

FISH FARMING TECHNOLOGY

I N T E R N A T I O N A L

AQUA FEED

AQUACULTURE IN BRAZIL

The US\$1 billion industry

- Rearing *Oncorhynchus mykiss* on corn fermented protein product
- Choosing the right organic acids blend for aquaculture feed
- Pursuing sustainable aquafeed production
- Do land-based RAS face insurmountable challenges?
- Preventing springtime fish deaths on your aqua farm

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Wheat Global, 2012-2020	88.00	12.08	0.34	0.19	0.26	0.45	0.34	0.15	0.58	0.41	0.79	0.51	0.27	0.54
Wheat Argentina, 2016-2017	88.00	12.09	0.38	0.18	0.27	0.45	0.36	0.13	0.60	0.42	0.80	0.52	0.27	0.53
Wheat Canada, 2014-2020	88.00	13.92	0.37	0.21	0.10	0.51	0.38	0.18	0.64	0.47	0.90	0.58	0.31	0.62
Wheat China, 2016-2017	88.00	13.16	0.35	0.21	0.31	0.11	0.36	0.16	0.64	0.44	0.84	0.56	0.31	0.58
Wheat Czech Republic, 2015-2019	88.00	13.17	0.35	0.20	0.11	0.48								
Wheat Denmark, 2015-2019	88.00	10.11												
Wheat Estonia, 2016-2018	88.00	13.11												
Wheat Finland, 2015-2020	88.00	15.11												

WELCOME

If you haven't heard already IAF is sponsoring the Online Milling School's latest course addition - a 12 week course on aquafeed production. The course has already started and will provide attendees who complete it with a certificate of attainment outlining the various processes and aspects learnt at its conclusion.

And no, it's not too late to join this Spring Edition as you will have a three-week opportunity at the end of 12 week course to catch up on missed sessions. The course provides a great insight into all aspects of producing top-quality feed products that farmers are requesting and which will help drive efficiencies into any aquafeed operation.

So take a look at the www.onlinemillingschool.com for details. It's well worth considering.

So much for the promo. I only mention this as it's important for our sector to become more globally unified in the way we are producing our aquafeeds; in order to meet the ever increasing demands from nutritionists, fish farmers and ultimately the consumer him/herself. Producing feeds according to past formulations and production practices are no longer ideal and much more is expected from us as seafood (of which aquaculture now provides over half) becomes more sustainable and the quality of food products produced continue to meet the expectations of consumers with regard to taste, enjoyment, nutritional need and price. Food safety is also an ever-present requirement that can't be overlooked.

Our columnist Petter Johannessen, the Director General of the IFFO (see page 16), who talks on the critical supporting role fishmeal and fish oil continue to play in aquafeed production, tells me separately that back in 1963 the WHO and FAO formed Codex Alimentarius to provide global guidance on food safety and in most cases formed the basis for the national legislation we have today. As a result science and good risk management principles have become pillars of national governments' food safety approach. And foodstuffs from aquaculture are included in these guidelines.

He also tells me that globally-fed aquaculture production was estimated at approximately 56 million tonnes in 2018 and compared favourable



Roger Gilbert
*Publisher – International Aquafeed
and Fish Farming Technology*

with pork production at 120 million tonnes and poultry at 111 million tonnes (source: IFFO and FAO) at that time.

But what does that mean in terms of feeding our global population today? Is aquaculture making a significant contribution to global food security or not? If so, do we fully appreciate the contribution it is making?

Understanding how important aquaculture has become to global sustenance might encourage us to take a more progressive stance in pushing forward our research and development agendas to become a more sustainable industry and to counter those who decry our achievements.

On the back of an envelope I have done a quick calculation that shows – and you might want to correct me if I have made incorrect assumptions – based on an adult weighing in at 80kg (175.5lbs) and consuming a 255g (9oz) portion of fish per meal, the aquaculture industry in 2018 would have supplied in excess of 244 billion meals – or a meal for every person on the planet for every day in any one month within that year! And if aquaculture was half of the total seafood produced at that time (with the balance coming from the capture fisheries industry) then fish and marine proteins were providing a daily protein meal for the world's population for a full two months in the year. That's a major contribution to our global health and nutritional requirement that can't be simply replaced by another protein source. And today, in 2021, that contribution can only have increased.

We have challenges to overcome without doubt. Some criticism is deserved, however we are well equipped with science and technology to address those concerns and provide an increasingly efficient, sustainable and environmentally supportive food production chain that can compete with the most efficient land-based protein food systems – including plant protein production.

Therefore, it is important that we in turn challenge the misinformation that aquaculture and fisheries now face and that we double our efforts to meet the growing demand for these valuable and nutritious fish protein foods that can and are being made available at affordable prices around the world. We are already making a significant contribution to food supply and that will only grow in the future.

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Do land-based RAS face insurmountable challenges?:

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The month of May heralds warmer temperatures for us in Northern Europe, but of course the start of autumn and shorter days in the Southern Hemisphere. Indeed the seasonal variations affect mostly everywhere except the equator and sub-tropical regions of our planet.

This has of course made aquaculture so diverse in nature reflecting our huge differences in climate and the nature of an array of species of every variety.

From salmon to tilapia, carp and to grouper, seabass and seabream, eel and shrimp - this has proven a constraint as well as an advantage in the location of so many aquaculture enterprises around the globe.

Now with the rapid advances in technology we see the RAS revolution allowing an expansion onto land to farm an infinite number of species.

The full control of the rearing environment such as water quality, oxygen, ammonia, pH, lighting, etc, provides a flexibility previously out of reach to the producer. In this respect, we can largely avoid the effects of external parameters on fish and shrimp and also greatly reduce the problems of outside vectors like pathogens (bacteria, viruses) and also protect stock from predation and changes in weather, etc.

Indeed, the costs maybe high but the engineering is becoming established with the advent of modular designs that can almost fit together like Lego bricks to enable expansion of facilities from 100 tonne units to much larger amounting to 1000 tonne production facilities and more.

I am quite amazed how the concept has taken and we now see fish farms in the desert with heavy investments by Arab nations including UAE and Saudi Arabia.

Fact and science ignorant

We continue to see controversy in the media and various launching of negative broadcasts and books that condemn aquaculture and also capture fisheries. Following the recent Netflix produced film 'Seaspiracy' that made headlines, we now have another output from Australia focusing on the Tasmanian salmon farming industry with a book by Richard Flanagan, causing a stir and a defensive feedback from many sectors of aquaculture.

Mr Flanagan is an Australian author with many books to his name, most are fictional novels and he is respected for those. However, in his recent publication called 'toxic' he hits out at the fish farming industry with many unsubstantiated claims similar to many we have seen and heard before by ardent critics of the industry globally.

It is incredible how ignorant these persons are of the facts and science. It's also so bad they do not enter into dialogues with experts and practitioners of the science and farmers directly.

One concern to me in the fish nutrition and feeding area is his specific views on the use of pigmentation products, describing these as synthetic chemical dyes to artificially colour the flesh of salmon.

This is such an old statement that I've heard often from such ill-informed people without any ideas of the facts. Of course, astaxanthin can originate from many sources and the standard products are indistinguishable from that found in nature and are manufactured to the highest specifications for quality.



Professor Simon Davies

Nutrition Editor, International Aquafeed

Indeed, many feed manufacturers offer diets for salmon containing carotenoids from natural single cell sources such as from algae, yeast and now bacterial derived carotenoids.

Some organic diets may use by-products from crustaceans such as shrimp waste from processing, crab meals and in certain cases krill meal.

The author has also stated that a third of the diets in Tasmanian salmon feeds is based on what is simply described as 'minced chicken'. He fails to note that it is actually poultry meat meal, a

high quality validated protein from the scrutinised rendering industry offering a processed 'cooked' ground meal derived from animals fit for human consumption that is, Category III. His knowledge of the use of fishmeal, oils and the quest to utilise alternative sustainable ingredients is non-existent it would appear.

Perhaps we should kindly provide him with a year's subscription free of charge of IAF. It would be an education indeed!

Freedom of expression from non-experts

There is no end to misinformation and today's social media allows non-experts to freely attack various enterprises without impunity. It is the duty of trade magazines like IAF/Fish Farming Technology to promote all the science and associated technological development, the new products being generated through hard work and investment to the global audience based on reliable facts and transparency.

Turning to our May edition of IAF, we include an article on using a high protein fermented corn protein resulting from advanced processing within the bio-refinery industry from Flint Hills Resources in the USA. We featured last year successful trials with Atlantic salmon but now we repost recent studies with rainbow trout. I have been fortunate to work with this team in the USA and delighted to again lead this report.

Phibro present an article on the use of bespoke feed additives to enhance the performance of shrimp and there is a very interesting report from my friend Claudia Figueiredo-Silvia on the latest applications of feed performance minerals produced by Zinco Corporation who specialise in this area of the feed sector.

In relation to the technology and engineering of feed manufacturing we have updates from one of the big names in milling and pelleting equipment, Wenger in Germany. They report on using their technology for promoting sustainable aquaculture solutions.

Finally, I was privileged to visit Brazil in 2008 and 2012 and as a growing powerhouse in South America with a very strong agri-tech based economy with a very keen interest to expand its aquaculture industry.

This dynamic BRIC nation has its eyes on diversifying its aquatic species and becoming one of Latin America's leading producers of farmed fish and crustaceans. It is well known for tilapia but other fish like cobia and snook are also of interest.

The Brazilian government is motivated to exploit its native fish species such as pacu and many Amazonian fresh water fish that are largely unfamiliar to most of us. So it's timely to include a report highlighting the Brazilian aquaculture scene from its humble beginnings to its current US\$1 billion industry in our May issue.

Happy reading, learn and enjoy!

In this issue, I would like to focus on technology that is impressive and fantastic, which depends on borrowing ideas from disciplines other than fish farming.

No matter what the opponents of aquaculture may say, there is an urgent need to increase aquaculture production in order to feed the world. The need for efficient food production is increasing in line with population growth, so an increase in production must be made with the least possible environmental footprint. It is less resource-intensive and more climate-friendly to produce animal protein through aquaculture than livestock on land. Growth in aquaculture will be crucial in providing food for future generations.

Traditional land-based methods of fish farming in ponds have their limitations, as does the well-known marine floating cage farming. So, the industry has started looking for other solutions. One possible solution is modern RAS technology is land-based recirculation technology, whilst another is offshore farming. The idea of moving further out to sea is not new. For decades we have been moving operations further out from the coast, but we are now ready to make a giant leap to the open sea. To a great extent, it will be based on the transformation and adaptation of offshore oil exploration technology.

The oil industry that is active in the North Sea has had to develop very robust structures to withstand the extremely tough weather conditions - especially during winter. This technology is now being built on, transformed and adapted to fish farming. Whilst the dreams of those behind these projects may still belong to the future, in many ways the future is already here.

Taking a big step into the future

With Ocean Farm 1, the Norwegian salmon farming company SalMar has taken a big step into the future. In 2017 the company built a 69-meter-high sea farm with a diameter of 110 meters in China and had it towed to the site off the coast of Trøndelag in mid-Norway.

In September of the same year, between 1.1 and 1.2 million 200-gram salmon were released into the facility. The first batch of fish was slaughtered in January 2019, with good results. The facility



Erik Hempel
The Nor-Fishing Foundation

has now finished the second generation, and the results are even better.

The experiences from the first batch were to a certain extent characterised by the fact that everything was new, but the company achieved very good results in terms of growth, feed conversion factor, survival and water quality.

It shows that the investment in farming outside the fjords is the right way to go. The Atlantic salmon thrive further out in the sea and farming there is both area-efficient and beneficial for the fish.

We distinguish between “exposed sites” and “offshore sites” as exposed sites are located within a nautical mile from the baseline and typically have between four and eight meters of significant wave height. This latter is the environment in which Ocean Farm 1 is operated. Offshore localities are categorised as being located beyond 20–30 nautical miles outside the baseline.

SalMar is now planning a new facility, and this time the plan is to carry out experiments with real offshore farming. Their Smart Fish Farm is planned with an approximate diameter of 160 meters and will be put into operation significantly further out than Ocean Farm 1.

The Smart Fish Farm construction is very similar to a semi-submersible oil rig and is based on a combination of jacket and semi-submersible offshore technology. But the dimensions will be even larger - 164 metres at its widest and with a height of 106 metres. Other Norwegian fish farming companies are developing various similar concepts.

Sea-based farming is not affected by infection

One of the great advantages of farming as far away from land as 30 nautical miles is, among other things, to ensure that the sea-based farming is not affected by infection from the coastal area. Research shows that 20–30 nautical miles outside the baseline is so far out that no infection will be able to move in or out.

There is no doubt that these challenges require a broad cooperation across a number of scientific fields. Borrowing ideas and technology from the offshore oil industry seems to hold great promise.

And by the way, the Norwegians are not the only ones who believe so - the Chinese are already building large offshore fish farms too.



