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*Red tilapia in cages in Malaysia.*
*Picture credit Abdullah Abdul Rahim, Universiti Pertanian Malaysia.*

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Zuridah Merican

# Route to market – necessity is the mother of invention?

Due to this Covid-19 pandemic, the organisers had to reschedule TARS 2020 to next year. While many countries are starting to reopen from confinement and lockdown, international travel is limited and remains uncertain. Today, the TARS theme of Markets, Margins and Productivity has become more relevant than ever for all species of aquaculture. The pandemic is often referred to as a 'black swan' - a metaphor that describes an event that comes as a surprise, has a major effect, and is difficult to explain after the fact, even with the benefit of hindsight.

Let us review the impact of Covid-19 on the seafood route to market. Restaurants were forced to close, thus reducing seafood consumption. Wholesale markets shut down disrupting the supply chain. Refrigerated containers and cargo vessels laid temporarily idle, choking logistics. In many countries, fresh chilled seafood transport was prohibited from crossing state borders as this was not deemed essential, resulting in an abundance in the producing state, and a scarcity in the market. So how did the industry react to this?

In China, the frozen seafood market expanded significantly and is currently rivalling the wet markets after the nation re-emerged from lockdown. Frozen seafood has finally come of age. It was only 5 years ago when the major form of seafood sales was fresh chilled. Big shrimp exporting countries (India and Ecuador) were only able to penetrate the China market with frozen shrimp in 2017. The frozen product is no longer perceived as one of lower quality and rightly so since shrimp are fresh frozen after harvest. Compare this to tuna, frozen on-board to be served as sashimi, a highly priced raw Japanese delicacy.

Many aquaculture farmers in Asia were stuck with harvestable crops with the collapse of brokers and hence sales revenue. Today, some farmers have resorted to on-line marketing to move their products. Consumers who have been stuck at home have become savvy on-line buyers for their daily food supply. Other farmers have taken to setting up the equivalent of food trucks to sell directly to consumers in the city from the back of a lorry. While this route to market may not overtake the conventional supermarkets and wet markets in the short term, the lockdown has created an impetus and a new route to market where there is no looking back. Some governments have tried to push for the eradication of middlemen and brokers in the past, to place margins in the hands of the producer and consumer. This pandemic has quickened the process.

Suddenly, more countries are seriously looking at food security. Singapore realised some time ago that it was over-reliant on other countries for its food source including seafood. The government is spearheading Project 30/30, aimed at the country achieving self-sufficiency for 30% of its food needs by 2030. This has led to investments in aquaculture, research in RAS systems and genetic selection of the Asian seabass. 'Locavore' restaurants in the city state are promoting locally sourced food which also tells the story of traceability and sustainability. The prices are able to return sufficient margins for the higher cost of production.

Certain marine fish sectors have suffered more than others during the lockdown. Sectors upended have been the live fish market in Asia, and the seabream and seabass markets in the Mediterranean. The upside of this model was the high prices but the downside was the limited shelf life of the product. When the food service and supply chains were disrupted, these marine fish lost its route to market as farmers could not think of a business continuity plan. Why has the shrimp, salmon and tilapia sectors suffered less? These sectors have the ability for post-harvest processing and freezing which extends the shelf life of the seafood and allows for storage.

Necessity is the mother of invention and Covid-19 has forced the whole industry to relook at its vulnerabilities and new routes to market. While mom-and-pop shops have given way to hypermarkets and giant retailers, the latter may soon have to give way to the on-line business model. However, it is interesting to note that the upside of seafood retail segment never compensated for the loss of the food service sector during the lockdown but this is a question for the economists.

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# SOFIA 2020: Sustainability in action

While the rise in global aquaculture production from 1990 to 2018 was +527%, the message was that more needs to be done to ensure that fisheries and aquaculture around the world are sustainable.

On June 8, FAO Fisheries and Aquaculture Department held a virtual launch of its 2020 edition flagship publication, State of World Fisheries and Aquaculture (SOFIA) 2020. SOFIA aims to provide objective, reliable and up-to-date information to a wide range of audience – policymakers, managers, scientists, stakeholders and those interested in the fisheries and aquaculture sector.

This 2020 edition has a focus on sustainability and reflects the 25th anniversary of the Code of Conduct for Responsible Fisheries (the Code). Several Sustainable Development Goal (SDGs) indicators mature in 2020. FAO hosted the International Symposium on Fisheries Sustainability in late 2019 and 2020 sees the finalisation of specific FAO guidelines on sustainable aquaculture growth, and on social sustainability along value chains. The message was, *"All of us must work together to protect the oceans, seas and inland waters and marine resources, and ensure sustainable livelihoods, diets and development for the future."*

## Record aquaculture production in 2018

World aquaculture production rose 527% from 1990 to 2018 to a record 114.5 million tonnes in live weight with a total farmgate value of USD263.6 billion. Some 82.1 million tonnes of aquaculture production were for food supply worth USD250.1 billion. Finfish dominated at 54.3 million tonnes, comprising 47 million tonnes from inland aquaculture and 7.3 million tonnes from marine and coastal aquaculture.

Average growth was 5.3% per year in the period 2001-2018; the slower growth was largely due to the slowdown in China where growth in production was only 2.2% in 2017 and 1.6% in 2018. The growth for the rest of the world was moderate at 6.7% in 2017 and 5.5% in 2018.

Asia dominated production at 89% over the last two decades. The major producing countries were China, India, Indonesia, Vietnam, Bangladesh, Egypt, Norway and Chile. Species-wise, the production of Chinese carps at 19.2 million tonnes, dominated finfish production at 20% in 2018. The production of farmed vannamei shrimp at 4.9 million tonnes was 52.9% of the total crustacean produced in 2018.

## Aquaculture surpassed fisheries

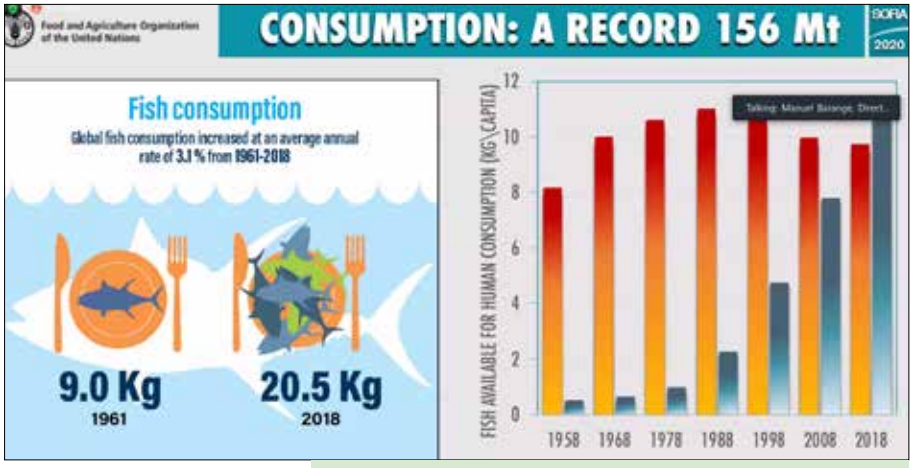
Based on time-series data of major species groups, world aquaculture production has progressively surpassed that of capture fisheries. The "farming more than catch" milestones were reached in 1986 for freshwater fish, 1997 for diadromous fishes and in 2014 for crustaceans. However, despite the increasing output from farming of marine fishes, this is unlikely to overtake marine capture production in the future.

The contribution of world aquaculture to world fish production has constantly increased, reaching 46% in 2016–2018, up from 25.7% in 2000. The share of aquaculture in Asian fish production (excluding China) rose to 42% in 2018, up from 19.3% in 2000.

The report noted that 39 countries produced more from aquaculture; combined they produced 63.6 million tonnes of farmed fish versus capture production at 26 million tonnes. Among the top ten aquaculture and fisheries producers, China had 76.5% from aquaculture, India 57%, Vietnam 55.3% and Bangladesh 56.2%. In Indonesia, aquaculture contributed only 42.9% to fish supply, Myanmar 35.7% and Thailand 34.3%.

## Fish consumption

In per capita terms, global food fish consumption rose from 9.0kg in 1961 to 20.3kg in 2017, at an average rate of about 1.5% per year. Globally, since 2016, aquaculture has been the main source of fish available for human consumption. In 2018, this share was 52%. Preliminary estimate for per capita fish consumption in 2018 was 20.5kg.




*Manuel Barange, Director, FAO Fisheries Department presented the above during the virtual launch of SOFIA 2020. Since 2016, aquaculture (in blue) has been the main source of fish available for human consumption.*

*Reference: FAO. 2020. The State of World Fisheries and Aquaculture 2020. Sustainability in action. Rome. https://doi.org/10.4060/ca9229en*

Asian fish consumption in 2017 totalled 108.7 million tonnes at a per capita consumption of 24.1kg compared with 8.1 tonnes for North America at per capita consumption of 22.1kg. Per capita fish consumption in Europe and North America has been increasing per year by 0.8% and 0.9% respectively, while it has decreased by 0.2% per year in Japan. Imports make up 70 and 80% fish consumed in Europe and North America, respectively.

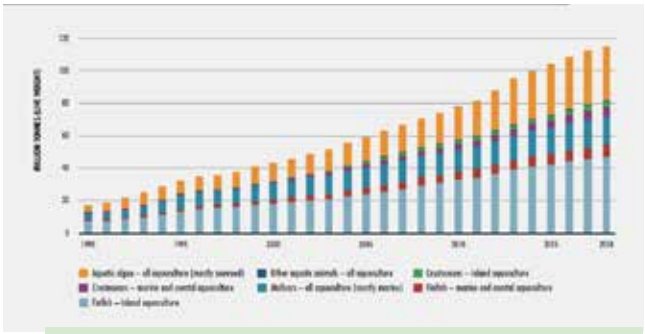
## Aquaculture projections to 2030

The report indicated that aquaculture production (excluding aquatic plants) is projected to reach 108.6 million tonnes in 2030, which is 26 million tonnes or 32% more than in 2018. But the average annual growth rate will slow from 4.6% in 2007–2018 to 2.3% in 2019–2030. The projected deceleration of China's aquaculture production is expected to be partially compensated by an increase in production in other countries.

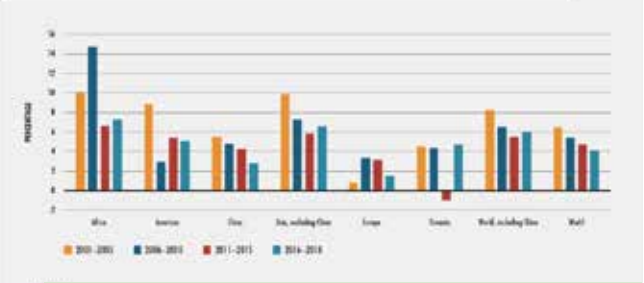
Asia will continue to dominate the aquaculture sector and will be responsible for more than 89% of the increase in production by 2030. Asia will account for 89% of 2030 global aquaculture production. China will remain the world's leading aquaculture producer, but its share of total production will decrease from 58% in 2018 to 56% in 2030. Aquaculture in Africa is expected to expand to 48% and in Latin America to 33% from 2018.

## Sustainability in action

Much has changed over the last 25 years, from overfishing, rapid development in international trade in fish and fish products to growth of aquaculture. The impact of climate change on fisheries and aquaculture is well recognised. The code has been universally adopted as a facilitator of change and most countries use it to instill key principles of sustainable and responsible development of fisheries and aquaculture, incorporating conservation, environmental and ecosystem approaches. As the importance of aquaculture in national agendas grew significantly between 2012 and 2018, 90 countries reported having a legal framework for the development of responsible aquaculture in line with the code. Although the figure has risen, there is still a need for some countries to adopt a legislative framework to better manage and benefit from aquaculture as an economic activity.



*World aquaculture production attained another record high of 114.5 million tonnes in live weight in 2018 with a total farmgate sale value of USD263.6. (FAO, 2020)*



*Annual growth rate of aquaculture fish production in the new millennium. (FAO, 2020)*

# F3 challenge prize money doubles

The F3 Challenge – Carnivore Edition —a sales competition designed to accelerate the development and adoption of fish meal and fish oil substitutes in feeds—has doubled its prize to USD70,000 per category. Awards will be given to the contestants that produce and sell the most 'fish-free feeds' in each of three categories—salmonid, shrimp, and other carnivorous species—without using wild-caught fish or any marine-animal ingredients.

Five companies have already registered for the contest, and most are seeking partners. Contest registration is currently open. A new timeline for the competition will be announced at a later date. The feeds for all categories must not contain any ingredients consisting of or derived from marine animals, including but not limited to, fish, squid, shrimp or krill.

Each year, an estimated 16 million tonnes of wild fish are caught exclusively for use as fish meal and fish oil in global food production. Salmon farms use over 20% of the fish meal and 60% of the fish oil is consumed by the aquaculture sector. Global shrimp farming is also one of the dominant consumers of the global fish meal supply. A recent study found that if 'business as usual' continues, forage fisheries will reach ecological limits by 2037.

The F3 Challenge aims to make it unnecessary to use wild fish in feeds, so that they can remain in the environment for other species, and aquaculture's growth becomes unconstrained from wild resource availability, assuring greater food security in the future.

The Future of Fish Feed (F3) is a collaborative effort between NGOs, academic institutions and private partnerships to accelerate the commercialisation of innovative, substitute aquaculture feed ingredients to replace wild-caught fish. www.f3challenge.org

## DIV1 in Taiwan's crayfish, prawn and shrimp ponds

In an inspection of crayfish and shrimp farms nationwide from May 8-21, the Council of Agriculture (COA) found 16 farms which tested positive for decapod iridescent virus 1 (DIV1);12 crayfish and 3 prawn farms and one monodon shrimp farm. At a news conference, COA said that all crayfish, shrimp and prawns tested positive for DIV1 are to be disposed although there is no risk of human transmission, reported the taipeinews.com. The origin of the virus is unknown but COA had notified customs to also test imported shrimp and prawns for DIV1. Most imported shrimp and prawns come from Vietnam, Thailand and Indonesia. However, it did not rule out the possibility that the ponds were infected by migratory birds, or that the disease was transferred via imported post larvae. Taiwan's crayfish, shrimp and prawn industry is valued at USD134.9 million annually. The council will compensate farms for the crayfish, shrimp and prawns destroyed due to DIV1, while the Fisheries Institute and the Animal Health Research Institute will aid farmers in rehabilitating their ponds.

## Pangasius exports down with COVID-19

The value of Vietnam's pangasius exports to three markets-China/Hong Kong, Singapore, UK in April 2020 grew by 20.1%, 127.6% and 20.3%, respectively. However, by the end of April 2020, the total export value of pangasius only reached USD449.5 million, down nearly 27% over the same period in 2019, reported VASEP in June. End April 2020, the total export value of pangasius to the China/Hong Kong market, the largest importer of pangasius, was down 20.2% compared to the same period in 2019. The export value of pangasius to the US and ASEAN markets decreased by 20.7% and 24.4%, respectively, compared to the same period in 2019. While exports to Thailand and Malaysia dropped by 30-31%, the export value to Singapore spiked by 127.6% over the same period in 2019. The value of exports to the EU also dropped 36%. VASEP said that with the COVID-19 pandemic in major export markets such as the US, EU, Brazil, it will be difficult for pangasius exports in Q2 to escape negative growth. A recovery can be expected if the pandemic in certain countries is controlled.

## Merger in Oman

Oman Investment Authority has announced the completion of the steps required for a merger between Blue Water, Al Wusta Fishery Industries and Oceanic Shrimp Aquaculture under the new name Oman Fisheries Development. Reported in Oman Observer, the new entity will be able to boost the investment efficiency and performance governance as well as achieve the unified economic and investment objectives. This step will spearhead the shrimp farming project located in Bar Al Hikman area to be the second largest project of its kind in the Middle East and North Africa (MENA) region with 40,000ha and a production capacity of 200,000 tonnes of shrimp/year.

## Charter flight for brood stock imports

Over five days in June, the RGCA-MPEDA run Aquatic Quarantine Facility (AQF) quarantined 6,600 *Litopenaeus vannamei* brood stock which came via a flight from Hawaii chartered by six hatchery operators on June 4. MPEDA Chairman KS Srinivas said that this played an important role in sustaining the shrimp farming sector in the country. He added that during the Covid-19 pandemic and prolonged lockdown, AQF remained open to the hatchery operators in May. Planning was done to accommodate the needs of a maximum number of hatcheries and import maximum brood stock to ensure that the hatcheries have enough brood stock for post larvae production. AQF has 20 cubicles to quarantine 412,500 brood stock a year and it quarantines an average of 250,000 vannamei shrimp brood stock annually.

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## EU authorisations for microbial solutions

**Lallemand Animal Nutrition** has announced the completion of several feed additive authorisations in the European Union (EU), including the extension of use to new target species. In addition, the authorisation of Lallemand Animal Nutrition's selenised yeast has also been renewed, and a new silage inoculant was authorised: *Lactobacillus hilgardii* CNCM I-4785 (in combination with *Lactobacillus buchneri* NCIMB 40788), which is a breakthrough for improving the aerobic stability of silage.

Ludovic Arnaud, Regulatory Affairs and Compliance Manager explained, "We are very pleased with these achievements. While renewal of authorisations focuses on product identity and safety, we do continuously work beyond these requirements. Even though some of our best-known solutions are backed by decades of in-market use, we do not rest on our laurels and keep on documenting their benefits with mechanistic and field studies."

He added, "Thanks to a positive evolution of EFSA requirements for 'efficacy demonstration' and to the demonstration of the efficacy of our products on many livestock species, it was possible to extrapolate their use to other species. For example, the use of BACTOCELL has been extended to all avian species and all fish and crustaceans, and the use of LEVUCELL SB has been extended to all pigs. This offers better flexibility to our customers in terms of feed formulations."

Yannig Le Treut, General Manager, Lallemand Animal Nutrition, added, "Our flagship probiotics, BACTOCELL, LEVUCELL SB and LEVUCELL SC, have been in the market for more than 20 years but are still very young and fresh and hold a promising future. Maintaining their authorisation more than 20 years after their introduction, while continuing to invest in significant R&D, demonstrates the commitment of Lallemand Animal Nutrition to offer the best products for the livestock and aquaculture industry."

"BACTOCELL (*P. acidilactici* CNCM I-4622-MA 18/5M) remains, to date, the only probiotic strain authorised for use in aquaculture in the EU. We continuously document the interest of those solutions for livestock and aquaculture producers. They are not only beneficial for animal performance but have also demonstrated strong health benefits in line with market trends and needs, such as food safety, reduction of antibiotic usage in livestock and aquaculture and more." www.lallemand.com

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# Optimizing shrimp production requires differentiated shrimp lines

Precision breeding for different culture systems and needs; intensive systems with fast growth shrimp and shorter days of culture require little disease resistance contrasting with less intensive systems where a priority is control on disease pressure.

By Robbert Blonk

Since 1923, Netherlands-based breeding company, Hendrix Genetics, with basic selection programs in layer poultry, has made rapid progress by embracing cutting edge breeding technologies. Today, as a multi-species breeding company, it develops and uses state of the art genetic selection tools for its genetic lines for laying hens, swine, turkeys, coloured broilers, salmonids and shrimp. For all species, differentiated products are bred, each tailor-made to specific market conditions and/or production systems.

## Applying the same science to shrimp

Globally, shrimp are cultured in extremely diverse environments; production takes place in countries located at the equator to those in colder climates cultured in recirculation aquaculture systems (RAS). Although most of the production takes place in tropical climates, culture environments are enormously different due to variation in terms of rainfall, temperature fluctuations and salinities, but also management factors such as culture densities, aeration or oxygenation practices, pond or tank design, water reuse technology, feed quality and types. Aquaculturists also encounter pressure from a growing list of diseases. Part of these differences can be classified into three main production systems, each with different management styles and levels of intensification:

- Intensive production systems with controlled oxygen levels, high culture densities, high quality feed, and high degree of control on disease pressure. These systems aim for short cycles to reduce risk.
- Medium intensive systems with aeration, medium culture densities, medium quality feed, some control on disease pressure and aiming for medium cycles.
- Low input systems without aeration, low quality feed, no disease prevention and long culture cycles.

All these systems have different economics, and all represent significant market shares in global shrimp production.

## Different systems, different shrimp lines: precision breeding

Importantly, these different systems require different types of shrimp. In intensive shrimp production systems, fast growing shrimp are more effective to obtain more cycles under relatively high fixed costs. However, little disease resistance is required as cycles are short, and health challenges are minimal. With lower intensity systems, the importance for more disease resistant strain increases as this is a bigger problem for farmers; while growth is of significant importance, it is not the top priority.

To optimize production levels in these different market segments and to support customers to a maximum level, Hendrix Genetics recently introduced three different genetic lines under their Kona Bay brand:

- Kona Bay Speed
- Kona Bay Strength
- Kona Bay Balance

There are two main reasons to have three separate lines. First, the production performance of one distinct genetic line can only be maximized for a limited set of traits at the same time. This is because the (genetic) correlations between the desired traits strongly determine which traits can be effectively selected at any one time. With low or even negative correlations between two particular traits, one can only effectively improve one trait (Figure 1).

## Balanced breeding

This is further complicated when more traits are added to the set. Particularly, traits related to disease resistance, and reproduction traits which are notorious for having unfavourable correlations with production traits like

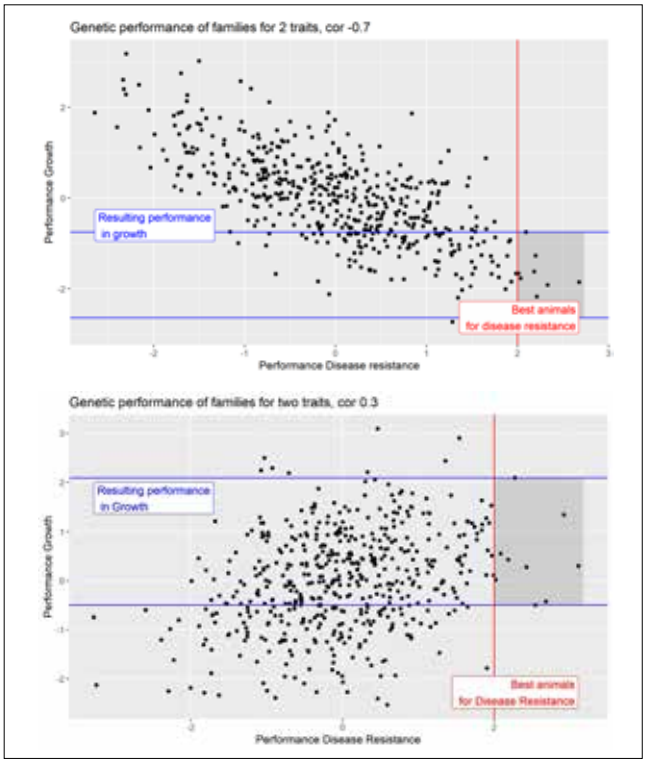


**Figure 1.** Examples of unfavourable correlations between disease resistant traits and growth.

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growth. Though "Balanced Breeding" is the breeding philosophy in all its breeding programs, balancing has its limits. When stretched too far, it may result in lower overall economic- performance. Hence, it is necessary to develop lines separately to better supply the different markets. This is exactly what Hendrix Genetics has done in this case with the Kona Bay shrimp lines.

## Genotype by environment

The second reason is a phenomenon which geneticists label as genotype by environment (GxE) interactions. GxE interactions are very important factors in selective breeding. With significant GxE interactions, ranking of animals on genetic performance of a particular trait is dependent on the type of environment – in this case intensive systems with good water quality and low disease pressure, versus extensive systems with more disease pressure etc.

In general, GxE interactions are expressed as genetic correlations where the lower the correlation, the higher the reranking of the families for the breeding program. In practice, this means that depending on the targeted environment, breeders should select different brood stock, with different genetic makeup to optimize results for that environment (Figure 2). Repeatedly, our trials have shown that in Atlantic salmon, rainbow trout and shrimp, GxE interactions play an important role with values between -0.2 and 0.7. This shows, it is essential to choose the right strain for the right environment to realize optimal results.

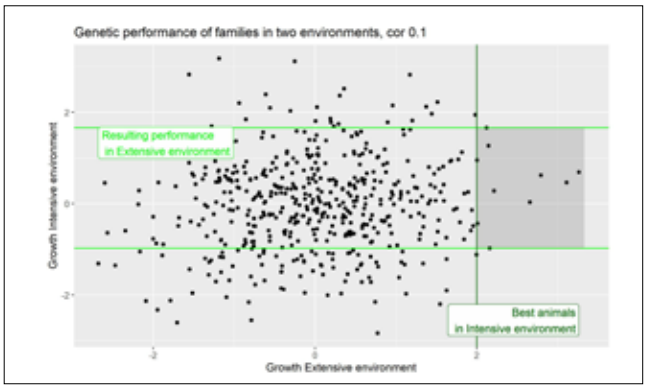


**Figure 2.** GxE interaction: animals with the highest performance in an intensive environment are underperformers in an extensive environment.

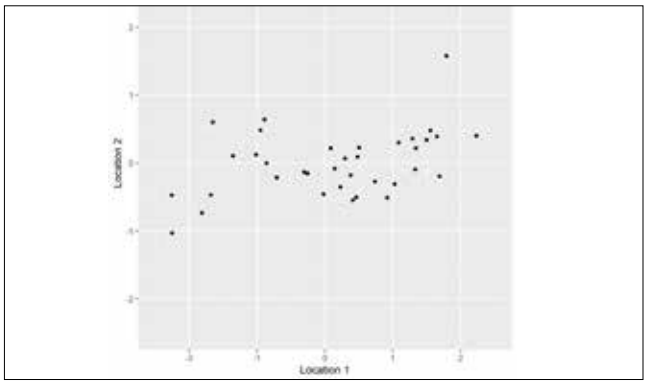


**Figure 3.** Family average genetic performance (breeding value) for growth as deviation from the average in two environments: Location 1 and Location 2. As an example, the top five families in Location 1 have an average performance of 1.7g, whereas the top five families in Location 2 have an average performance of 0.7g, indicating a difference of ca. 40%.

### Are GxE interactions important in the context of shrimp breeding, even if we already select a separate growth line next to a disease resistant line?

Yes, because in our disease resistant line, growth remains one of the traits of major importance. Growth is of lower importance than disease resistant traits in extensive systems, but nevertheless it plays a prominent role in the economics of the shrimp farmer and has to be optimized as part of the overall breeding goal. The relevance is enormous: lost opportunity for genetic improvement can quickly grow to 50%, for example when the growth performance trait is not selected under the right environment (Figure 3), implying that a particular shrimp line improves with only half of the genetic potential one could have gained. This directly translates to lower performance at the farm level.

## The benefits of using the right product line

For a breeding company it is tempting to breed for "one solution - one product line" - to supply the entire industry, as obviously fixed costs are lower when spread out over the same volume. However, the benefits of a precision breeding program for Asian shrimp are significant. For example, this means that new generations are improving by 10% for each generation for the most important and most heritable traits, such as growth performance. Use of the wrong shrimp line can easily amount to a loss of 50% of the expected genetic gain, in case the influence of environmental factors (system, feed, management) on the farm performance of shrimp is high. (In shrimp more than 40% has been demonstrated, see figure 3). In that case one would end up with 5% improvement versus the potential 10%. Or worse, as in some cases there is even a chance of getting inversed results, i.e. negative trends. The impact of the lost profit, because that is what it is, can be massive, depending on the overall cost structure and volume of the farm.

