed mill. We are also interested to work globally through joint ventures.

Christopher: There are numerous feed mills north of Manila which service farmers in Luzon. This is a great advantage over our feed mill which is based in Cebu. Our strength is in central and south Philippines. Oversea studied and rejected the idea of putting up a feed mill in Manila. The study showed that whatever savings garnered by being close to the customer were negated by the transport of bringing in feed ingredients.

On common demands from customers..

Henrik: It is important for feed companies to listen to customers but also see the global developments and look ahead for the needs of the farmer. Innovation is a major focus for us, implementing best practice across markets. We see a lot of novel ingredients that help aquaculture's sustainability which is not driven by the customer but by the value chain. For BioMar, it is innovation, sustainability, environmental performance and the capacity to grow.

Central America's shrimp industry have started focusing on sustainability and branding themselves as such. This is where they sell at a premium compared to Asia. Their approach seems to fit well with ours on the sustainability brand.

Palanisamy: India is a tough competitive market and the next criteria of farmers is more credit. But in today's situation, disciplined farming practices will enable them to sustain, such as Gujarat farmers who seem to have more teamwork and discipline. Gujarat has a market size of 100,000 tonnes of feed per year. Almost 80% of the fry come from one hatchery, so perhaps there is more trust amongst the smaller industry there.

Christopher: With any feed complaint, we have to give it serious thought. The vannamei shrimp is more tolerant to formulation fluctuations compared to the monodon shrimp but the feed company always gets blamed for any problem. It is important to ensure that the hatchery provides quality fry. Even with good genetics, one sees variation among different batches. Feed companies do have a role to play to provide technical service for farmers. Farmers tend not to adapt so an operating procedure that worked years ago may not work today and hence education is crucial.

INTERACTIVE BREAKOUT SESSION
Industry Group: Shrimp Feeds

Disease mitigation
While functional feeds could provide solutions for health and disease challenges, these cannot substitute for good farm management. Functional feeds should be specifically developed for each disease, so it will take time and continuous trials. Developing a functional feed for a specific disease is not easy. For example, a feedmiller in India has been developing functional feeds since 2017 and it has taken a minimum 2 to 3 years to address the specific problem.

Another example is of a feed producer working on a functional feed for white faeces and EMS. When farmers are challenged with disease, they try to save cost and not invest further in their crop. Some compounds against pathogenic bacteria were incorporated into the feeds, adding to the formulation cost which farmers were not willing to pay. This is the disconnect between functional feeds; functionality is going to increase the cost but when farmers are challenged with disease, they become more risk-averse, and look more to reduce cost than add cost to save the crop.

Low shrimp selling price
Ways to increase and improve marketing were considered. Reduction in production cost to maintain margin needs good feed and farm management – the latter with more technologically advanced methods. A common practice is over-feeding although better results can be obtained just by reducing the feed amount. Finding ways to reduce production cost in other areas to maintain margins was an issue mentioned.

John Diener (left) led the group. Roundtable leaders were, from second left, Ramesh G, Ravikumar Bangarusamy , Haris Muhtadi, Brett Glencross and Rizky Darmawan. Others were Ester Santigosa, Nguyen Duy Hoa and Jarin Sawanboonchun (not in the picture).

Feed technology
There is a dichotomy in using automated feeding systems; either as feed devices or systems with artificial intelligence (AI) to determine when the shrimp is hungry and feeding. There are online systems which can compare feeding tables versus the genetic strain of shrimp being farmed or with other pond parameters. In India, Growel Feeds is promoting the use of a sensor-based auto feeder which can provide details of a particular pond- linking all details; feed, oxygen and other parameters. Usually it is assumed that cheap labour deters the adoption of automation in feeding, but Ravikumar reminded that with auto feeders, the worker does not need to enter the water area at all. Auto feeders should be regarded as a way to maintain full biosecurity, rather than as a labour-saving device. With a higher % protein feed, the use of sensor-based auto feeders is recommended, where feed amount correlates with the needs of the shrimp.

Technical support
Disease is a daily challenge. Farmers' expectations include more technical day-by-day support from a feed producer, said Ravikumar. For this technical support, data analysis is very important. His feed company has developed an app where the farmers can log in privately, enter their data, upload photos of shrimp with certain symptoms and request for solutions. with aqua and field labs across India, farmers can submit samples to the lab and that data also goes to the factory. Usually in a feedmill, the marketing team is large while the technical team is much smaller.