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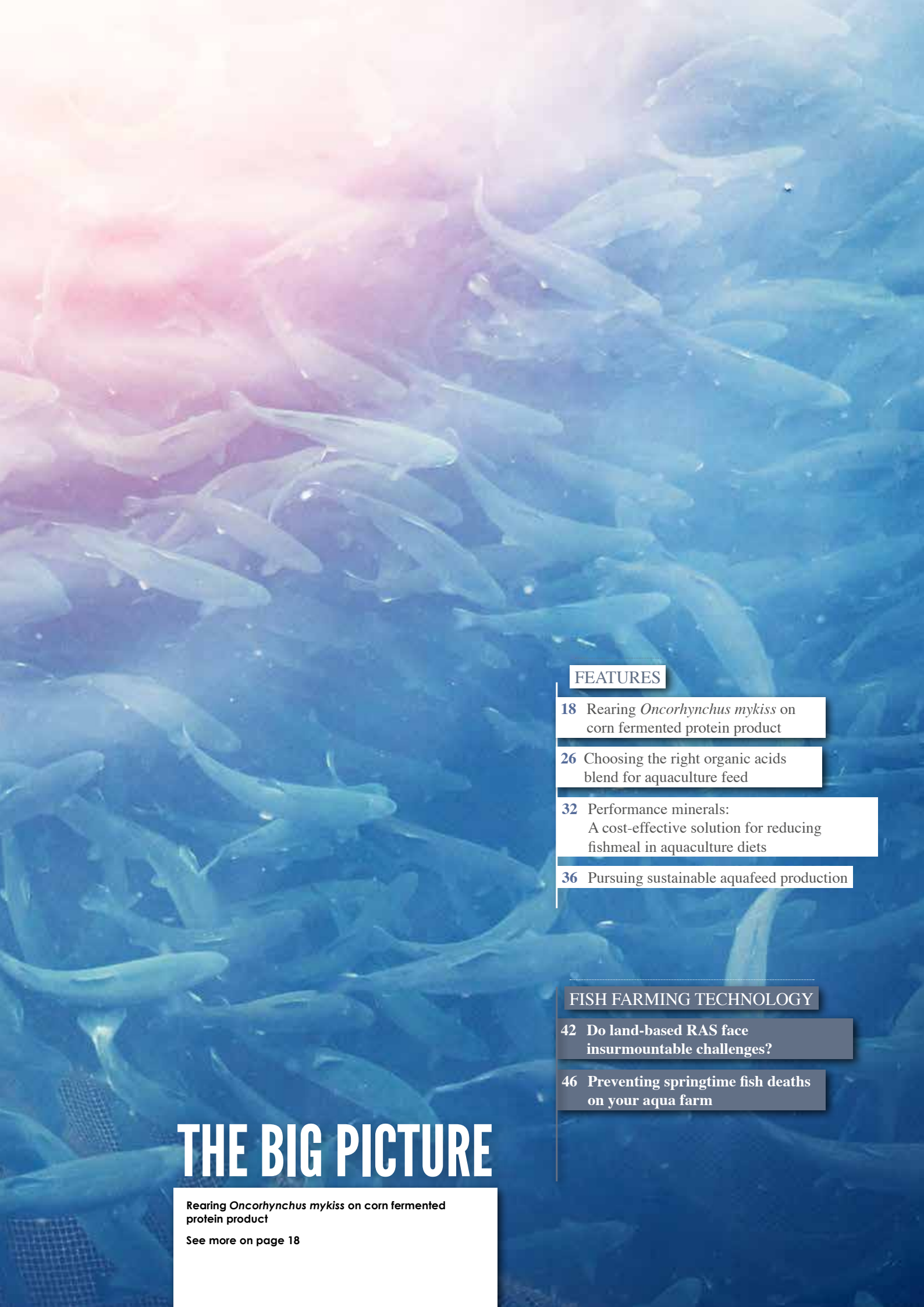
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THE BIG PICTURE

Rearing *Oncorhynchus mykiss* on corn fermented protein product

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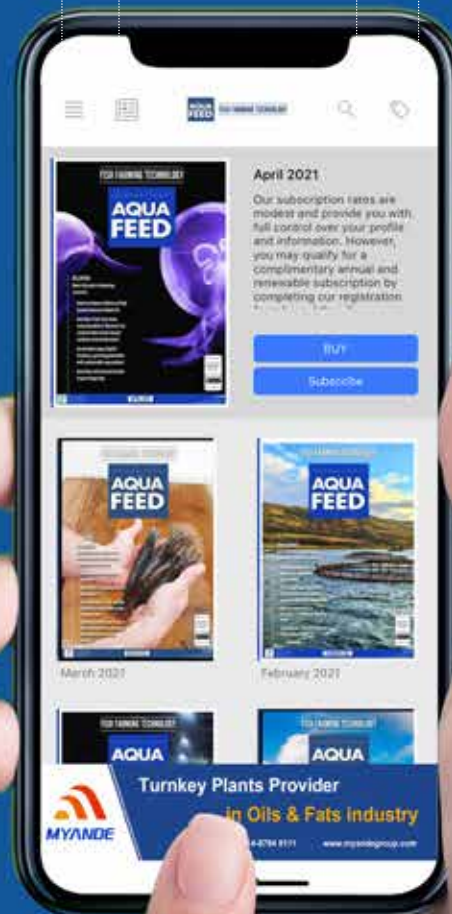
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Blue Aqua join forces with dnata to boost food security in Singapore

A Memorandum of Understanding (MoU) has been signed between dnata, a leading global air services provider and Blue Aqua Food Tech to boost food security in Singapore.

The partnership will see Blue Aqua up-cycle organic waste from dnata's catering and ground handling operations into alternative insect protein for aquafeeds.

Blue Aqua's innovative bio-conversion solution processes underutilised nutrients from the leftovers that can be transformed into quality insect proteins for aquacultural use. The bio-conversion is a virtuous circle that makes the insect protein a sustainable and efficient alternative to traditional fishmeal.

Domestically-produced feed

Compared to traditional protein, insect protein is a sustainable solution with low land, water, and carbon footprint, offering a very high yield. The partnership will supply Singapore's farmers with sustainable access to domestically

produced animal feed, which is traditionally imported.

The MoU is the starting point to a deeper partnership between Blue Aqua and dnata, which will look into the development and implementation of a 'Zero Waste' master plan. The air services provider will also add Blue Aqua to its list of suppliers to purchase locally-farmed seafood for its catering operations.

Dirk Goovaerts, dnata's Regional CEO for Asia Pacific, says, "We are delighted to partner with Blue Aqua to further decrease food waste and support the local food production supply chain. This initiative will help us minimise our environmental footprint whilst delivering the highest value for our customers and the communities around us."

Dr Farshad Shishehchian, CEO & Founder of Blue Aqua International Group, adds, "Blue Aqua has been a strong advocate for sustainable and practical farming since its inception, this partnership with dnata is a perfect fit. We are excited to grow our efforts in food technology to develop a circular economy in aquaculture globally through our network, starting with Singapore."

The global population is expected

to reach 9.9 billion by 2050, and food production has to increase by 70 percent to fulfil this demand.

This is further implicated by food security concerns worldwide and the rapid degradation of valuable farmland. Waste management is a global issue that governments and companies are racing to solve.

Singapore imports more than 90 percent of its food, yet, its food waste amounts to 744,000 tonnes annually. Today, less than 20 percent of Singapore's food waste is recycled.

Blue Aqua's Waste-to-Protein Program aspires to significantly reduce food waste across Singapore's food supply chain through aquaculture. This is in line with Singapore's vision of being a 'Zero Waste Nation', which means the recycling rate has to be increased to 70 percent.

Singapore has also set a '30-by-30' goal, aiming to have the nation produce 30 percent of its food domestically by 2030. With this mandate, aquaculture will play an important role in the future of Singapore's food security.

However, local farms still rely heavily on imported feed and raw materials, which the program is aiming to mitigate.



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Unibio and Protelux deepen their strategic sustainable protein partnership

Unibio, a sustainable protein company, has announced that it has signed a partnership agreement with Stafilies, the holding company of Protelux, to further deepen their collaboration in developing the industrial-scale production of its high-quality Uniprotein®, which is a critical input for fish farming industry.

Protelux is the first industrial plant that has brought Unibio's patented U-Loop® continuous-flow fermentation process into industrial-scale production.

Protelux is located in Ivangorod, Russia, close to the border with Estonia, which is an EU member state.

This location has access to cost-effective natural gas, as well as proximity to the European Union and the Baltic Sea for shipping.

Protelux currently has an installed capacity of 6000 tonnes of Uniprotein® per year, which can be scaled up to 20,000 tonnes. Under the agreement, Stafilies, the Protelux parent company, will buy a shareholding in Unibio in exchange for cash and intellectual property.

The intellectual property includes all of the knowledge gained over the past five years of how to install and operate industrial-scale production of Uniprotein®. Unibio has also secured an option to acquire a stake in Protelux in the future.

An innovative process

Unibio has developed an innovative process that allows the cost-effective production of high-quality protein using microbial continuous-flow fermentation with natural gas or methane as the primary feedstock.

Unibio's technology is a highly efficient resource in terms of its land and water usage and mimics microbial consumption of gas emitted by decaying plant material that happens every day in nature.

Uniprotein® has been approved by the EU for animal

and fish feed and is certified organic by Organic Farmers & Growers Ltd, the leading organic certification control body approved by the UK Government.

One of the key challenges for any protein technology is to upscale production from the laboratory to an industrial setting. Since 2016, Unibio and Stafilies have worked closely together developing solutions and operational guidelines that will benefit future projects and plants all over the world.

With the commencement of industrial scale production at Protelux, Unibio will benefit from being able to showcase the proven technology and processes to potential partners and customers.

It will also use the facility to accelerate further product and production improvements and the global roll-out of its technology.

"Global population growth has made protein scarcity a critical issue, and unsustainable soy production and uncontrolled extraction of wild fish for fishmeal are causing major environmental degradation.

"After many years under development, Uniprotein® is now in full industrial scale production and is ready to help address the world's rapidly growing protein demand. The collaboration with Protelux is consistent with our strategy of building a presence where natural gas is in abundance and may be revalued," says Jan Boeg Hansen, Chairman of the Board at Unibio.

"We are proud of all the technological innovation and hard work that we have put into scaling up production of Uniprotein® at our Protelux facility.

"The complex challenge of taking these groundbreaking processes and successfully commissioning them at scale should not be underestimated and has been the key hurdle where many other technologies have failed.

"We have always had faith in the importance of Uniprotein® as a critical input for the meat and fish farming industries. We are delighted to become a shareholder in Unibio and build further on their success," says Mikhail Serdtsev, Founding shareholder at Protelux.

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Raising awareness of World Day for Safety and Health at Work 2021

Delacon's vision is to unlock the plant universe for better lives. Using nature in its phytogenics, the company has been caring about the resilience in livestock animals for 33 years. On the World Day for Safety and Health at Work (April 28), the Delacon team raised awareness of the importance of health and resilience at work.

The global pandemic brought resilience back to one of the top priorities on Delacon's agenda.

Covid-19 has challenged the population as a society, as an industry and as individuals – from an economic, social and health perspective. The feed-to-food chain has been under

pressure to ensure the food supply for more than 7.9 billion people worldwide, while considering the changing consumer habits due to lockdowns and increased teleworking.

For Delacon, taking responsibility for better lives is linked to the company's vision and deeply rooted in its

core values: make a difference, grow together, impact life.

"Especially in challenging times, values are guiding stars," explains Delacon CEO Markus Dedl.

"We have made a difference with the creativity in serving our customers.

"The Delacon team has grown together even further and ensured close connections with our partners globally – and we have impacted lives through actions of solidarity, within the team and for local communities.

"I strongly believe that it needs healthy people for a sustainable and healthy organisation", adds Mr Dedl.

According to the Centre for Disease Control and Prevention, one-quarter of all employees worldwide name the workplace as a high stressor in life.

"The workplace can have a high impact on people's overall resilience. Therefore, we decided to not only focus on safety and health related aspects, but also to create more awareness on resilience in general," Mr Dedl notes.

"We recently kicked off our awareness program and decided to take one day off on April 28 for the entire company – to remind ourselves of the importance of health and resilience, and to recharge our batteries."



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Petter Johannessen

Marine ingredients' role in the food production system

Combining a set of regulations with consumers' expectations is a responsibility faced by all industries. With a growing population, increased volumes of food are needed. Not only must food be tasty, healthy and nutritious, it must also comply with food safety regulations.

All food production systems generate their own impacts on the ecosystems. Therefore, it is expected – and is also part of the existing regulations – that environmental and social impacts be minimised.

All-in-all, the industry's responsibility is multi-faceted, from ensuring mass distribution and food safety to demonstrating nutritional properties, being a contributor to healthy diets and minimising its impacts on people and the planet.

Food safety

Back in 1963, the WHO and FAO published the Codex Alimentarius which serves as a guideline to food safety and in many cases as a basis for national legislation.

Science and good risk management principles are the pillars of national governments' food safety approach. Food safety is highly dependent on feed safety. Global fed aquaculture production in 2018 was estimated at approximately 56 million tonnes (source: IFFO and FAO). Pork production was 120 million tonnes, and poultry (chicken) was 111 million tonnes (source: IFFO and FAO).

Fishmeal and fish oil plays a crucial role in supporting this production, thereby making a significant contribution to global food security.

Environmental and social impacts

With a mission to feed a growing population with nutritious protein, the marine ingredients industry's responsibility is also to abide to environmental and social regulations.

Certification standards, applying to more than 50 percent of all marine ingredients produced worldwide, provide assurances from third-party accredited certification bodies. Following the standards, marine ingredients are sourced in fisheries championing best practices, such as effective fishery management, including monitoring and enforcement.

Plants must ensure that certified raw materials are properly segregated from non-approved when being processed. They must also comply with all their national environmental regulations, as well as with their country's social regulations.

Health and welfare

Beyond these requirements, the marine ingredients industry's responsibility is also to demonstrate that marine ingredients' nutritional properties contribute to the growth and welfare of fish and other animals.