## The solution

Precision-bred products thrive in specific environments. Hence, Kona Bay Speed is specifically designed for fast growth. It is the product line for intensive growth, high quality feed and clean, controlled environments. Kona Bay Strength is made for tough conditions, lower water quality, and with stronger disease pressure. Kona Bay Balance is made for intermediate environments, where a little more control is possible and where the farmer is turning its focus to growth.

With precision breeding in mind, one line for different environments is sub-optimal. Whether we like it or not, differentiated product lines are important to serve the customers with a tailor-made product. At its Kona Bay breeding center, we doubled the breeding program in size to select the right families for their three product lines. In addition, the company is actively working with farmers and laboratories to collect field data on their lines to optimize farm performance, without compromises.

**Robbert Blonk,** R&D Director of Aquaculture at Hendrix Genetics is responsible for the aquaculture breeding programs and product development for the Atlantic salmon in Scotland and Chile, rainbow trout in the US and whiteleg shrimp in the USA and Ecuador.

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HENDRIX GENETICS

# New study confirms positive impact of astaxanthin krill oil on growth of Pacific white shrimp under hypersaline conditions

Dr Alberto J.P. Nunes shares his latest findings from a 74-day study with shrimp raised intensively in enclosed and exposed tank systems under salinity stress.

In the north-eastern part of Brazil, intensive farming of the Pacific white shrimp *Litopenaeus vannamei* is typically in earthen ponds with high salinity conditions taking place during the dry season. A previous study showed that hypersalinity causes suppressed growth and poor feed efficiency in juveniles of this shrimp (Castro, Burri & Nunes 2018). However, a dietary supplementation with oils containing highly unsaturated fatty acids (HUFA) has been shown to offset these effects. When juvenile *L. vannamei* reared at 44 ± 2.0 g/L salinity were fed astaxanthin krill oil-supplemented diets for 64 days, a minimum total dietary n-3 HUFA content of 0.7% of the diet was required to avoid reduced growth.

Recently, a team of marine scientists from Instituto de Ciências do Mar (Labomar), Brazil and Aker BioMarine joined forces to find out whether the effects of high salinity conditions in shrimp culture could be offset by dietary supplementation of astaxanthin krill oil and soybean oil. **Dr Alberto J.P. Nunes** who led the research at Labomar, shares some reflections on the findings from this new study and how it can be applicable to farming white shrimp under hypersaline conditions both in Latin America and Asia.

***Dr Alberto J.P. Nunes**, Professor, has been working on commercial shrimp aquaculture, research and teaching. Nunes has extensive international experience in the feed industry gained in Latin America and Asia. His research has focused on shrimp feeding behaviour, nutrient requirements, alternative ingredients, feed attractants and stimulants and feed management. Labomar has a research facility with over 300 rearing tanks where Nunes has conducted more than 100 applied studies in shrimp nutrition.*

## What was the objective of this new study?

***Nunes:*** We wanted to find out if dietary supplementation of astaxanthin krill oil, with or without soybean oil, has an impact on the growth of Pacific white shrimp, particularly in high salinity. High salinity conditions (>35g/L) can be seasonal or a permanent condition in commercial shrimp farms located in both Latin America and Asia. It often occurs when increased water temperature and water evaporation rates prevail. High salinity can often be found in shrimp farms located in semi-arid climates during the dry season; when water recirculation or minimum water exchange are adopted; or when nursery tanks or ponds are operated under a greenhouse to raise temperature above 30°C to control white spot virus outbreaks.

## How did you set up the experiment?

First, we developed an experimental protocol where we can simulate salinity changes in the field. We had fifty 1,000L tanks. Half of these tanks were enclosed, where there was a rigid plastic lid covered with a milky-coloured waterproof plastic sheet, except for two openings for the automatic feeding device and aeration piping. This set-up minimised penetration of freshwater from rainfall and increased evaporation rates. The other set of tanks were fully exposed to sunlight and rainfall, but just had an 8-mm mesh screen to avoid shrimp escaping. In this way, we had both systems exposed to varying levels of salinity over the culture period but only the enclosed tanks continuously maintained hypersaline conditions.

We divided 7,182 shrimp juveniles of about 1.08g among these 50 exposed and enclosed tanks. Stocking density was 135 juveniles/m$^2$. The two sources of oil, soybean and astaxanthin krill oil were applied as top-coating to a 37.8% crude protein commercial grower shrimp feed. The oils were either used in combination or alone for the various feeds in the experiment, while the control diet was simply the commercial feed without any oil. We had 5 replicates for each of the four dietary treatments. The shrimp were fed with an automated feeder four times a day, and after 74 days in total, each shrimp was counted and weighed.

## What were the main findings?

We saw marked differences in water temperature, salinity, and pH between the exposed and enclosed tank systems throughout the culture period. Water temperature was stable in the enclosed tank system and shrimp were exposed to longer hypersaline conditions in these tanks, from 42g/L to 29g/L as compared to from 43g/L to 18g/L in the exposed tank system. Mean salinity was significantly higher in the enclosed tanks at 36±4 g/L as compared to 31±6g/L in exposed tanks.

We confirmed our previous findings on the impact of hypersalinity on the growth and feed efficiency of this shrimp. Overall, we showed that shrimp weekly growth, final body weight, yield, apparent feed intake and feed conversion ratio were all significantly influenced by astaxanthin krill oil and/or soybean oil supplementation in diets.

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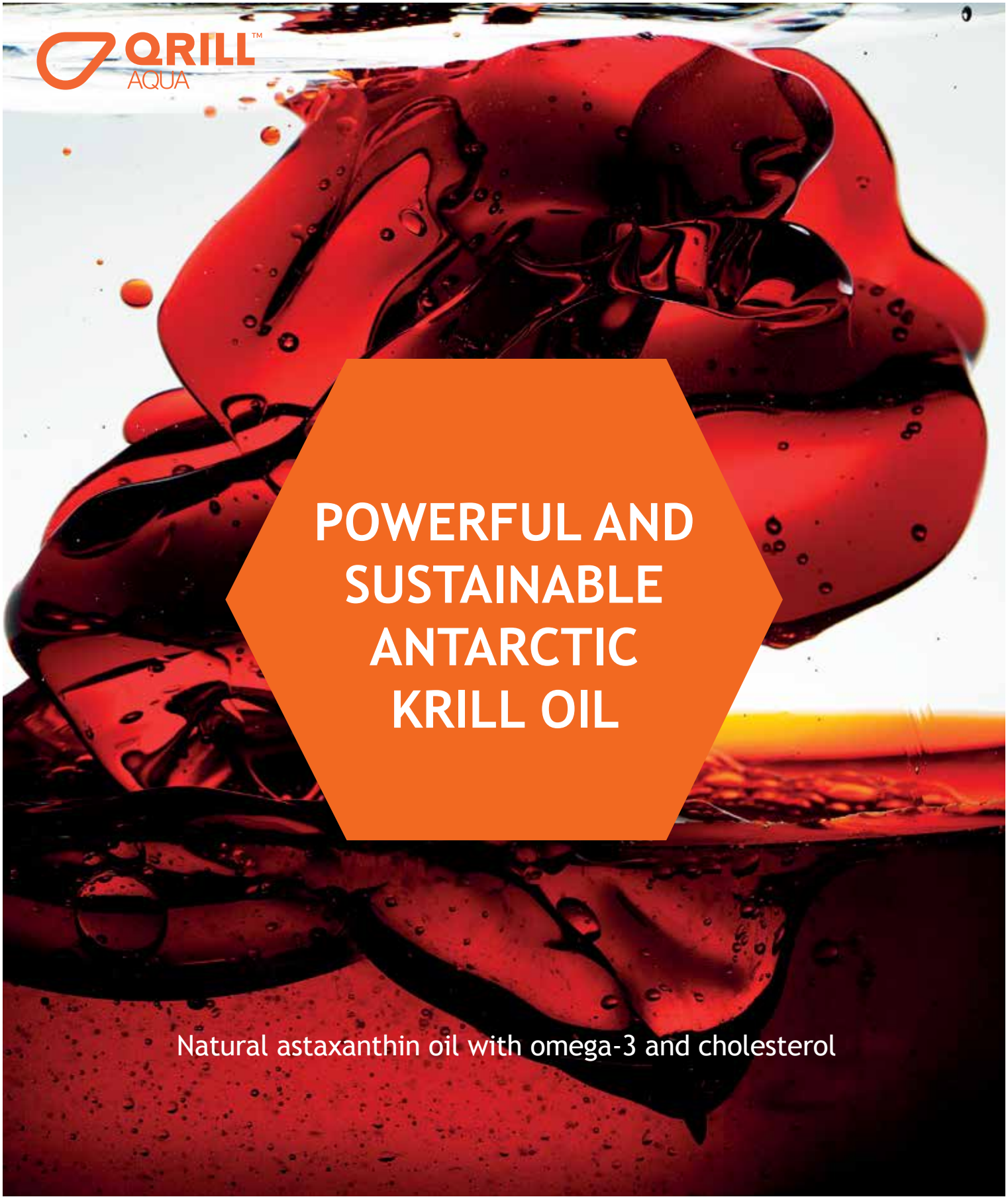

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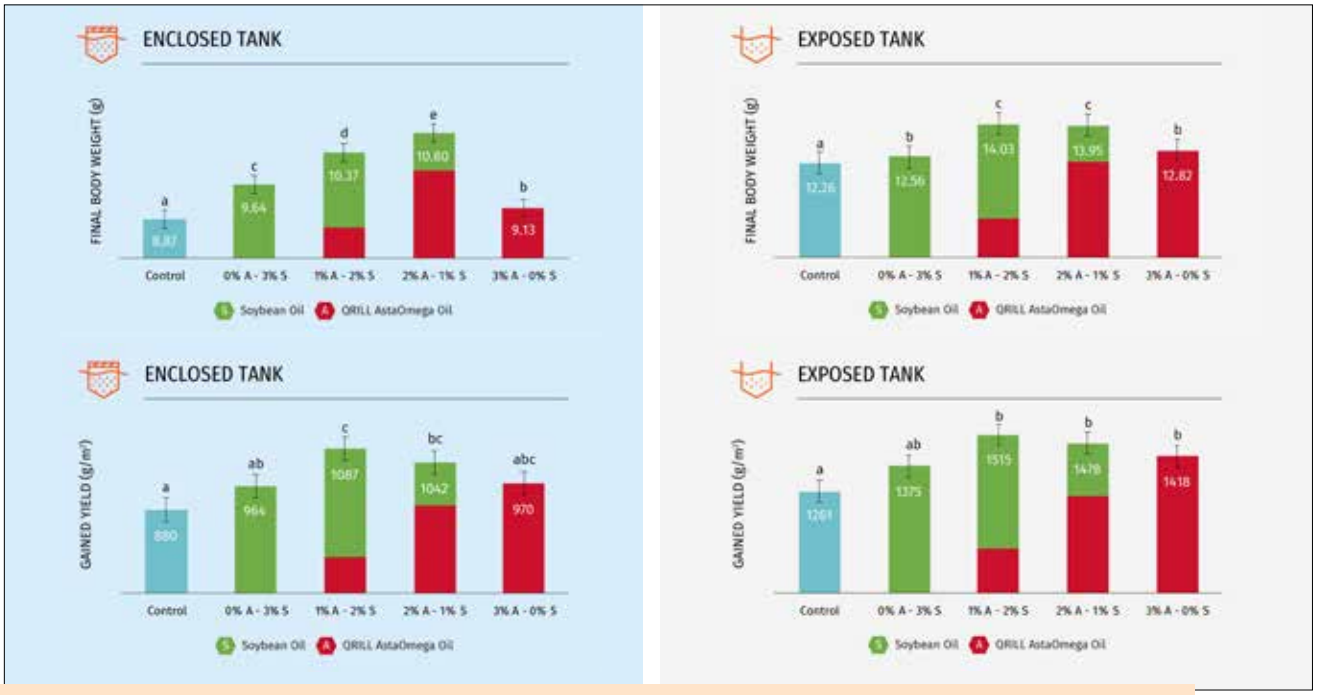



*Mean ±SD of final body weight (g) and gained yield (g/m²) of Litopenaeus vannamei reared in enclosed and exposed 1000L tanks for 74 days with 135 juveniles/m², fed a commercial feed (control) and commercial feed supplemented with different combinations (%) of astaxanthin krill oil (K) and soybean oil (S). Data obtained from five tanks are expressed as mean ± standard deviation. Letters indicate differences between diets within the same rearing system (P < .05).*

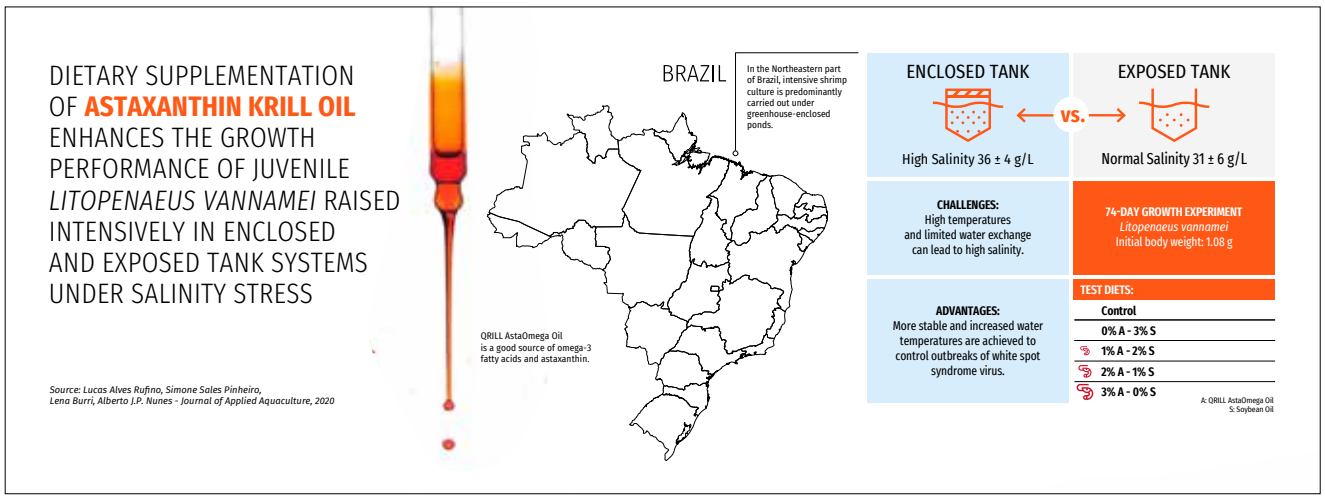
The shrimp could achieve a higher body weight when fed diets supplemented with 1% krill oil and 2% soybean oil, when in the exposed tanks with lower salinity conditions. However, in the enclosed tanks, where salinity concentration was consistently high, maximising body weight required a slightly higher supplementation of 2% krill oil and 1% soybean oil. Shrimp yield was positively influenced by the oil-enhanced diets in both types of tanks.

## Based on this work, what are your recommendations for shrimp farmers?

It is clear that shrimp farmers can reduce feed costs by taking measures to mitigate the effects of high salinity conditions. By simply adding a supplementary oil mix to the grower feed, consisting of 1% astaxanthin krill oil and 2% soybean oil (at normal salinity levels), farmers will experience faster shrimp growth and improve feed efficiency. However, when the exposure to high salinity is greater, then a minimum of 2% astaxanthin krill oil and 1% soybean oil is recommended.

In this publication we also discussed the mechanism behind this enhancement effect, based on three hypotheses: improvement of osmoregulatory capacity; higher levels of digestible energy provided by supplementation of dietary lipids; and the presence of astaxanthin ester (930 mg/kg) in krill oil.

More information:
Lucas Alves Rufino, Simone Sales Pinheiro, Lena Burri, Alberto J. P. Nunes. 2020. Dietary supplementation of astaxanthin krill oil enhances the growth performance of juvenile *Litopenaeus vannamei* raised intensively in enclosed and exposed tank systems under salinity stress, Journal of Applied Aquaculture https://doi.org/10.1080/10454438.2020.1760165

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# Balancing the pond environment

## A commercial probiotic enhances environmental conditions in a shrimp farm, improving margins.

By Wen Wei

In Asia's shrimp farms, a continuous challenge faced by farmers is how to improve farm efficiency. Although as an aquafeed producer, we always tell our customers that the key is water quality and a right balance of pond environment, it is easier said than done. Balancing the pond environment needs an accurate estimation or prediction on inputs such as feed and waste output, algae population and environment impacts of aquaculture operations.

Together with these, we need to minimise the release of waste output by making improvements in feed quality as well as feed efficiency with better feed conversion ratios (FCR). Managing the release of feed waste into the pond environment is also through better farm production practices and feed management.

The goal is good margins through optimal survival rates and reduced disease-related losses. When we cannot manage a balanced pond environment, disease outbreaks occur. The worse scenario is high shrimp mortality. But first, it is important to understand the farm environment- from how much water exchange is required and probiotics to use, and how to control the feeding program (feeding rate and frequency). Probiotics can be applied directly into the pond water or supplemented in feeds.

As part of our support to farmers, we had a 3-year industry-academia co-operation applying Taiwanese and Japanese technology to select a special species suitable for aquaculture. This PSB (photosynthetic bacteria) was introduced in 2015 as Uni Light PSB. This commercial probiotic is in a liquid form, either darkish red or purple in colour. The bacteria *Rhodopseudomonas palustris* is present at ≥ $10^9$ CFU/mL. Recently, we conducted trials at a farm in Vietnam. Results led to recommendations on the use of this probiotic in Vietnam and in other farms such as recently in the Philippines.

## Why PSB

The key target of the research on probiotics for aquaculture is to enhance the environmental conditions in a farm, towards a balanced pond condition for the best growth of fish and shrimp. PSB is very efficient and has the following features for aquaculture:

- It can live and work very well in pond sediments, enhancing decomposition of organic matter and reducing nitrogen compounds. It easily removes hydrogen sulphide ($H_2S$) in pond sludge.
- The bacteria only requires sunlight for energy and carbon source to eliminate nitrites.
- Products from organic waste decomposition are suitable for algae growth and facilitate stable water conditions in ponds.
- It inhibits proliferation of microbes and pathogens, altering the pond microbial populations when it becomes the dominant species in the pond water.

## Changes in nitrite, ammonia and *Vibrio* levels

Trials were conducted by the Laboratory of Nha Trang Mariculture Research and Development Center - Research Institute of Aquaculture No.3 (RIA 3). Three treatment and three control ponds, each of 3,000$m^2$ at the farm of Mr Vo Duc Ky were used. Stocking density was 220 post larvae (PL)/$m^2$ and the duration of the trial was 90 days.

For the first 2 months, the probiotic dosage was 3L/1,000$m^3$ (20L/acre)/ week, applied at a frequency of twice a week. Therefore, each treatment pond used 9L/week of the probiotic. Direct application into pond water was at 8-10am during sunny mornings. After the second month, the probiotic was incorporated into the feed at IL PSB/30kg shrimp feed and fed twice/week. The pond water parameters studied were

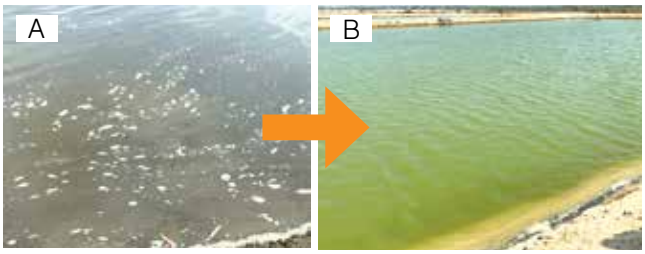



**Figure 1.** Changes in pond water colour and quality, before and after 3 days of PSB application, measured at 15.30 pm. A. Before probiotic application-deep green colour; pH 9.0 and ammonia1ppm. B. Three days after probiotic application, light green colour; pH 8.5, ammonia 0ppm.

temperature, salinity, dissolved oxygen, ammonia-nitrogen ($NH_3$-N), nitrate ($NO_3$), $H_2S$, zooplankton, phytoplankton, benthos and pond bottom conditions. Shrimp growth performance parameters included growth rate, survival rate, FCR and harvest yields.

Measurements of $H_2S$, $NH_3$-N, and $NO_3$ in treatment ponds after 90 days of culture were 30% lower. This demonstrated the efficiency of the probiotics to maintain good water quality. However, the critical issue was to have a stable environment as a large algal bloom would cause a huge difference in the day and night levels of ammonia and pH. After 3 days, pond water was lighter, and algae density became more stable. A comparison of the pond bottom sludge also showed an improvement.

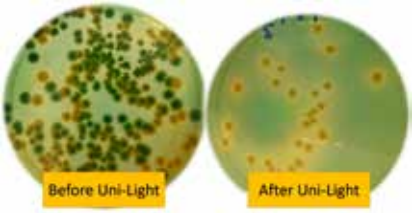
Probiotics can inhibit *Vibrios*.The changes were shown over the 90 days of culture with 20 times lower density of *Vibrios* in the treatment ponds as compared to that in control ponds (Table 3). We know that early mortality syndrome (EMS), white faeces syndrome (WFS) and running mortality syndrome (RMS) will likely occur when density of *Vibrio* spp. rises. If we can control the *Vibrio* populations to a stable level, we can avoid WFS etc. With regards to survival rates, it was 10% higher in the treatment ponds as compared to that in the control ponds. A similar finding was also reported in farmers' ponds in the Philippines.

| | Uni Light | | | | Control | | | |
|---|---|---|---|---|---|---|---|---|
| | T1 | T2 | T3 | Mean±SD | C1 | C2 | C3 | Mean±SD |
| SR% | 86.2 | 90.3 | 81.5 | 86±0.04[a] | 82.7 | 82.2 | 69.7 | 78.2±0.07[b] |
| FCR | 1.18 | 1.02 | 1.32 | 1.17±0.15[a] | 1.22 | 1.08 | 1.55 | 1.28±0.24[a] |

Superscripts with different letters within rows are significantly different ($p<0.05$)

**Table 1.** Improvements in survival rate and feed conversion ratio (FCR) with application of Uni Light PSB in the treatment ponds at a farm in central Vietnam.

**Figure 2.** Checks on the pond sediment showed that in the PSB treated ponds, sludge turned brown in colour and the odour was reduced as compared to the control.



However, pond and farming conditions will vary from one location to another, depending on whether there are constraints with water exchange and weather conditions. For example, water turbidity is higher with adverse conditions such as during the rainy season. Therefore, we need to develop suitable protocols for the probiotic for all culture systems and provide the best solutions for farmers.

## Conclusion

When faced with an environmental imbalance, PSB probiotics can help improve and maintain water quality and solve some of the disease and quality issues. For example, shrimp with yellow or black gills will command a lower market price. The application of the PSB probiotic improved pond bottom conditions and mitigated such problems. The benefits are 10% higher margins than from a pond without the use of the probiotic. This is the result of better harvest with higher growth and survival rates and improvements in FCR.

| | Treatment ponds | Control ponds |
|---|---|---|
| Stocking density (PL/m$^2$) | 220 | 220 |
| Days of culture | 90 | 90 |
| Harvest size (g) | 15.85 | 14.24 |
| Survival (%) | 86% | 78.2% |
| FCR | 1.17 | 1.28 |
| *Vibrio* (CFU/mL) | 1.2x10$^2$ | 3.8x10$^3$ |
| Income from sales (USD) | 227,159 | 183,113 |
| Probiotic cost (USD) | 574 | 0 |
| Margin (%) | 56% | 43% |

**Table 2.** Comparison of pond parameters in the treatment ponds with Uni Light PSP applications and controlled ponds at a farm in central Vietnam.

| Days of Culture (DOC) | Total bacteria (CFU/mL) | Ponds with addition of Uni-Light | | | Control Ponds | | |
|---|---|---|---|---|---|---|---|
| | | T1 | T2 | T3 | C1 | C2 | C3 |
| 30 | *Aeromonas* | 1.4 x 10$^2$ | 1.0 x 10$^2$ | 1.1 x 10$^2$ | 1.5 x 10$^2$ | 1.3 x 10$^2$ | 1.2 x 10$^2$ |
| | *Pseudomonas* | 1.2 x 10$^2$ | 1.1 x 10$^2$ | 1.1 x 10$^2$ | 1.3 x 10$^2$ | 1.5 x 10$^2$ | 1.2 x 10$^2$ |
| | *Vibrio* | 3.4 x 10$^2$ | 3.8 x 10$^2$ | 2.5 x 10$^2$ | 1.3 x 10$^2$ | 2.0 x 10$^3$ | 4.2 x 10$^3$ |
| 60 | *Aeromonas* | 25.7 x 10$^2$ | 31.5 x 10$^2$ | 27.1 x 10$^2$ | 57.8 x 10$^2$ | 5.7 x 10$^3$ | 85.3 x 10$^2$ |
| | *Pseudomonas* | 21.4 x 10$^2$ | 40.1 x 10$^2$ | 29.6 x 10$^2$ | 72.8 x 10$^2$ | 31.2 x 10$^3$ | 54.7 x 10$^2$ |
| | *Vibrio* | 1.7 x 10$^2$ | 3.3 x 10$^2$ | 2.1 x 10$^2$ | 4.8 x 10$^2$ | 3.5 x 10$^3$ | 3.3 x 10$^3$ |
| 90 | *Aeromonas* | 34.3 x 10$^2$ | 57.2 x 10$^2$ | 45.0 x 10$^2$ | 69.5 x 10$^2$ | 2.5 x 10$^3$ | 61.8 x 10$^2$ |
| | *Pseudomonas* | 27.2 x 10$^2$ | 43.4 x 10$^2$ | 35.2x 10$^2$ | 1.2 x 10$^3$ | 74.5 x 10$^2$ | 81.8 x 10$^2$ |
| | *Vibrio* | 1.2 x 10$^2$ | 2.7x 10$^2$ | 1.2 x 10$^2$ | 3.8 x 10$^3$ | 2.7 x 10$^3$ | 3.2 x 10$^3$ |

**Table 3.** Inhibition of *Vibrio* spp. with application of PSB probiotic over the 90-day production cycle.

### Uni President Vietnam

Currently Uni-President Group, headquartered in Taiwan is a large food conglomerate which includes 7-eleven, Starbucks, and transport logistics. Turnover was USD13.48 billion in 2018. Since 1999, Uni-President Vietnam has been focussing on aquafeed together with animal health products. Turnover from its livestock, food and aquafeed businesses in Vietnam was more than USD400 million in 2019. Today its shrimp and marine fish feeds business is spread all over Asia. Feeds are imported into India, Malaysia, Philippines, Thailand, Sri Lanka, Singapore and Indonesia. In Vietnam, it has three feed mills in Binh Duong, Quang Nam, Tien Giang and a shrimp hatchery in Ninh Thuan. Aquafeed production capacity is up to 460,000 tonnes per year (tpy), comprising 250,000 tpy of shrimp feeds and 210,000 tpy of fish feeds. Aquafeed products include feeds for vannamei and monodon shrimp, freshwater prawn, marine fish (groupers and snappers) and various freshwater fish including tilapia and snakehead fish.