Most feedmillers promote a general SOP. A comment was that SOP should be region-specific. For example, a generalised SOP throughout India may not work where there are more than 10 or 20 different localities, each requiring different feed and pond management styles.

Farmers' knowledge
During the time of monodon shrimp farming, following basic farming practices worked. With industrial-scale production of the vannamei shrimp many new entrants such as from the IT industry do not have the basics but see shrimp farming as a profitable business opportunity. More investment from the feed segment to increase farmers' knowledge was proposed.

Genetics and hatchery
Genetics companies should do a better job in communicating implications around nutrition and genetic potential to the farmers using their genetics. There is lack of action on "If I switch from this genetic strain to another, do I need to change my feeding strategy?" There is poor information from hatcheries or breeding programs around what should they do differently for one genetics versus another. The comments were around "should we look more into feed formulated for specific genetics or should genetics companies or hatcheries say, "Look, when you're using this post larvae, you really should be using a higher protein feed because they grow faster or they need a higher nutritional density in order to achieve their maximum genetic potential".

In the poultry industry, for a specific breed, there is a specific nutritional requirement especially on the amino acid requirements. In shrimp farming, there are specific pathogen-free shrimp (SPF) but do breeding programs work on the nutritional requirements specific for their genetic lines? Do we need to have the right nutrition for growth? Brett Glencross showed in his presentation on how those critical control points of growth could be affected by nutrition and genetics interaction.

Feed specifications and quality

The concept of feeds specific to a grow-out environment, such as customised feeds for low salinity or high salinity farming conditions, type of post larvae and RAS farming is interesting but may be difficult operationally for the feedmiller. Discussion centred on solutions for feeds which are more specific to farming applications - less generic feed, more precision nutrition.

At a roundtable on shrimp feeds; Rizky Darmawan (centre) with Dr Preecha Ekatumasuit, TRF Feed Mill, Thailand and Abung Maruli, Biomin, Indonesia.

Brett Glencross stressed that we need to better understand nutrient utilisation by shrimp. When we look at how fish uses protein, it uses about 50% which is no different from chicken. This is not the case with shrimp; in shrimp trials, measuring protein utilisation by shrimp in a clean water system (i.e. taking out the endogenous influence), utilisation was only 25%. We can push this to 40% by adding microbial biomass to their diet. This shows that the shrimp are not inefficient, but we are really missing something. There is actually something affecting the way the shrimp work, that we still do not know. At TARS 2014, he coined this term "The Unknown Unknowns". These unknown unknowns still exist.

Are farmers reluctant to pay more for functional feeds but will do top dressing? In Indonesia, Haris Muhtadi clarified that some relatively large farms are eager to use a functional feed during some specific farm situation and specific production stage. Maybe this will be during month 1 to month 2 of the crop. Most Indonesian feedmillers are likely to produce the specific feed or functional feed for the farms. For example, a farm in Lampung is adding IDR 3,000/kg (USD 0.25 USD/kg) to the feed cost by using a functional feed. The psychological or maximum level that most farmers can accept is IDR 2,000/kg of additional cost for improving feed quality. The problem is showing consistent results to farmers. In one crop where the functional feed was proven, this meant that the IDR 2,000/kg is value for money but in the next crop, it becomes expensive with no proof that the additional functional feed was beneficial for the shrimp. There are also management, disease outbreaks, post larvae sources, and other factors to consider. In summary, to convince farmers, the result must be proven and consistent.

Although he and other younger farmers are starting to accept the idea of higher feed costs with functional additives, Rizky is of the opinion that elder farmers will not accept paying more for such feeds. They do not want to take that risk.

There was a general comment that to do top dressing or some kind of treatment to the feed, it should be done at the feedmill since the feedmill would have the technology. The circumstances with on-farm top dressing was explained. When a farmer has a problem, top dressing is quickly done at the farm, if the products are available at the farm. The farmer wants a solution on the spot. To have the feed plant process the feed means having to wait for the feed to be delivered. Rizky said that this would result in the likelihood of spoilage of the functional feed stored at the farm for 3-4 months. Another reason for top dressing at the farm is because only farmers know exactly when, where and how much a functional additive should be added to the feed for the crop. Additions may be for the crop during specific periods (shrimp moulting, fluctuating temperatures, white faeces syndrome outbreaks, etc).