Fishmeal is an excellent source of a number of micronutrients that are key components for farmed fish and farmed animal health. This includes calcium, phosphorus, magnesium, potassium, selenium, as well as vitamins such as B1, B2, B6 and B12.

Fishmeal also includes a component of fats (fish oil), usually at 8-12 percent, thereby also providing a supply of EPA and DHA (omega-3) outside of fish oil itself.

Fishmeal is highly digestible. The proteins in fishmeal have excellent amino acid profiles that fit precisely the amino acid requirements for carnivorous fish species. And in turn, these nutritional benefits are passed to humans: quality feed means quality food.

The addition of fishmeal to animal diets increases feed efficiency and growth through better food palatability, enhancement of nutrient uptake and absorption. It can also be of primary importance in key juvenile stages where there may only be a short window of time to get juvenile fish onto feed.

Scaleability

Being a responsible industry also means supplying the world with the required volumes that are needed to support the growth of aquaculture.

According to the FAO an additional 20 million tonnes of fed farmed fish needs to be produced by 2030. This means that there is a need for an additional 25-30 million tonnes of feed ingredients in a decade.

Innovation in the food systems, combined with certification schemes to provide the necessary assurances, is imperative to securing healthy food in volumes to meet the demand.

Better utilisation of marine by-products represents a vast potential that needs more attention. Indeed, the world's global supply of fishmeal is not produced solely from fisheries; and there is another segment that contributes a smaller but important volume.

A significant and increasing proportion of annual supply now comes from the processing of seafood byproduct, where frames, heads, viscera and other trimmings are used to produce marine ingredients.

The FAO estimates that around 30 percent of global fishmeal supply comes from this material at the current time, and that is clearly an efficient use of material for which other uses are relatively restricted.

It must be underlined that the fisheries that supply whole fish into fishmeal and fish oil production are on the whole from species for which the direct human consumption market is weak, or in some cases non-existent. Most of the time, this is ensured by law. The managed harvesting of these stocks to provide fishmeal and fish oil utilises a natural resource for food production that would otherwise go to waste.

Traceability

Covid-19 has triggered a renewed interest in traceability: the marine ingredients industry has a specific interest in developing traceability schemes further, given the span of the value chain it is part of across the world.

Chain of custody standards already ensure that the chain between all stages, from sourcing and primary processing to

further processing, trading and transport, remains unbroken. Blockchain technologies offer an opportunity to go further and improve traceability of by-products.

These technologies are also expected to support cultural changes, which are a prerequisite from all stakeholders involved in the supply chain.

Our responsibility

Often hidden or overlooked, the feed sector bears a huge responsibility in supporting the challenges met by the food production system. Quality feed means quality food.

Petter Martin Johannessen joined IFFO in 2018 as Director General. He was previously Global Business Director for Risk Management and Sourcing at Cargill Aqua Nutrition and before that Supply Chain Director and Global Sourcing and Purchasing lead at EWOS Group. Before joining the aquafeed and marine ingredients industry, he worked at PwC (Consulting and large international process industry businesses branch). He holds a Diploma in International Marketing and a degree in Business Administration from the Norwegian School of Management.

Solid start of the year for BioMar

BioMar continues the strong growth in the salmon markets with an important increase in volumes sold compared to Q1 2020 in most markets.

At the same time the shrimp feed business showed robust results due to new product offerings and service solutions within high-performing and sustainable shrimp feed.

BioMar concluded 2020 with a solid growth across the business, despite the impact of the pandemic and a lethal storm in the Mediterranean area. 2021 continues the positive trend.

However, the first quarter was impacted by lower sales in Chile and foreign exchange developments. Chile volumes were lower than last year due to a coincidence of factors: Lower biomass, a change in customer contracts and changing feeding plans due to the pandemic as well as the emerging algae bloom.

"We are in a very good position in Norway, UK and Australia, collaborating closely with our customers striving to be the preferred feed supplier.

"I believe they experience the change that has happened in BioMar over

the last years in terms of new novel ingredients, new product solutions and high-performing teams.

"Now we just need to pass the bump on the road in Chile," explains Carlos Diaz, CEO BioMar Group.

In the LATAM division, BioMar continues the positive development within shrimp feed after being impacted by the tough market conditions during 2020.

"Since the beginning of the pandemic, the shrimp industry in Ecuador has been suffering, both in terms of the actual pandemic and the Chinese import restrictions.

"However, BioMar has managed to get reasonably well through the first waves of the pandemic. We have been working full steam introducing new products and technical services to the market, including products from our new extruded line.

"Now, we see our effort paying off in terms of increased volumes and revenue compared to Q1 2020," adds Carlos Diaz.

In the remaining parts of BioMar, volumes and revenue were comparable to levels in 2020.

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Rainbow trout

Rearing *Oncorhynchus mykiss* on corn fermented protein product

by Professor Simon J Davies, International Aquaculture Editor, Emeritus Professor, Harper Adams University.& Derek Balk and Melissa Jolly-Breithaupt, Flint Hills Resources, USA

Rainbow trout production contributes significantly to the global salmonid industry and is an iconic species of high value and acceptability. It is reared extensively in many temperate regions of the world such as in the USA, Canada, Norway, Denmark, and UK and in most areas of Europe and regions of Latin America like Mexico and, Chile as well as in parts of Australia.

The global rainbow trout market was estimated to be valued at US\$3,524.08 million in 2018 and projected to reach US\$4,998.19 million by 2025, at a CAGR of 5.14 percent during the 2018 to 2025 period with attaining well over one million tons production.

Rainbow trout is a carnivorous fish and requires diets containing a high level of protein and energy as oils (typically 45 and 25 percent) in commercial feeds. Consequently, aquafeed production must keep expanding in order to meet demand. Feed formulations for salmonids have traditionally relied on fishmeal to provide the bulk of dietary protein. Although total fishmeal

use in aquaculture feeds increased each year until 2007-08, the percentage of fishmeal in feed formulations has decreased for most species by between 35 and 50 percent (Tacon and Metian, 2008). Alternative feed ingredients such as soybean meal, soy protein concentrate, canola meal, canola protein concentrate, corn gluten meal, cottonseed meal, peas, and wheat gluten meal have been investigated to replace fishmeal and reduce the cost of fish production (Gatlin et al, 2007).

Notably, many plant-derived protein ingredients contain anti-nutrients such as phytic acid and protease inhibitors that interfere with nutrient assimilation. Plant protein-based diets may also contain lower levels of limiting amino acids such as methionine, lysine and threonine, than fishmeal-based diets. However, supplementing the limiting EAA's with crystalline sources can restore growth rates in fish, to some extent (Cheng et al, 2003). Consumer's today have raised serious ethical concerns about the sustainability of soybean meal, primarily driven by the issue of deforestation.

From 2000 to 2020, the US biorefinery industry has grown from 56 to 209 large scale fermentation facilities for the production of

Table 1. Nutrient composition of DDGS and NexPro® (% unless mentioned otherwise, dry-matter basis)

Nutrient	DDGS	NEXPRO
Dry matter	91.35	96.17
Crude protein (N x 6.25)	28.36	50.87
Crude fat	11.60	4.03
Ash	3.24	4.78
Organic matter	96.76	95.22
Gross energy (MJ/kg)	22.4	21.9
Minerals		
Calcium	0.04	0.03
Magnesium	0.24	0.32
Phosphorus	0.63	1.19
Potassium	0.87	0.81
Sodium	0.12	0.18
Sulfur	0.33	0.47
Boron (mg/kg)	39.52	<16
Copper (mg/kg)	9.06	9.75
Iron (mg/kg)	118	172
Manganese (mg/kg)	11.9	15.1
Zinc (mg/kg)	48.9	114

Table 2. Ingredient and nutrient composition of the reference diet for the digestibility trial with rainbow trout (% unless mentioned otherwise, as-fed basis)

Ingredient	Reference diet	Nutrient	
Fishmeal, sardine	33.00	Dry matter	95.0
Soy protein concentrate, Profine VF	15.00	Crude protein (N x 6.25)	44.74
Corn protein concentrate, 75% CP	10.00	Crude fat	17.82
Wheat starch, gelatinized	18.00	Ash	9.33
Dicalcium phosphate	1.20	Gross energy (MJ/kg)	21.4
Trace mineral mix, Trouw Nutrition	0.10	Minerals	
Yttrium oxide	0.10	Calcium	2.47
Vitamin premix, ARS 702	0.80	Magnesium	0.16
Choline chloride (60%)	0.60	Phosphorus	1.52
Vitamin C (Stay C, 35%)	0.20	Potassium	0.65
Fish oil, Alaska pollock	14.00	Sodium	0.43
		Sulphur	0.25
		Boron (mg/kg)	31.7
		Copper (mg/kg)	8.67
		Iron (mg/kg)	224
		Manganese (mg/kg)	27.6
		Zinc (mg/kg)	135

alcohol also known as ethanol from different cereal grains. The dry milling ethanol production resulted in 3.3 billion pounds of corn distillers' oil and 29.4 million metric tons of dried distillers' grains in 2020 (Renewable Fuels Association, 2020).

Among all the DDG products from different grains, corn DDGS is the predominant one. Corn DDGS is produced in ethanol plants by using a dry-grind method (Overland et al, 2013). Conventional DDGS contains a moderate level of crude protein (24 -32 percent) compared to fishmeal and soy protein products, and has less phosphorus than fishmeal (Gatlin et al, 2007).

Use of DDGS has been studied in the diets of many aquaculture species including rainbow trout (Cheng et al., 2003; Cheng and Hardy, 2004; Barnes et al, 2012). Also, diets containing 10 or 20 percent DDGS appeared to reduce growth in rainbow trout even with supplementation of essential amino acids and phytase due to high fiber content (Barnes et al, 2012a).

In another study, DDGS was included in rainbow trout diets up to 22.5 percent without affecting growth when lysine and methionine were supplemented (Cheng and Hardy, 2004). Stone et al (2005) stated that if the crude protein content could be increased and indigestible fiber decreased, the inclusion level of DDGS may be increased in fish feeds. This can be achieved by fractionating and removing non-fermentable fractions before or after ethanol production. Pre-fermentation fractionation creating a high protein DDG (HPDDG, 42 and 45 percent crude protein) has been evaluated in rainbow trout with contrasting results (Barnes et al, 2012; Overland et al, 2013).

The result of post-fermentation mechanical separation

NexPro fermented protein, a product of U.S. based Flint Hills Resources, is the result of post-fermentation mechanical separation of the DDG product utilising a patented technology called Maximized Stillage Co-Products. Fractionating the product post-fermentation allows the fermentation process to assist with separation and weaken the cellular wall structure of the fibrous fractions and concentration of inactive *Saccharomyces cerevisiae* yeast, which is utilised for the production of alcohol.

NexPro® has a superior crude protein (~50 vs ~28 percent), lower crude fiber levels and improved nutritional composition compared to traditional DDGS. As a result, (NexPro®) will likely compete with soy protein concentrate, corn protein concentrate, corn gluten meal and brewer's yeast as an ingredient in fish feed formulations.

This study evaluated NexPro® as a sustainable protein source in feeds for rainbow trout by replacement of soy protein concentrate (SPC) in a balanced series of diets, including other ingredients and fishmeal. The chosen parameters of the study include growth performance, feed efficiency, digestibility and nutrient retention, the latter of which is important from the perspective of reducing nutrient losses from fish farms that cause environmental impact (such as phosphorus and nitrogen).

Flint Hills Resources supplied NexPro® corn fermented protein to Bozeman Fish Technology Center (BFTC), Bozeman, Montana, for experimental feed production as described below. First, the digestibility trial and then the growth trial were conducted by the University of Idaho's Aquaculture Research Institute, specifically the Hagerman Fish Culture Experiment Station (HFCES) in Hagerman, Idaho. The product was analysed at HFCES for nutrient composition (Table 1).

Diet composition and application

Experimental feeds: In vivo apparent nutrient digestibility of

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NexPro® was determined by feeding separate groups of sub-adult rainbow trout a diet containing the product at 30 percent. A reference diet (10-kg batch) containing practical ingredients and 0.1 percent indigestible inert marker (yttrium oxide) was prepared at the HFCES (Table 2). Test diets containing 30 percent NexPro® and 70 percent reference diet mash on dry-matter basis were prepared. Both diets were cold-pelleted with a California pellet mill fitted with a four millimetre die. Pellets were dried in a forced-air dryer at 35 °C for 48 hrs. Samples of each diet were taken for proximate composition and mineral analyses, including yttrium analysis.

Fish maintenance and feeding regime: Rainbow trout from the HFCES in-house broodstock (House Creek strain) were used for the study. Twenty-five fish (~250 g) were stocked in four 145-L tanks, each supplied with 12 L min⁻¹ of constant temperature (15 °C) spring water supplied by gravity to the fish rearing laboratory.

Each of the reference and test diets was randomly assigned to two tanks of fish. Fish were fed their respective diets twice daily, at 0830 to 0900 and 1530 to 1600h to apparent satiation for one week. On day 4 and 8, fish in each tank were lightly anaesthetised using tricaine - methanesulfonate (MS-222, 100 mg L⁻¹, buffered to pH 7.0), removed from water for 30 to 60 seconds, and feces gently expelled using light pressure on the abdomen near the vent, a process called “stripping”.

Experimental feeds: All experimental diets for the growth trial were formulated with a feed formulation software (WinFeed 2.8, Cambridge, UK) after the nutrient digestibility data were available for NexPro®.