**Wen Wei** is Sales Manager with the Export Aquafeed Department, Uni President Vietnam. He gave this presentation on "The current application of commercial probiotics in aquaculture" at the 12th Philippines Shrimp Congress, Bacolod, Philippines, November 12-14, 2019.
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# eDNA and water quality tests to pre-empt disease outbreaks

Research out of Hong Kong which combines environmental DNA testing with water quality monitoring is showing promise as a method to predict risk of disease in aquaculture operations.

by Helen Taylor

Dr Giana Bastos Gomes is not your typical veterinarian. Instead of caring for cats and dogs, she looks after fish, specifically how to prevent disease outbreaks within aquaculture farms. At City University of Hong Kong, Giana is conducting groundbreaking research on early identification of disease in fish and shrimp using environmental DNA (eDNA) quantification paired with water quality monitoring.

## The challenge

Disease prevention is a common struggle among fish and shrimp farmers worldwide. It has been estimated that diseases are responsible for up to 40% of production losses (depending on species and system), valued at more than USD100 billion per year. The challenge, says Giana, is that by the time fish are showing signs of disease, it is usually too late to save them and the stock is lost. Also, many of the chemicals used to treat disease outbreaks are detrimental to the animals and to the environment. So, a tool that could reliably predict the risk of a disease outbreak in time to prevent it would be invaluable.

**Dr Giana Bastos Gomes** *is Assistant Professor in aquatic animal health at City University of Hong Kong. As part of her doctorate at James Cook University (JCU) in Townsville, Australia, she developed innovative approaches for the early detection of pathogens in aquaculture. This new approach is based on eDNA to detect genetic material of pathogens in water and integrates this data with water quality information from aquaculture farms. In 2016 Giana received two awards: "Science and Innovation Award, and Minister Award", which recognises the best emerging young talent in rural Australian industries. Since graduating in Veterinary Medicine in 2003 in Brazil, Giana has dedicated her professional career to aquatic animal health and biosecurity within the aquaculture industry in Brazil, Australia, Singapore and more recently in Hong Kong.*

*At the freshwater pond station of Hong Kong government (Au Tau), monitoring installations deliver real-time data to In-Situ's data services platform, HydroVu, for the team to download for analysis at anytime from anywhere.*

## The solution

This project, which is a continuation of research she began in Australia, is the first instance in which eDNA analysis, often factored into ecological studies, is being used in aquaculture to quantify pathogen abundance in water. It is also one of the first times, eDNA data is being used in conjunction with water quality data to provide information on both water-borne parasites and water quality parameters and how they are connected, and to give us clues to disease risks.

"A strong R&D focus on early identification of disease risk within aquaculture farms using environmental eDNA techniques and water quality monitoring (environmental sensing) associated with microbiome investigation can be used to solve one of the biggest challenges the aquaculture industry faces - outbreaks," Giana says. She is adopting IoT, AI and molecular techniques as innovative ways to predict and manage disease risk in aquaculture.

## The method

Giana is sampling in both open pen (marine) and pond (fresh water) operations. Every week a research assistant collects water from the sites and brings it to the laboratory to analyze the genetic information it carries.

In the meantime, monitoring installations that include In-Situ's Aqua TROLL 500 Multiparameter Sondes and HydroMace data loggers, as well as rain gauges, deliver real-time data to In-Situ's data services platform, HydroVu. The Aqua TROLL 500 is a fully customizable multiprobe with interchangeable sensors, automated antifouling wiper and smartphone interface designed to deliver accurate water quality data and simplified calibration. Built to withstand harsh environments, Aqua TROLL 500 is commonly used for both spot sampling and long-term, low-maintenance deployment in both fresh water and saltwater. Data transmission via telemetry to HydroVu gives Giana instant access to her data.

Giana's team can download it for analysis at anytime from anywhere. The online app provided with the system helps both farmers and the team to monitor, in real time, the changes in water parameters. This is particularly important because in warm water aquaculture, water quality and production data collection and recording keeping are not as common as they are in the salmon industry.

Collecting continuous data on temperature, salinity, DO, pH, turbidity and rain measurement gives Giana the information she needs to correlate water quality and pathogen DNA abundance in water to find connections which can pre-empt disease outbreaks. Additionally, she is able to alert her participating farmers if there is a significant change in their water parameters and what measures to implement to avoid losses. Her current project idea originated from her PhD work based on eDNA and has been published elsewhere (https://www.sciencedirect.com/science/article/pii/S0044848617307615?via%3Dihub).

Giana's study was one of first to show the association between ciliate protozoan abundance in water and environmental parameters as a way to predict outbreaks. In the same study, she demonstrated that environmental DNA and qPCR could be used to determine the probability of mortalities in fish farms.

Reliable water quality monitoring equipment has been key to her project progress, says Giana. "With this equipment, I can trust that data is always being collected. The cost comparison was favorable, especially given the amount of data we're getting; the installation was straightforward; and the company representatives were very helpful in getting everything set up."

> **"If we can measure, we can predict. Then we can be proactive."**
> **- Dr Giana Bastos Gomes**

## The determination

Giana has been collecting data since late 2019 and will continue the project through the summer months in Hong Kong, because weather is an important contributing factor to water quality conditions in farms. Despite disruptions caused by the protests in Hong Kong and consequently, Covid-19, she is determined to complete the project and develop a model that will give farmers the assistance they need to predict disease risk in their stocks.

"I'd like to create an app that could predict disease risk," she says. "There's so much uncertainty in the industry because there is no data. The ability to use information to lower risk could benefit the farmers, investors, insurance companies and government policy teams."

As the fastest growing agribusiness in the world, aquaculture has the potential to provide a critical food source for a growing population, with fewer environmental impacts than traditional agriculture.

"If we can measure, we can predict," says Giana. "Then we can be proactive. Even a small improvement in mortality numbers can make a big difference to farmers."

**Helen Taylor**, is Content Manager at In-Situ Inc. USA.
Email: htaylor@in-situ.com

# AIP Directory: a new one-stop shop for aquaculture improvement projects

## Sharing information to support sourcing decisions

By Anton Immink, Jenna Stoner and Paul Bulcock

Aquaculture Improvement Projects (AIPs) are gaining momentum within the seafood industry. They are an important mechanism for the supply chain to support aquaculture industries through the process of adopting more sustainable practices. But what are these projects and where are they occurring?

### What are AIPs?

In short, AIPs are multi-stakeholder efforts that aim to utilise the power of the private sector to promote positive changes toward sustainability, seek to make those changes endure through policy change, and improve performance at the farm and zonal scale. The characteristics of an AIP mirror the core attributes of a FIP: public supply chain commitments, published needs assessments, workplans with time-bound objectives, and regular reporting of progress.

The general concept of improvement projects is not new. Fishery improvement projects (FIPs) have existed for over 10 years and there are currently some 170 projects operating in over 60 countries. Improvement projects in aquaculture, however, have been slower to develop.

Dominique Gautier, Director of Sustainability at Seafresh Group, remarks that "AIPs are an important tool to drive sustainability, whether participating farms have certified responsible management practices in place or not. It is important for ensuring impact and credibility that projects have a clear set of goals and a defined workplan, and that they are publicly reporting on progress."

### Introducing the AIP Directory

A new website called The AIP Directory (www.aipdirectory.org) has been created to serve as an independent, online platform to showcase active AIPs. The website is a free, online resource that allows those actively involved or interested in AIPs to learn where and how these improvements are taking place and what progress is being made on specific projects.

The site currently lists six active AIPs that cover three countries (China, Indonesia and Thailand) and two species (shrimp and tilapia). Gautier notes the website "gives project managers a mechanism to tell the world about their progress, and buyers and funders greater insight into what improvement projects are underway and how they can get involved".

The AIP Directory is an initiative of the Sustainable Fisheries Partnership (SFP), but maintained as an independent, free online platform, a one-stop shop for all stakeholders in the supply chain and where seafood buyers are able to find information about active projects.

## AIPs in action


*In Chumphon, Surat Thani and Rayong, Thailand, the Shrimp Health Resources Improvement Project (SHRImp) is collaborating with shrimp clubs, co-ops and local governments to manage emerging disease risks and cumulative environmental impacts.*
*https://aipdirectory.org/aip/shrimp-surat-thani/*
*https://aipdirectory.org/aip/shrimp-chumphon/*
*https://aipdirectory.org/aip/shrimp-rayong/*

*In East Java, Indonesia, the Shrimp Improvement Program (SIP) is piloting a suite of tools to improve governance and farm management in order to reduce risk, improve productivity, and protect natural resources.*
*https://aipdirectory.org/aip/shrimp-east-java/*

*In Hainan China, a project under the China Blue Sustainability Institute is promoting industry associations and a code of good practice for tilapia farmers. https://aipdirectory.org/aip/hainan-tilapia/*


*In South Sulawesi, Indonesia, the ASIC EcoShrimp project is verifying local Penaeus monodon farming practices to the ASEAN Seafood Improvement Collaborative (ASIC) shrimp protocol to promote extensive farming and reduce disease risks.*
*https://aipdirectory.org/aip/south-sulawesi-asic-ecoshrimp/*

## How to be involved

As an AIP implementer, you can showcase your project and report progress. You are invited to register for free via the Directory homepage < https://aipdirectory.org/>.

If you are looking to start a new project, the AIP Directory has the tools to help you. You can find these under its Resources page <https://aipdirectory.org/resources/>. Here you will find the AIP toolkit, a step-by-step guide and a range of downloadable tools to help users develop, launch and monitor the progress of an AIP.

Visitors can also sign up for a newsletter and receive updates on all things AIP-related, including new projects, AIP progress and outcomes.



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The authors are part of the aquaculture team at Sustainable Fisheries Partnership (SFP), a non-profit organisation dedicated to helping the seafood supply chain function in an environmentally-friendly way, through the provision of information and the development of tools to support improvement.

# AquaScape

## The digital platform that gives Asia's aquaculture stakeholders the step-up to sustainability in seafood production

By Rui Gomes Ferreira

AquaScape transforms the way shrimp, fish and bivalve aquaculture is managed in Asia –providing visibility to farm registration, carrying capacity, water quality, disease metrics and other attributes. All of these are integral components to promoting global seafood sustainability. The post Covid-19 era will inevitably mandate improved aquaculture governance where national authorities will need to address farm registry, animal traceability, disease monitoring metrics and water quality assessment.

*Intensive shrimp farm, north coast of Bali , Indonesia.*

## Towards a radical transparency for sustainable aquaculture

AquaScape (www.aquascape.tech) is a cloud-based, scalable platform that responds to the need for sustainable aquaculture governance - enabling regulators, farmers, the supply chain and others to obtain visibility into aquaculture metrics and analytics that provide actionable insights. This data-driven platform provides quantitative aquaculture sustainability metrics and analytics that have the potential to place Asian aquaculture amongst the most sustainable producers of food protein.

The platform is engineered to maximise aquaculture sustainability outcomes over the next decade through:

- adoption of technology for aquaculture licensing and regulatory policy;
- the modelling of production and environmental footprints to support the sustainability of coastal systems;
- analytics on disease incidence and severity;
- the provision of analytics to the supply chain to improve sourcing transparency.

The adoption of technology that regulates farm registration, carrying capacity and disease metrics will provide a significant competitive advantage in food production where it is most needed. AquaScape shifts policy-making for aquaculture sustainability from being an opinion-based discussion to a more factually grounded approach.

## Focus on Asia

As Asia grows its aquaculture, technology will provide more cost-effective methods to enforce legislation efficiently, set policy that promotes responsible stewardship, and assist in minimising the boom and bust side of the aquaculture business, due to factors such as water quality and disease. The sustainable seafood of the future must come, will come from regulatory jurisdictions with strong institutions and producers that assume their production and environmental responsibilities. AquaScape assists in bridging those gaps in information-challenged aquaculture production areas.

Business-as-usual (BAU) scenarios in Asia mean that environmental impacts of aquaculture are externalities whose cost is born by the environment, which as production increases, provides the potential for degradation. Agriculture and other primary sectors contribute significantly to water quality degradation through the introduction of nutrient pollution into aquatic systems and largely benefit from passing on the environmental externalities to society as non-point source polluters.

AquaScape provides transparency regarding numerous metrics of relevance to aquaculture regulation. The social and economic consequences associated with the boom

and bust of aquaculture in Asia due to poor water quality, disease outbreaks, and a race to the bottom, magnify these challenges. The ability to align the legal framework with social and economic components associated with a sustainable aquaculture industry, is largely dependent on making provisions for the regulatory and governance issues.

## What can AquaScape do?

AquaScape is structured in modular components that are layered according to the regulatory and governance objectives. This provides the ability to build the foundations of a regulatory aquaculture framework that can accommodate carrying capacity, disease metrics along with integration of areas such as agriculture and climate change to address governance risks in a holistic manner.

There is actionable information on aquaculture spatial planning, supply chain transparency, bio-security programmes and other uses. The main modular features driving AquaScape analytics are:

### *Aquaculture zones/management areas (AMAs) module*

Here the zones assist in determining the maximum sustainable aquaculture production and environmental thresholds per aquaculture management area. Zones display the combined outputs of the modular components, which receive data from aquaculture farms, land and oceans. Aquaculture zones represent management units, combining the nutrient pollution from land and aquaculture farms, coupled with ocean transport, to make representation of the assimilative capacity per zone.

Conceptually, every zone that has land, oceans, and aquaculture assets modelled is given a guidance carrying capacity (emission) allocation. The carrying capacity per zone methodology requires calibration prior to public release but acts as a baseline for regulators to determine nutrient emissions carrying capacity across aquaculture, agriculture, and urban wastewater treatment.

### *Farm registry module*

This is the base component where we already have 50,000 shrimp ponds and cages incorporated in Indonesia and Thailand, and by the end of 2020 will have 300,000 ponds across Asia. The farm registry provides attributes associated with each pond, including farm sizes, species, ownership, production estimates, and environmental footprint. Additional metrics include identification of the types of ponds, disease history and other registry related metrics.

The farm registry provides a farm passport for each pond and applies a carrying capacity assessment driven by metadata and culture practice declared by local farmers. Culture practice refers to driver data used for farm-scale modelling. AquaScape provides a significant contribution in digitising farm property records, including unique identifiers, polygons for all ponds, area, volume, species and district. The farm-scale modelling algorithm calculates the estimated production and nitrogen balance per shrimp pond.


### *Oceans module*

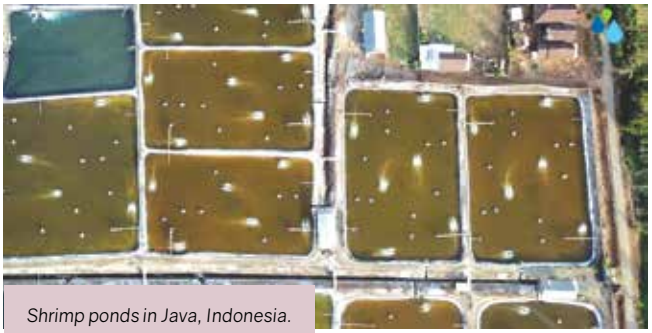
This module is geared towards regulators that require increased detail regarding the assimilative capacity of water bodies to receive emissions for aquaculture, land and urban sources. The oceans module uses a water circulation model to show system connectivity and linkages, which informs licensing decisions based on nutrient emission flows and dilution in space and time.

The oceans layer makes use of detailed bathymetry, current and tide gauge data to inform connectivity between carrying capacity zones. The ocean layer also has the ability to show disease risk maps and other value-added metrics that inform governance and sustainability. The metrics associated with the oceans module are key to assisting with some of the core elements of marine spatial planning.

### *Land module*

This encompasses a state-of-art coastal management approach whereby coastal zone management accounts for all point and non-point source emissions (aquaculture, agriculture, urban, and natural areas) such that systems are managed holistically. These regulatory frameworks are standard practice in the European Union (Water Framework Directive) and in the United States (Clean Water Act).

The land module makes use of the land use maps, atmospheric, hydrometric and water quality data that drive the modelling assessment to calculate the nutrient export contribution of each watershed basin. The outputs provide a breakdown of the nitrogen and phosphorous loads in tonnes per year for each region, sub-basin and stream. The land components feed into the carrying capacity zones with the objectives of determining the source and non-point source nutrient contribution by sub-basin.



Shrimp ponds in Java, Indonesia.

## Creating an impact

AquaScape is a platform that presents a paradigm-shift in aquaculture governance which accounts for the main factors that contribute towards sustainability. It can help actors at every step of the supply chain. The focus is on developing core capabilities for the following user groups:

***Regulatory bodies*** who want to manage towards sustainable aquaculture at a regional or national level, increase food security and resilience to climate change, reduce the boom-and-bust nature of aquaculture, and develop effective partnerships with the supply chain to increase prosperity for their people.

***Insurance companies and investors*** that are exposed to the aquaculture sector by offering an engagement platform to provide value-added risk transfer and financing solutions for aquaculture producers.

***Supply chain support*** to improve commitment targets for sustainable protein purchasing and governance initiatives that contribute to the accountability of the global aquaculture supply chain.

***Scientific community*** by providing analytical data to further catalyse the decision delivery, relevant recommendations, and fostering cutting-edge research and innovation.

## The team

AquaScape is a Longline Environment (www.longline.co.uk) initiative. Longline's mission is to increase efficiency and impact in decision-making through technology for aquaculture, fisheries and water stakeholders. Longline specialises in modelling, data and risk solutions, providing value-added outcomes across the supply chain. We approach projects that have the aspiration and riskiness of research with the speed and ambition of a start-up, delivering outcomes on aquatic systems to support growth of sustainable aquaculture. We have a combined experience of decades in research and its application to market-delivery, focusing on the delivery of scalable digital solution for stakeholders, such as outputs of modelling frameworks and insurance risk analytics. Longline retains modelling experts, data scientists and coastal management specialists, and focuses on transdisciplinary questions combining expertise in hydrology, oceanography, risk transfer, systems analysis and environmental management.

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# SHRImp- The Shrimp Health Resources Improvement Project

An Aquaculture Improvement Project to provide farmers with tools to improve their productivity and for government and industry stakeholders to better manage emerging disease outbreaks and cumulative environmental impacts

Disease is one of the top challenges and constraints to continued aquaculture growth. The history of aquaculture abounds with examples of disease outbreaks causing catastrophic declines in production and enormous economic losses. Investing in health control systems, including early warning and emergency disease responses is therefore critical.

The Shrimp Health Resources Improvement Project (SHRImp) therefore intends to improve the profitability and attract investment into the local shrimp industry by reducing the risks of disease, improving profitability, and protecting natural resources, through better governance and farm management. This will be achieved by providing farmers with the tools to improve their productivity and by enabling government and industry stakeholders to better manage emerging disease outbreaks and cumulative environmental impacts.

The AIP was launched in 2018 in Surat Thani, Thailand, as a collaboration between the Sustainable Fisheries Partnership, Benchmark Asia (formerly Fish Vet Group Asia), FAI Farms, XpertSea, Longline Environment, IDH the Sustainable Trade and the Tha Thong Plain Shrimp Farmers' Cooperative. The project focusses on *Penaeus vannamei* production – an industry that has suffered from a succession of disease outbreaks.

Through the roll out of diagnostic testing by Benchmark Asia and the introduction of smart shrimp club application myshrimp.farm, farmers and club/coop staff are now able to quickly identify and react to disease problems and share real-time data. The participation of local shrimp clubs and cooperatives helps ensure these services will be valued and used in the future, while the increased involvement of local government agencies is crucial in ensuring this approach can be adopted nationally.

Since its launch, the project has expanded, and has now been joined by two additional AIPs in Chumphon, and Rayong provinces.

As recent reports indicate that the global shrimp industry is at risk from new or emerging diseases such as Decapod Iridescent Virus 1 and Hepatopancreatic Translucence Virus, these three AIPs aim to create more resilient and robust local aquaculture industries and provide a transferable model of how to improve the management of others.

The project aims to add value for the industry by bringing together disease risk information in a meaningful way for clubs. www.myshrimp.org

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# A long-term approach to increase profitability and sustainability in aquaculture

By Henry Wong and Niamh McNally

Globally, the Covid-19 coronavirus pandemic has disrupted the economy, including the agriculture sector and its related supply chains. Nevertheless, the pandemic has highlighted some challenges that the aquafeed industry has faced for the last number of years. The nature of the current environment — increasing prices of raw materials, reduced availability of animal-based proteins, disease risks and health pandemics — are ongoing concerns and will continue to influence the industry for years to come.

Considering this, the health and welfare of fish and shrimp will still be critical for efficient production. Adopting new strategies and learning to co-exist with these new norms will be challenging. But there are some long-term approaches that the industry can adopt to help increase profitability and sustainability.

Achieving optimal growth and minimising operational costs are the two main goals of aquaculturists. Improving weight gain and lowering feed conversion ratio (FCR) put increased pressure on the digestive tract to function at the highest efficiency. In farmed environments, stress is a constant feature, from the rigours of production, disease resistance, age and feed, combined with external factors — such as temperature, salinity and pH — can cause imbalances in the gut, potentially leading to disease. Most of these factors are controllable, and we must focus on improving and protecting the gut to optimise efficiency.

As we adapt to the ever-changing global environmental circumstances, diets will continue to be modified and improved. Each aquatic species has a different set of nutritional requirements that also fluctuates, depending on the stage in their lifecycle. Imbalances in diets will lead to a lack of required nutrients, and this will have a direct impact on animal performance and welfare.

## Target is economical and responsible feed solutions

Aquafeeds comprise a selection of natural feed ingredients with essential amino acid sources, essential fatty acids, vitamins and minerals. Feed ultimately provides energy and nutrients to support the development of the internal organs, protect against external pathogens and is critical for the optimal functioning of the system. When considering any change to the existing diets, the nutritional requirements of the species must not be compromised; feeds must be highly digestible, and each ingredient must add value and enrichment to the diet to impact performance. As feed ingredients are derived from several different sources, significant planning, coupled with research and development, can lead to more sustainable, economical and responsible feed solutions.

## Address the first point of interaction

In order to fully safeguard the health of fish and shrimp for long-term success, it is crucial to protect them at their first point of interaction with the environment — the skin, gut and gills. External and internal barriers play a vital role in protecting the animal against the environment and its internal physiology. The gastrointestinal tract (GI) or gut is a complex system comprising tissues and organs that play an essential role in food digestion and absorption, metabolism, defence mechanisms, immune response and all interactions among these components.

Therefore, a healthy, balanced diet is critical for maintaining a healthy system that will operate optimally and protect against opportunistic pathogen attacks. An unhealthy gut cannot defend itself against these pathogens. Gut integrity can be improved and maintained through the correct selection of ingredients to prevent gut inflammation and increase the growth of good bacteria, creating a solid foundation for health and growth. The right diet strengthens the gut and overall well-being. A healthy gut can digest and absorb the maximum amount of nutrients, providing the most benefit for the farmer.

## MOS

The use of mannan oligosaccharides or MOS in diets has been shown to improve gut performance. However, their function can be altered depending on the strain of yeast, fermentation conditions and processing methods. Bio-Mos® (Alltech Inc., USA) is a unique MOS derived from the outer cell of a specific strain of yeast (*Saccharomyces cerevisiae 1062*) using a proprietary process developed by Alltech. Actigen® (Alltech Inc., USA) is a second-generation refined component — a more concentrated source of yeast cell wall bioactive components.

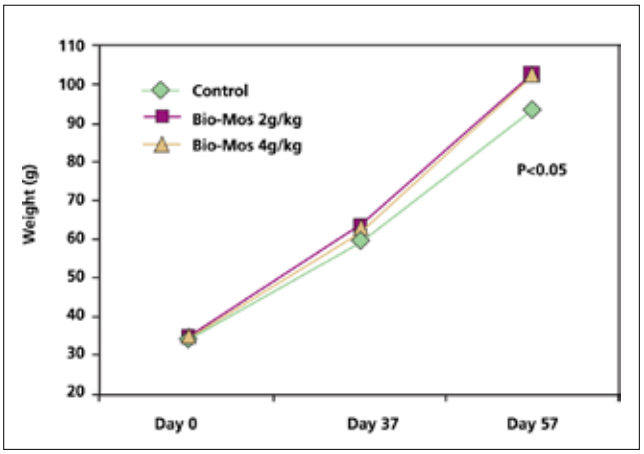


**Figure 1.** An example of the effectiveness of Bio-Mos® on the growth of European seabass (*Dicentrarchus labrax*) (Torrecillas et al., 2006)

## Gut is the key to success

Trials carried out with trout, carp, catfish, tilapia, seabass, sea bream, sole and salmon showed the effectiveness of MOS in aquaculture species, in promoting a healthy growth rate and improving intestinal morphology. Different concentrations of dietary MOS in carp (*Cyprinus carpio*) have been reported to improve weight gains as well as improved FCR, productivity and immune parameters (Zhou and Li, 2004). Improvements in growth performance, reduced FCR and mortality have been observed for MOS-

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treated juvenile common carp (Culjak et al., 2006) and rainbow trout (Staykov, 2007). Similar results were also observed in the European seabass (*Dicentrarchus labrax*) by Torrecillas et al. (2006) and Ramirez et al. (2016).

The mucosal layer is a protective layer that surrounds the gut and is protected by a layer of epithelial cells. Its function is to protect the immune response system and aid in nutrient absorption. Bio-Mos supplementation was shown to increase the number of goblet cells releasing mucins in the posterior intestine (Torrecillas et al., 2015). The integrity of this layer is fundamental to the health, performance and quality of the fish. The interactions among intestinal microflora, gut morphology, the immune system and nutrient uptake have a significant influence on animal health and performance.

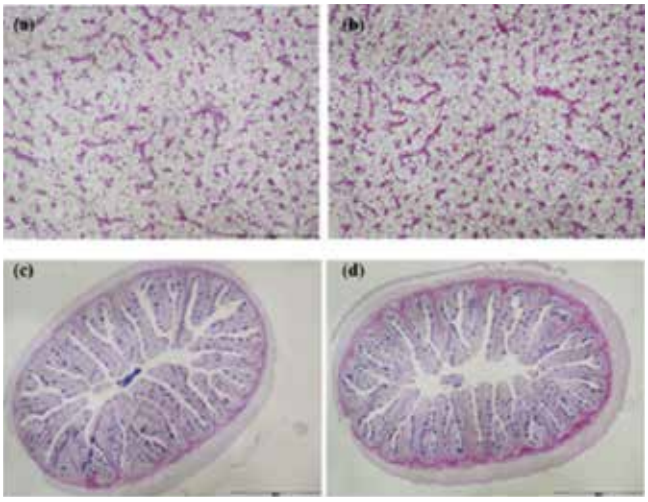


**Figure 1.** A & B: Hepatocytes C & D: Display goblet cell density in the intestine cross-section (Torrecillas et al., 2015)

Bio-Mos has been proven to display significant effects on gut morphology, resulting in increased growth and lower FCR. It also shows its ability to increase the absorptive surface area and help to support the immune system, leading to improved disease resistance and health status. Including this MOS in diets improves the gut morphology by increasing the microvilli density and increasing microvilli length, leading to an enhanced absorptive surface. Dimitroglou et al. (2007) reported the effects on the gut morphology of several species. Similarly, in the European seabass, an increased number of folds was noted, indicating a larger surface area for nutrient management (Torrecillas et al., 2015).