Fish meal, fish oil replacement

In shrimp feeds this is no longer a technical challenge. It is more of a marketing challenge to get the customers to start adopting feeds with alternative ingredients.

Extrusion

On digestible protein, the question was how to improvise feed processing conditions to ensure that the ideal digestible protein is achieved. There were suggestions on extruded shrimp feeds, common in the Latin American feed market. In Asia, the usage is only 5% of extruded and 95% of pelleted shrimp feed. The growing use of automatic and more uniformed feeding means extruded feed would be more suitable.

The high level of dust and breakage of pellets was pointed out in pelleted feeds. With extrusion, feed is pasteurised because of the high temperature and high-pressure cooking, eliminating most pathogens and this makes the feed more digestible because the cooked levels are much better. With more unconventional feed ingredients and new alternative protein sources are being used, this could be one of the solutions.

Low or high protein feeds?

In the feed industry, an assumption is that very high growth genetics require high-density feeds, but in Indonesia, farms are using low price, low protein feeds. There seems to be a mismatch here.

Haris Muhtadi noted that in Indonesia, there is inadequate information on genetic improvement and whether an improved formulation or nutrition is required. The focus is more on management. No matter how good the quality and functional properties of the feed are, if the pond and water quality are not managed well, shrimp will not eat well. In Indonesia, even if the feed is only 30% of crude protein, ADGs can reach 0.3, 0.4, and 0.5. The formulation has not changed but the change is feed management, feeding regime, and also how to address the spread of WFS. Feed management should change when using feeds of different % protein (34%, 36%, 38% or 41%). It is very important when using a higher protein feed, to follow a stringent protocol on feeding management. At the early stages, higher % protein feed is recommended for a higher success rate and animal immunity.

This multifactorial equation was exemplified by the scenario at a farm in North Bali using a custom-made low protein feed to suit a farming style. The need was higher C:N ratio in the feed. ADGs were high at 0.25g, 0.3g, 0.35g. Farm management was specific with semi-biofloc. The pond had natural productivity and feed nitrogen was not required to be high. At a clearwater broodstock facility in Thailand of a genetics company, 38% protein feed was used with good results. Feed with 42% protein feed gave a jump in growth. The possible reason was that the full genetic potential of the shrimp came with higher nitrogen density in the feed. It is common for farmers to get very good results from low nitrogen feed and very high nitrogen feed. Thus, this depends on the farming style and how all other variables interact. The big factor with overall shrimp nutrition is the environment. There is no easy answer to this low or high protein feed question.

Together, feed price and crude protein is judged by feed performance at the end of the crop. It is important to compare the unit of feed price to produce 1 kg of shrimp. The 38% protein functional feed gives a much better growth rate and lower costs as compared to a lower 36% protein feed. Cost-wise, 16 kg of USD 1.2/kg feed versus 28 kg of maybe USD 1.00/kg feed gives more value. When the shrimp is 10g in weight, the recommendation is for the farmer to use the normal 36% protein feed at 28 kg/100,000 PL and to use the functional 38% protein feed at 18kg/100,000PL.

The Industry Group on Freshwater Fish Feeds was led by Ning Widjaja (left). Seated are roundtable leaders, from right, Marc Campet, M A Kabir Chowdhury, Fuci Guo, Martin Guerin and Henrik Aarestrup.

Industry Group: Freshwater Fish Feeds

Specialised nutrition

With regards to feeds for fillet yield, the group focused on the pangasius and tilapia. In Thailand, the tilapia is mainly for domestic consumption of whole fish. Therefore, there is less attention on feeds for higher fillet yield. Yield is mostly biologically and genetically determined for a particular species. Fillet yield can be genetically improved; salmon has >60% fillet yield whereas in tilapia, it is still 33-35% fillet yield. Fillet yield will also depend on fat deposition. When there is excess energy, the deposition is in the viscera. Fat mobilisation is dependent on the right protein: energy ratio. A way to mobilise fat is with emulsifiers, such as bile salts.