A control diet plus five experimental feeds were formulated to contain 40 percent digestible protein and 17.2 MJ/kg digestible

Table 3. Apparent digestibility coefficients of nutrients for NexPro® in rainbow trout (Mean ±SEM, n = 2 tanks per ingredient)

Nutrient	ADC
Dry matter	50.5±1.4
Crude protein	86.4±1.3
Crude fat	89.3±2.2
Organic matter	53.1±1.6
Energy	59.6±1.4

energy, three percent lysine and ~0.8 percent digestible phosphorus (as-is basis, Table 4).

The feeds were formulated as follows:

Diet 1: Control – standard level of fishmeal in commercial trout feeds: Diets 2 to 5 (25 to 100 percent incremental replacement of SCP with NexPro®); Diet 6: 25 percent replacement of SPC with dried brewer’s yeast (BY) on a crude protein basis.

All diets met or exceeded the minimum nutrient requirements of rainbow trout (NRC, 2011). Dried brewer’s yeast (*Saccharomyces cerevisiae*) was also tested by replacing 25 percent SPC on a crude protein basis so as to compare it with the control and the diet with NexPro® replacing 25 percent SPC on a crude protein basis. Diets were produced by extrusion pelleting similar to commercial fish feed production technology. The nutritional composition of the test products are presented in Table 1. Crude protein content of NexPro® (50.87 percent) was higher than that of DDGS (28.36 percent) whereas crude fat was lower in NexPro® (4%) than that in DDGS (11.6%). Energy content was higher in DDGS than in NexPro®.

The approximate composition and energy content of diets used

in the growth trial are presented in Table 4, whilst the mineral composition of the diets is presented on as-fed basis in Table 5.

Fish and feeding: Rainbow trout fingerlings, hatched from eggs purchased from a commercial source (TroutLodge, Sumner, WA) were used in the study. Thirty fish (initial average weight: 15.6 g) were stocked into each of 18, 145-L tanks. Each tank was supplied with 10 to 12 L/min of constant temperature (15 °C) spring water supplied by gravity to the fish rearing laboratory.

In a completely randomised design, each of the six experimental diets was randomly assigned to triplicate tanks within the laboratory system to account for any tank position effects. Each diet was fed by hand to respective tanks of fish to apparent satiation, three times per day and six days per week for 12 weeks. Photoperiod was held constant at 14 h light: 10 h dark.

Proximate composition (moisture, protein, fat and ash) of feed, whole-body fish and fecal samples were determined using AOAC (2002) procedures.

Table 4. Ingredient and proximate composition of experimental diets with graded levels of corn fermented protein product NexPro® (NXP) or Brewer’s yeast (BY) fed to juvenile rainbow trout in the growth trial (% as-fed basis unless mentioned otherwise).

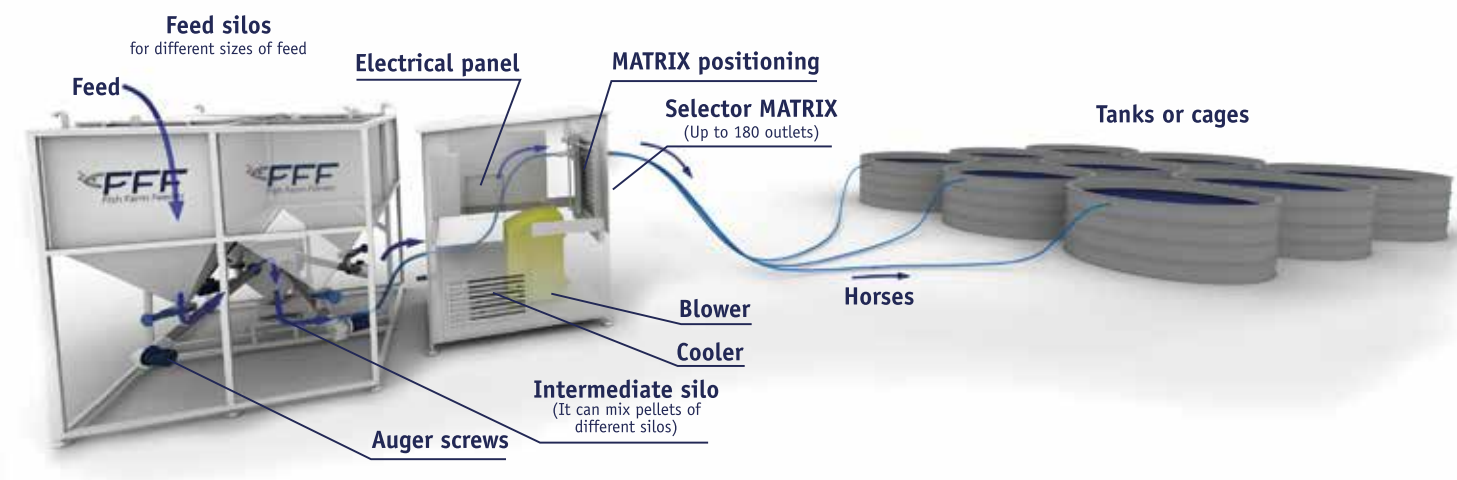
	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
Ingredients	Control	25NXP	50NXP	75NXP	100NXP	BY
Fishmeal, sardine	20.65	20.65	20.65	20.65	20.65	20.65
Poultry by-product meal, feed grade	16.00	16.00	16.00	16.00	16.00	16.00
Blood meal, spray-dried	2.00	2.00	2.00	2.00	2.00	2.00
Soybean meal, dehulled & solvent-extracted	12.00	12.00	12.00	12.00	12.00	14.43
Soy protein concentrate, Profine VF	16.00	12.00	8.00	4.00	0.00	12.00
NexPro®, FHR	0.00	6.00	12.00	18.00	24.00	0.00
Brewer’s yeast, dried	0.00	0.00	0.00	0.00	0.00	6.90
Wheat gluten meal	1.20	1.20	1.20	1.20	1.20	1.20
L-Lysine HCl	0.00	0.08	0.15	0.23	0.31	0.00
Wheat flour	16.90	14.88	13.14	11.39	9.64	11.85
Dicalcium phosphate	1.65	1.39	0.93	0.46	0.00	1.44
Trace mineral mix, Trouw Nutrition I	0.10	0.10	0.10	0.10	0.10	0.10
Vitamin premix, ARS 7022	1.00	1.00	1.00	1.00	1.00	1.00
Choline chloride (60%)	0.60	0.60	0.60	0.60	0.60	0.60
Vitamin C (Stay-C, 35%)	0.20	0.20	0.20	0.20	0.20	0.20
Fish oil	11.70	11.90	12.03	12.17	12.30	11.63
Proximate composition (analyzed)						
Moisture	2.58	2.56	2.39	2.77	2.31	2.68
Crude protein (N × 6.25)	46.77	47.56	47.21	48.56	46.95	48.18
Crude fat	16.43	16.77	17.46	17.02	18.40	16.20
Ash	9.76	8.64	9.37	9.04	8.67	10.02
Gross energy (MJ/kg)	21.8	21.7	22.1	22.2	22.7	21.6

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Calculations of apparent digestibility coefficients of diets

Apparent digestibility coefficients (ADC), for both diets and NexPro®, for dry matter, organic matter, protein, lipid, energy and minerals, (including phosphorus), were calculated using the formula described by Bureau et al. (2002): Employing the live-weight and feed consumption data, and indices calculated as by Hardy and Barrows (2002)

Statistical analysis of data: Data were tested for normality and homogeneity of variance prior to one-way analysis of variance (ANOVA). When required, data were transformed to achieve normal distribution and subjected to Tukey's HSD test to separate the means at a significance level of $P < 0.05$.

In case of non-homogeneous variance, Welch's ANOVA was performed. If significant differences were found, Tukey's test, which corresponded to the Games-Howell test, was conducted to separate the means. In case of non-normal distribution, the non-parametric Kruskal-Wallis test was performed. All statistical tests were performed with SAS 9.3 software.

Feed conversion ratios were very good

The nutrient composition of the reference diet used for digestibility trial is presented in Table 2. The diet contained 44.7 percent crude protein and 17.8 percent crude fat which are typical of diets used for a growth trial in our laboratory. Apparent digestibility coefficients of nutrients for DDGS in rainbow trout are presented in Table 3. Even though dry matter digestibility (50.5 percent) was lower, crude protein digestibility was very good (86.4 percent). ADC for energy was slightly low (59.6 percent). Minerals especially Mg, P, K, Cu and Zn were highly digestible.

In the growth trial the rainbow trout juveniles were fed diets containing graded levels of NexPro® (NXP) and a single level of brewer's yeast for 12 weeks. Fish readily accepted the experimental diets. Overall, fish were robust with no abnormalities or deformities. Growth and feed utilisation indices of the fish are presented in Table 6.

Mean final weight of fish was significantly different among the dietary groups ($P < 0.05$). Fish fed the 75NXP (240 g) diet

Table 5. Mineral composition of experimental diets with graded levels of corn fermented protein product (NexPro®) or Brewer's yeast (BY) fed to juvenile rainbow trout in the growth trial (% as-fed basis unless mentioned otherwise).

	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
Minerals	Control	25NXP	50NXP	75NXP	100NXP	BY
Calcium	2.04	1.95	1.86	1.86	1.77	2.02
Magnesium	0.19	0.18	0.18	0.17	0.18	0.20
Phosphorus	1.59	1.54	1.48	1.47	1.40	1.67
Potassium	0.90	0.85	0.80	0.78	0.76	0.99
Sodium	0.38	0.38	0.38	0.44	0.42	0.40
Sulfur	0.30	0.28	0.30	0.26	0.34	0.30
Copper (ppm)	32.2	30.7	27.5	31.7	25.4	33.5
Iron (ppm)	433	398	339	345	308	392
Manganese (ppm)	50.8	47.1	41.9	39.4	35.2	48.7
Zinc (ppm)	164	193	185	153	198	194

had significantly higher final weight than that fed BY diet (217 g). However, there was no significant difference in final weight among the fish fed NexPro® diets.

Weight gain was highest in fish fed 75NXP diet (224 g/fish) than in fish fed BY diet (202 g/fish) and they were significantly different. There were no significant differences in percent weight gain, specific growth rate, daily growth index, survival, feed consumption of fish or FCR among the dietary treatment groups after 12 weeks of feeding ($P > 0.05$).

Mean percent weight gain was the highest in the 75NXP (1421) and the lowest in the BY (1296). Specific growth rate ranged from 3.14 percent/day (BY) to 3.24 percent/day (75NXP). Survival was high in all dietary treatment groups (93.3 to 100 percent) at the end of 12 weeks. Feed consumption per fish varied from 179 g (BY) to 209 g (100NXP) whereas daily feed consumption ranged from 1.83 percent body weight/day (75NXP and BY) to 2.02 percent bodyweight/day (100NXP).

Feed conversion ratios were very good for all the feeds (0.87 to 0.97). Protein efficiency ratio was significantly lower in fish fed 100NXP diet (2.20) than in fish fed other diets (2.33 to 2.39). Condition factors of fish were high across the diets (1.55 to 1.63) and were not significantly different among the dietary treatments.

Whole body proximate composition and mineral composition of the fish fed the experimental diets are presented in Table 7. This did not vary significantly among the dietary treatments ($P > 0.05$). Phosphorus ranged from 0.365 percent (75NXP) to 0.40 percent

Table 6. Growth performance and feed utilization of juvenile rainbow trout fed diets with graded levels of corn fermented protein product (NexPro®) or Brewer's yeast (BY) for 12 weeks.

	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
	Control	25NXP	50NXP	75NXP	100NXP	BY
Initial weight (g/fish)	15.5±0.2	15.7±0.1	15.6±0.1	15.8±0	15.6±0.1	15.6±0.2
Final weight (g/fish)	228±2ab	232±7ab	231±6ab	240±1a	232±0ab	217±3b
Weight gain (g/fish)	212±3ab	216±7ab	215±6ab	224±1a	216±0ab	202±3b
Mean weight gain (%)	1368±36	1377±52	1377±47	1421±13	1388±11	1296±33
Specific growth rate (SGR, %/d)	3.20±0.03	3.20±0.04	3.21±0.04	3.24±0.01	3.21±0.01	3.14±0.03
Daily growth index (DGI, g1/3/d)	4.30±0.04	4.33±0.07	4.32±0.07	4.41±0.02	4.34±0.01	4.18±0.04
Feed consumed (g/fish)	190±3	195±4	195±8	197±1	209±1	179±3
Daily feed consumption (% Body weight/day)	1.86±0.01	1.87±0.01	1.88±0.04	1.83±0.01	2.02±0.02	1.83±0.02
Feed conversion ratio	0.89±0	0.90±0.01	0.91±0.02	0.87±0	0.97±0.01	0.89±0.01
Survival (%)	100	98.9±1.1	93.3±5.1	98.9±1.1	98.9±1.1	100
Protein efficiency ratio (PER)	2.39±0.01a	2.33±0.02a	2.34±0.04a	2.35±0.01a	2.20±0.02b	2.34±0.03a
Condition factor	1.55±0.02	1.57±0.01	1.61±0.03	1.63±0.03	1.56±0.02	1.62±0.03

Table 7. Whole-body proximate and mineral composition of juvenile rainbow trout (average initial weight, 15.6 g) fed experimental diets containing graded levels of corn fermented protein product (NexPro®) or Brewer's yeast (BY) for 12 weeks (% wet basis).

		Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
	Initial fish	Control	25NXP	50NXP	75NXP	100NXP	BY
Dry matter	23.0	31.0±0.4	30.6±0.3	31.0±0.1	31.2±0.6	31.4±0.2	30.0±0.2
Crude protein	13.7	16.7±0.1	16.6±0.1	17.2±0.1	16.9±0.1	16.9±0.3	16.3±0.3
Crude fat	7.09	11.8±0.4	11.5±0.4	11.5±0.2	11.9±0.5	12.4±0	11.2±0.4
Ash	1.93	2.15±0.11	2.02±0.02	1.93±0.15	1.96±0.05	1.91±0.11	1.95±0.05
Gross energy (MJ/kg)	5.98	8.65±0.17	8.54±0.12	8.61±0.1	8.76±0.24	8.76±0.12	8.29±0.1
Minerals							
Calcium	0.299	0.337±0.051	0.343±0.024	0.381±0.050	0.352±0.020	0.375±0.047	0.379±0.026
Magnesium	0.021	0.025±0.0	0.027±0.002	0.029±0.001	0.029±0.0	0.028±0.002	0.027±0.0
Phosphorus	0.359	0.40±0.03	0.370±0.016	0.395±0.026	0.365±0.011	0.386±0.033	0.387±0.009
Potassium	0.288	0.312±0.002	0.304±0.007	0.305±0.004	0.307±0.007	0.320±0.009	0.305±0.006
Sodium	0.087	0.088±0.0ab	0.090±0.007ab	0.076±0.002b	0.080±0.001b	0.102±0.005a	0.1±0.002a
Sulfur	0.057	0.061±0.002	0.065±0.004	0.064±0.003	0.061±0.003	0.070±0.005	0.062±0.001
Copper (ppm)	2.09	3.34±0.11ab	3.26±0.21ab	2.59±0.19b	2.67±0.1b	3.36±0.37ab	3.69±0.20a
Iron (ppm)	13.0	15.9±0.2	15.8±0.5	18.3±3.1	14.5±0.1	15.7±1.13	15.3±0.9
Zinc (ppm)	19.1	25.3±0.5	21.3±1.4	25.7±3.4	25.6±3.0	31.0±4.0	25.7±1.9

(Control) and decreased as HP 330 level increased in the diets. Whole-body iron level varied from 14.5 ppm to 18.3 ppm. Zinc level varied from 21.3 ppm (25NXP) to 31.0 ppm (100NXP).

Nutrient retention of juvenile rainbow trout fed the experimental diets for 12 weeks are presented in Table 8. There was no significant difference among the dietary groups for fat and protein retention ($P>0.05$). Fat retention ranged from 71.62 percent (100NXP) to 82.3 percent (Control).

Protein retention in rainbow trout ranged from 37.8 percent (100NXP) to 40.8 percent (50NXP). Energy retention was significantly higher in Control (45.3 percent) and 75NXP (46 percent) groups than in 100NXP group (40.8 percent). Retention values for calcium (18.6 to 23.1 percent) and phosphorus (26.4 to 29.8 percent) were not significantly different among the dietary treatments ($P>0.05$).



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Corn fermented protein, being a combination of recovered corn protein and spent yeast, is rich in protein and provides a better amino acid profile than traditional corn gluten meal, especially lysine. NexPro® has lower carbohydrate and crude fiber content than DDGS. Moreover, levels of minerals such as phosphorus, iron and zinc are substantially higher in NexPro® than in DDGS. NexPro® is also different than the high protein dried distiller's grain in that it's produced after ethanol production whereas HPDDG is produced via a fractionation before ethanol production. NexPro has higher crude protein (50 vs. 45 percent) than HPDDG but has slightly lower lysine (1.93 and 2.1 percent) and similar methionine (0.83 and 0.89 percent) levels. All these favourable characteristics of NexPro® make it an excellent candidate as a protein source in fish feed.

The ADC values obtained were similar or higher than the values obtained by Cheng and Hardy (2004) for different proximate categories of DDGS and were used for the formulation of diets used for growth trial later. The present study evaluated NexPro® as a replacement for soy protein concentrate in rainbow trout diets while levels of fishmeal, other animal proteins, and soybean meal were kept constant to avoid any confounding effects of variable levels of other protein sources.

Fish grew well with low FCRs (0.87 to 0.97) similar to what we generally observe with good commercial diets used in our laboratory. Even though significant differences in final weight or weight gain per fish existed among the dietary treatments, percent weight gain or specific growth rates were not significantly different. Also, there was no difference between the control and NexPro® containing diets in terms of growth performance. Similar findings were also obtained by Cheng and Hardy (2004), when 22.5 percent DDGS was included in rainbow trout diets with lysine and methionine supplementation and replaced 75 percent of fishmeal.

This study also corroborates with the findings of Overland et al (2013) who successfully replaced a mixture of plant proteins such as SPC, sunflower meal and rapeseed meal, with 22.5 and 45 an excellent candidate as a protein source in fish feed high protein dried distiller's grain (HPDDG) in the diets of 143 g rainbow trout.

In their study, just like in the present study, fishmeal level was constant across the diets (~21 percent). In another study with 34 g rainbow trout, similar results were obtained when 10 percent

or 20 percent HPDDG was included by replacing fishmeal in the diets (30–40 percent fishmeal) but supplementing essential amino acids including lysine and methionine (Barnes et al, 2012).

Rainbow trout fed the highest level of NexPro (24 percent, 100NXP) tended to consume more feed, though not significantly more than the control group. As the level of NexPro® increased (0–24 percent) in the diet, feed intake appeared to increase marginally indicating no palatability issue associated with tested levels of NexPro®. However, protein efficiency ratio (weight gain per unit protein consumed) of fish was significantly lower in the 100NXP group than the other dietary groups.

Protein retention was numerically lower and energy retention was significantly lower in the 100NXP group than in the control group. The results suggested that when fish were fed the highest level of NexPro® (24 percent), they tended to eat more but not utilise the nutrients as efficiently as the control group. This is in contrast to the findings of Overland et al. (2013) who observed no differences in feed intake with 22.5 or 45 percent HPDDG in the diets of rainbow trout.

Also, they did not see significant differences in protein or energy retention among the dietary treatments despite a decrease in protein digestibility and an increase in energy digestibility. In general, protein and phosphorus retention were higher across the treatments in that study than in the present study due to lower dietary crude protein and phosphorus levels in the earlier study. In that study, HPDDG replaced a mixture of SPC, sunflower meal and rapeseed meal whereas NexPro® replaced only SPC in the present study. Soy protein concentrate is a highly digestible protein (90–95 percent crude protein digestibility).

Even though NexPro® replaced SPC in terms of digestible protein incrementally in the diets in the present investigation, the values used were actually of DDGS in the absence of digestibility values for NexPro®. Corn co-products' quality and nutrient profile vary widely due to the grain source and processing methods employed (Liu, 2011; Welker et al, 2014) but NexPro® has consistently uniform quality control and specifications.

Brewers' yeast in the diet (6.9 percent) reduced the weight but not the growth rate of fish as compared to control diet. It might have slightly reduced the palatability of the diet causing marginally lower feed intake that was not apparent during feeding of fish.

In summary, NexPro® corn fermented protein can effectively replace SPC up to 100 percent in a rainbow trout diet without significantly affecting growth performance or feed efficiency.

An inclusion at 18 to 24 percent in the diet in the presence of other good quality protein sources was deemed to be optimal under the trial conditions. NexPro® is a viable solution for mitigating the 'protein gap' in advanced trout feeds for a sustainable trout industry. The relative prices of NexPro® and SPC and effects of NexPro® on feed conversion ratio will likely dictate decisions by feed formulators as to appropriate levels of SPC and/or NexPro® in rainbow trout diet formulations.

(References are available on request)

www.intellectualresearchpartners.com/report/rainbow-trout-70

Table 8. Nutrient retention of juvenile rainbow trout (average initial weight, 15.6 g) fed experimental diets containing graded levels of corn fermented protein product (NexPro®) or Brewer's yeast (BY) for 12 weeks (%).

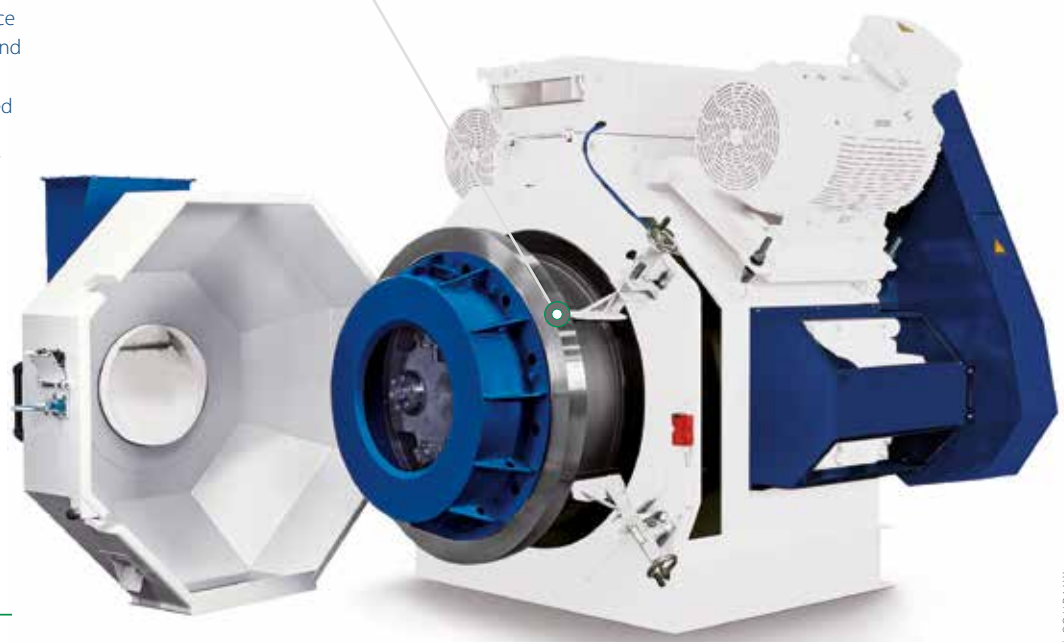
	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
	Control	25NXP	50NXP	75NXP	100NXP	BY
Fat	82.3±2.7	78.5±1.9	75.0±1.2	81.8±3.9	71.6±0.8	80.2±4.0
Protein	40.5±0.4	39.3±0.5	40.8±0.8	40.2±0.3	37.8±0.9	38.7±0.8
Energy	45.3±0.8a	44.5±0.3ab	44.0±0.6ab	46.0±1.5a	40.8±0.8b	44.3±1.1ab
Minerals						
Calcium	18.6±2.9	19.7±1.4	23.1±3.5	21.8±1.3	22.2±3.0	21.5±1.7
Magnesium	15.3±0.5b	16.6±1.2ab	18.2±0.7ab	19.1±0.2a	16.0±1.0ab	15.9±0.1ab
Phosphorus	28.3±2.2	26.7±1.1	29.8±2.6	28.4±1.0	28.6±2.6	26.4±0.9
Potassium	38.9±0.1bc	39.9±0.9b	42.2±1.3ab	45.1±1.4a	43.7±1.3ab	34.9±0.3c
Sodium	25.7±0.1ab	26.6±2.3abc	22.2±1.1abc	20.5±0.4c	25.6±1.2abc	28.8±0.7ab
Sulphur	23.2±0.9	25.6±1.4	23.7±1.6	27.1±1.5	21.5±1.8	23.4±0.4
Copper	11.9±0.5	12.1±0.8	10.6±0.8	9.80±0.4	14.0±1.5	12.9±0.8
Iron3	4.16±0.07	4.46±0.10	6.13±1.12	4.82±0.06	5.32±0.36	4.47±0.3
Zinc	17.6±0.4	12.3±1.0	15.7±2.4	19.4±2.4	16.5±2.1	15.2±1.0

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Choosing the right organic acids blend for aquaculture feed



by Dr Dafna Israel, Research manager and animal nutrition expert at Phibro Aqua

The quest for the best performing feed additive is a major mission in the aqua feed world. There is a variety of useful additives that raise the crucial debate regarding the selection of the best option. Acidifiers are functional feed additives with acidic properties. They first and most importantly improve growth performance and survival in intensive farming operations.

They do this through several modes of action that can benefit the cultivated animal in the following ways including providing an antimicrobial effect, activating digestive enzymes, increasing protein digestibility and improving feed hygiene by preventing spoilage and contamination.

An antimicrobial effect

Organic acids have the capacity to reduce bacterial loads in the proximal gastrointestinal tract of aquaculture species. As a result, fewer pathogens reach the gut from the stomach, leading to improved feed hygiene and minimising the risk of infections.

Organic acids inhibit the growth of micro-organisms, causing very extended lag phases. The inhibition of micro-organisms occurs by rapid diffusion of the undissociated molecule into the cell. Dissociation (release of the H⁺ Ion) of these molecules in the cell of the bacteria causes acidification of the cytoplasm, thereby preventing growth.

Most organic acids are effective in a strong or moderately acidic environment. Since each acid has a different pH optimum, depending on their pKa values, a blend of organic acids would significantly increase the efficacy against microorganisms, rather than using only one acidifier.