A similar case in shrimp (*Litopenaeus vannamei*) was reported by Rodrigues et al. (2015), showing increased survival, and increased surface area of the gastrointestinal tract when diets were supplemented in a biofloc system.

| | Actigen® (%) | | | | |
|---|---|---|---|---|---|
| | Control (0) | 0.02 | 0.08 | 0.12 | P |
| Length(µm) | 381.2$^{a}$ | 572.1$^{b}$ | 472.3$^{ab}$ | 440.4$^{ab}$ | 0.0159 |
| Width (µm) | 189.07$^{a}$ | 300.97$^{b}$ | 282.35$^{b}$ | 271.24$^{b}$ | 0.0001 |
| Perimeter (µm) | 712.1$^{a}$ | 837.38$^{ab}$ | 1007.9$^{b}$ | 1122.2$^{b}$ | 0.0026 |
| $^{ab}$ means differ by Tukey test (p<0.05) | | | | | |

**Table 1.** Histomorphometry of gastrointestinal tract of shrimp receiving different doses of Actigen from Rodrigues et al. (2015)

| Parameters | Actigen® (%) | | | | |
|---|---|---|---|---|---|
| | Control (0) | 0.02 | 0.08 | 0.12 | P |
| Final weight (g) | 12.53 | 11.63 | 11.23 | 11.77 | 0.0050 |
| Weekly weight gain (g/week) | 0.96 | 0.86 | 0.82 | 0.87 | 0.5064 |
| Final biomass (kg/m$^3$) | 3.01 | 3.12 | 3.00 | 3.14 | 0.7497 |
| Survival (%) | 74.77$^{a}$ | 84.50$^{b}$ | 83.53$^{b}$ | 83.27$^{b}$ | 0.0210 |
| Feed efficiency | 0.40 | 0.35 | 0.33 | 0.35 | 0.1811 |
| $^{ab}$ means differ by Tukey test (p<0.05) | | | | | |

**Table 2.** Performance parameters of shrimp receiving different doses of Actigen from Rodrigues et al. (2015)

> "Cutting costs will always be an important factor in the financial viability of farmed species. Providing fish with quality nutrients plays an important role in ensuring financial success."

Bio-Mos and Actigen are key components in aquafeeds of a modern, strategic feeding program. More and more fish and shrimp farmers around the world are finding that using these as part of their health management strategy provides a successful and cost-effective solution to animal health problems. Getting this aspect right as early as possible in the production cycle will be fundamental to performance in later life. This is a practical and functional nutritional solution for producers to combat diseases and improve the overall health of their stock.

In a post-Covid-19 world, research and nutritional advancements will ultimately have the most impact when helping producers overcome challenges. It is also clearer that positive impacts on gut health affect production and performance, and meet the challenges faced by poor gut health. Cutting costs will always be an important factor in the financial viability of farmed species. Providing fish with quality nutrients, backed by innovative technological solutions based on sound research and development, is critical in ensuring financial success.

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# Organic trace minerals can support sustainability of shrimp production

## Half doses of OTM maintained shrimp growth performance and feed efficiency, while reducing mineral excretion

By Mieke Zoon

Shrimp is a very popular source of protein globally, with few limitations from a religious perspective; it is easy to prepare and offers high nutritional value. As general wealth has increased across the global population, protein consumption per capita has increased as well. However, not only do we eat more protein, but there has also been a shift towards more high-value species, such as shrimp. As a result, shrimp consumption has grown rapidly over the last few decades, both in the traditional importing markets, such as Japan, Europe and the US, as well as in major regions of shrimp production in Latin America and Southeast Asia. As the growth potential of capture fisheries is limited by fishing quotas, availability of resources and historical supply chains, aquaculture has been rapidly increasing and has even overtaken capture fisheries in the volume of products (including shrimp) available for human consumption (FAO, 2018, Figure 1).

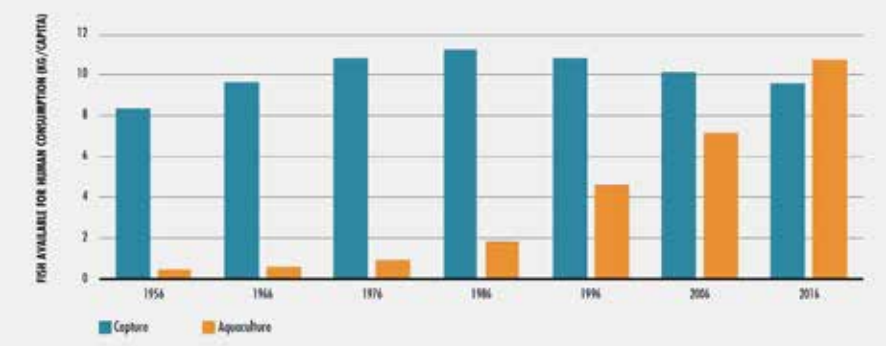


**Figure 1.** Contribution of aquaculture and capture fisheries to global fish supply for human consumption (FAO, 2018).

## Sustainability challenges

With increasing aquaculture, the predictability of quality and availability has greatly improved, but the higher inputs and outputs resulting from intensifying production have led to new challenges. As an example, and this is also true for livestock production, intensive production increases the risk of pathogenic diseases, which has resulted in the increased use of antibiotics, major disease outbreaks and decimation of stocks in important production areas from time to time, such as in Thailand (FAO, 2018).

In recent years, there has been a lot of attention on more sustainable production through the use of the following strategies: replacing fish meal and fish oil in feed (with vegetable-based and even insect-sourced substitutes), reducing environmental effects (with water recycling systems), preventing disease (via biosecurity) and improving feed efficiency (by optimizing feed and management).

Major improvements have been made in all these areas, but there is still more to be done (FAO, 2018). For example, the lack of an adaptive immune system in shrimp provides an additional challenge for their biosecurity when compared to livestock, as this means that they cannot be vaccinated. The reduction of fish meal and fish oil in shrimp feeds leads to other challenges, not only in replacing high quality protein, but also other nutrients, like minerals, as they are no longer provided in a highly available form. Trace minerals are known to be important for several metabolic functions, improving not only growth, but also development, fertility, final product quality and immunity. Organic forms of trace minerals, for example B-TRAXIM minerals (PANCOSMA, Switzerland), have been shown to offer higher bioavailability and additional benefits in livestock species compared to traditionally used inorganic forms (Spears et al., 2004; Hansen et al., 2008; Leeson et al., 2008; De Marco et al., 2017; Zhang et al, 2017; Männer & Schlegel, 2006 and Jang et al., 2010). Organic trace minerals (OTM) may also contribute to improved efficacy in feed formulations and to a reduction in the environmental impact of shrimp production.

## Benefits of organic trace minerals

In line with more sustainable production methods, OTM can help to reduce the impact of wastes from shrimp production on the environment by reducing mineral excretion. Although aquafeeds already contain much less fish meal and fish oil than before, they remain as important ingredients, especially for high value and more carnivorous species, such as for shrimp and salmon production (FAO, 2018). The high levels of unsaturated fats from fish sources are a challenge to the stability of aquafeeds. Metal ions, and especially zinc, iron and copper, are known to be major catalyzers of oxidation (McDowell, 2008). If metals are stabilized with an organic bond, this may not only increase their bioavailability, but reduce oxidation of important nutrients as well.

> "Shrimp fed BT1X showed the fastest growth, best feed conversion and numerically the highest survival."

## OTM on growth and immune parameters in shrimp

After earlier confirmation of the practical advantages and the potential positive impact of using OTM on shrimp performance, commercial use of glycine based OTM has begun both in Latin America and Southeast Asia. To confirm the positive benefits of OTM, a new trial in a controlled environment was set up in Thailand by Professor Orapint Jintasataporn (Department of Aquaculture, Faculty of Fisheries, Kasetsart University, Thailand).

In this trial, the effect of OTM on the growth performance and immune parameters of white shrimp (*Litopenaeus vannamei*) was studied. The shrimp were fed either a non-supplemented diet (negative control, NC), or subjected to one of the following treatments: a full dose of inorganic minerals (positive control, PC), a full dose of B-TRAXIM minerals (BT1X), or a half dose of B-TRAXIM minerals (BT0.5X). Shrimp fed BT1X showed the fastest growth, best feed conversion and numerically the highest survival. The total shrimp production per tank will be of interest to shrimp producers, as it combines the result of growth performance and survival rate in one parameter (Figure 2). The glycine based OTM (BT1X) consistently showed the highest production.

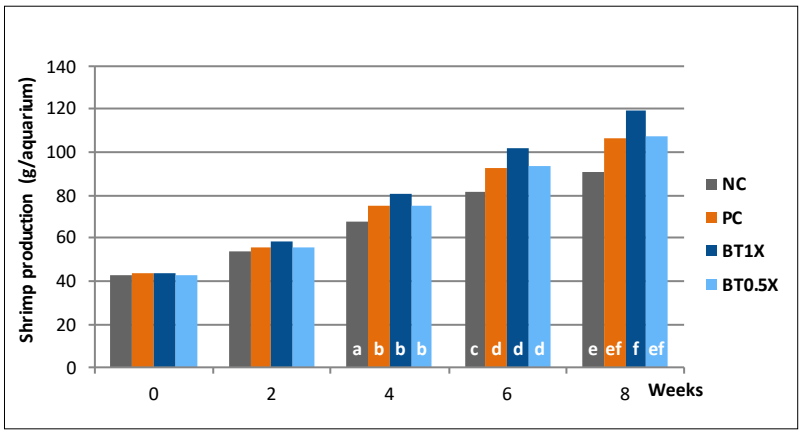


**Figure 2.** Total shrimp weight produced over time, in gram per aquarium

Another interesting trial carried out in this study was to reduce inorganic mineral supplementation by 50% and instead use OTM (BT0.5X). This has been shown to maintain growth performance and feed efficiency, while reducing mineral excretion. This is fully in line with results from other species, e.g. in broilers (De Marco et al., 2017).

In the same trial some important immunity parameters were checked. This is of interest as disease-related mortality in shrimp production is a common issue. Stimulating general immunity and optimizing the immune response are important, as vaccination is not possible because shrimp rely only on their innate immune system. Lysozyme is an enzyme with antibacterial properties which acts as part of the innate immune system by cutting the carbohydrate chains forming the main structure of bacterial cell walls (Lacono et al., 1980). The BT1X shrimp showed a significant increase of lysozyme activity in the hemolymph (which plays the same role as blood in mammals). Also, superoxide-dismutase (SOD) activity, as part of the antioxidant system, showed a trend towards higher levels

in the hemolymph of BT1X shrimp. The increased levels of lysozyme and SOD activities showed that the BT1X shrimp had an improved ability to protect themselves against bacterial and oxidative challenges.

## More sustainable shrimp

Summarizing the results from available trial data as well as practical experience, the glycine based OTM have been shown to be able to support shrimp producers in mitigating some of their main challenges towards better sustainability.

Mineral excretion into the aquatic environment by shrimp can be reduced with OTM supplementation in shrimp feeds. An efficient immune response was also supported, which could reduce the impact of disease and improve growth and feed efficiency, allowing for a better return on investment. OTM will not solve all the challenges faced in aquaculture, but it can be used as a solution to support shrimp producers on their path towards a more sustainable way to provide high quality food globally.

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# Free nucleotides, β-glucans and MOS

## The perfect combination to increase survival rates and fish production

By Liliana Borges and Melina Bonato

The rapid expansion of commercial aquaculture over the last 15 years has been followed by a global increase in fish farmed in ponds (Kobayashi et al., 2015). However, producers face health-related issues with the consequent use of medications. Like in any intensive farming activity, intensive aquaculture causes tissue and environmental microbial flora accumulation.

Fish, like mammals, have an innate and an adaptive immune system; the innate system provides quick, primary, unspecific and no-memory responses against recontamination. On the other hand, the adaptive system provides specific responses or, in other words, intense responses using pathogen-specific antibodies.

Macrophages, neutrophils, dendritic cells, and natural killers are the most widely known cells in the innate immune system (Sharma, 2003). Toll-type receptors, located on the surface of immune cells, recognise microbial standards and induce an immediate innate immune response. After such induction and phagocytosis, phagocytes respond with the adaptative immune system and are able to stimulate a non-pathogenic response. Therefore, phagocytes are called antigen-presenting cells. Pathogen recognition by the innate immune system triggers immediate innate defences and, subsequently, activates an adaptative immune response (Lee & Iwasaki, 2007).

Therefore, the use of compounds or feed additives to increase survival rate, disease resistance and growth of fish and shrimp has been more frequent as well as more successful. *Saccharomyces cerevisiae* yeast is a natural and immuno stimulant additive (Abu-Elala et al., 2013) used in farming to promote better intestinal health, thus resulting in greater disease resistance and better production rates.

### Hydrolyzed yeast

Yeast is composed of manno-oligosaccharides (MOS) and β-glucans 1.3-1.6 and is a rich source of RNA and amino acids, especially glutamine and cytoplasm proteins. To make these nutrients fully available, ICC Brazil, a leader in the production of yeast-based compounds for animal nutrition, has developed hydrolyzed *Saccharomyces cerevisiae* yeast obtained from sugarcane fermentation in ethanol production. This yeast contains RNA and polypeptide hydrolyzed by some added specific enzymes, resulting in free nucleotides and nucleosides, highly digestible amino acids, and short-chain peptides and polypeptides. The hydrolyzed yeast also contains yeast cell wall, composed of MOS and high levels of β-glucans 1.3-1.6 (immune system modulators).

Free nucleotides and nucleosides can be readily absorbed by enterocytes in the intestine and are especially important in rapid proliferation of cell tissues, but have limited capacity for *de novo* synthesis. Free nucleotides can be used by the recycling pathway, where the body can synthesise nucleotides using less energy, resulting from recycling bases and nucleotides from the metabolic degradation of nucleic acids derived from dead cells or food. However, when endogenous supply is insufficient, the dietary sources of exogenous nucleotides can become semi-essential nutrients.

## Nucleotides in fish nutrition

Although nucleotides are not specifically defined as immunostimulants, they are related to the the immune system, as they provide substrates and co-factors needed for immunity (Murthy et al., 2009), being essential for the development and functioning of all cells (Lehninger, 2005). The use of nucleotides in fish nutrition has several benefits, including increased food intake, rapid intestinal repair and improved intestinal flora in the mucosa and mucosal surfaces (Li, 2006). These have been used in aquaculture as a source of nitrogen or as a functional food (Lim et al., 2001) and as compensation for insufficient nucleotides in food with high content of vegetable protein (Zhang et al., 2012).

Every component of hydrolyzed yeast provides a synergetic effect, by improving intestine integrity and health, promoting higher cell proliferation, and strengthening the immune system. This is important for animals during accelerated growth periods (initial phases), reproduction, stress, and challenging conditions posed by diseases.

## Tilapia in Egypt

In a study conducted by Abu-Elala et al. (2020) in Cairo University School of Veterinary Medicine, in Egypt, 270 *Oreochromis niloticus* (50.7 ± 0.8g of body weight) were acclimated and distributed in 3 experimental groups with 3 replicates. There was a total of 9 aquaria (40x30x100cm) with 30 fish/aquarium. The experimental groups were: control, and 0.2% and 0.4% hydrolyzed yeast.

For 2 months, fish performance was measured every 2 weeks and, at the end of the study, 5 fish/replicate were euthanised to assess clinicopathological parameters, oxidative and antioxidative substances, immune-related gene expression by quantitative PCR, phagocytosis activity and rate (%) and lysozyme activity (µg/mL). After 2 months, fish were challenged with Gram-positive *Lactococcus garvieae* and Gram-negative *Aeromonas hydrophila* bacteria and mortality rates were observed for a week.

Hydrolyzed yeast diet supplementation at 0.4% increased fish body weight after 2 months to 32.6g (+33.3%) compared to the control group (Table 1). Additionally, there was a 67.3% weight gain and a 28.6% reduction in feed conversion ($P<0.05$). The supplementation at 0.4% improved results for catalase and G-reductase activities ($P<0.05$). Nucleotides found in this hydrolyzed yeast provided support to cellular mechanisms that increased antioxidant activity, and β-glucans stimulated the immune system, where some cells produced hydrogen peroxide as a form of defence against bacteria. The joint action of both compounds promoted the increased activity of antioxidant enzymes (catalase and G-reductase). Diet supplementation with hydrolyzed yeast showed a significant increase in pro-inflammatory cytokines and TNF-α immune gene in both supplemented groups and increased IL1-β gene at 0.4% ($P<0.05$).

The innate response was influenced by both treatments, conferring improved phagocytic activity and lysozyme activity, as well as increased phagocytosis rate (P<0.05). β-glucans acted in the innate immune system, i.e., where the first immune response to pathogenic contamination was observed; it avoided higher use of energy during an extended inflammatory process and more quickly engaged the adaptative immune system, thus avoiding production losses and high mortality rates. (Table 1).

| | Parameters | Control | 0.2% Hilyses® | 0.4% Hilyses® |
|---|---|---|---|---|
| Performance | Body weight (g) months | $97.86^{b}$ | $123.6^{a}$ | $130.5^{a}$ |
| | Weight gain (g) | $48.1^{b}$ | $71.3^{a}$ | $80.5^{a}$ |
| | Feed conversion | $2.1^{b}$ | $1.7^{a}$ | $1.52^{a}$ |
| Oxidative and Antioxidative compound | Catalase | $268.73^{c} \pm 43.85$ | $354.87^{b} \pm 339.60$ | $402.27^{a} \pm 25.39$ |
| | G-reductase | $142.70^{b} \pm 3.55$ | $160.76^{b} \pm 2.34$ | $269.93^{a} \pm 20.6$ |
| Immune-related gene expression by quantitative PCR | IL1-β gene | $1^{b}$ | $0.6^{b} \pm 1.9$ | $4^{a} \pm 2.2$ |
| | TNF-α gene | $1^{b}$ | $3.07^{a} \pm 0.2$ | $4.28^{a} \pm 0.3$ |
| Innate immunity | Phagocytic activity (%) | $57^{b}$ | $66^{a}$ | $68^{a}$ |
| | Phagocytosis rate | $1.8^{b}$ | $2.3^{a}$ | $2.1^{a}$ |
| | Lysozyme activity (µg/mL) | $435.8^{b}$ | $466.1^{a}$ | $481^{a}$ |

$^{abc}$ Means with different letters in the same row are significantly different based on Tukey's test (P<0.05).

**Table 1.** Performance, clinicopathological results, oxidative stress, immune-related gene expression, innate immunity and mortality parameters for *Oreochromis niloticus* fed treatment diets

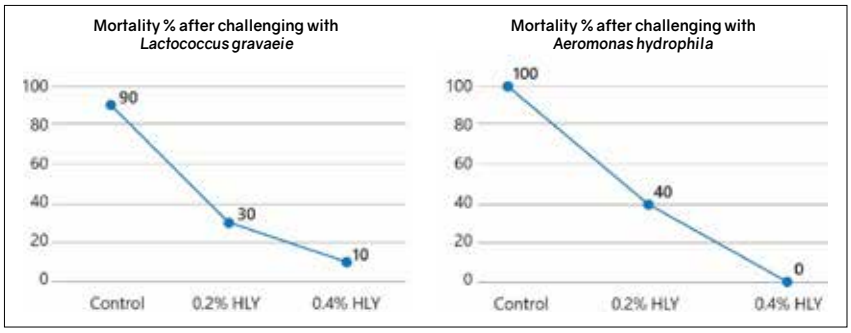


**Figure 1.** Effect of Hilyses® (HLY - hydrolyzed yeast) on the mortality of *Oreochromis niloticus* challenged with Gram-positive *Lactococcus garvieae* and Gram-negative *Aeromonas hydrophila* bacteria.

The results of *L. garvieae* challenge showed that Hilyses supplementation at 0.2% and 0.4% reduced mortality by 66.7% and 89%, respectively. *Aeromonas hydrophila* challenge showed that Hilyses at 0.2% and 0.4% reduced mortality by 60% and 100%, respectively (P<0.05). These results confirmed the efficacy of β-glucans in the innate immune system, of MOS acting against pathogenic bacteria, and of nucleotides that provided support to immunity cell mechanisms.

Innate immune system modulation can be one of the strategies used to fight contamination, reduce mortality and improve fish and shrimp productivity. When yeast is offered to animals at an early stage, the immune system is modulated and gets ready to detect different infections or contaminations.

**References are available on request**

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# Getting it right at every step

## Getting the benefits of vitamins at every step in the aquaculture cycle.

By Thomas Wilson

At each step in the aquaculture production cycle of fish and shrimp, in order to be sustainable and profitable, from spawning brood stock through to harvest of animals at the end of the production cycle, operating procedures specific to each stage have to be measured and controlled effectively. When businesses want to measure operational and financial performance against investments they have made, they set key performance indicators (KPIs), usually assigned to personnel so they can track their achievements against company goals.

In aquaculture, as in any other business, KPIs can be established to track the achievement of success too, such as below:

- For brood stock in the hatchery, KPIs relate to: Gonadosomatic index, high fecundity and high hatching rates.
- For larval stages in the hatchery, KPIs relate to: Successful transition through larval stages, optimal growth, high health and high survival.
- For fry in the nursery, KPIs relate to: Rapid growth, good health and high survival, especially throughout the period of handling, transport and delivery to the customer's farm.
- During grow out stages at a farm, KPIs relate to: High growth rates, low incidence of disease, rapid attainment of final weight at harvest.

### Use of vitamins to improve operational success

Here, in our discussion on vitamins, we want to highlight the ways where adding vitamins to feeds can improve operational success against common aquaculture KPIs and deliver more profitable and sustainable food systems. This overview will show some of the benefits of feeding vitamins to brood stock, larval and fry stages, and through grow-out to harvest.

> "Vitamins are key nutrients in this stage of production. Why go to all this effort, and then underestimate the value of vitamins in boosting brood stock performance?"

### Brood stock

It all starts with the brood stock. Genetic selection and breeding programs are utilised to domesticate and adapt fish and shrimp to aquaculture. Maintaining a large group of animals for breeding purposes is an expensive proposition. Naturally, KPIs here are related to spawning success, but more significantly, to offsprings which are strong and healthy and grow well. Vitamins are key nutrients in this stage of production. Why go to all this effort, and then underestimate the value of vitamins in boosting brood stock performance?

*KPIs in the hatchery are gonadosomatic index, high fecundity and high hatching rates.*

*In shrimp grow-out, KPIs are high growth rates, low incidence of disease, rapid attainment of final weight at harvest.*

Pavlov et al. (2004) increased the vitamin E in feeds for Atlantic salmon brood stock from 60 to 250mg in diets containing high levels of polyunsaturated fatty acids. The percentage of spawned egg lots with hatching rates greater than 70% increased from 30% to 40%, a 25% improvement. Additionally, the number of spawned egg lots with survival greater than 90% increased from 55% to nearly 80%, a 45% improvement. The much-improved hatchability and survival, obtained by the researchers were attributed to the vitamin E giving better antioxidant protection from in vivo lipid oxidation in the fish eggs.

Clearly, when the much higher hatchability and survival are considered, adding five times more vitamin E to the Atlantic salmon brood stock diets had a very high return on investment (ROI). Adding elevated levels of vitamin E to brood stock diets for any farmed species will likely produce similar benefits and deliver impressive cost-effectiveness. (Note: The historical vitamin E requirement, based on purified chemically-defined experimental diets for weight gain for Atlantic salmon was reported to be between 35 and 60mg/kg diet (NRC 2011). The standard DSM OVN recommendation for salmon is 200-400mg/kg feed, high enough to significantly improve flesh quality. The advice is to increase all vitamins in brood stock feeds by 30% above the standard recommendation.)

## Larval stages in the hatchery

The metabolic rate of larval fish is much higher compared to later life stages. Spectacular growth rates mean protein deposition in muscle occurs very rapidly, and at the same time, there are high energy demands due to inefficient swimming activity (Dabrowski, 1986). Protein catabolism is the main source of energy in larval fish. Research suggests that this metabolic emphasis on protein deposition in new muscle coupled with a high rate of amino acid catabolism for energy indicates that larval fish are the most sensitive to deficiencies of vitamins A and B6 (pyridoxine), vitamin C and vitamin E (Dabrowski, 1986). Indeed, it is safe to assume that other vitamins important for cell proliferation and energy metabolism, basically all the remaining B-complex vitamins are needed in much greater quantities relative to body weight, than for larger fish. Unfortunately, due to the difficulties of conducting requirement studies with such small animals, vitamin requirements for larval species are mostly unknown.

Providing supplementary vitamins to fish larvae still consuming live feeds and unable to eat manufactured feeds is quite challenging, particularly for water-soluble vitamins. Live foods such as rotifers, *Brachionus* and brine shrimp, *Artemia* have been shown to contain insufficient vitamin C (ascorbic acid or AA) for marine fish larvae, which impairs larval skeletal development and growth. For this reason, enrichment of live foods with ascorbic acid (as ascorbyl palmitate or ascorbyl-2-phosphate) is common, and feeding larvae with vitamin C has been researched more than for any other vitamin. In some examples on vitamins in early larval nutrition, clearly, vitamin C enrichment of live foods significantly improves growth, survival and stress resistance in several species of fish and can improve productivity and profitability of hatcheries.

Merchie et al. (1995) said that feeding *Clarias gariepinus* larvae enriched *Artemia* (2,260µg AA/g dry weight) for 20 days before a salinity stress test (freshwater to 25ppt salinity for 1 hr) resulted in only 2.5% mortality, whereas larvae fed non-enriched *Artemia* (555µg AA/g dry weight) had a much higher mortality of 40%.

Merchie et al. (1997) then reported that compared with feeding non-enriched *Artemia* nauplii (560µg AA/g dry weight), feeding enriched *Artemia* (2,260µg AA/g dry weight) to larval *C. gariepinus* resulted in a 30% greater dry body weight after 8 days.

Gapasin et al. (1998) fed larval milkfish (*Chanos chanos*) unenriched *Chlorella* (550µg AA/g dry weight) as well as enriched *Chlorella* (1,760µg AA/g dry weight) and reported that opercular deformities in 40-day old milkfish were about 50% lower than in fish fed unenriched algae.

## Fry in the nursery

According to Dabrowski (1986), as fish transition from larvae to fry, their physiological development shifts and this then impacts nutrient requirements. For example, skeletal development becomes a metabolic priority, so adequate intake of dietary minerals and vitamin D (Taveekijakarn et al., 1996; Darius et al., 2011) becomes important. KPIs focus on growth and on survival above all else, since at this stage, for many species, high survival is frustratingly difficult to manage. Inadequate nutrition is the likely cause, and not knowing vitamin requirements limits our ability to overcome this.