On reducing yellow colouration in pangasius fillet, the experience in Canada (as reported by Kabir Chowdhury) was by adding 1-2% of stick water (from distilleries) in the feed for rainbow trout decrease yellow colouration from some feed ingredients such as corn. Avoiding ingredients with xanthophylls is another way to reduce yellow colouration. With fillet quality, there is the prevention of lipid oxidation by adding antioxidants to the diet, specifically methionine because it is a precursor to glutathione and organic selenium. At the forefront of sustainability, is the impact that farming has on the local environment, effluents to the water body, antibiotics residues, etc. Not mentioned is the other part with raw materials which is less visible to the farmer, such as the use of soybean from Brazil in terms of deforestation.

With regards to eutrophication in the lakes in Indonesia and in the Philippines, some of the solutions ranged from switching fully from pelleted feed (where management of feeding is difficult) to floating feeds but according to one feed company, what was required was farmer education and managing floating feeds. Issues arise when some farmers do not follow regulations and continue polluting the lakes with lower cost of production (COP) but those following regulations face a higher COP. To minimise phosphorus and nitrogen output, enzymes will help. In some countries, there is still the use of standard, sinking pellets. But aquafeed millers need to be responsible and push for the use of floating or slow sinking extruded feeds which allows for better feed management. Some countries have advanced with only extruded pellets. For example, in Vietnam no feedmiller is producing pelleted fish feeds.

Functional feeds

During the dry season in Indonesia, the main issue in intensive catfish farming is temperature fluctuations (hot in the day and cold at night) leading to stress. The proposed solutions include anti-stress diets, with antioxidants and immunostimulants. There were queries on enzyme application in extruded feed to increase feed digestibility. A suggestion was to modify finisher diets (applied a few weeks before harvest) to speed up growth performance.

Specific feeds for RAS

Feeds for RAS farming can be high density and low pollution feeds. The group recognised that feed production will be determined by the uptake of RAS in Asia Pacific. Most likely in the coming years in Southeast Asia, some large companies will invest in RAS shifting the structure of the aquaculture business. Over the last 20 years, Denmark has developed RAS systems, and companies like BioMar has years of specialisation in RAS diets. Initially when RAS systems were first developed, it was a response to poor water quality due to fish farming. In Denmark, farmers were left with two choices: either leave fish farming or invest in RAS systems. To switch to RAS technology the government helped with loans.

In the case of farming freshwater fish in RAS, from a purely economic point of view, the freshwater fish should be of high value. On a cost basis, RAS cannot compete with open pond production, such as 400 tonnes/ha of pangasius in Vietnam. However, in China, the industry is realising that they have destroyed their water systems and whether the species is of high or low value, there should be a change in the production method. Henrik Aarestrup foresees that farming of low-value species will have to move into RAS. Catfish farming in Indonesia resembles some kind of RAS and just needs RAS feeds.

RAS for grow-out of low-value species will be difficult but the opportunity is at the nursery level to produce quality fingerlings. An RAS nursery to produce and supply 25g tilapia to farmers is ongoing in Indonesia. In China, there are 20m^3 container-based RAS and in India, there is a development of a modular hatchery system, movable from one location to another and 3 containers for 3 species. AI will help with cost-effective systems.

On how prepared are feed producers in Asia with feeds specifically tailored to RAS farming? The requirement for the species is clearly known but what is the effect of each of the raw materials on, for instance, faeces structure? The utilisation of binders may be needed or not depending on the feed ingredients. The knowledge is there but it just requires application.

Henrik Aarestrup led a roundtable with participants from China, Canada, Vietnam and Australia.

Industry Group: Marine Fish Feeds

The group chose three species to review and discuss key areas of improvements: barramundi (Asian seabass *Lates calcarifer*), grouper *Epinephelus* spp and pompano *Trachinotus* spp. The yellowtail *Seriola* spp was also discussed but its feed requirements are a bit more specific.

Growing the farming business will help the feed industry. The barramundi is mostly for local consumption and there is an impact on price when supply is high. While large volumes of the milkfish are produced in Asia, the feeds for the fish have received less attention because its farming utilises little feed inputs. Industrialising this sector could significantly change the feed industry balance.

Feed prices were determined as an issue; prices are much higher compared to feeds for freshwater and brackish water fish. Lower feed prices as well as options to have functional feed or better feed formulations in the future were discussed. The group acknowledged the difficulty with reducing feed costs.