Composing a blend of different acidifiers comprises

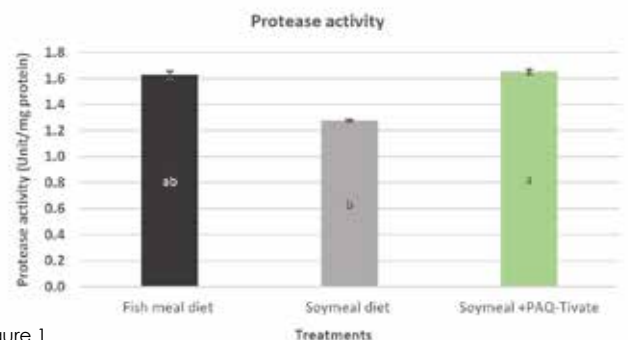


Figure 1

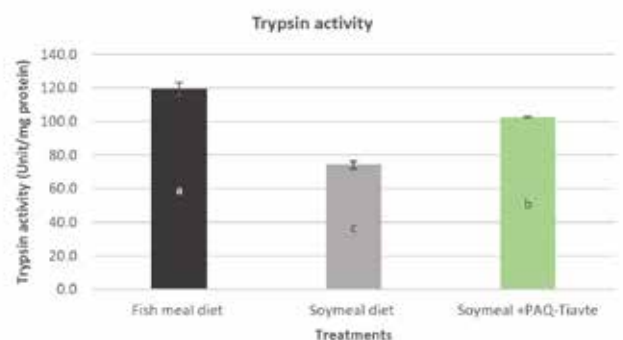


Figure 2

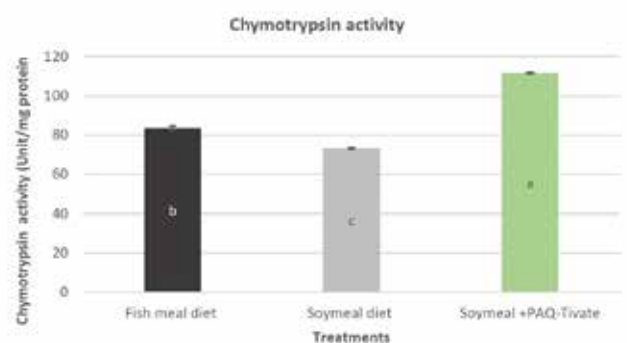


Figure 3



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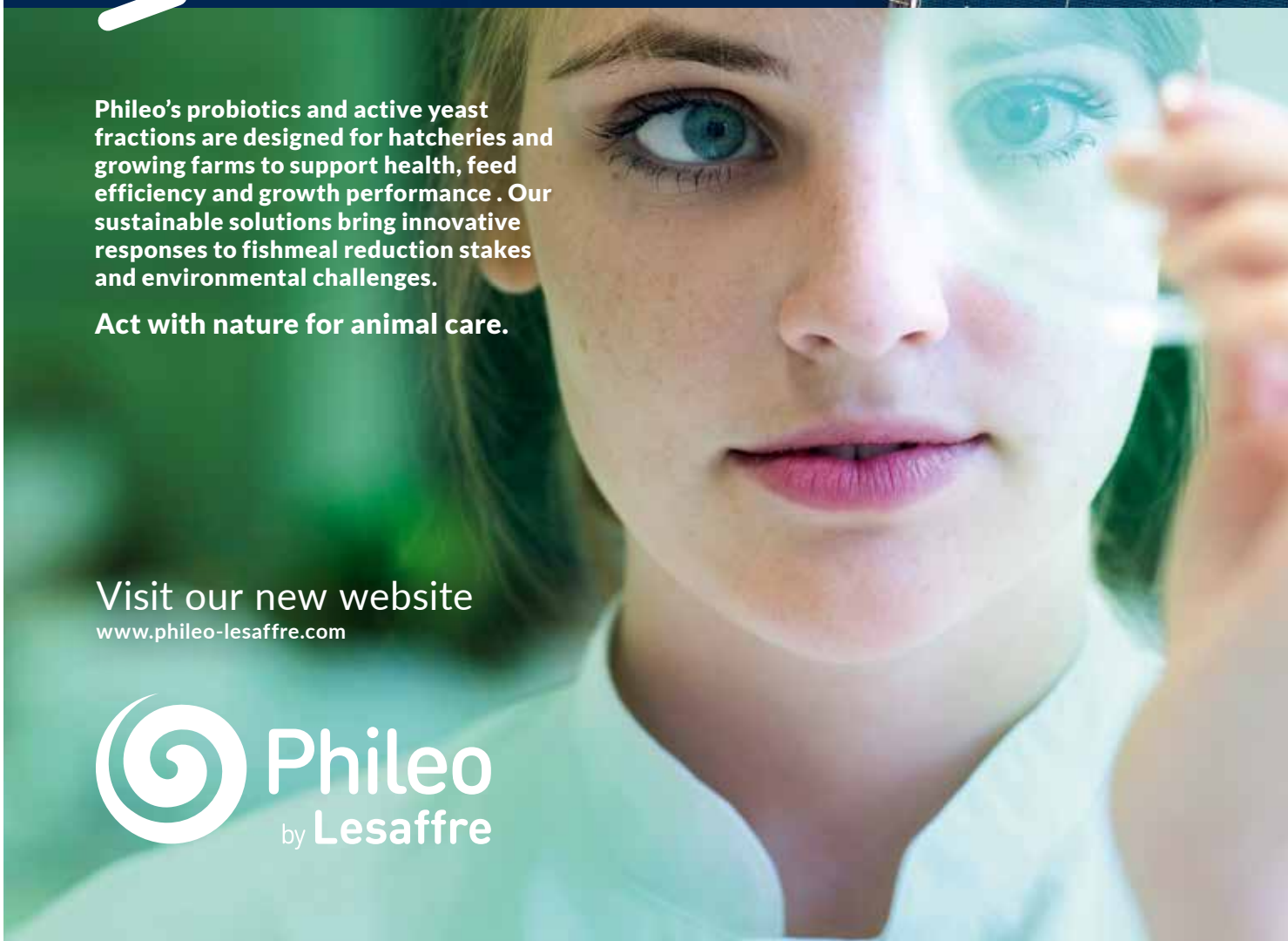
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a broader spectrum of pH environments to match different applications (anti-mould, anti-yeast, anti-bacterial). Additionally, this also creates synergistic effects at the molecular level. For example, combining formic and propionic acids is more effective than each of these acids on their own.

Activate digestive enzymes

Increasing nutrient utilisation is crucial in aquaculture due to the high costs of feed that comprises about 50 percent of the overall production costs. Protein is one of the most expensive macronutrients. The attributes of acidifiers on protein digestion have been well investigated on terrestrial animals and it is known that they stimulate the gastric and pancreatic enzymes.

The optimum pH level for pepsin activity is 1.5-2.0; though, the pH range level in the tilapia's intestine is higher (6.5-7.8). Consequently, lowering the pH level of the digesta in the stomach and intestine of the tilapia with the use of acidifiers can improve digestion by stimulating secretion and activation of digestive enzymes.

This was also demonstrated in shrimp as various acidifiers had the effect of elevating the activity of trypsin and chymotrypsin. These results aligned with a trial conducted with an acidifier blend product formulated by Phibro Aqua.

PAQ-Tivate™ was strategically developed as a joint project with experts from Dr Eckel Germany and it was specifically designated for aquatic species.

The trial results showed increased enzyme activity in whiteleg shrimp (*L. vannamei*). In this trial three formulations were examined: 1) highly digestible (nine percent fish meal) formulation 2) soybean base formulation and 3) soybean base formulation +0.5 percent of PAQ-Tivate.

The enzyme activity in the hepatopancreas presented similar trends between the diet with the fish meal and with PAQ-Tivate as the enzyme activities were significantly higher than soybean meal diet (Figures 1-4).

Also, trinitrobenzene sulfonic acid (TNBS) was significantly higher in the PAQ-Tivate treatment indicating enhanced protein digestibility when it was added (Figures 1-4).

This study documented that soybean meal-based formulation supplemented with PAQ-Tivate could significantly increase feed utilisation, proteolytic enzymes activity and in vitro protein digestibility of whiteleg shrimp (*L. vannamei*).

These results were supported with better performance: enhanced growth and higher survival.

Improving feed hygiene

Moulds in feed are causing economic and health problems in aquaculture operations because they consume the main nutrients and affect the palatability of the feed. Losses of nutrients caused by moulds can occur in magnitudes up to 10 percent.

Propionic acid and its salts are especially effective against mould development due to its pKa value of 4.8, propionic acid is also active at a less acidic pH, which more closely matches the native pH value in grain and feed.

The pKa value is one method used to indicate the strength of an acid. A lower pKa value indicates a stronger acid. That is, the lower value indicates the acid more fully dissociates in water.

To examine its effectiveness as a preservative agent against bacteria and fungi in formulated tilapia feed, two doses (0.2 and 0.5 percent) of PAQ-Tivate were examined. The feed samples were moistened with 15 percent distilled water. A sample with no water and no PAQ-Tivate served as a negative control, while a sample which included 15 percent distilled water (v/w) but without any PAQ-Tivate served as the positive control.

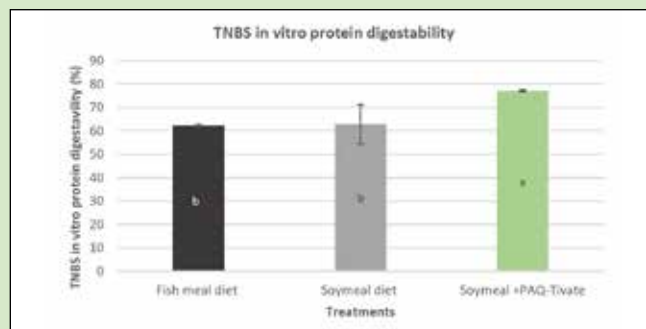


Table 1: Counts of bacteria per treatment per sampling day (CFU/g of feed)

Day/ treatment	Negative control	Positive control	PAQ-Tivate™ 0.2%	PAQ-Tivate™ 0.5%
Day 0	20,000	NA	NA	NA
Day 1	NA	23,333a	57,500b	75,000b
Day 3	NA	123,333a	20,000b	23,333b
Day 7	NA	303,750,000	220,250,000	132,500,000
Day 14	NA	67,500,000a	60,000ab	32,500b

Table 2: Counts of fungi/molds per treatment per sampling day (CFU/g of feed)

Day/ treatment	Negative control	Positive control	PAQ-Tivate™ 0.2%	PAQ-Tivate™ 0.5%
Day 0	1,250	NA	NA	NA
Day 1	NA	2,500	0	0
Day 3	NA	25,000	125,000	110,000
Day 7	NA	10,500,000	13,250,000	6,827,500
Day 14	NA	72,500,000a	23,666,667a	247,500b



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Control – without PAQ-Tivate



PAQ-Tivate at 2 g/kg feed



PAQ-Tivate at 5 g/kg feed



Figure 5: Feed samples on day 7 of incubation. There is no visual presence of molds or fungi in any of the test samples. All the replicates for all the treatments in the experiment were similar to the images above.

Control – without PAQ-Tivate



PAQ-Tivate at 2 g/kg feed



PAQ-Tivate at 5 g/kg feed



Figure 6: Feed samples on day 14 of incubation. There is no visual presence of molds or fungi in the PAQ-Tivate™ 5 g/Kg sample, but there is a clear growth of fungi in the positive control and in the PAQ-T2 groups. All the replicates for all the treatments in the experiment.

All the samples were incubated at 28°C and the humidity level was maintained at 75-85 percent. Each treatment was sampled at days 1, 3, 7 and 14 from wetting. The results showed that at day 3, the levels of bacteria in the positive control samples were significantly higher compared to the PAQ-Tivate treatments (Table 1).

At day 14, both PAQ-Tivate treatments of 0.2 and 0.5 percent feed had a significantly lower levels of bacteria compared to the positive control group (Table 1). There was no significant difference between the two doses treatments of PAQ-Tivate (Table 1).

With respect to fungal levels on day 14, the 0.5 percent feed treatment of PAQ-Tivate had significantly lower count of fungi compared to the 0.2 percent feed treatment of PAQ-Tivate and the positive control groups (Table 2). The 0.5 percent treatment of the product resulted in a significant reduction in the fungi/moulds count from day 7 to day 14 (Table 2).

At day 14, there was a visual growth of fungi on the feed samples of the positive control and the 0.2 percent feed treatments, whilst there was no visible growth of fungi in the 0.5 percent treatment group on day 14 (Figures 5 & 6).

In addition to these nutrient losses, moulds also produce mycotoxins, threatening animal and human health. Aflatoxins for instance can be transferred into animal tissues and therefore pose a serious risk for the consumer (carry-through-effect).

The detrimental effects of mycotoxins on animal health and performance have been comprehensively studied in terrestrial animals but there are relatively few studies in aquaculture systems.

The most important mycotoxicosis in fish and shrimp is caused by aflatoxins, primarily produced by *Aspergillus* spp. during storage of feed and raw materials. Propionates have been shown to prevent the formation of Ochratoxin A by *Aspergillus sulphureus* and *Penicillium viridicatum*.

Choosing the most beneficial blend

There are many organic acids available to the animal feed industry, including formic acid, acetic acid, propionic acid, lactic acid, fumaric acids, citric acid, sodium formate, butyric acids, sorbic acids and malic acids.

The question is, how do we choose the appropriate and most beneficial acid blend? In order to arrive at the correct solution, the consumer needs to consider the wanted benefits and the required technical traits (e.g., increase protein digestibility and high recovery following extruder).

In order to ensure that PAQ-Tivate was suitable to the needs of the aquaculture feed industry, low leaching, thermal stability, small average particle size with a homogeneous distribution and easy handling (less corrosive) were characteristics considered to be of the highest priority.

The treatment was developed to contain fumaric acid in the form of its magnesium salt, formic and propionic acid and their calcium salts.