On the positive side, animals are now consuming manufactured feeds, and vitamin supplementation becomes much easier. Experience with several species (grouper, tilapia, catfish, Asian seabass) shows that poor

water quality and crowding greatly increase stress levels, which can cause feed intake to drop, growth rates to slow, immunity to weaken and mortality to increase. At this stage, then, vitamin requirements remain higher than for larger fish, which are better able to adapt to existing conditions. As such, DSM's OVN™ guidelines suggest vitamin supplementation of fry feeds should be increased by 30% above NRC's recommendations.

While it is very important that all vitamins be supplemented at the correct levels in feeds, compensation must be made to counter the effects of feed processing on vitamin retention in finished feeds. Sub-optimal intake of one or more vitamins, as shown in the following table, will cause a significant reduction of feed intake and decrease feed efficiency (increase the feed conversion ratio), which slows growth, wastes feed and increases production costs in the farm.

Effect of vitamin deficiency on feed intake and feed conversion ratio (FCR). Adapted from Bureau and Cho (1999).

| | Fat-soluble vitamins | | | | Water-soluble vitamins | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vitamin A | Vitamin D | Vitamin E | Vitamin K | Thiamin (B1) | Riboflavin (B2) | Biotin | Pyridoxine (B6) | Vitamin B12 | Folic Acid | Pantothenic Acid | Niacin | Vitamin C | Inositol | Choline |
| **Common deficiency signs** | | | | | | | | | | | | | | | |
| Poorfeed efficiency | | | | | | X | X | | | X | | X | | X | X |
| Reduced feed intake | X | | | | X | | X | X | X | X | X | X | X | X | |

## Grow-out stages

As fish grow, vitamin requirements are reduced compared to the larval and fry stages. However as total biomass increases in their farm enclosures, environmental conditions (low dissolved oxygen, high dissolved nitrogen), crowding stress, handling and grading stress and greater exposure to pathogens with animals closer together increasingly impact feed intake, growth rates and animal health. It becomes harder to attain excellent KPIs for growth rates, disease outbreaks and survival. Oxidative stress, as well as leaking oxygen radicals from white blood cells involved in a cellular immune response, increase the need for antioxidant vitamins C and E to protect cells and membranes from damage. At this point, if problems with animal performance continue, nutritionists should consider boosting supplementation of antioxidant vitamins to much higher levels (vitamin E > 500mg/kg and vitamin C 1,000-2,000mg/kg).

Ortunõ et al. (2003) compared the stress response of gilthead seabream (*Sparus aurata*) fed a commercial feed with 100mg/kg diet of both vitamin C and vitamin E (control group) against three experimental diets:
A) 3,000mg vitamin C/kg;
B) 1,200mg vitamin E/kg; and
C) 3,000mg vitamin C and 1,200mg vitamin E/kg.

After 2, 4 and 6 weeks of feeding, one control group was left unstressed while another control group and fish fed diets A, B and C were exposed to stressors typical in aquaculture operations. Stress was applied by:

- Mechanically stirring tank water with a paddle at 80RPM for 15 minutes.
- Increasing fish density from 9kg/$m^3$ to 100kg/$m^3$ by reducing the tank water level.
- Fish were exposed to air for 2 minutes (netting fish and holding them out of the water).

Consequently, fish stress response was estimated by measuring blood plasma cortisol, blood glucose level, blood complement activity, and respiratory burst activity of head-kidney leucocytes.

For all four of these indicators of response to stress, the additional vitamin supplementation of diets A, B and C had significant effects. Compared with controls, fish fed diets A and B had 33% lower blood glucose at 2 weeks, and blood glucose was 50% for fish fed diet C. After 6 weeks, blood complement activity was significantly higher in fish fed diets A, B and C, compared to controls. The respiratory burst activity of fish fed diets A, B and C exposed to the three stressors was the same as the unstressed controls, and significantly lower than fish in the stressed control group fed the non-vitamin-supplemented diet.

This is just one example demonstrating that higher levels of antioxidant vitamins can reduce the stress response and strengthen immune response against pathogens; such benefits have been shown for a number of different species of fish, shrimp and other crustaceans. Certainly, as fish grow and reach harvest size, using antioxidant vitamins C and E prophylactically improves all farm KPIs.

We have shown several examples of research which show the positive effects of supplementing live feeds for larval stages with vitamins, or meeting or exceeding recommended vitamin supplementation for grow out stages. We can state with certainty that nutritionists and feed formulators, and indeed feed companies can obtain significant benefits, cost effectiveness, and a very positive ROI with formulating vitamins to meet the nutrtional needs at all stages of the aquaculture production cycle and under all growing conditions.

This article reinforces the importance of "Getting It Right At Every Step" in the feed and farming industry to achieve more sustainable feed manufacturing and aquaculture production. It also addresses the quality of final products and how improved quality of feeds through optimum vitamin nutrition, can help tackle life time performance – a key performance indicator for sustainable food systems.

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# Functional hydrolysates increase shrimp feed consistency, sustainability and performance

While these preserve a maximum of bioactive peptides from native proteins, a change in farmers' mindset is required regarding the need for darker shrimp feed with high levels of fish meal, and the belief that high soybean meal levels enhance disease risks.

By Mikael Herault, Buddhi E. Gunathilaka and Kyeong-Jun Lee

The recent HATCH survey revealed that for shrimp farmers, the main concern is disease risks, far beyond feed costs, while quality of feed was hardly mentioned (https://www.shrimpfarm.tech/, 2019). This is despite the fact that feed contributes a lot to shrimp productivity. Even though "a feed is as good as its ingredients" (Glencross et al., 2007), the shrimp feed industry is still facing some conservatism and reluctance in replacing long established raw materials, such as squid liver meal or fish meal, with alternative protein sources. In this article, we will demonstrate that there could be everything to gain by changing this mindset.

## From valuable raw materials to limited feed ingredients

Fish meal is still perceived as a necessary ingredient in shrimp feed formulations, especially in Asia, where many farmers believe, without any scientific backing, that soybean meal, its main plant substitute, is responsible for higher disease risks. An illustration of this belief is the fact that darker shrimp feed are more popular among shrimp farmers, and the industry has complied with this cosmetic trend as an indicator of higher dietary fish meal. Also, it is worth noting that the industry often uses highly variable quality co-product fish meals to match the ambivalent need of high fish meal in diets and limited formulation costs.

Unfortunately fish meal processing technology does not maximise the potential of this valuable raw material. Fish meal undergoes harsh processing conditions, whereby the native proteins are denatured, soluble protein factions removed and polyunsaturated fatty acids (PUFAs) oxidised, thereby limiting their uptake and assimilation by shrimp. Figure 1 summarises an analytical survey on 14 different co-product fish meals sourced in Asia, mostly manufactured from tuna species. As it can be seen, the two important drawbacks in using co-product fish meal are their limited nutritional value (crude and soluble protein, ash content, pepsin digestibility), worsened by the huge variability observed from one source or batch to another, making shrimp feed formulations (and their performances) uncertain, if not requiring permanent formula adjustments to compensate for its quality. These drawbacks may limit co-product fish meal "net" cost-effectiveness.

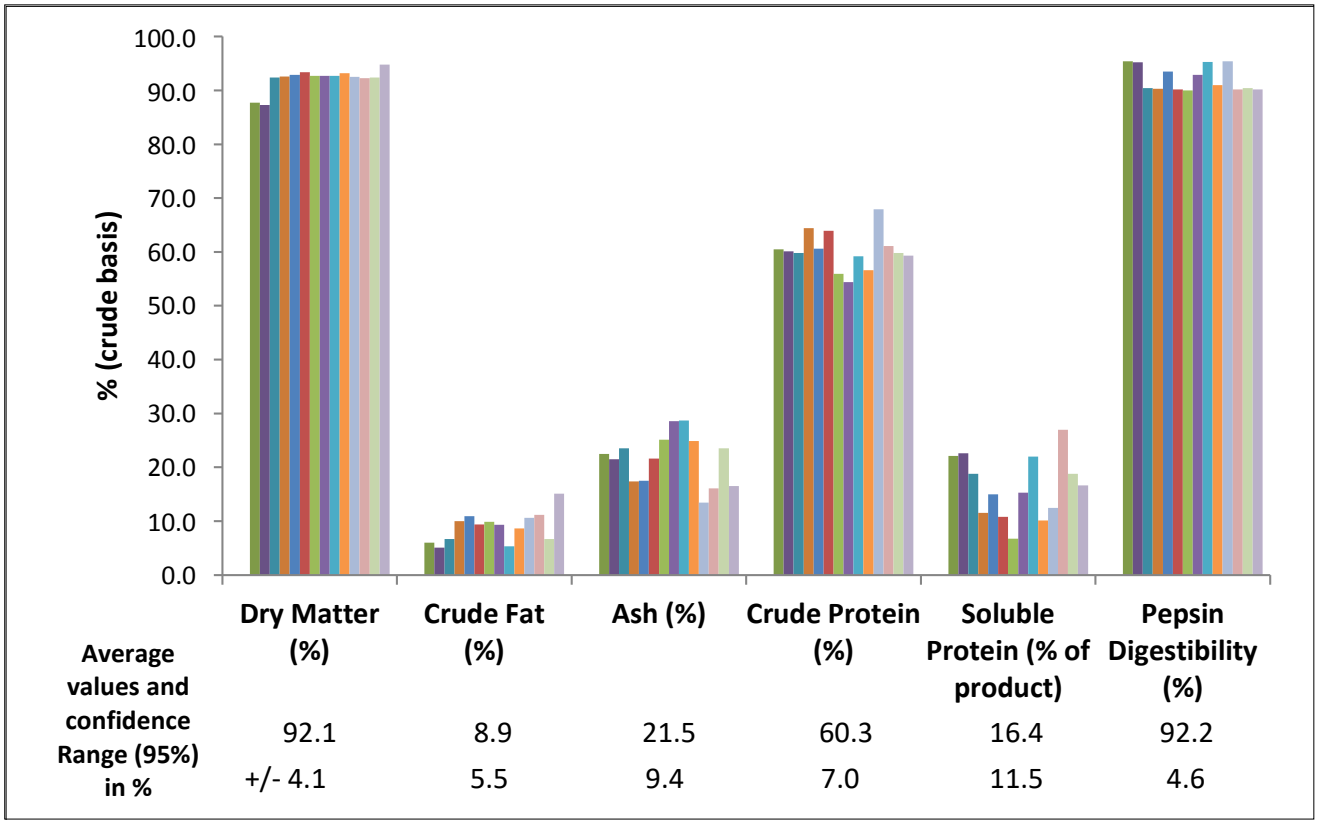


**Figure 1.** Summary of an in-house nutritional survey implemented on 14 Asian co-product fish meals

Fish soluble is another popular ingredient resulting from fish meal processing, and is mostly used in shrimp feed formulations to increase diet attractability. It is especially true in South America where large pond surfaces may justify such a need. A nutritional survey conducted on Asian sourced fish solubles had demonstrated not only great variability of compositions (dry matter and protein content) but also protein (peptide profile) and freshness quality (biogenic amines content; Seguin and Martineau, 2019).

Squid-based ingredients are still considered as the growth promoting reference in shrimp feed formulations due to the possible presence of a protein growth promoting factor (Cruz-Rique et al., 1987). Furthermore, squid paste products provide several valuable components for shrimp nutrition such as omega-3 PUFA, cholesterol and phospholipids. Unfortunately, squid paste is often used as squid liver meal (or powder), after heating and mixing with soybean cake, in order to facilitate its inclusion in shrimp feed matrixes. Again, the quality and consistency of this valuable raw material can be compromised by inadequate squid paste storage conditions, variable soybean cake concentrations and poor drying conditions.

## Maximising the value of marine raw materials with hydrolysis

Thanks to mild and standardised processing conditions, protein hydrolysis can preserve marine raw material fat and protein qualities while yielding the maximum of bioactive peptides in native proteins. There is extensive literature demonstrating the different biological activities resulting from these functional hydrolysates (Chalamaiah et al., 2012; Batista, 2013). Reports on aquatic species include the enhancement of feed intake and feed conversion, immune system stimulation, stress reduction and microbiota modulation. A precedent article had shown the superiority of hydrolysis process in yielding almost perfect product standardisation and consistency (Soller et al., 2018).

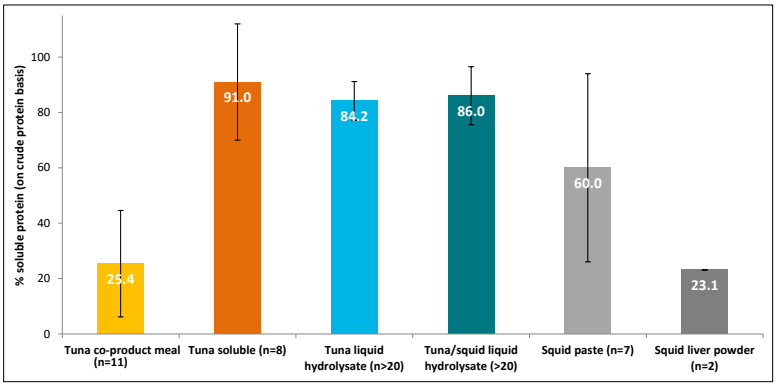


**Figure 2.** Percentage of soluble protein (on crude protein basis), with 95% confidence range, measured on tuna or squid raw materials, processed in different ways.

Figure 2 illustrates that, besides stickwater from fish meal process (similar to a "juice" with genuinely present free amino acids and peptides), only protein hydrolysis process, allows such a high yield of soluble proteins, releasing encrypted bioactive peptides from native proteins. The hydrolysis process also allows a higher product consistency from batch to batch.

> "There is no reason to maintain high fish meal levels in shrimp diets– soybean meal is a good alternative when supplemented with functional hydrolysates."

## Fish meal replacement is not an issue but advisable

A nutritional and immunological study was conducted in 2019 in white shrimp (*Litopenaeus vannamei*) at Jeju National University. In this study, we benchmarked tuna and squid based ingredients obtained from different processes. Experimental diets were formulated to be iso-nutritional for macro-nutrients and are presented in Table 1.

| Ingredients (% wet basis, equal to 100% after drying) | Squid liver meal | Tuna cop meal | Tuna liquid soluble | Tuna/squid liquid hydrolysate | Tuna liquid hydrolysate |
|---|---|---|---|---|---|
| Tuna co-product meal (60% CP) | 10.7 | 21.4 | 10.7 | 10.7 | 10.7 |
| Squid liver powder | 5.0 | | | | |
| Tuna liquid soluble | | | 3.0 | | |
| Tuna/squid liquid hydrolysate | | | | 3.0 | |
| Tuna liquid hydrolysate | | | | | 3.0 |
| Corn gluten | 2.08 | 2.08 | 2.08 | 2.08 | 2.08 |
| Wheat gluten | 2.81 | 2.81 | 2.81 | 2.81 | 2.81 |
| Soybean meal | 48.26 | 38.50 | 48.26 | 51.85 | 52.75 |
| Wheat flour | 20.74 | 20.74 | 20.74 | 20.74 | 20.74 |
| Starch | 6.89 | 10.35 | 6.89 | 6.28 | 5.99 |
| Soybean oil | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fish oil | 2.43 | 2.32 | 2.43 | 3.10 | 3.15 |
| Lecithin | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Mineral mix | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Vitamin mix | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Cholesterol | 0.03 | 0.05 | 0.03 | 0.03 | 0.08 |
| Choline chloride | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Monocalcium phosphate | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Guar gum | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

**Table 1.** Experimental feed formulations (as-is basis).

The diet containing 5% squid liver meal was regarded as the current market reference while the diet containing 21.4% tuna co-product meal (HFM) was used to observe shrimp performance when dietary soybean meal (SBM) was reduced significantly.

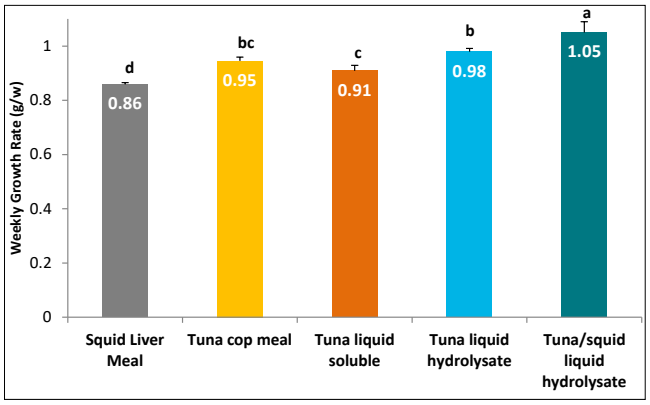


**Figure 3.** Weekly growth rates of *Litopenaeus vannamei* after 8 weeks feeding trials in aquarium (+SEM, One way ANOVA, <0.001).

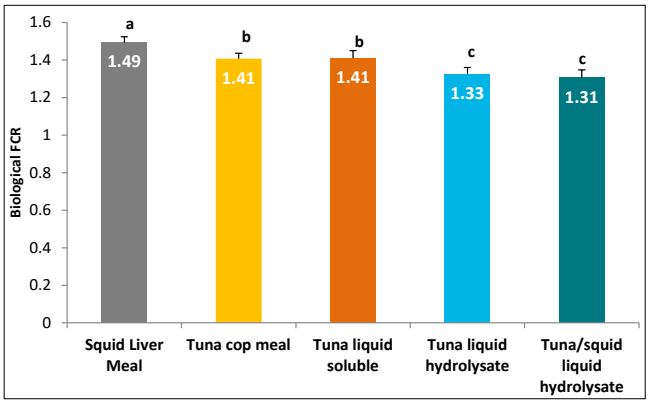


**Figure 4.** Biological feed conversion rate (FCR) of *Litopenaeus vannamei* after 8 weeks feeding trials in aquarium (+SEM, One way ANOVA, <0.001).

Figures 3 and 4 illustrate the zootechnical performances observed in shrimp fed conventional marine protein sources when compared to substituting soybean protein, supplemented with functional hydrolysates. Due to their moisture content, functional hydrolysate supplemented diets contained the highest levels of soybean meal and also resulted in the best observed zootechnical performance. These results showed that a high dietary level of feed grade soybean meal can result in high feed and shrimp performances when combined with the right functional hydrolysate. This observation remained true under the early mortality syndrome (EMS) infection challenge we implemented following the feeding trial, as illustrated in Figure 5. In this challenge, response to EMS infection was very acute but groups fed high levels of soybean meal, supplemented with the functional hydrolysates, showed the highest survival rates.

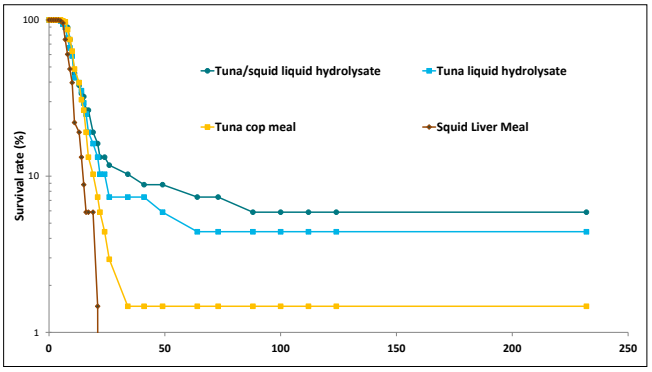


**Figure 5.** Survival rate kinetics (hours) of *Litopenaeus vannamei* subjected to an EMS challenge by 1h immersion (1.83x10$^5$ CFU/mL, logarithmic scale, log rank - Kaplan Meyer: <0,001).

On the other hand, these figures also demonstrate that maintaining high co-product fish meal levels in shrimp diets is not enough, or even necessary, to maximise shrimp zootechnical and health performance. Table 2 summarises some innate immune parameters analysed at the end of the feeding trials. Levels of immune cells and activities of antioxidative serum enzymes were higher for the dietary groups supplemented with the functional hydrolysates.

This, supports the relevance of supplementing shrimp diets containing high level of soybean meals, or other alternatives to fish meal, with functional hydrolysates to maximise shrimp productivity and feed costs. The feed cost reduction may be direct, with lower costs in use, but also indirect with enhanced FCR, biomass and size homogeneity. Therefore, there is no reason to maintain high fish meal levels in shrimp diets– soybean meal is a good alternative when supplemented with functional hydrolysates.

| | Hyaline cell[3] | SOD[5] | GPx[6] | Catalase[7] |
|---|---|---|---|---|
| Squid liver meal | 52.3±9.55$^b$ | 80.94±1.99$^b$ | 18.39±1.37$^d$ | 2.02±0.11$^d$ |
| Tuna cop meal | 54.3±8.55$^b$ | 85.00±4.11$^{ab}$ | 21.39±2.96$^c$ | 2.33±0.16$^c$ |
| Tuna liquid soluble | 54.7±12.7$^b$ | 86.53±2.99$^{ab}$ | 27.75±0.63$^a$ | 2.94±0.22$^a$ |
| Tuna/squid liquid hydrolysate | 73.0±13.8$^a$ | 87.01±2.52$^a$ | 26.64±1.33$^b$ | 2.63±0.21$^b$ |

(± S.D; 1 way ANOVA: <0,05; [3]Hyaline cells count (10$^5$ cells ml-$^1$); [5]Superoxide dismutase (% inhibition); [6]Glutathione peroxidase activity (mU ml-$^1$); [7]Catalase (absorbance).

**Table 2.** Non-specific immune parameters of *Litopenaeus vannamei* fed the eight experimental diets for 8 weeks.

## Changing times with squid liver meal

Squid liver meal was referenced as an important shrimp feed ingredient several decades ago when there was a much lower diversity of available proteins, and most likely quality. During these times, laboratory scale (whole) squid protein components demonstrated their growth promoting efficiency in shrimp feed formulations.

Today our research (figures 3, 4 and 5) shows that there are better dietary solutions than squid liver meals, with higher performance, consistency and sustainability. For lower costs-in use, the functional liquid hydrolysates have demonstrated their superiority both in terms of growth performance and health through the enhanced immune parameters, resulting in higher resistance to EMS disease challenge. Consequently, squid liver meal should not be the reference for promoting growth in shrimp, since functional hydrolysates can bring more benefits.

*Experimental tanks*

## Conclusions

The belief that it is not possible to replace fish meal proteins with plant proteins without adverse effects on shrimp zootechnical and health performance is a fallacy. For sure, there are some critical points to control but they are mostly related to the consistency of the quality of ingredients, an adequate balance of macro and micro nutrients when formulating feeds, and its palatability. By significantly enhancing feed attributes, the use of functional hydrolysates may offset most of the remaining inconsistencies coming from other ingredients, leading to high performing functional aquafeeds for market premiumisation.

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# Butyrate glycerides mitigate the negative effects of high dietary soybean meal on fish and gut health

A protected form of butyrate acts as a functional feed additive by increasing the activity of intestinal digestive enzymes, improving the antioxidative capacity as well as alleviating the negative effects of soybean meal on gut morphology, contributing to better growth performance of juvenile black sea bream in China. Growth performance of fish increases with increasing dietary butyrate glycerides supplementation up to fish fed 6g/kg diet.

By Qingjun Shao, Josie Ancella Volatiana, Gladstone Sagada, Bingying Xu, Jinzhi Zhang and Wing-Keong Ng

*Soybeans contain anti-nutritional factors that are known to negatively affect gut health and cause intestinal enteritis in farmed fish when high levels of soybean meals are used in aquafeeds.*

Soybean meal (SBM) is currently the most commonly used plant protein source in commercial aquafeeds. This plant-based ingredient is a good alternative to fish meal in aquafeed formulations due to its high protein content, reasonable amino acid profile, availability and competitive pricing. However, SBM does contain anti-nutritional factors such as protease inhibitors that have been reported to reduce digestive enzyme activities and lectins, saponins and phytic acid which are known to disrupt gut metabolism and damage gut villi. Prolonged use of feeds containing high dietary levels of SBM may cause intestinal enteritis with a subsequent loss in fish growth and health. Even though much progress has been made in the use of SBM in aquafeeds, the negative effects of high SBM inclusion on fish gut health require further research.

Short-chain fatty acids (SCFA) are part of a group of compounds collectively known as organic acids which have been of great research and commercial interests in aquafeeds. SCFA are mainly produced by microbial fermentation of indigestible carbohydrates in the intestinal tract of animals. Of the SCFA, butyrate has received much interest as a functional feed additive in aquafeeds. Butyrate is known to be a major energy source for colonocyte cells and postulated to play an important role in maintaining intestinal homeostasis and overall gut health status in animals.

Recent research on functional feed additives reported promising results on the role of butyrate in enhancing the intestinal epithelial defense barrier in various fish species. However, direct application of butyrate in feed poses some challenges due to its strong odour and its very short half-life, i.e. it is rapidly absorbed in the stomach without reaching further along the digestive tract. Therefore, butyrate glyceride (BG), consisting of a varied number of butyric acids attached to the glycerol backbone, may be an alternative form of butyrate to overcome these limitations.

When presented as BG in the fish gut, the butyrate is expected to be released from the glycerol backbone through the action of lipase, thus allowing the butyrate to travel further along the digestive tract to impart its beneficial effects. Previous studies have shown that the supplementation of BG had a positive effect on the performance of various terrestrial animals, including pigs and broilers. However, as far as we know, the effects of dietary BG in aquatic animals have not been reported.

Therefore, we initiated a study to investigate the effects of adding graded levels of BG in high SBM diets on the growth performance, intestinal morphology and antioxidative capacity of juvenile black sea bream (*Acanthopagrus schlegelii*), which is a high-value carnivorous marine fish.

## Butyrate glyceride supplementation in aquafeeds

A basal diet with 45% SBM was formulated. Six iso-nitrogenous (390g/kg crude protein) and iso-energetic (187kJ/g) diets were prepared with BG added to the basal diet at 0, 2, 4, 6, 8 or 16g/kg and designated as BG0 (control), BG2, BG4, BG6, BG8 and BG16, respectively. The active butyrate glycerides in each diet were analysed as 0, 1.12, 2.24, 3.36, 4.48 and 8.96g/kg respectively. The butyrate glyceride (BG) includes mono (340g/kg), di (190g/kg) and tri (30 g/kg)-butyrin and was provided by South China University of Technology, China.

An 8-week feeding trial was conducted at the Marine Fisheries Research Institute of Zhejiang Province in Zhoushan, China, which houses a flow-through seawater tank system. Each treatment diet was fed to triplicate groups of 20 fish per tank (initial mean weight: 9.98±0.13g) to apparent satiation twice daily. At the end of the feeding trial, fish blood and tissue samples were obtained and subjected to various proximate, digestive and antioxidant enzyme activities and histological analyses. Detailed information on the protocols used and results is provided in Volatiana et al. (2020).

## Enhancing fish growth and digestive enzyme activity

Black sea bream fed the high SBM-based control diet without BG supplementation showed the poorest growth performance (Table 1). This is consistent with other studies on marine carnivorous fish species that reported a high-level replacement of fish meal with SBM could decrease growth performance. The addition of increasing levels of BG in diets promoted a progressive increase in fish growth but dietary levels beyond 8g/kg diet did not result in further improvement in growth performance. A significant improvement in feed intake as well as the highest growth performance was observed in fish fed diets supplemented with BG at 6g/kg diet. As far as we know, studies on the use of butyric acid in aquafeeds have until now been with the butyrate salts and the present study is the first to deliver butyrate in a glyceride form.