Trash fish and semi moist feeds

A current challenge is the need for trash fish or feed with a fishy smell for the marine fish. For the barramundi and grouper, feed formulation is not an issue as much as getting small farmers to adopt formulated feeds. Today, farmers look at the cost of such feeds as a premium on a per/kg basis compared to trash fish.

To encourage complete replacement of trash fish, farmer education on the negative effects of trash fish was proposed. Farmers are really comparing trash fish to formulated feed on a per kg basis, not accounting for the fact they are buying 80% water with trash fish. In freshwater fish farming in ponds it was easy to convince farmers to move away from trash fish as they can see deterioration of water quality. But in an open marine environment, this is more difficult. Therefore, showing evidence of improvements, educating and running pilot projects could elicit change. Farmers must be convinced as formulated marine fish feed prices are high.

Currently, trash fish is used, as in the case of seabass, at the late stage of the hatchery phase. But in the case of yellowtail, part of the production in Japan uses wild fish as farmed fish are not weaned on pellets. Feeds and feed management for marine fish farming in Japan was described. Red sea bream is fed on pellets and warmer temperature species such as the greater amberjack *Seriola* sp will have low digestibility during winter, and farmers will then start using semi-moist pellets. But these are not factory produced but on farm-made feeds. The blue fin tuna also uses semi-moist feeds. Use of such feeds will depend on species and location. The composition can be 50% fish and 50% mash; therefore, the moisture content will be more than 25%. Freshness is important. Some semi-moist feeds are produced at the feed plant close to the farm, but most are farm-made.

There were doubts on the practicality of semi-moist feeds for marine fish. Although there was agreement that digestion or ingestion of the feed can be improved, 3 factors were considered. 1) Disease transmission could be a problem if non-sustainable feed materials are used. 2) It i s difficult to scale up industrial production of semi-moist feed. 3) What are the physical properties of the semi-moist feed?

Some participants are of the opinion that semi-moist feed is not a good idea due to spoilage (during transportation from feedmill to farm), shorter shelf life and product stability. It is better to invest time and effort elsewhere than to increase moisture content of feeds. Semi-moist feeds are common in land-based flow through Olive flounder farming in Korea. These operate with constant exchange of water. The Korean government is pushing farms to move away from semi-moist to compound feeds. In Thailand, registration of semi-moist feeds is an issue as the government is concerned on shelf life.

Functional feeds

On the use of functional feeds to combat stress and parasites, the group agreed that there should be information on the functional properties and efficacy of the functional feed. The feed miller must provide hard evidence to the farmer and perform continuous R&D to develop a better feed formulation for marine fish. With a functional feed, which is preventive against disease, it is always very hard to prove that the feed works; the lack of a disease is not obviously attributed to the functional feed. The group also commented that none of the vaccines such as for the Asian seabass, give full protection. Thus, there is a need to see how a combination of functional feed and vaccination process could achieve better performance.

A question was whether just by meeting the nutritional requirement for fish, such as for the barramundi, it is sufficient to prevent the spread of parasites and that it will not be necessary to have functional additives. Feed can certainly help mitigate parasites but this will depend on the parasite. In Greece, a feed with additives is utilised against parasites but this is not a bulletproof solution.

Romi Novriad (centre) led the 4 member group. Roundtable leaders were Allan LeBlanc (right) and Olivier Decamp (left). The fourth member was Benedict Standen.

An example of the dilemma with demonstrating efficacy of functional additives was described by a feedmiller in Thailand. Based on a farmer complaint, the feedmiller included some functional additives in the feed. Feeding was then monitored over 4-6 weeks, but it was not clear whether the problem was solved or partially solved. In one case it was dark colouration of the skin but growth performance was not affected.

In the case of eradication of parasites in marine fish, a simple and straight solution would be medicated feed. However, there are national regulations to overcome. In Vietnam, this is not allowed but to improve and support farmers with disease control, medicated feed should be explored at the regulatory level. The progress demonstrated with salmon came with the right product when faced with pathological issues.

Fish meal and oil replacements

There is continuous progress on fish meal and oil replacements in marine fish feed at the same performance and cost with available plant proteins, single cell protein and algae oils. There is research indicating high inclusion rates of soybean meal or plant protein meals result in problems with the liver and condition of the distal intestine because of these antinutritional factors. Phytic acid inhibits nutrient utilisation by the fish. Research with the Florida pompano *Trachinotus carolinus* in the Alabama Centre showed that complete replacement of fish meal can generate better performance if there is a complement of the limiting amino acids and some attractants. A point raised was whether breeding programs such as for seabass can make the fish ready for the switch to less fish meal in the feed or zero fish meal feeds.