These organic acids function as feed attractants (propionate), antibacterial agents (propionate, formate), and growth promoters (fumarate) all of which are aligned with the required performance of this blend.



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Performance minerals

A cost-effective solution for reducing fishmeal in aquaculture diets

by Cláudia Figueiredo-Silva, Zinpro Corporation, USA, & Stavros Chatzifotis HCMR, Gournes Heraklion, Greece

When moving towards precise and sustainable aquaculture nutrition, a re-evaluation of the nutritional needs of the fish is always required. By conducting a comparison of the trace mineral (TM) composition of alternative protein sources to fish meal, the researchers expose significant limitations amongst zinc (Zn), Selenium (Se), Iron (Fe) and other nutrients.

In addition to a lower content in TM, antinutritional factors such as phytic acid found in many plant meals that are currently used to replace fish meal (FM), are not digested by fish and have negative effects on availability of minerals (NRC, 2011), making TM needs more difficult to be met. In this respect, stability and the way different supplemental TM are absorbed affects their availability and ultimately, animal performance.

Metal-AA complexes (a mixture of a single specific metal complexed with different AA in a 1:1 ratio) are taken up by AA-transporters instead of common metal ion transporters, reducing the risk for transport saturation and improving absorption efficiency.

Another advantage of using metal-AA complexes, instead of

metals in their inorganic form, is that they are more stable and minimally antagonised by other dietary ingredients like phytic acid.

Previous research conducted by Paripatananont and Lovell (1995) showed that zinc methionine complex was three-to-five times more bioavailable than inorganic zinc (ZnSO_4), in meeting the growth requirements of channel catfish that were fed purified and practical diets containing phytic acid, respectively.

Metal AA-complexes supplemented at half the rate of inorganic sources proved to maintain or even improve growth performance of European sea bass (*Dicentrarchus labrax*) and Atlantic salmon (*Salmo salar*), respectively.

Moreover, partial or complete replacement at 0.5 times the rate of inorganic minerals with metal-AA complexes, reduced skin lesions in Atlantic salmon after infestation with *Caligus* and increased number of goblet cells in intestine and skin of European seabass. This indicates the existence of an enhanced barrier defense mechanisms against pathogens.

In the later study, conducted in collaboration with HCMR, different TM premixes sources and levels in 20 percent FM diets were evaluated, which reflected FM inclusion levels practiced in commercial diets.

In a follow up study at HCMR and co-funded by the AquaExcel EU programme, the researchers evaluated how, by adjusting inclusion of a complete metal-AA complex, premix contributes

Figure 1: Specific growth rate and whole-body zinc in European sea bass at the end of the 12 week feeding study

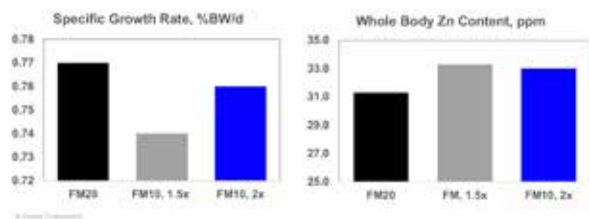
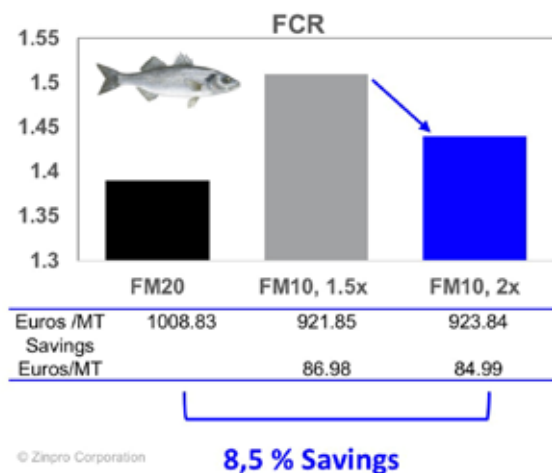


Figure 2: Change of feed conversion rate of seabass fed three different diets



to a cost-effective reduction of FM from 20 to 10 percent in European sea bass diets.

Three diets with varying fishmeal levels

Quadruplicated groups of European sea bass with an initial body weight of 47g (35 fish per tank) were fed to apparent satiety for 12 weeks, one of three diets formulated to vary in their FM level (20 or 10 percent) and adjusted for their trace mineral content.

A control diet had FM at 20 percent (FM20) and was supplemented with 50 ppm Zn as Availa® Zn, 40 ppm Fe as Availa® Fe, 12 ppm Mn as Availa® Mn, 3 ppm Cu as Availa® Cu and 0.12 ppm Se as Availa® Se, (Zinpro Performance Minerals, Availa®Mins line).

Two additional diets were formulated to reduce FM level in control diet by 50 percent (10 percent FM) and supplemented with same premix at 1.5 x (diet FM10, 1.5x) or 2x (diet FM10, 2x) that used in the control diet.

The analysed TM composition of FM20 and FM10 diets is shown in Table 1. Apart from FM, main protein sources used were soybean protein concentrate (10 vs 13.5 percent), soybean meal (10 vs 13.5 percent), wheat gluten (8 vs 9.2 percent), rapeseed meal (7.5 vs 8.63 percent), corn gluten (7 vs 8.05 percent) and haemoglobin (5 vs 5.75 percent); values within brackets are given for FM20 vs FM10 diets.

Maintaining growth performance

By adjusting mineral premix in FM10 at 1.5 or 2x the level used in FM20, the researchers manage to maintain growth performance and even slightly increase whole body Zn content of European sea bass, although not statistically significant (Figure 1). Yet,

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specific growth rate (SGR) and feed conversion ratio (FCR) were superior when TM premix was doubled, compared with one-and-a-half-times that in FM20 (Figure 1).

Results indicate that adjusting the dietary TM content of FM10 to similar levels of that in FM20 may not be enough to keep performance of European seabass. Increase of the TM inclusion level from one-and-a-half-times to double that used in FM20 improved SGR and FCR by three and five percent respectively, back to levels closer to that seen with FM20 (Figure 2). This may be at least partly explained by the likely lower nutrient availability in FM10 as a result of its higher plant protein content and antinutritional factors compared to FM20 diet.

Recent study shows that performance and health of European sea bass fed 10 percent FM or FMK-based diets could be kept similar but required tested inorganic TM premix to be increased by 260–300 percent, corresponding to dietary levels of approximately 200–285 ppm of Zn, 260–320 ppm of Fe, 70–90 ppm of Mn and 0.8–1.0 ppm of Se.

Although results are promising as they confirm the possibility to reduce FM significantly in sea bass diets without negatively impacting performance, required Zn levels would surpass EU upper allowed levels in sea bass diets (Table 1).

In this study, the researchers showed that supplementation with metal-AA complexes contributes towards a cost-effective reduction of FM from 20 to 10 percent, while respecting EU upper limits for TM supplementation and TM content in sea bass feeds.

The exception to this was that dietary Se content in the feed

Table 1: Analysed nutrient composition of the different diets

Dietary Nutrient Composition	FM20	FM10, 1.5x	FM10, 2x	EU Upper TM Limits
DM, %	94.80	95.70	95.00	
CP, % DM	48.10	47.73	47.63	
Fat, % DM	16.72	16.07	16.10	
Ash, % DM	7.33	6.28	6.29	
Energy, kJ/g, %DM	23.13	23.10	23.07	
Zn mg/kg	95.2	111	144	150
Cu mg/kg	8.28	10.6	12.7	25
Mn mg/kg	35.0	42.3	47.4	100
Fe mg/kg	391	418	483	750
Se mg/kg	0.860	0.755	0.876	0.5

that in this study, like in Henry's study, could not be kept at or below 0.5 ppm. Ingredient contribution to dietary Se content in aquafeeds, mainly contribution of FM and other marine ingredients, makes practically impossible to keep Se levels in diets within EU allowed levels.

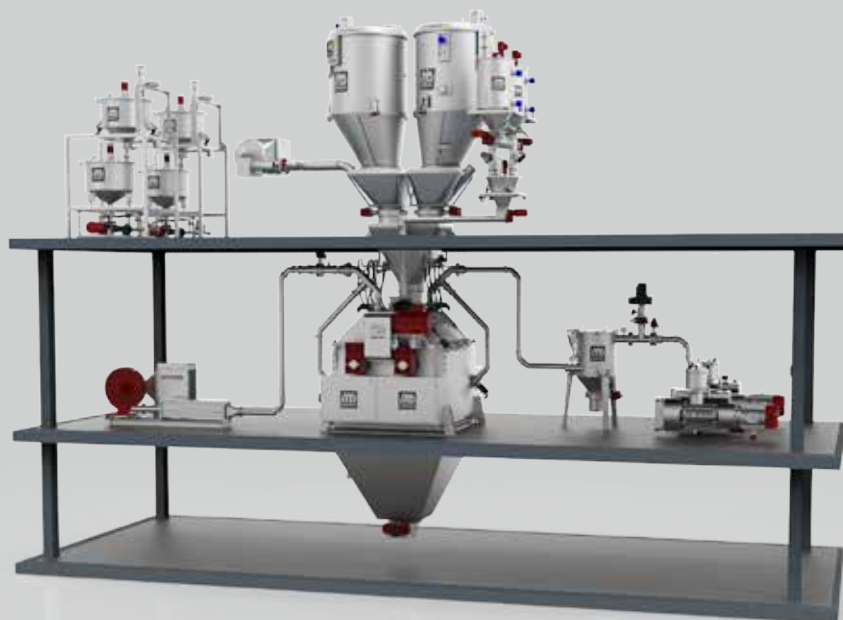
Overall, the findings of this study indicated that metal-AA complexes allowed FM to be reduced from 20 to 10 percent without significantly affecting growth or FCR while respecting EU upper limits for TM in sea bass diets.

Moreover, this strategy resulted in 8.5 percent savings with feed cost becoming a more sustainable and cost-efficient solution to the industry.

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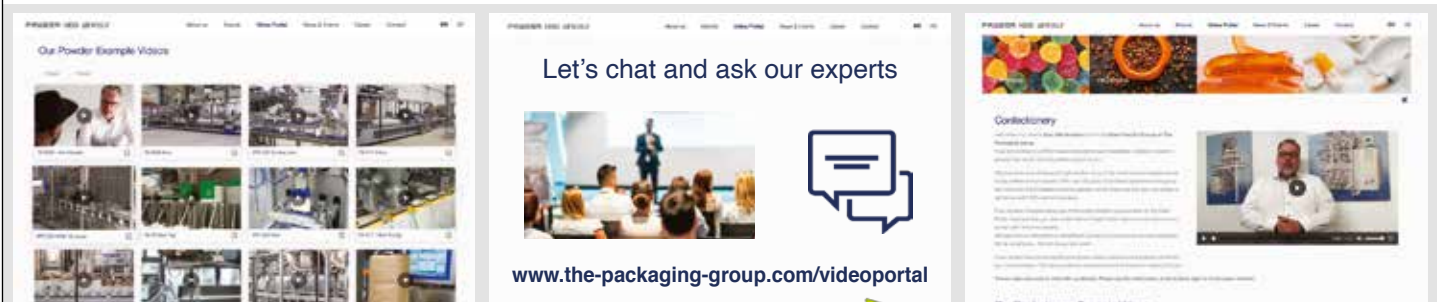
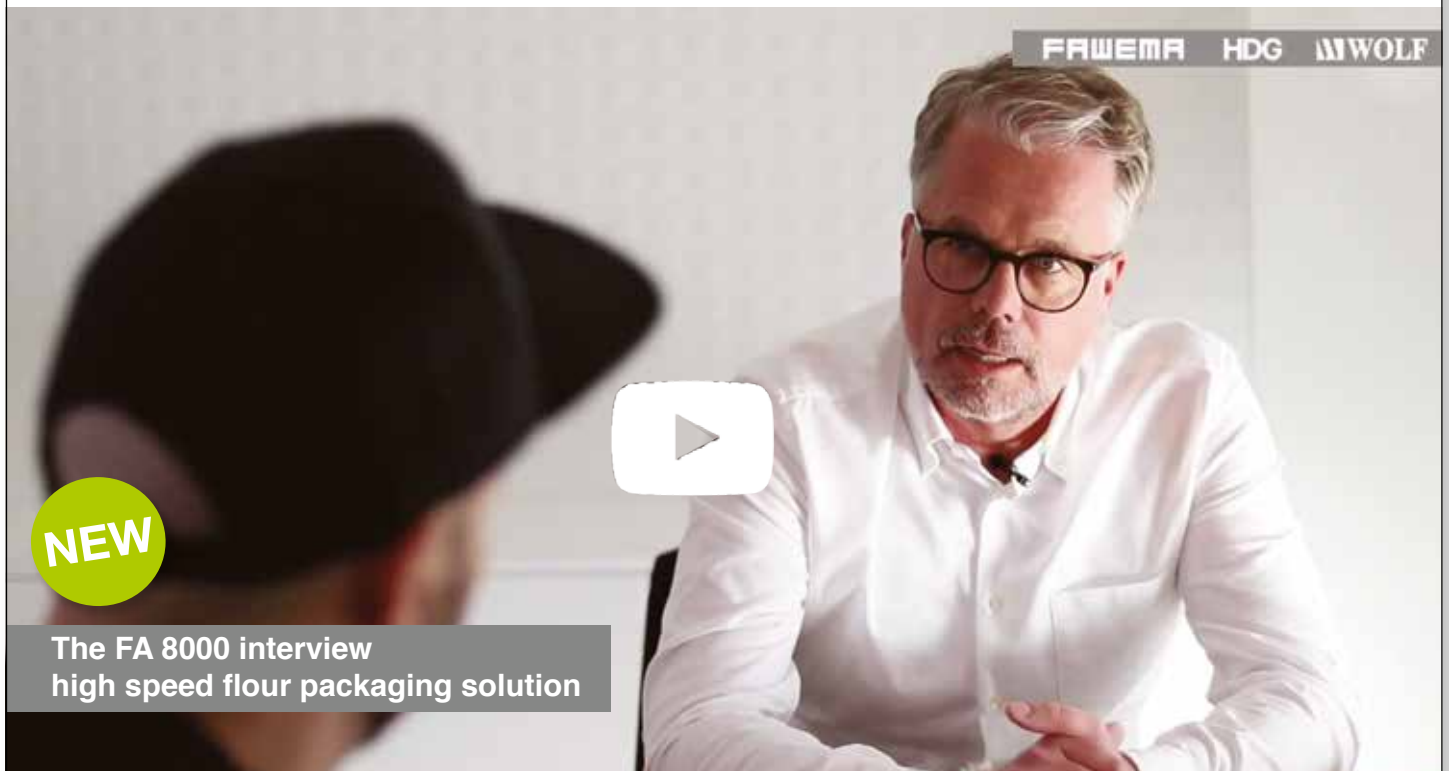
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Pursuing sustainable aquafeed production

Using advanced technology to reduce, monitor and control energy usage

by Jonathan Iman, Corporate Project Services, Wenger Manufacturing, USA



Consumers are increasingly interested in knowing the sustainability story behind the food they buy, particularly when it comes to marine conservation. The spotlight is shining brightly on the food we are eating and tracing it from the dinner table all the way back to the farm and/or fishery ... and even further back to the eco-friendliness of the feed these marine animals and fish are consuming.