Protease enzyme activity in the foregut, midgut and hindgut of black sea bream significantly increased with increasing dietary BG supplementation (Figure 1). A similar trend was found in lipase and amylase activities despite the lack of statistical significance. Our results suggested that growth improvement of black sea bream may be due in part to the increase of protease activity. Generally, changes in the digestive enzyme activities determine the digestive and absorptive capacity of nutrients, which influence the growth of fish. The enhanced protease activity in the gut of fish fed diets supplemented with BG may also mitigate some of the negative effects of protease inhibitors that may be present in SBM.

*The trial was conducted in a series of 350L fiberglass tanks with flow-through seawater at 2L/min on Xixuan Island, Zhoushan. Water temperature was maintained at 28±1°C and salinity at 26-28 ppt with a natural photoperiod. Insert: black sea bream, a commercially farmed marine fish in China.*

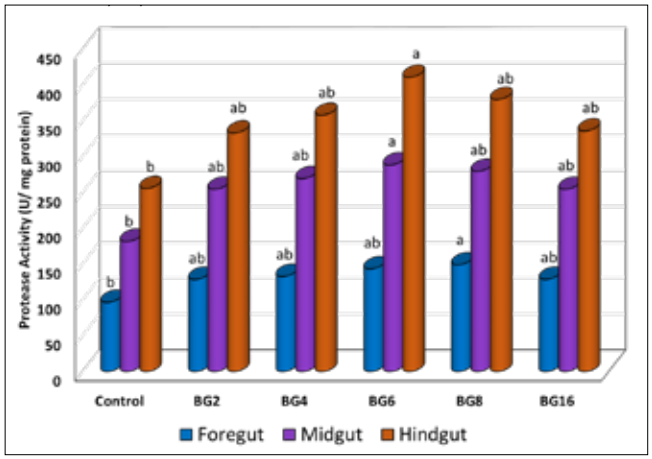


**Figure 1.** Protease digestive enzyme activity in the foregut, midgut and hindgut of black seabream fed diets with increasing butyrate glycerides (BG, g/kg) supplementation. Protease activity increased in the gut of fish fed diets supplemented with BG compared to control. Significantly higher ($P<0.05$) peak activity was observed in fish fed 6 to 8g BG per kg feed. Lipase and amylase activities showed a similar trend as protease activity with higher enzyme activities in all BG-fed fish compared to control, but these were not significantly different ($P>0.05$). Adapted from Volatiana et al. (2020).

**Table 1**. Growth performance and feed utilisation efficiency of black sea bream fed high soybean meal-based diets with increasing butyrate glycerides (BG) supplementation.

| Parameters | Diets[1] | | | | | |
|---|---|---|---|---|---|---|
| | Control | BG2 | BG4 | BG6 | BG8 | BG16 |
| WG[2] | 517.4±14.7$^{c}$ | 558.8±1.6$^{bc}$ | 581.2±17.7$^{ab}$ | 618.9±4.8$^{a}$ | 586.5±14.8$^{ab}$ | 554.2±22.6$^{bc}$ |
| SGR[3] | 3.25 ± 0.04$^{c}$ | 3.37 ± 0.03$^{bc}$ | 3.42 ± 0.05$^{ab}$ | 3.52 ± 0.01$^{a}$ | 3.44 ± 0.04$^{ab}$ | 3.35 ± 0.06$^{bc}$ |
| FI[4] | 0.85 ± 0.03$^{c}$ | 0.90 ± 0.03$^{bc}$ | 0.97 ± 0.02$^{ab}$ | 1.01 ± 0.05$^{a}$ | 0.93 ± 0.04$^{abc}$ | 0.88 ± 0.03$^{c}$ |
| FCR[5] | 1.33 ± 0.04 | 1.30 ± 0.03 | 1.33 ± 0.03 | 1.30 ± 0.07 | 1.33 ± 0.04 | 1.33 ± 0.05 |

[1]The control diet is a high soybean meal (SBM)-based diet without butyrate glycerides (BG) supplementation at 0 (BG0), 2g/kg (BG2), 4g/kg (BG4), 6g/kg (BG6), 8g/kg (BG8) or 16g/kg (BG16). Data are represented as the means ± SD (n = 3). Values with different superscripts in each row are significantly different ($P < 0.05$).
[2]Weight gain (WG, %) = 100 × (final body weight – initial body weight)/initial body weight.
[3]Specific growth rate (SGR, %/day) = 100 × (ln final body weight – ln initial body weight)/day.
[4]Feed intake (FI, g/fish/day) = feed consumption (dry weight)/final fish number/feeding days.
[5]Feed conversion ratio (FCR) = dry feed consumption/body weight gain.

Our results also indicated that supplementation of BG in the diets could enhance the antioxidant activity of fish and alleviate oxidative damage caused by the anti-nutritional factors found in high SBM-based diets. Antioxidant enzymes such as superoxide dismutase (SOD) and glutathione peroxidase (GSH-Px) act as oxygen radical scavengers that protect hosts against oxidative stress which might compromise the immune response. In the present study, SOD and GSH-Px activities significantly increased with increasing dietary BG supplementation reaching peak activities in the serum of fish fed the BG6 diet.

## Dietary butyrate glyceride restored intestinal integrity

The anterior gut of fish fed the high SBM-based control diet displayed multiple signs of damage characterised by a significant decrease of villi height, reduction of microvilli density and goblet cells, disruption and atrophy of villi morphology and reduction of digestive and absorptive surface (Figure 2). Fish fed ≥ 4g/kg BG diets showed normal morphological structures with intact villi fold and a large absorptive surface which was full of microvilli.

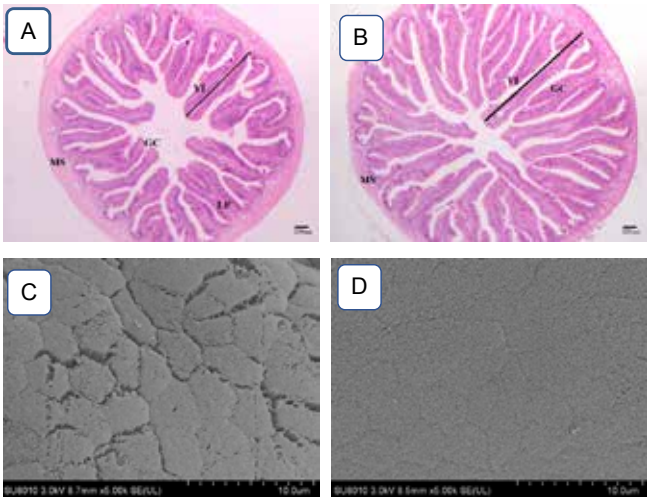


**Figure 2.** Histology (x4 magnification) and scanning electron microscopy (x 30,000 magnification) of anterior gut sections of black sea bream in fish fed control diet with high soybean meal without butyrate glyceride (BG) supplementation (A and C) or with added 6g BG/kg diet (B and D). (A) showed short-disrupted villi (VI) with less goblet cells (GC) whereas (B) showed long stretched villi filled with goblet cells. (C) also revealed damaged intestinal villi structures whereas (D) was observed to have well-integrated intestinal villi structures with more absorptive surfaces. Adapted from Volatiana et al. (2020).

Fish gut is known to be highly sensitive to dietary anti-nutritional factors (especially raffinose, stachyose, saponins, lectins) found in soy products. The adverse effects of lectin together with polysaccharides may result in the destruction of intestinal microvilli and reduction of digestive and absorptive surfaces. SBM saponins have been reported to be responsible for intestinal impairment and the inducement of intestinal enteritis.

The addition of BG in feeds for the black sea bream mitigated the negative impact of high dietary SBM on gut morphology. Adding BG in the diet increased villi height, the number of goblet cells and microvilli density, which conferred a larger nutrient absorptive surface. This may be possible due to the provision of butyrate in glyceride form allowing it to be transported further along the digestive tract of black sea bream where it can exert a beneficial impact on the gut morphology.

Butyrate is known to be a principal energy source of the colonic epithelium which can modulate enterocyte differentiation, proliferation and restitution, as well as mucus secretion from goblet cells in the small intestine of animals. Our results indicated that addition of BG in high SBM diets alleviated the negative effect caused by SBM on gut morphology and contributed to better fish growth performance.

In conclusion, our study demonstrated that BG supplementation in high SBM diets was beneficial for black sea bream, and possibly for other carnivorous marine fish species. Dietary BG has beneficial effects; it reduces damage caused by high dietary SBM by restoring intestinal integrity and increasing digestive and absorptive surface of the gut with a corresponding increase in protease activity. Subsequently growth performance of fish improved. In addition, in the presence of oxidative damage, BG can enhance antioxidant enzymes' activities and reduce oxidative stress.

The findings of this research contribute to the application of BG as a functional feed additive in the aquafeed industry and are of significant importance, considering the increasing use of plant protein sources such as SBM in the formulation of cost-effective commercial feeds.

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# Algal 1,3-β glucan and vitamin C: a synergistic combination

## Pulse dosing of this combination improved immune response of shrimp, growth and FCR, leading to profitable shrimp farming

By Edward Gnana Jothi George, Harikumar S, Vidya A, Rajalekshmi M and Sugumar C

In several countries, shrimp diseases are considered a limiting factor for its development (Flegel, 2006). Resistance of shrimp against various pathogens is strongly influenced by its immune status. Shrimp do not have the ability to produce immunoglobulins, and apparently depend only on their innate defence systems. Apart from physical barriers, the cellular and humoral components of the innate immune system can contribute to enhanced immune responses and thereby improve survival. This would eventually lead to higher profitability in shrimp farming.

The objective of this study is to examine the efficacy of the algal 1,3–β glucan coated vitamin C combination in improving the immune response, survival, growth performance and productivity in commercial shrimp farming. The study also focussed on demonstrating the profitability and return on investment (ROI) to the shrimp farmers.

The innate immune system includes the physical barriers, cellular and humoral components (Jiravanichpaisal et al., 2006). Exoskeleton of shrimp serves as the first line of defence, protecting them from microbial attacks. Cellular defence components include all those reactions performed directly by haemocytes (phagocytosis, encapsulation, nodule formation). Humoral components include the activation and release of molecules stored within the haemocytes, such as anticoagulant proteins, agglutinins, phenoloxidase (PO) enzyme, antimicrobial peptides, protease inhibitors, etc. (Jiravanichpaisal et al., 2006).

Haemocytes are immune cells in the shrimp and their numbers reflect their immune status which can be stimulated by algal 1,3–β glucan. Haemocytes are classified into three types based on the presence and size of the cytoplasmic granules, hyalinocytes (5-15% in circulation and involved in clotting), semi-granulocytes (75% in circulation which are involved in phagocytosis, encapsulation and clotting) and granulocytes (10-20% in circulation and are involved in encapsulation, initiation of prophenoloxidase (proPO) cascade and phagocytosis). Haemocytes are also involved in the regulation of different physiological functions i.e., exoskeleton hardening, cuticle damage healing, coagulation, carbohydrate metabolism, and protein/amino acid transportation and storage.

## Algal 1,3-β glucan

A homopolysaccharide of glucose molecule, algal 1,3-β glucan is a promising immunostimulant. Figure 1 shows that it is linked by the glycoside bond (Wu et al., 2006).

Algal 1,3–β glucan is involved in the following mechanisms:

- Stimulates the granulocytes to provoke exocytosis and enzyme release.
- Binds with β–glucan binding protein (BGBP) and forms glucan–BGBP complex which activates the serine proteinase cascade, eventually leading to the cleavage of the inactive proPO to the active PO that functions to produce the melanin and toxic reactive intermediates against invading pathogens.
- Increases the phagocytic capacity of haemocytes to destroy pathogens.
- Activates the cellular clotting proteins (coagulogens) in plasma which regulate the coagulation process.

## Vitamin C: an essential antioxidant and immunomodulator

Although vitamin C is a powerful antioxidant, shrimp lack the ability to efficiently synthesise vitamin C. This is correlated to the absence of the enzyme, L-gulonolactone oxidase, which is necessary for the last step of vitamin C biosynthesis. In the shrimp, dietary vitamin C in shrimp plays a vital role in the mechanisms below:

- Enhances the total and differential haemocyte count, thereby improving non-specific immune response.
- Elevates the level of antioxidant enzymes superoxide dismutase (SOD), catalase (CAT), glutamic-oxaloacetic transaminase (GOT) and glutamic pyruvic transaminase (GPT) activities.
- Regulates the growth and moult cycle via its role in collagen synthesis.
- Helps in maintaining the normal physiological function and tissue storage to maintain maximal growth.
- Improves activity of digestive enzymes such as amylase, lipase and protease.

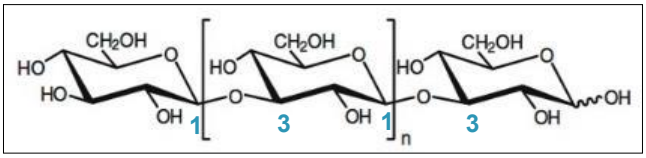


**Figure 1.** Structure of algal 1,3 – β glucan

## An immunstimulant and stress reliever

HydroLETA™ (Kemin, USA) contains algal 1,3–β glucan, with more than 90% of linear chains along with coated vitamin C. The former is derived from a specific *Euglena gracilis* strain and is produced from a proprietary process. Studies in *Litopenaeus vannamei* have demonstrated a synergistic effect between 1,3–β glucan and vitamin C in inducing the non-specific immune response (Wu et al., 2016).

Experiments were conducted to evaluate the effects of supplementation of HydroLETA on immune parameters in shrimp. In addition, a commercial trial using this product was conducted in *L. vannamei* farms in Ongole, Andhra Pradesh, India. The 2-acre (0.81ha) ponds selected for the study were divided into control and treatment (T1 and T2) ponds. The trial was over a full crop cycle of 109 days. Two treatment diets were tested against a control diet. The latter was a commercial 36% crude protein diet (Table 1). The immunostimulant was mixed with water and top dressed over the commercial feed. It was allowed to dry for 10 minutes and was again top dressed with a standard binder and allowed to dry for 15 mins, and then broadcasted over the pond.

| Parameters | Control | Treatment 1 (T1) | Treatment 2 (T2) |
|---|---|---|---|
| Pond area (ha) | 0.81 | 0.81 | 0.81 |
| Stocking density (PL/acre) | 185,000 | 185,000 | 185,000 |
| (PL/m$^2$) | 46 | 46 | 46 |
| Diet | Commercial feed | Commercial shrimp feed + 5-10g/kg of HydroLETA | Commercial shrimp feed + 5-10g/kg of HydroLETA |
| Frequency of feeding | Only commercial feed, 4X/day | Two meals once in 3 days (pulse dosage) were admini stered with immunostimulant | Two meals once in 3 days (pulse dosage) were administered with immunostimulant |

**Table 1.** Details of the *Litopenaeus vannamei* farm trials over a crop cycle (109 days) in 0.81ha ponds at a farm in Ongole, Andhra Pradesh, India.

We studied the following parameters:

- Non-specific immune parameters: total haemocyte count (THC) and granular haemocytes (GH)
- Growth parameters: average daily gain (ADG), average body weight (ABW) and survival rate (SR%)
- Water quality parameters: dissolved oxygen (DO), ammonia and nitrate levels
- Productivity: total biomass and feed conversion ratio (FCR)
- Profitability: gross profit margin and return on investment (ROI)

## Enhanced immune response

THC and GH were counted in *L. vannamei* juveniles at a culture duration of 90 days. A gradual increase of THC was observed in both the groups with increases in the days of culture. Significant increase in the THC and GH cell counts were observed in the treatment group with increasing days of culture (DOC) and peaked at DOC 90. Inclusions of the HydroLETA in the diet were observed to be able to achieve immune stimulation. This result was supported by the increase in THC and granular cells in the treatment ponds at DOC 60 and DOC 90 (Figures 2 and 3)

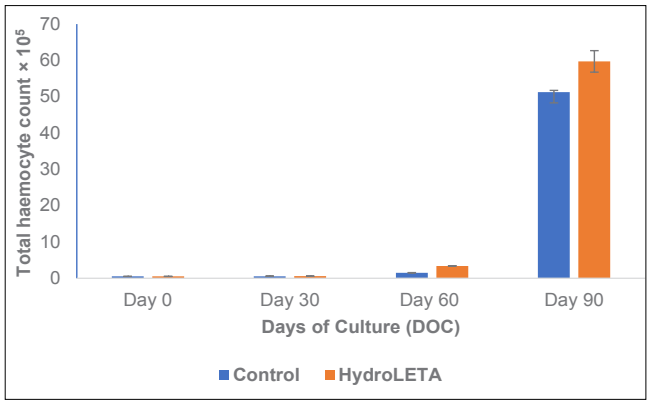


**Figure 2.** Total haemocyte count in test and control shrimp ponds . Data are represented as mean ± SD: N=3 ($p<0.05$)

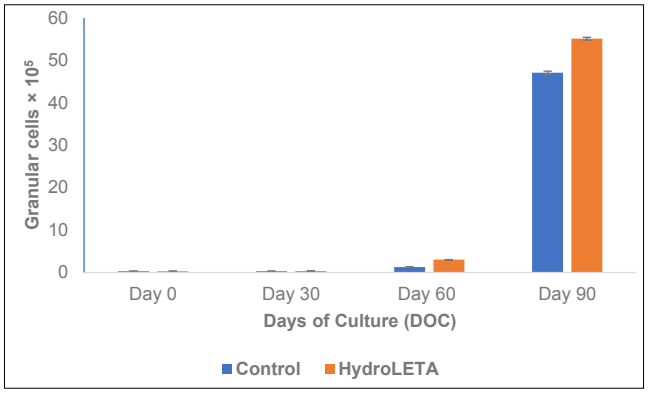


**Figure 3.** Total granular cells in test and control shrimp ponds. Data are represented as mean ± SD: N=3 ($p<0.05$)

## Growth performance, survival and productivity

In all the treatment groups, ADG was calculated on a weekly basis. Significant differences in the ADG were observed, at 0.24g in control pond, 0.31g in treatment T1 and 0.34g in treatment T2 ponds (Figure 4). Total biomass between the treatment groups registered significant differences, with 2,569kg in control, 3,574kg in treatment T1 and 4,497kg in treatment T2 ponds. In addition, significant differences were observed in % survival among the treatment groups. Treatment (T1 and T2) and control ponds recorded 100% and 71%, respectively. Survival was higher in the treatment ponds which can be attributed to the effectiveness of the immunostimulant. This demonstrated that HydroLETA helped in enhancing the immune response and survival in shrimp ponds. Subsequently, significant differences were observed in FCRs with 2.06 in the control group and 1.27 in treatement T1 and 1.0 in the treatment T2 ponds (Figure 5).

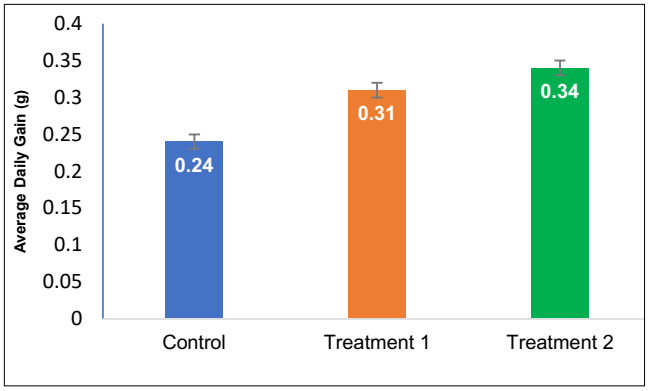


**Figure 4.** Average daily growth (ADG) in control and treatment ponds. Data are represented as mean ± SD: N=3 (p>0.05)

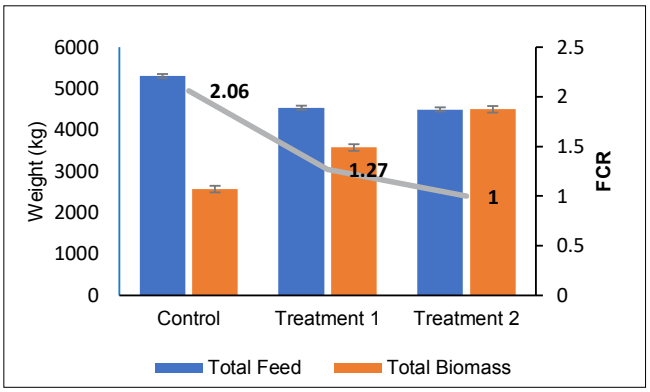


**Figure 5.** Feed conversion ratios (FCRs) in control and treatment groups

This combination of algal 1,3–β glucan and vitamin C has been proven to be essential for growth and immune response in shrimp. Deficiencies in vitamin C can result in poor feed conversion, poor growth, incomplete moulting, decreased resistance to stress, high mortality, impaired wound healing and melanised lesions underneath the exoskeleton.

Stress resistance, good growth, digestive enzyme activity, muscle biochemical composition and antioxidant status of the shrimp have been positively correlated with dietary vitamin C levels (Annamalai et al., 2016). This effect of vitamin C might be the major reason for the higher growth and lower FCR, when used in combination with algal 1,3–β glucan. These findings agree with those reported by various researchers on the benefits of 1,3– β glucan and vitamin C. This significant improvement in growth and lower FCR can also be correlated with the results of Chen et al., (2015) where nutrient absorption and tissue storage were higher with elevated immune response to the pathogens leading to higher growth and lower FCR which remains as the rule of thumb for profitable commercial scale farming.

## Better profitabilty and ROI

The profit margin for the treatment and control ponds was calculated. The profit margins for the treatment ponds (T1 and T2) when compared with the control ponds were INR272,016/acre (USD9,228/ha) and INR507,672/acre (USD 17,082/ha) respectively. The return on investments (ROI) of the treatment ponds (T1 and T2) were 1:43 and 1:81 respectively (Table 2). Shrimp in the control ponds were harvested at size 90/kg as the pond encountered white gut disease at DOC 47 and the growth was very slow post infection, which resulted in an unprofitable harvest (Table 3).

| Parameters | Control | Treatment 1 | Treatment 2 |
|---|---|---|---|
| Count (shrimp/kg) | 90 | 50 | 50 |
| Biomass yield (kg/ha) | 6,166 | 8578 | 10793 |
| Sale price (USD/kg) | 2.85 | 3.5 | 3.5 |
| Gross income (USD/ha) | 17572 | 30022 | 37775 |
| Fixed cost (USD/ha) | 7200 | 7200 | 7200 |
| Feed cost (USD/ha) | 13054 | 11194 | 11093 |
| Juvenile cost (USD/ha) | 2400 | 2400 | 2400 |
| Cost of products (USD) | - | 161 | 161 |
| Total cost (USD/ha) - A | 22654 | 20794 | 20693 |
| Net profit (USD) - B | -5081.64 | 9228 | 17082 |
| **ROI of the product** | **0** | **1:43** | **1:81** |

**Table 2.** Calculations on the return on investment (ROI) of the treatment ponds (T1 and T2) versus that for the control pond.

| Parameters | Treatments (T1 and T2) | Control (C) |
|---|---|---|
| Immune response (THC and GH) | High | Low |
| Survival | High | Low |
| Average daily gain (ADG) | High | Low |
| Feed conversion ratio (FCR) | Low | High |
| Gross profit margin | High | X |
| Return on Investment (ROI) | High | X |

**Table 3.** Summary of results on the trials using HydroLETA™ in shrimp diets

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# The global tilapia

## Resilience in tilapia culture continues despite lower prices since 2017 and recent upheavals with Covid-19.

By Eric Roderick

*Ecuador hybrid salt tolerant tilapia used in polyculture with shrimp. The range of body colour is not important as the fish are all filleted for the export market.*

As an important internationally traded product, the tilapia was initially impacted significantly by the recent trade war between the USA (one of the main importers and consumers of tilapia) and China (the world's biggest producer at 26% of total supply, and the biggest exporter of tilapia products). The 25% tariff on Chinese tilapia imports was rescinded in early 2020 but then came the Covid-19 pandemic with the dramatic slump in demand, when retailers, restaurants and large-scale buyers have to reduce or cease activities; there was disruption to the logistics and supply chain as well. Margins have been negatively impacted, especially since 2017, following the slump in prices. With this pandemic, certifiers and accreditors are under pressure too, with the travel bans and lockdowns around the world. In China, Covid-19 changed the demand pattern, said Jason Carter, from China's tilapia giant, Baiyang Group, during a Global Aquaculture Alliance webinar in June. The shift was towards smaller size fillets and at the farmer level, no difference in prices between large and small size fish.

> "Despite an apparent slowdown in consumption in the USA and Europe, production is still increasing."

## Produced in over 140 countries

The World Bank produced a report "Fish to 2030" which predicted that 62% of the food fish will come from aquaculture by 2030 with the fastest supply growth coming from tilapia, carp and catfish. Tilapia is currently produced in over 140 countries in a wide range of culture conditions, from extensive subsistence farming in earthen ponds, cages in lakes and rivers, intensive and super-intensive recirculation aquaculture systems (RAS), biofloc systems, and more recently as the fish component of aquaponic systems.

Over 6.5 million tonnes of tilapia were produced in 2019 with a global value of over USD12 billion. Despite an apparent slowdown in consumption in the USA and Europe, production is still increasing. Global tilapia production is expected to reach 6.8 million tonnes in 2020, and almost 8 million tonnes by 2030.

There has been a rapid global expansion in tilapia culture over the last 10 years particularly by large agri-industrial businesses using intensive rearing systems. Tilapia is a major global commodity as well as providing food security in developing countries. Tilapia is now part of the global "white fish" market, competing with wild caught cod, pollack, hake and hoki, as well as farmed pangasius and catfish. With its green credentials- its ability to convert most plant proteins into a high quality firm mild tasting flesh - the, tilapia is seen as a real challenge to the dominance of these other white fish, in terms of the value added convenience food market which is expanding year on year.

## More production

Since 2018, tilapia global production has increased by 4% in 2019 to over 6.5 million tonnes, despite losses of 300,000 tonnes due to diseases, mainly by the bacteria *Streptococcus* in Asia. The increase is mainly due to the production of 50,000 tonnes from China, and a significant increase in production in South and Central America helped by the US-China trade war. Colombia and Brazil have increased their exports to the USA, as they can now compete more effectively with Chinese imports. Baiyang exports around 2,000 containers of tilapia a year, mostly to the USA but has diversified recently to Mexico (where domestic consumption massively exceeds production), Africa and the Middle East.

The league tables for tilapia production are holding firm with China, the clear leader producing 1.7 million tonnes in 2019, followed by Indonesia with 1.1 million tonnes and Egypt with a reported 900,000 tonnes (an increase of 80% over the last decade and nearly all consumed domestically).

Colombia is now the main supplier of fresh fillets to the USA and continues to invest in sustainable development with improvement to production standards to meet the strict USA import requirements. Colombia has several new tilapia projects on-going and there is a big push by the Colombian government to increase domestic consumption too. UK's Overseas Aid Department has funded a series of tilapia training workshops through the ESTA (Extending and Supporting Tilapia Aquaculture) project. Fishgen, the UK tilapia genetics company has delivered the training, which is focused mainly on delivering on-farm training to Colombian women in the poor post conflict regions of Colombia.