With replacement of fish meal and fish oil, managing cost and sustainability is often mentioned. Less discussed is the opportunity for value creation, particularly for marine fish. In replacing fish oil with plant oils, there is a decline in EPA and DHA in the fillet, exactly in the same way as was seen with salmon. Value creation opportunity comes with the replacement of fish meal and fish oil with sustainable alternatives, not only to manage cost but in creating value through and ensuring that we maintain the supply of healthy EPA and DHA to consumers to give them all of the benefits. In shrimp, the supply is 0.3/100g of EPA & DHA.

Assuming that fish meal alternatives and fish oil alternatives come with a higher price, in order to provide the same performance, feed prices will increase. Should the farmer bear this cost for the overall concept of value creation? It is well recognised that unless fish meal and fish oil are replaced, growth of the industry growth will be curtailed. There is a need to bring new sustainable alternatives into the formulation. Any sort of breakthrough innovation comes at an incremental cost in the early stages, and then as it moves to scale, it starts to become more affordable.

Asia's aquaculture industry has the responsibility to face up to this situation. Leading farmers in the salmon industry are already acknowleding that there will be a small incremental cost to their feeds in order to bring these new technologies which will enable them to continue to grow this industry in the longer term. Another point is to explore the opportunity at the end of the value chain with retailers and consumers, where there is a high willingness to pay for healthy seafood and also for sustainable seafood. Based on Veramaris' consumer research, the willingness to pay for healthier salmon is in the region of 9 to 11%. The incremental cost at the moment of supplementing fish oil with algal oil is in the region of 2 to 3%. Thus, from a business perspective, it works well.

One issue is whether the feedmiller should bear any incremental cost instead of the farmer. The farmer should not be expected to bear 100% of the cost. It is justifying, working with the processors, wholesalers, distributors, retailers, and making sure that the health benefit is communicated to the consumer because once it has been through processing, it may result in a significant premium at the feedmill or at the farm level, by the time final product is delivered to the consumer.

From feedmiller's perspective, it is recognised that replacing fish meal and fish oil is happening and it an opportunity to grow. The difficulty is that even though consumers say they will pay a premium for sustainable seafood, the farm does not see this. Often forgotten is that some of these ingredients which allow the feed supply to be more constant in price adds huge value to the production process which is an assurance of budget. However, the worst impact is when there is an increase per tonne, disrupting the budget. The challenge is how to connect with the farm and get them to understand that there is not a direct value added to the seafood, but there's a lot of value in planning.

Should feedmillers in Thailand apply for BAP certification which specifies the use of local marine meal from by-products. For the carnivorous seabass, it is difficult to formulate with such meals. The best is still fish meal, but the government is pushing for the use of local fish meal certified to IFFO-RS (an independent third-party audit and certification program). Costs are acceptable as the margins are still high in Thailand and farmers can accept the feed prices. In terms of fish meal replacements, single cell proteins are acceptable but for the moment, not for insect meal which is not allowed under current regulations.

Olivier Decamp led a roundtable with participants from Thailand, Indonesia, Vietnam and India.

NETWORKING @ TARS





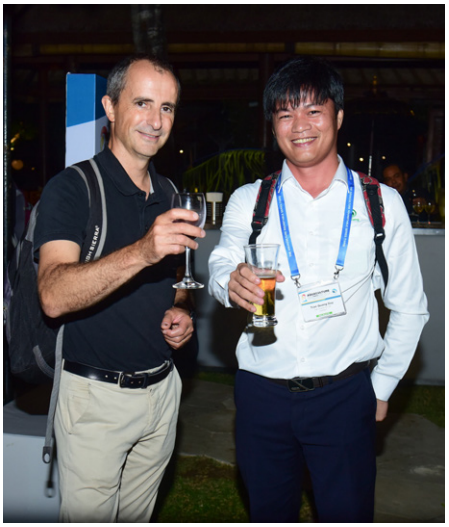























Supported By

Organizers

Sponsors

Supporting Media