## Developments in the Americas

In the Americas, where most of the production is either consumed domestically or exported as fresh fillets daily to the USA, there is a steady increase in most of the main producer countries- Brazil, Ecuador, Honduras, Costa Rica and Colombia. Brazil, currently the fourth largest producer is where major expansion is occurring, mostly to supply local demand but also to compete in an overcrowded export market into the USA. The fast-growing local demand for tilapia, reported a 12.4% increase in 2019 to 450,000 tonnes.

According to the Brazilian Fisheries Association (PEIXE BR) Yearbook, growth in tilapia production in Brazil has exceeded growth rates of other farmed fish species, driven by heavy investment and strong demand both domestically and abroad. Tilapia now represents around 55% of Brazil's total aquaculture production. Tilapia farming is Brazil's largest aquaculture industry, helped by the abundance of freshwater and its tropical climate. Brazilian tilapia company, GeneSeas Aquacultura Ltda. is leading the expansion and in February, acquired Tropical Aquaculture, a US-based seafood distributor. Tropical Aquaculture is one of the biggest suppliers of tilapia and other fish for the US market from Brazil, Ecuador and Colombia.

Regal Springs, the largest tilapia producer in the world, plans to further increase production in 2020 with most of the growth coming from their Mexican and Honduran operations. Most of the increase will be generated in Mexico, with a planned 30-35% increase in production as new farms come on-line fully. In 2019, Regal Springs announced that it will begin using blockchain technology (in collaboration with Dutch blockchain technology company SIM Supply Chain Information Management) to support the full traceability of its *Naturally Better Tilapia* brand range in Europe, the first aquaculture white fish producer to do so.

*An incubation system in Brazil, where there is a big expansion of the industry with the involvement of many large companies.*

Some interesting trends include the consolidation amongst fish genetics companies, particularly in tilapia. AquaGen (part of EW group) which has stakes in AquaBel acquired GenoMar in 2017. Aquabel is a large Brazilian tilapia breeding and fingerling producer which emphasises on the importance of good genetic strains in global tilapia expansion plans.

A recently completed Brazilian project, relating to dietary implications on sub-optimal temperature culture of tilapia, could have implications for many of the global tilapia culture regions which are impacted by low temperatures in winter (Nobrega et al, 2019). The experiments were run at 22°C, well under the 28-30°C optimum range for Nile tilapia culture. The researchers found that growth and feed conversion efficiency were improved when the tilapia were fed a diet higher in polyunsaturated omega-3 fatty acids (PUFAs). The diets were produced by Alltech and utilised the marine algae *Aurantiochytrium* sp. which are naturally high in omega-3 PUFAs. This feed could also improve the fatty acid profiles of tilapia flesh, which would have significant health benefits for consumers.

## Developments in Asia

Vietnam is expanding its tilapia production to diversify from its dependence on pangasius exports. Total tilapia production was nearly 300,000 tonnes in 2019. The target by the Directorate of Fisheries, Ministry of Agriculture and Rural Development (MARD) is 400,000 tonnes by 2030. Many of the old pangasius cages along the Mekong River are now used for tilapia farming as many of the pangasius farmers moved to closed pond production systems. In 2018, an estimated 30,000ha of earthen ponds and 1.5 million $m^3$ cages were used for tilapia farming in Vietnam. According to Mavin Aquaculture, Vietnam has a number of rivers, ponds, and big lakes/reservoirs/dams which are suitable for tilapia farming, and there is a large domestic market, with a 100 million population that is familiar with freshwater fish consumption. Exports of tilapia have been increasing, at USD45 million in 2017, a 32% increase from that in 2016.

The Philippines is another major tilapia producing country at 279,005.81 tonnes in 2019 (see pages 54-55). The volcanic eruption at Lake Taal led to the loss of around 6,000 tilapia cages, equating to financial damages of around USD31.4 million. Thailand's production reached 221,000 tonnes in 2019 (Tveteras et al, 2019), with a rapid increase in the farming of the red tilapia, mainly due to its higher value at 25-30%, relative to that of Nile tilapia (Leungnaruemitchai et al, 2020). Myanmar is also a major producer but is currently focused on tilapia polyculture mainly with Indian major carps and Chinese carps.

The Indian subcontinent is also rapidly expanding its tilapia industry, with India, Pakistan and Nepal all seeking to replicate Bangladesh's successful production. The Bangladesh Fisheries Research Institute (BFRI) is instrumental to this success story. India is eyeing the export market as it is already a global leader in shrimp production. The Indian government in 2018 had invested USD1.55 billion in support of Fisheries and Aquaculture sectors through its Fishery and Aquaculture Development fund. Tilapia production is not expanding as predicted in India due to slow consumer acceptance. The Rajiv Gandhi Centre for Aquaculture (RGCA) of the Marine Products Export Development Authority (MPEDA) is trying to stimulate interest by supplying many farms with tilapia fingerlings from its hatcheries. It is now working with the WorldFish Centre and are distributing GIFT tilapia fingerlings to farmers.

The Middle East is a latecomer to aquaculture, but rising food security issues and increasing importation costs are galvanising many Middle East countries to invest heavily in aquaculture to reduce their dependence on imported products. High imported feed costs, low seed availability and limited local technical skills are the main obstacles which need to be addressed. With the shortage of water, many high-tech RAS and aquaponics projects are under construction throughout the region. Several government-funded research centres are also under construction or already operational, such as the Qatar Aquaculture Research Centre. In Oman, a new aquaculture centre offers training courses and carries out research on local and imported species. There are several tilapia farms in Saudi Arabia which produced a total of 3,400 tonnes in 2019. There are also several large aquaponics farms using tilapia in the United Arab Emirates.

## Africa: Home of the tilapia

Africa has seen many false dawns in its aquaculture industry, but the recent expansion has significant momentum, with investors eager to capitalise on the growing demand for tilapia throughout Africa. African tilapia production usually refers to Egyptian production plus a small percentage spread thinly throughout Africa. In the last few years, scientists are expressing major concerns on the large number of endemic strains of tilapia found throughout East Africa which are being neglected in favour of imported genetically improved Nile tilapia stocks. Many of these local strains have shown considerable promise as aquaculture candidates; they are locally adapted and are also often the preferred option for consumers. Most of these species have declined dramatically due to overfishing and many East African countries have started breeding and selection programs to re-stock depleted fisheries and to start new aquaculture projects.

*Zambia KFL is one of the first tilapia farms in Zambia using extensive pond-based grow-out. Harvesting involves a lot of manpower which provides a lot of local employment.*

There are new farms planned in Egypt, Namibia, Zimbabwe, Uganda and South Africa. Egypt is projecting a 10% increase in production in 2020 if issues on hatchery production can be resolved. Most of its tilapia produced is sold in the domestic market as whole and live fish of 300-500g which takes 4-6 months to grow to this size. There are also demands for larger fish of 500-600g. More production will enable exports to regional markets. In Egypt, tilapia is farmed in earthen ponds usually 1-2 acres (0.25-0.5ha) and semi extensively at 1kg/m$^2$.

In Uganda with its abundance of freshwater, there is a major expansion through "Aquaculture parks" on Lake Victoria for tilapia production. Two new tilapia farms funded by the EU are under construction, each with a capacity of 20,000 tonnes, effectively tripling Uganda's production of tilapia.

Ghana has been rapidly expanding its tilapia industry over many years but has suffered badly from disease mainly at the hatchery and fingerling stages. UK scientists have been studying the mortalities and there is currently a mass tilapia vaccination program underway after heavy losses in the Volta Lake region which were linked to viral diseases. The Volta lake is the main production region in Ghana and the diseases are probably linked to imported strains of Nile tilapia. Ghana has its own genetic strain of Nile tilapia which should be preserved.

In South Africa, the Tilapia Aquaculture Association of Southern Africa (TAASA) is helping to drive the expansion. Lack of quality feed and fingerlings have been major

*One of the largest tilapia farms in South Africa contributing to the steady increase in production of tilapia there. This has a hatchery and a grow-out facility.*

*Cage culture of mainly red tilapia in Malaysia. Picture credit Abdullah Abdul Rahim, Universiti Pertanian Malaysia.*

limiting factors in Africa's expansion, but new confidence in the region has led to Aller-Aqua building a new tilapia feed mill in Zambia and expanding its factories in Egypt. A new entrant to the tilapia feed market in Egypt and the region is Grand Fish Feed. It has an annual capacity of 60,000 tonnes of fish feed.

In Kenya, Victory Tilapia Farm in Homa Bay, on Lake Victoria is one of the largest tilapia farms in East Africa currently producing 10,000 tonnes of tilapia annually in cages, and has in 2019, started construction of the biggest tilapia hatchery in East Africa to supply quality fingerlings to the region. The Kenyan government is very supportive of the aquaculture industry and in 2020, a new RAS project was completed in Kisumu. The project VicInAqua is an EU Horizon 2020 project in partnership with DALF (Department of Agriculture, Irrigation, Livestock and Fisheries of Kisumu County). The pilot plant will be maintained and operated as a training and demonstration facility. Genetics experts Xelect have just completed a genetic analysis project supported by Msingi East Africa. This project helps to enable modern genetic selective breeding in tilapia operations in Kenya and Uganda. The data will help East African tilapia producers to create long-term plans for sustainable breeding programs (see page 63).

During a June webinar organised by Aquaculture Africa magazine, panelists listed some concerns in the tilapia farming industry. While the commercialisation of tilapia farming is fast increasing, low inputs still persist in small-scale subsistence tilapia farming. Locally farmed tilapia competes with cheap imports from the Far East. The call was for Africans to consume locally produced tilapia. A bottleneck to expanding production is the lack of hatcheries to supply quality seed stock. While the Nile tilapia is the most common species farmed in brackish water systems, Neil Stallard, proposed a relook at *Oreochromis mossambicus* which does far better in saline environments. Its growth increases with salinity, and chronic stress is handled by upregulation of ion excretion and cortisol. Furthermore, the Nile tilapia is more susceptible to bacterial infections and other pathogens at a salinity of 15ppt and higher.

## Disease management and TiLV

As with all rapidly expanding agricultural enterprises, diseases tend to accompany global expansion. Historically the biggest threat to tilapia health was through *Streptococcus* infections (*S.agalacticae* and *S.iniae*) which caused mortality ranging from 40-80% resulting in significant economic losses especially when larger fish are affected. MSD Animal Health has developed Aquavac, a vaccine which immunises against both *Streptococcus* species. The vaccine is now available in Latin America. Another company Spring Genetics (Part of the Benchmark group) in conjunction with Akvaforsk is undertaking genetic selection breeding programs to provide resistance to both *Streptococcus* species mainly in Latin America but is still advising customers to use vaccination in conjunction with selective breeding. There have been many studies over the last few years which indicate that optimum feed quality can minimise the impact of *Streptococcus* infections. Lipid inclusion seems very important.

A major challenge to the tilapia industry is the Tilapia Lake Virus (TiLV) sweeping through many countries from Ecuador, Colombia, Thailand, Taiwan, Egypt, India, Malaysia and Israel. However, subclinical infections have been detected in the Tanzanian and Ugandan basins of Lake Victoria. Reports showed that at least 10 Sub-Saharan African (SSA) countries have likely imported TiLV infected tilapia fry and fingerlings from hatcheries in Thailand; Burundi, Congo, Mozambique, Nigeria, Rwanda, South Africa, Togo, Zambia, Tanzania and Uganda have been suspected to be infected with TiLV with the two latter countries recently confirmed. SSA is a newly reported region of TiLV circulation and all tilapia farming countries in the region may have risk of infection. Over 150,000 tonnes of tilapia from farming and more from the tilapia fisheries could be threatened in SSA due to TiLV.

A study by Fathi et al (2017) reported that 37% of Egyptian farms were affected by "summer mortality syndrome" in 2015. TiLV PCR positive tilapia was found on three of the seven farms surveyed. Most of the outbreaks occurred a month after the fish were transferred from the hatchery to the grow-out systems. Egyptian farmers are looking at a nursery phase to grow fish to 20-50g and reduce the time in open grow-out ponds. A research aim is to develop quick detection kits for TiLV.

All the main tilapia producing countries are monitoring the spread of the TiLV closely with some countries reporting mortalities of up to 90%. There is some evidence that certain genetic strains of tilapia are resistant to this disease. Ferguson et al. (2014) noted that one strain of tilapia (GMT-genetically male tilapia) incurred a significantly lower level of mortality (10-20%) compared with other strains. This was echoed by the OIE (World Organisation for Animal Health). Preliminary work suggests that there is vertical transmission of the virus from brood stock to fertilised eggs and fry.

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# The tilapia in the Philippines

## The trend is saline tilapia in brackishwater ponds with overcrowding of cages in major lakes and limited supply of freshwater for pond culture.

By Rafael D. Guerrero III

The introduced Nile tilapia (*Oreochromis niloticus*) is the second most important cultured fish next to the native milkfish (*Chanos chanos*) in the Philippines. In 2019, the production of farmed tilapia in the country was 279,006 tonnes from pond and cage culture, according to the Philippine Statistics Authority. The two regions producing the bulk of tilapia were Central Luzon (49%) for pond systems and Southern Tagalog (33%) for cage culture. The annual per capita consumption of tilapia in the country was 4.6kg in 2012.

The Philippines was the world's largest producer of farmed tilapia from 1986-1988. This was the result of the technologies developed by researchers of the Freshwater Aquaculture Center of the Central Luzon State University (FAC-CLSU) in Muñoz, Nueva Ecija in Central Luzon since the 1970s for the breeding, nursery, monosex culture (with hormonal sex reversal) in freshwater ponds and cages, and use of formulated feeds for commercial production of the fish. The assistance of the National Science Development Board, Bureau of Fisheries and Aquatic Resources (BFAR) and the United States Agency for International Development was also a significant factor for the successful transfer of the technologies to fish farmers throughout the country.

## Genetic improvements

In 1986, the collaboration between FAC-CLSU and the Southeast Asian Fisheries Center's Aquaculture Department through the Aquaculture Genetics Network In Asia (AGNA) organised by the International Development and Research Center of Canada (IDRC) was initiated to improve the genetics of the tilapia in the Philippines. In 1988, the then International Center for Living Aquatic Resources Management (ICLARM), now the WorldFish Center, in partnership with the BFAR, United Nations Development Programme, Food and Agriculture Organisation and the Asian Development Bank, started the project for the genetic improvement of farmed tilapia (GIFT). As an outcome of these projects, we have today the FaST (Freshwater Aquaculture Center selected tilapia) or IDRC strain, the genetically-enhanced tilapia excellent strain (GET-EXCEL) of the BFAR and the GenoMar Supreme Tilapia of a Norwegian company which are GIFT-derived strains of the Nile tilapia.

There are also tilapia hybrids used for culture in the country such as the brackishwater enhanced saline tilapia (*O. niloticus, Oreochromis mossambicus* and *Oreochromis spirulus*) or BEST and BFAR's Molobicus strain (*O. niloticus* and *O. mossambicus*) for brackishwater pond farming. A red tilapia hybrid *O. mossambicus* and *Oreochromis hornorum*) is being used for freshwater pond and sea cage culture by the private sector.

## Hatchery and nursery technology

For producing fry and fingerlings of the Nile tilapia, earthen ponds, tanks and hapas (fine-mesh net enclosures) are

*BAC-UPV's saline Nile tilapia strain. Successfully grown in seawater ponds in Iloilo, its culture is promising, according to Director Dr Rex Ferdinand Trafalgar. (Picture credit R.F. Trafalgar).*

used. The brood stock, each weighing 50-150g are stocked at 2-4/m$^2$ with a sex ratio of 1 male to 3-4 females and fed with a commercial diet (25% crude protein) at 2-3% of their body weight daily for 21-28 days. After stocking in ponds (200-400m$^2$ and 0.5-1m deep) and tanks (5x2.5x1m) for 10 days, the schooling fry, which have been released by the mouth-brooding females, are collected daily with a dip net for 11-18 days and transferred to nursery units. With hapas (5x2.5x1m) in ponds and tanks, the fertilised eggs and embryos inside the mouths of the females are gently removed by hand every 5 days and transferred to artificial incubation jars or trays with water exchange for further rearing until the young are ready to accept artificial feed. In this manner, the female brood stock which have only spawned partially, will readily return to breeding.

*Trays for artificial incubation of Nile tilapia eggs and embryos*

After the breeding cycle, the ponds and tanks are drained and the brood stock are removed and stocked separately by sex in hapas in ponds or tanks for conditioning for 1-2 weeks. The female brood stock are fed with a high protein diet (30% crude protein) at 3% of their body weight daily while the male brood stock are fed with a finisher diet (25% crude protein) at 2% of their body weight. The brood stock are restocked in the breeding units after conditioning for the next cycle. While the number of eggs spawned by a female tilapia increases with its size, the frequency of breeding decreases. Brood stock are replaced when their productivity decline, usually after 6 months to a year.

The fry are stocked in nursery units (ponds, tanks and hapas) at 50-200/m$^2$ (with or without artificial aeration and water exchange) and reared for 1-1.5 months to fingerling sizes (0.5-1g each) with feeding of fry mash (35-40% crude protein) given at 5-20% of body weight per day in

2-4 feedings. Sex-reversal treatment for producing all-male fingerlings that grow faster than the untreated young is done for the first 21 days of rearing by feeding the fry with feed supplemented with 17-α methyltestosterone at 20% per day for the first week, 15% per day for the second week and 10% per day for the third week. The average survival of fry is 70%.

To improve the spawning performance and fry survival of the Nile tilapia during the hot months (April-May) when water temperatures in the pond can exceed 32°C (the upper limit for the fish), researchers of the FAC-CLSU have proposed the use of net shades over the breeding ponds to provide at least 40% shade. A 500-$m^2$ pond with such shade ("Aquashade") has reduced water temperature by as much as 40°C and increased the spawning rate of the brood stock and fry production more than twice compared to those in the unshaded pond. Using bamboo poles and galvanised iron wire, the cost of the net shade is recovered within 6 months with a return of investment of 180%.

There are more than 2,000 hatchery/nursery operators in the Philippines with an annual production of more than 1 billion fingerlings.

## Grow-out technology

For intensive grow-out of the Nile tilapia in ponds (with commercial feeds, aeration and water exchange), fingerlings (2-5g) are stocked at 5-10/$m^2$ with water depth of at least 1m. Commercial feeds are given at 3-5% of fish body weight/day for 3-4 months to produce market-size fish weighing 150-250g at harvest with 85% survival. Commercial feeds cost PHP29.6/kg (USD 0.59/kg) and feed conversion ratios of 1.1-1.2 are reported.

## *Polyculture with marine shrimp*

Aside from monoculture of Nile tilapia in freshwater ponds, the fish is also polycultured with the introduced white shrimp (*Litopenaeus vannamei*) and the native tiger shrimp (*Penaeus monodon*) in brackishwater ponds. Vannamei shrimp post larvae (PL) are stocked at 40,000-50,000 and monodon PL at 5,000-10,000 and grown to sizes of 2-3g each before Nile tilapia fingerlings are stocked at 30,000-50,000/ha. Only the tilapia are fed with commercial feeds as in the monoculture system. After 4-5 months of culture, fish are harvested at marketable sizes of 200-250g each and the shrimp sizes are 20-30/kg for the monodon shrimp and size 60/kg for the vannamei shrimp.

## *Cage culture*

Cage culture of Nile tilapia is mainly done with fixed cages in shallow lakes and in floating cages in deep lakes and reservoirs. In Laguna de Bay (a shallow lake), the cages (10x10x1.5m) are made of polyethylene netting that are attached to bamboo poles which are staked into the bottom and stocked with fingerlings (1-2g) at 10-15/$m^2$. With the abundance of natural food in the lake, no feeds are given.

The fish are harvested after 6-8 months of culture with market sizes of 150-200g each, survival of 80% and yields of 160-180kg/cage. In deep lakes like Taal Lake in Batangas (Luzon), the floating cages (10x10x5m) with rafts built from galvanised iron pipes or bamboo poles from which the polyethylene net cages are suspended, are stocked with fingerlings (2-5g each) at 10-20/$m^2$. The fish are harvested after 4-5 months of culture (with feeding of commercial sinking/floating pellets) at market sizes of 250-350g each, survival of 85% and yields of 2-4.5 tonnes/cage. On the average, the cost of the commercial grow-out feed is PHP30/kg (USD 0.60/kg) with a feed conversion ratio of 1.8.

## *Saline red tilapia*

The "King Fish," a saline red tilapia hybrid, is cultured in floating cages (10x10x5m) in the coastal waters of Davao del Norte (Mindanao). Its fingerlings are produced in a freshwater hatchery/nursery with ponds and hapas. Prior to stocking in the grow-out sea cages, the 20g post-fingerlings are acclimated at a salinity of 5ppt per day for 7 days up to a salinity of 35ppt. The fish grow to 250-350g in 4 months with commercial pellet feeding and survival of 85%.

With the limited freshwater supply for ponds in Luzon and the crowding of cages in most of the country's major lakes, further expansion of tilapia production in these areas is unlikely. However, there is still potential for the culture of the fish in the country's 200,000ha of brackishwater ponds that are only partly utilised for milkfish and shrimp culture. Thus, the emergence of a saline Nile tilapia strain that has been successfully grown in seawater ponds of the Brackishwater Aquaculture Center of the University of the Philippines Visayas (BAC-UPV) in Iloilo shows promise, according to its Director, Dr Rex Ferdinand Trafalgar.

The harvested farmed tilapia are transported to wet markets as chilled fish in boxes containing ice or live in containers with aeration/oxygen. Most of the fish are sold fresh throughout the country, although there is some processing for dried and value-added products such as tilapia sausage, nuggets and even ice cream. Export of frozen whole (degutted) and filleted tilapia has been limited because of the high demand for the fish in the domestic market. Producers also get better returns with small size fish.


*Nile tilapia being sold in a wet market. In early June, prices dropped from PHP130/kg (USD 2.6/kg) to PHP110/kg (USD2.2/kg, msn.com/en-ph)*

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# Adapting GLOBALG.A.P. during the Covid-19 pandemic

The coronavirus pandemic has changed everything that is known and nothing is untouched, according to the team at GLOBALG.A.P. The company usually has its annual conference with updates on activities during the Seafood Expo Global 2020 (SEG).

This changed with the Covid-19 pandemic, and subsequently SEG in April was cancelled. "Undeterred, we arranged for virtual updates by our aquaculture experts for those wanting to know how to be certified, queries on certification and just to "pick our aquaculture experts' brains", said Dr Kristian Moeller, CEO. This was held over three days from April 21-23."

"This downtime also gave us the opportunity to rethink on virtual ways to reach out to customers and on how to collect inputs to set approvals, make it more inclusive, move to digitalisation and remote auditing. In the latter, we need to consider what we can collect virtually. How can we trust the supply chain using technology? We want to help farmers during this time. Our mission is to connect farmers with markets," added Moeller. "During these difficult times, consumer health as well as ethical issues like animal welfare are important. We need to have the holistic approach."

## Quick response to support producers: 6-month extension

"We all have to adjust daily as new information is released. We also had to re-evaluate our emergency procedure for certificate extension. We have decided to adapt our policy, like other certification program owners, to be aligned and to ensure transparency in the food supply chain and support those producers that need to show compliance with a Global Food Safety Initiative (GFSI) recognised standard," said Valeska Weymann, Senior Expert/Technical Key Account Aquaculture. "Compliance is important for us. In the case of food safety in aquaculture issues, only GLOBALG.A.P. is recognised by GFSI at the farming level."

A procedure which allows for a 6-month extension of GLOBALG.A.P. certificates without a remote audit/ inspection requirement has been published.

## Remote inspections and audits

As mentioned by Pham Viet Anh, Technical Key Account Manager based in Hanoi, Vietnam, "Although the pandemic is well controlled in Vietnam, our government do not encourage farm visits. Therefore, the 6-month extension and remote auditing process will help producers and suppliers."

Weymann added, "We are continuing to monitor and assess risks and recommendations in the face of the pandemic. Recent global developments have led to significant health and safety concerns, as well as to travel/movement restrictions in numerous countries and territories. To support our producers in this extraordinary situation, to safeguard the health and safety of inspectors and auditors, and to ensure a continuous supply of products from GLOBALG.A.P. certified production processes, we are considering alternative ways of conducting inspections and audits, including remote inspections and audits."

The current emergency procedure (published on 26 March 2020 is in line with the requirements of the Global Food Safety Initiative (GFSI). However, they do not include certification for new and existing clients based solely on remote inspections and audits. To meet this need, it is developing GLOBALG.A.P. Remote. There is a dedicated email address to streamline all feedback (remote@globalgap.org) and invitation to join the public consultation. However, initial thoughts can be sent to this email address.

## Aquaculture standards

These cover the entire stages on supply chain: feed, seed, farming, grow-out and post-harvest. For example, farmer/producers need to have feed and seed sourced from GLOBALG.A.P certified companies for their farming activities to get aquaculture GLOBALG.A.P. certificate for farms. The criteria cover four pillars on the FAO Guidelines on aquaculture production: on food safety, environment, animal welfare and social issues.

Pham said, "GLOBALG.A.P. certification has been taken up by those involved mainly in the export of pangasius, marine shrimp and barramundi and European consumers are very demanding in terms of sustainability, food safety etc." He added, that pangasius exporters are still reeling from the crisis in 2015 with a slump in demand for pangasius products. However, post-pandemic Pham expects a boost in demand. "Animal welfare is also big issue and how can we in Asian aquaculture follow these trends in Europe. Animal welfare is fully covered in GLOBALG.A.P.'s standards but how can we get our producers to be more aware and be ready for the future."

As of March 2020, GLOBALG.A.P. now has 2 million tonnes of aquaculture products put to the market from certified farms globally. There are 129 producers certified in Asia for various fish species including barramundi, pangasius, white grouper, seabream, seabass and marine shrimp.

## V6 revision: a more risk- and customer driven modular approach

Moeller reiterated on the need to remove duplication of standards by the three major bodies; ASC, GLOBALG.A.P. and BAP to assist producers. GLOBALG.A.P.'s V6 revision plans to offer a more risk- and customer driven modular approach. "This means that if producers want to combine certain features, such as animal welfare, they should be able to do so. I want the producer, wherever they are, to choose the different requirements, with the right risks and with no duplication. We will suggest customising checklists in such a way that there should not be three different audits, rather one synchronised combi-audit. GLOBALG.A.P. was founded to serve the market by reducing costs and reducing unnecessary duplications."

## Podcasts

The company has started podcasts called "G.A.P. Talks" and one on aquaculture Mark Nijhof, Quality Assurance and Product Integrity Manager of the Heiploeg Group has already been featured "We increase our communication with partners and producers," explained Moeller. https://bit.ly/31NcgLO

## The future

Now is also a time to look to the future and prepare for recovery. The company must continue to focus on innovation and move forward in matters of quality, traceability, and sustainability. Moeller quoted, Chris White, journalist and co-director at Fruitnet Media International GmbH, who in the latest G.A.P. Talk said, "Every season brings new opportunity and another season will come. We should make use of the skills that we have learned over a long period of time – and this applies to everybody in the supply chain. We're having to rethink why and how we do things and come up with new ideas and innovations."

"At GLOBALG.A.P. we are placing great importance in revising our IFA standard for version 6. The revised standard will shortly be reviewed in co-operation with many stakeholders during the World Consultation Tour." www.globalgap.org

*During a virtual discussion, Pham Viet Anh who covers certification activities in Asia, from his base in Hanoi, said that with restrictions o visits, the 6-month extension and remote auditing process will help producers and suppliers.*

# FeedKind® aquafeed project with Calysseo in Chongqing

The first commercial-scale new plant in the world fully funded through the Calysseo joint-venture between Adisseo and Calysta will be built in Chongqing's Changshou district. This is an important milestone for Feedkind® project. It will develop a major business supplying aquafeed ingredient in Asia with a market size of USD28 billion, representing 70% of the global market.

FeedKind protein, a sustainable, and traceable feed ingredient, provides innovative solutions for the growth of the aquafeed industry. It is produced via natural fermentation of natural gas, an abundant source of energy to create a safe, nutritious, traceable and affordable protein. It is made using little water and no agricultural land.

The project will be the very first commercial FeedKind facility in the world. The first phase with a 20,000 tonnes capacity is expected to go into operation by 2022. Once the first phase runs successfully, the second phase investment will follow, adding another 80,000 tonnes capacity and allowing a prompt market penetration with a potentially rapid expansion in the Asian market and building a profitable and sizeable business opportunity for all parties.

Adisseo, one of the world's leading experts in feed additives and one of the main subsidiaries of China National BlueStar, leader in the Chinese chemical industry, announced the location during a signing ceremony. This reflects the company's commitment to increase its investment in China and pursue aquafeed opportunities in Asia.

Despite difficulties around the COVID-19 pandemic, the project has continuously progressed with support from all parties, thus enabling the successful organisation of the signing ceremony convened via a cloud meeting. Participation included representatives from all parties; China Bluestar Group in Beijing, Calysta in US and in Shanghai, Adisseo in Paris and in Shanghai as well as officials from Chongqing municipal and Changshou District government in Chongqing.

During the ceremony, Zheng Xiangdong, Deputy Mayor of Chongqing, on behalf of the Chongqing government and Changshou Region, extended his sincere gratitude to Bluestar Group, Adisseo and Calysta for choosing the Changshou region as the home for this production facility. He believes the project's location will contribute to the transformation and upgrade of the natural gas chemical industry in Chongqing and Changshou regions and further reinforce China's leading position in the global biochemistry industry.

Zhao Shiqing, Party Secretary of Changshou District said that the Changshou District is committed to further deepen the reform of "regulation and service", striving to create a market-oriented, law-based and internationalised business environment. It is vigorously supporting the project implementation, future development and operation.

Chairman of Bluestar Group and Adisseo, Hao Zhigang, said, "I am delighted to join the investment signing ceremony, which marks another key step for the rollout of Adisseo business diversification strategy as well as its China development strategy. I would like to, on behalf of Adisseo's and all our business partners, express our gratitude to Chongqing and Changshou governments, for all the support extended to the project."

Hao added, "Adisseo and Calysta, have very high expectations for the project. It is a major strategic investment for us. Being the controlling shareholder of Adisseo, we will continue to give our strongest support to Calysseo in building the first high-tech, safe and environmentally friendly manufacturing unit for FeedKind in Chongqing. On the business front, Adisseo is already developing and marketing high-quality feed additives for aquaculture and is moving into a new dimension with FeedKind.

"Today's announcement brings us another step closer to realising our ambition and we are delighted by the ambition and support of our partners in this. We believe that this project will be successfully completed and put into operation, and will rapidly realise its returns, bring real benefits to consumers and provide more innovation capabilities for the industry."
www.adisseo.com; www.calysta.com

*Hao Zhigang, Chairman of Bluestar Group and Adisseo*

# DSM to acquire Erber Group's Biomin and Romer Labs

In June, Royal DSM, a global science-based company in nutrition, health and sustainable living, announced that it has reached agreement to acquire Erber Group for an enterprise value of €980 million. The value of the transaction represents an EV/EBITDA multiple of about 14x the 2020 EBITDA (fiscal year ending September 2020). The transaction – which excludes two smaller units in the Erber Group – is expected to be earnings enhancing in the first year upon completion.

Erber Group's specialty animal nutrition and health businesses, Biomin and Romer Labs, specialise primarily in mycotoxin risk management, gut health performance management, and food and feed safety diagnostic solutions, expanding DSM's range of higher value-add specialty solutions. Romer Labs also complements DSM's human nutrition and health offering to food industry customers. Sanphar and EFB, representing 7% of Erber Group's total sales, are not included in this transaction.

The acquired businesses have combined sales of €330 million and an adjusted EBITDA margin above 20% for the twelve months to the end of March 2020, with a high single-digit organic sales growth rate over the past 5 years. The acquisition will be debt financed, with committed bridge financing in place. DSM continues to benefit from a strong balance sheet and remains committed to maintaining a strong investment grade credit profile.

With state-of-the-art research and manufacturing facilities and approximately 1,200 employees around the world, the acquisition of Erber Group is a unique strategic opportunity that provides revenue-enhancing synergies from the combined offering, global customer base, and complementary geographic strengths. Austrian-based Erber Group offers DSM the opportunity to enter the mycotoxin risk management market as the world leader and extends the company's position as one of the top suppliers in the rapidly growing animal gut performance management market.

Mycotoxins in animal feed threaten the health of both animals and humans. Biomin's patented and proprietary technology provides the most scientifically advanced mycotoxin protection available. Biomin is also a major producer of phytogenic and probiotic feed alternatives to antibiotics, which complements and strengthens DSM's position in the rapidly growing global eubiotics market for improving animal gut health.

Romer Labs is at the forefront of diagnostic technology with innovative testing solutions for the analysis of mycotoxins in feed and food, food allergens and pathogens as well as veterinary drug residues, with accredited full-service laboratories in Austria, UK, USA and Singapore. DSM's extensive global network of food and beverage customers as well as feed customers stand to benefit from Romer Labs' expertise and the combined group's data-based quality assurance offering.

The acquisition of Erber Group further strengthens DSM's expertise and reputation as a leading provider of animal health and nutrition solutions for farm productivity and sustainability, with an emphasis on emissions reduction, feed consumption efficiency, and better use of water and land.

Geraldine Matchett and Dimitri de Vreeze, Co-CEOs of DSM, said, "These are great businesses with strong and sustained track records of profitable growth and attractive margins. Biomin and Romer Labs will help strengthen and accelerate the growth of our specialty animal nutrition and health offering, including our big data and diagnostic capabilities, and it is exciting to be entrusted to take these family-founded businesses forward. It was immediately clear to us that the people at Erber Group share our purpose-led mission and will make a wonderful addition to DSM".

Dr Erich Erber, Founder and President of Erber Group, said, "In DSM, I recognise the mutual values of sustainable stewardship that are so important to us. The world must reduce farming's environmental impact at the same time as increasing protein production to feed 10 billion people by 2050. To do that, we must make sure protein is produced sustainably, using renewable ingredients as much as possible, while protecting the well-being of animals. DSM is the perfect home for our businesses, as Biomin and Romer Labs will be able to use their new scale to intensify our joint contribution to a more sustainable world's food supply". The transaction, which remains subject to customary conditions, is expected to close in Q4 2020. www.dsm.com/www.biomin.net

# Getting it right at every step with vitamins in aquafeed with DSM'S APAC

In July, DSM Aqua Asia Pacific (APAC) kicks off its regional launch of 'Getting It Right At Every Step' with vitamins. The growth and success of the aquaculture industry is based on the ability to raise animals to harvest size with survival rates that allow farmers to generate sustainable income and profits; and to achieve that, vitamins are indispensable.

At each stage in the culture of aquatic animals, from brood stock and larvae in the hatchery to successful grow out to harvest weight in ponds or cages, there are expected goals and outcomes, which are key indicators of performance or success.

"Getting It Right at Every Step" focuses on the key indicators and expected goals for successful aquaculture, the steps are as follows.

- Right for Animals
- Right for Aquafeed Processing and Handling Conditions
- Right Value and Right Fit for Sustainable Aquaculture
- Right Supply Chain Partner

"The campaign reinforces the importance of 'Getting It Right At Every Step' in the value chain to achieve more sustainable feed manufacturing and aquaculture production while also addressing the quality of final products and how improved quality can help tackle food loss and waste – a key performance indicator for sustainable food systems", says Pieter Nuboer, Vice President ANH APAC. It aims to help companies build their capabilities towards more profitable, sustainable aquaculture.

It is yet another step forward by DSM in providing tangible, measurable, and science-based solutions to the biggest challenges facing society and the sustainability of the animal protein industry.

The awareness of this campaign will be promoted through a series of planned, sequenced activities, from hands on to virtual experiences that will highlight how connected actions can help a feed company further build its differentiation in the marketplace. The campaign reinforces DSM's commitment of bringing better food, nutrition and health for all within planetary boundaries. www.dsm.com/anh

# BioMar achieves a 5-year average FIFO of below 1:1

High use of trimmings and the use of novel ingredients has enabled BioMar Group to achieve a five-year average fish in: fish out ratio of 1:1 or below Forage Fish Dependency Ratio for its raw material usage. This is one of many findings revealed in its Integrated Sustainability Report for 2019, released in June.

"Although it seemed unlikely that it would be possibleto achieve a great FIFO ratio every year, due to ever changing market conditions. We see that by embedding a sustainability mindset in our culture we have been able to achieve this impressive milestone while still delivering on our financial results", said Carlos Diaz, CEO, BioMar Group.

Sustainability has long been a core pillar in BioMar alongside innovation, and although market conditions for raw materials will change from year-to-year, the investment in innovation for alternative ingredients is paying off. There is no end point to sustainability and innovation and as BioMar is solely dedicated to aquaculture feeds the success of the company depends on the sustainable future of the aquaculture industry.

"Only with the wider adoption of novel ingredients in sustainable feeds will these products become cost competitive and mass market scale can be achieved. We see a future where seafood from aquaculture will be seen by consumers as the sustainable protein choice for the good of the planet", stated Vidar Gundersen, Global Sustainability Director, BioMar Group.

BioMar is this year, reporting more of its community and society activities as the United Nations (UN) Sustainable Development Goals clearly state that sustainability goes beyond your own products and operations. "We have always believed that education and knowledge exchange is the key to driving long term sustainable development and we are proud to this year add to the report our achievements in these areas. Later this year we will review our corporate KPIs with the intention of setting ambitious targets that will continue to drive us even further", added Diaz.

Gundersen explains why setting ambitious sustainable development targets are important. "We are now entering the decade of ocean science as declared by the UN, and this year's report highlights the importance for good stewardship and management of our oceans. We see the wider adoption of novel ingredients as being important for achieving this. We are also taking transparency and traceability one step further and our partner Orivo recently launched a solution for DNA-based authenticity of marine products which we already have implemented to our quality procedures".

The World Resources Institute in their Creating a Sustainable Food Future report pointed to sustainable aquaculture feeds as one of their top five solutions. That is why BioMar accepted the invitation to be part of the advisory board for the High-Level Panel for A Sustainable Ocean Economy along with the UN, 14 serving government leaders and other business leaders. BioMar launches this year's sustainability report with a marketing campaign to help promote sustainable practices and facilitate in the wider adoption of sustainable feeds across the aquaculture industry. www.biomar.com

# Ocialis unveils new brand identity

In June, **ADM Animal Nutrition's** aquaculture brand, Ocialis launched a new brand identity as part of its long term strategy to strengthen its industrial and commercial footprint, in addition to consolidating its position as a leading aquaculture player in the Asia Pacific region. The move also reflects the company's investment in developing Ocialis as a global provider of aquaculture solutions.

"The new logo reflects the brand's evolution, as well as our vision, mission and core values. In addition, we have given our packaging a new look to reflect the brand's strong development, high quality products and customer focus," said Pierre Domps, Marketing and Commercial Development Director for ADM Animal Nutrition in Asia.

In recent years, Ocialis has invested in innovations such as Biosipec, an innovative and intensive shrimp farming model; Nanolis, feed dedicated to the nursery stage; an application with a chatbot function to offer real-time technical support to aquaculture farmers; a mobile lab to support aquaculture farmers with water quality analysis, farm evaluation and technical farming advice; and Best Aquaculture Practices (BAP) certification at some of its feed mills to enable Ocialis customers to export their products all over the world, as well as to the US market.

"The brand refresh reflects our commitment for Ocialis to be the leading partner for aquaculture nutrition customers by delivering high performing, safe and profitable solutions for all species, which are adapted to local requirements. What makes us unique in the market is that we can leverage numerous synergies in R&D and innovation across ADM's Animal Nutrition portfolio worldwide, including Epicore, a well-known producer of probiotics for the global shrimp market; Pancosma, a global provider of innovative animal feed additives and concepts; Wisium, a global leader in the premix industry, and Bernaqua, one of the top providers of hatchery feeds," said Marc Campet, Aquaculture Manager for ADM Animal Nutrition in Asia.


Since it was first introduced in 2003 in Vietnam, Ocialis has been trusted by local aquaculture farmers as the go-to brand for high quality aquaculture nutrition. For nearly two decades, Ocialis has strived to meet global standards, reaching customers across Asia Pacific, including Indonesia, the Philippines and more recently, China.

"With our network of local and international experts, and aquaculture R&D centre located in Nha Be, Vietnam, we have developed and tested proven aquaculture solutions. Our mission is to support aquaculture producers with a comprehensive approach to nutrition to optimise technical results, profitability and growth, with a focus on sustainability," added Domps. www.adm.com

# New partnership in Kenya: Unlocking the genetic potential of tilapia

Genetics experts **Xelect** have just completed a genetic analysis project supported by Msingi East Africa. This project helps to enable modern genetic selective breeding in tilapia operations in Kenya and Uganda. The project is a significant step forward in sustainable aquaculture in the area, and began with Xelect's experts providing the partner farms with on-the-ground training in the best methods to take tissue samples. The samples were then brought back to Xelect's custom built laboratory in Scotland for DNA extraction and genetic analysis.

This data will help East African Tilapia producers create long-term, sustainable breeding programme plans. Operations Director, Dr Tom Ashton, who visited the teams in Kenya earlier this year, commented, "We're delighted to be working with East African tilapia hatcheries. We're now a major step closer to helping with regional food stability for the area".

2020 has already been a period of considerable expansion for the St Andrews based laboratory, which has secured 6 new partnerships in recent months. The company recently announced an expansion of its breeding programme management team, a new rapid response genetics service and made a number of key hires in genetics and marketing.

CEO Professor Ian Johnston believes this growth is due to an increasing maturity in the market. "With so much inward investment in the industry we've reached a tipping point. We believe the market will ultimately fracture into major producers, using the latest genetics best practice and smaller local operations. Investors would be very unwise to commit significant resources to aquaculture operations if they don't truly understand - and protect - the genetic capital of their brood stock." www. xelect.co.uk

# From pioneer in aquafeed additives to leading aquaculture innovator

Adisseo is a global leader in animal nutrition that offers solutions for precision feeding, animal performance, feed integrity and technology services. Its Business Unit Aquaculture, acquired with Nutriad in 2018, globally leads product development, product management, technical services and sales for a specialised range of feed additives.


*Dr Peter Coutteau (back row, left), BU Director Aquaculture with teams from BU Aquaculture, Adisseo France and Adisseo Asia Pacific during the December 2019 opening of the Aquaculture Station by Adisseo (ASA), a RAS test facility at St Johns Island, Singapore. Picture by Adisseo.*

The history of the BU Aquaculture began in the late 1990s when Dr Peter Coutteau, currently BU Director Aquaculture, initiated pioneering research on the development of nutritional and health promoting concepts for a diversity of aquaculture species. Throughout the incorporation of the aqua team into Nutriad in 2009 and Adisseo in 2018, a specialised portfolio of additives was developed for aquafeed producers. Its ambitions in aquaculture have further empowered the rapid development of the BU.

Adisseo continues to expand the global/local aqua teams and increase its presence in key markets for aquaculture in Asia, China, Latin America, Middle East and Europe. The focus on R&D and innovation in aquaculture was reinforced with the inauguration of the Aquaculture Station by Adisseo (ASA) in December 2019. This is a RAS test facility at St Johns Island, Singapore. These significant investments will enhance Adisseo's capacity in applied research as well as its leadership position in aquaculture innovation. The recently announced joint venture with Calysta to produce and commercialise a novel single-cell protein illustrates Adisseo's ambition to continuously seek for innovative and added-value solutions for the aquaculture industry.

## One ambition: Grow customers business in a sustainable and profitable way

Consumer trends around the world point out an increased awareness on the health benefits of seafood. This growing demand is being filled by aquaculture, which showed a staggering growth during the past three decades. As a result, today over 50% of the seafood we consume is farmed. Farmed seafood production is expected to remain the fastest animal protein-producing industry in the next decade.

Aquaculture is a rapidly evolving industry driven by multiple technological developments in the field of disease prevention, nutrition and farming technology. This is an opportunity for aquafeed producers to consolidate their role at the centre of the value chain. Adisseo is determined to take the lead on innovation in aquafeed and support the sustainable and profitable growth of its aqua customers.

Adisseo has two pillars to achieve this ambition. The first pillar is the development of species-specific solutions. Farmers produce a wide diversity of species of fish and shrimp around the world in different culture systems and climate conditions. Understanding species-specific challenges and local farming conditions is the starting point for any aquaculture solution at Adisseo. The complete portfolio for aquaculture covers now six different programs: health, digestion, palatability, feed quality, specialty nutrition and farm care.

The second pillar is to support the customer with dedicated aqua experts, to optimise the application of the wide range of health and nutritional solutions. In a young industry like aquaculture, many problems do not have a proven solution yet. Adisseo's aqua team works alongside with its customers to optimise the application.

Two service platforms are available for aquafeed producers and integrated farmers of fish and shrimp:

- The Aqua Nutrition platform provides services related to optimising the feed formulation, feed processing, QC/QA of raw materials and finished feed.
- The Aqua Health platform focusses on optimising disease prevention programs with in-feed additives and complementary farm care solutions.

"Regional aquaculture specialists are an integral part of our strategy to increase our footprint in the key aquaculture markets around the world. The sustainability of the industry is challenged in all species by disease outbreaks and scarcity of marine ingredients, two areas where Adisseo offers multiple solutions and services", says Dr Peter Coutteau.

"Developing and supplying species-specific solutions for the aqua market, is a challenge for a global company like Adisseo, but it has helped us to create a leadership position in the industry that recognises us for how we convert science into practical solutions. This builds on a deep understanding of the challenges producers around the world face. At Adisseo, we have a unique combination of technical knowledge across a wide variety of specialty additive platforms to support our developments in aquaculture," says Francois Pellet, Adisseo's SBU Director Specialties. www.adisseo.com

# More technologies for warm-water aquaculture

**Bayer Animal Health** is boosting its solution offerings for shrimp and other warm-water aquaculture species through supply and distribution agreements with water treatment technology suppliers, Cytozyme Laboratories Inc. and Chengdu Kehongda Technology Co., Ltd, as well as farm management technology provider, XpertSea Solutions Inc.

With these agreements, Bayer Animal Health extends to farmers in key shrimp producing countries greater access to pond water environment management technologies, further enhancing operational efficiency and sustainability.

## Optimising pond environments

Water treatment solutions play an important role in aquaculture, enabling producers to manage the complex pond ecosystem and provide an optimal environment for shrimp to thrive. As part of the agreement with Cytozyme, Bayer Animal Health will commercialise Proquatic™ PondRestore, a product that enhances metabolisation activities in the pond-soil and pond-water environment, in several key aquaculture countries. The product is already part of Bayer Animal Health's water treatment portfolio in China.

The agreement with Kehonda will enable the rollout of Fetant™ Complex Iodine Solution technology as part of Bayer Animal Health's portfolio in China and Vietnam. This partnership follows the inclusion of Dyvon™ PondAcid to Bayer Animal Health's water treatment solution program in China. The product is a pond-water conditioner that supports the quality of phytoplankton populations and maintains levels of dissolved oxygen in the pond water.

## Advancing digital in aquaculture

Together with XpertSea, Bayer Animal Health advances digital farming in shrimp aquaculture. The agreement offers smart devices and artificial intelligence powered software for a comprehensive approach to data driven farm management, as part of its integrated services in China, Ecuador, India and Vietnam. The devices leverage optics to measure vital pond statistics over time and identify changes in the health of a population. Insights are aggregated into XpertSea's online Growth Platform, which aids producers in making data-driven management and treatment decisions.

"We are proud to be able to play a leading role in offering shrimp producers an application program of non-pharmaceutical pond-water treatment products that make up a comprehensive solution. Together with our partners, we are committed to continue bringing technology to shrimp producers and supporting the sustainable development of the industry," said Jan Koesling, Global Aquaculture Manager at Bayer Animal Health.

Over the last decades, Bayer Animal Health has fine-tuned its offering of water treatment solutions to address the needs of warm-water pond aquaculture customers in different segments. These agreements follow successful pilot projects in China and Vietnam in 2019. www.bayer.com; www.cytozyme.com; www.xpertsea.com

# New Artemia innovation drives efficiency in shrimp and fish hatcheries

**INVE Aquaculture** part of Benchmark has launched new tools for farmers to drive efficiency in hatcheries. The SEP-*ART* Tools are a sustainable solution designed to maintain quality nauplii, reduce losses and ensure safety for workers and the environment.

Traditionally Artemia nauplii are separated from cysts using a double sieve or a decapsulation method which can cause mortalities in the nauplii, quality issues and is often labour intensive. Decapsulation is also a chemical exothermic process resulting in the release of waste product and toxic gasses which can be a risk to the environment and operators. During the decapsulation process heat is also produced which can damage Artemia cysts.

The newly launched tools are based on the Artemia SEP-Art technology produced by INVE Aquaculture in 2008. The SEP-Art technology consists of cysts covered with iron particles which are attracted to magnets leaving nauplii in the solution. Available in manual, semi-manual and fully automatic, the tools are tailored to all hatchery sizes.

SEP-*Art*

Geert Rombaut, Product Portfolio Manager commented, "We have been working on this innovation over two years and are now very pleased to bring our new tools to the market.

"We always work closely with our customers to understand their needs. Efficiency is an important part of any aquaculture production system and we hope that these tools will support the healthy growth of fish and shrimp and our customers businesses".

The three new products, HandyMag, CystTM 2.0, and AutoMag allows all hatcheries, small, medium or large, to produce higher quality nauplii in a standardised and efficient way. www.inveaquaculture.com

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# WA 2020

## NEXT GENERATION AQUACULTURE

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**For more info on the CONFERENCE: www.was.org - worldaqua@was.org**
**For more info on the TRADESHOW: mario@marevent.com**

# Announcement on new dates:

## November 3-4 2021, South Carolina, USA

The RAStech Conference, originally scheduled for November 16-17, 2020, has now been moved to November 3-4, 2021. The RAS Investors' Workshop has also been rescheduled for November 5, 2021. The event will remain in the same location at the Westin Hilton Head Island Resort in South Carolina, USA.

"The continued call by government and public health officials around the world to practice social distancing and avoid large gatherings to reduce health risks associated with COVID-19 has influenced our decision to postpone the RAStech conference," said Todd Humber, group publisher at Annex Business Media. "We look forward to safely welcoming professionals from across the world next year at this industry-leading event."

Attendees, sponsors and exhibitors who have registered for RAStech 2020 will automatically be rolled over to the 2021 event. More than 75% of the 2021 tradeshow booths are currently sold out.

The annual RAStech Conference and Tradeshow is hosted by Annex Business Media, publishers of RAStech magazine, Hatchery International, Aquaculture North America, in cooperation with Virginia Tech. This international event welcomed close to 400 attendees from 21 countries in Washington, DC in 2019. www.ras-tec.com

Rescheduled to 2021

## January 10-15 2021, Busan Korea

The local organising and international scientific committee of International Symposium on Fish Nutrition and Feeding (ISFNF) had to make changes to the dates. The meeting will be held at BEXCO, Busan, Korea. Some changes to dates are as follows:

Early registration deadline date: **October 15, 2020**
Abstract submission date: **November 18, 2020**

Organisers will continue to monitor the global spread of Covid-19. In addition, the LOC is discussing the possibility of an online version of ISFNF 2020.

The aim of ISFNF is to advance all aspects of aquatic animal nutrition research. It brings together researchers, industry, government and other stakeholders to identify and address constraints limiting aquaculture production, fish health and food safety, with a view to recognising the need for adopting approaches based on new knowledge, emerging technology and novel ideas.
www.isfnf2020busan.com/

# 2020

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

**August 26-28**
**Vietfish 2020**
**Ho Chi Minh City, Vietnam**
www.vietfish.com.vn

**September 30-October 2**
**22nd Japan International Seafood & Technology Expo**
**Tokyo, Japan**
www.exhibitiontech.com

**October 7-9**
**VietShrimp Aquaculture International Fair 2020**
**Cantho City, Vietnam**
https://vietshrimp.net

**November 28-December 1**
**Aquaculture Africa 2020**
**Alexandria, Egypt**
www.was.org

**December 3-5**
**Taiwan International Fisheries and Seafood Show**
**Taipei**
www.taiwanfishery.com

**December 14-18**
**World Aquaculture 2020**
**Singapore**
www.was.org

# New Dates 2021

**January 10-15**
**ISFNF 2020**
**Busan, Korea**
www.isfnf2020busan.com

**April 12-15**
**Aquaculture Europe (AE2020 Cork)**
**Cork, Ireland**
https://aquaeas.eu/

**April 27-29**
**Seafood Expo Global 2021**
**Barcelona, Spain**
https://www.seafoodexpo.com/global/

**August 18-19**
**TARS 2021: Shrimp Aquaculture**
**Ho Chi Minh City, Vietnam**
www.tarsaquaculture.com

**August 24-26**
**Livestock Malaysia 2020**
**Melaka**
www.livestockmalaysia.com

**September 14-17**
**SPACE 2021**
**Rennes, France**
www.space.fr

**November 3-4**
**RAStech**
**South Carolina, USA**
www.ras-tec.com

**TBA**
**11th Symposium on Diseases in Asian Aquaculture (DAA11 2020)**
**Kuching, Malaysia**
www.daa11.org

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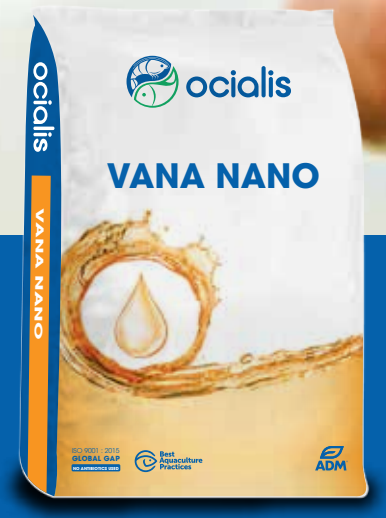


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