Seafood is widely recognised for its low environmental impact compared to alternative sources of animal protein. Yet, within the aquaculture sector, feed production - with its robust manufacturing processes and equipment - can be burdensome on the environment.

Aquafeed production is an influential link in the supply chain, and we have tremendous opportunities to lessen environmental impacts at the plant level. In this article, we will review 'green concepts' and more sustainable practices for the aquafeed facility including responsible facility design, certifications and traceability.

Making production facilities more sustainable

In the late 1980s the Brundtland Commission released a report called *Our Common Future*, where it defined sustainability as, "... meeting our own needs without compromising the ability of future generations to meet their needs." This definition integrates environmental, social and economic development.

Sustainability is not just for environmentalists; rather, it incorporates businesses such as feed manufacturers who strive for responsible profits, employee rights and a positive impact for the present and future.

Of course, we cannot completely escape the environmental impacts of manufacturing. Aquafeed facilities, like many other industries, use ingredients harvested from the land or sea, have building and packaging materials that will one day be thrown in a landfill, consume unrenewable utilities and burn fossil fuels for transportation of goods and people - all of which impact the

environment to varying degrees.

However, there are many ways to incorporate sustainably minded practices into the design and operations of your facility; and even incremental changes can add up to big improvements.

Early collaboration is crucial

When planning a new feed facility or installation, the best time to apply sustainable concepts is in the beginning stages of your project. So you should start by creating an Owner's Project Requirements document; a high-level outline of the company's requirements for the project.

This is where you can determine your sustainability goals, such as reducing energy demand, reducing water usage, reducing your target carbon footprint and target certification goals. Applying these concepts early in your project will help integrate them into the design and practices of your facility, saving you time and money in the long run as early collaboration is crucial.

Bring together your design teams, extrusion process experts, project stakeholders, architects, engineering, plant management and sustainability consultants during the predesign phase of your project. This encourages efficient feedback and reduces time loss caused by developing your project in isolation.

If you invest a great deal of effort in the project design phase, you will have a greater ability to control design changes and costs later during construction and operation. This multifunctional team should not only reference the Owner's Project Requirements but move deeper into the planning of energy and water use reduction for the manufacturing process, building and grounds.

They also should consider creating a conceptual design and utility analysis of your project, which includes the building and equipment. This will provide a visual analysis for your energy and water usage savings.

A few areas stand out as the most advantageous steps toward creating a greener production environment, which are materials, site selection and utilities. Making improvements in these areas can drastically increase the overall sustainability of your facility, so they are a critical place for your team to focus attention.

Assess material longevity

In the past, many aquafeed facilities devoted little attention to the lifecycle of their facility.

Modern projects should look beyond a price tag and recognise how the materials are sourced, how long they may last, and what will happen to them at the end of their life.

To be more sustainable, projects should source high efficiency building materials and equipment with advanced technology to reduce, monitor and control manufacturing energy. The cost may be more upfront, but the return on investment can be much greater.

During this phase of your project, be aware of ‘greenwashing’ (companies professing to be environmentally friendly by words only) and find reputable suppliers who can provide efficient equipment with a long life. To help quantify longevity, you can perform a life cycle assessment (LCA). LCA models help you compare the environmental impact over the entire life cycle of your process, equipment and building materials. Having this analysis will help you make responsible decisions for your project design.

Select an eco-friendly processing site

The building site should also be considered when designing a sustainably minded project.

One strategy to reduce your building’s environmental impact is to reuse existing building space and materials. Obviously, this is not always possible, but when applicable it can offset the environmental impact of new material generation and reduce landfill waste.

Additionally, selecting a brownfield site saves undeveloped land



that could be used for agriculture or natural purposes. Brownfield sites generally mean the site is already in an area with existing infrastructure, which can improve project cost savings and reduce emissions generated from transportation of goods and employees.

For example, if your facility is in or near a populated area, you can encourage alternative modes of transportation, such as public transportation, carpooling and biking. (Populated areas do tend to have regulations regarding the air pollution from nearby manufacturing, so be sure to select the appropriate air abatement system for your site.)

The project property also needs to be part of this planning.

Reduce your environmental impact by creating a rainwater management plant. You can control runoff on your site by incorporating bioswales, a green roof and permeable surfaces such as pavers for parking and sidewalks.

Reduce utility demands

There are multiple strategies for reducing your utility demands. A few basic suggestions for your project teams to consider relate to water, energy and waste management.

When identifying ways of reducing your process water

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requirements, selecting equipment with lower steam requirements, dry wash equipment and use closed loop water systems is of key importance.

Monitoring your water use with meters is crucial for identifying waste or reduction opportunities, whilst the inclusion of greywater recycling and rainwater harvesting into your water system will also enable this.

Designing your layout to be as efficient as possible is crucial when seeking to conserve energy. A more compact layout design can reduce the need for some transport equipment and utilities. When possible, try to keep the receiving, storage, processing and shipping in the same vicinity to reduce the building size, energy requirements and transport distances.

Renewable energy technology does have its limitations, but it should still be considered by your project team.

Try to identify modern equipment and technology with increased energy savings, looking for Energy Star equipment for office furniture and appliances is one example of this, whilst using daylight-responsive controls and occupant sensors is another. Like with water usage management, tracking all energy sources with meters is the best way method for identifying additional saving opportunities.

The first rule of waste management is that the collection of recyclables is a must, so developing a collection and storage program for your production and office areas should be a priority.

Similarly, for the construction phase you should implement a waste management plan with the goal of separating recyclable waste from landfill waste.

Packaging generates a considerable amount of waste for you and your clients, so you should try to package your products in recyclable or biodegradable material and demand that your suppliers do the same. You should also seek to implement waste recovery systems that can place startup material and byproducts back into the process.

Certifications and traceability

As you can see, there are many places where small changes can lead to great progress toward a more environmentally friendly production facility, putting you in a favourable position for earning desired certifications that validate your green practices.

Feed industries are continually making changes in order to comply with government mandated food safety regulations. Most recently, big shifts in consumer awareness have put even more scrutiny on the feed and food industry. Consumers not only want to know where their food came from, but also its environmental impact all along the supply chain.

Their mindsets are evolving from, “Is this fish on the menu a threatened species?” to, “Was this fish grown in a fishery

with sustainable feed and fair working conditions for the labourers?” The consumer wants assurance that the food they are consuming can be traced all the way back to the beginning.

The Food and Drug Administration (FDA) in the USA, defines traceability as, “The ability to follow the movement of a food product and its ingredients through all steps in the supply chain, both backward and forward. Traceability involves

documenting and linking the production, processing and distribution chain of food products and ingredients.”

Traceability has been documented in feed manufacturing facilities for years, but there is a growing demand for increased ingredient transparency and proof of origin.

The sustainably minded aquafeed facility needs to show proof that their raw materials are responsibly sourced. Marine ingredients, such as fishmeal and fish oil, should be from documented suppliers that follow the responsible practices such as the Food and Agriculture Organization’s (FAO) Code of conduct for responsible fisheries and feed facilities themselves should work toward certifications such as the ASC or MarinTrust to aid in traceability.

As the industry offsets some marine resources to plant-based resources, a sustainably minded company also needs to obtain these inputs from a certified source.

For example, consider soybean and palm oil usage in feed recipes. Awareness is growing of the environmental impact of soy and palm production with regards to carbon footprint, chemical use, water depletion and deforestation.

There is a wide range of certification programs available to the aquatic industry that includes both extruded aquafeed and fishmeal producers. A few of the more recognised entities include the Marine Stewardship Council (MSC), the Aquaculture Stewardship Council (ASC) and MarinTrust.

These certification entities have various programs that focus on specific portions of the value chain, but all share the goal of reducing the environmental impacts within the aquaculture industry.

As an example, the ASC is releasing a new feed standard that will define requirements for responsible factory practices and requirements for responsible ingredients including marine ingredients, terrestrial plant ingredients and terrestrial animal ingredients. This will also address habitat loss, over-harvesting, human rights abuse and sustainable environmental indicators, such as water and energy consumption.

Navigating the complexities of the aquafeed industry

As a result of heightened consumer scrutiny, governmental regulations and a growing interest in environmental consciousness, the aquafeed industry faces increasing pressures to be ‘green’.

Within the aquafeed industry, we must do our part to make our work less burdensome on the environment and that requires attention to detail and innovations that allow us to adopt more sustainable practices.

Corporate Project Services helps companies design production facilities and navigate the complexities of certification, all in pursuit of establishing a more sustainable operation overall.

Implementing and designing more sustainable practices into your aquatic feed facility impacts your community and your environment, but it also can reduce your utilities, increase your return on investment, create a comfortable space for employees and help increase sales, and qualify your company for government programs.

Corporate Project Services is a division of Wenger Manufacturing that specialises in extrusion project management and facility design. Wenger is actively developing equipment and controls solutions for sustainability in our own equipment manufacturing practices, including our systems used to produce aquafeed products.

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FISH FARMING TECHNOLOGY

Tech update

A new era in offshore fish farming

Ocean Farm 1, the world's first offshore fish farm, has now arrived at Frohavet, Norway in an event that may represent the first step towards a new era in aquaculture.

Based on world-class Norwegian aquaculture and offshore technology, the Ocean Farm 1 aspires to address central issues related to sustainable growth in the aquaculture industry.

As a full-scale pilot facility, Ocean Farm 1 is designed to test out both the biological as well as the technological limits of offshore fish farming. Behind the project is a unique interdisciplinary partnership between world-leading players in Norway within aquaculture, offshore and research.

The result is a structure built on the robust technology and principles used at submersible offshore installations, whilst safeguarding the biological needs of the farmed salmon.

When developing technical solutions, every fish farming process has been considered, with new approaches established in order to cater for the various operating procedures.

Built by the China Shipbuilding Industry Corporation (CSIS) in the Chinese city of Qingdao, the structure complies with the aquaculture industry's own fabrication standards, as well as relevant offshore oil and gas standards.



Do land-based RAS face insurmountable challenges?

by Mette Cristine
Schou Frandsen,
communications
adviser for OxyGuard
International,
Denmark

**Early maturation,
disastrous events
that kill entire
stocks, off-flavours,
construction flaws
and red figures on
the bottom line: the
media is full of stories
like this. Critiques
say that land-based
Recirculating
Aquaculture Systems
(RAS) are dead.**

In the early days of the wind turbines, experts considered the venture a failure. They stated that there was no future for wind power. The same was the case for refrigerators, smartphones and space travels. They were wrong. We only know this because someone did not listen and kept developing, improving and believing in their innovation.

It takes time to introduce entirely new technology and methodology. There will be bumps along the way, and it is expectable – and acceptable. Today, frontline companies are paving the way, taking the risk and they dare to make the mistakes others will learn from and thereby grow.

We have been looking through the list of failed RAS companies and we have evaluated disastrous events, re-calculated flows and loads and extrapolated technological development that can support RAS.

Our conclusion? There is a bright, promising future for land-based RAS – as long as we are willing for them to accept that it takes time to develop and implement such complex innovation in their sector.

Main challenges one-by-one

We have done a short walk-through of the main challenges and possible solutions faced by land-based RAS below.

1: Mass die-offs

We can read about these unfortunate and dramatic events once a year in the media, that are always followed by plummeting stocks and blooms of negative articles on the future for RAS.

A major part of these events are caused by hydrogen sulphide (H₂S) formed under anaerobic conditions in the biofilters and/or pipe system where sludge can be accumulated and released to the production water during cleaning or reinforced water flow.

H₂S formation is often associated with drops in nitrate concentrations (Nitrate keeps hydrogen sulphide in check following this reaction: $5\text{H}_2\text{S} + 8\text{NO}_3^- \rightarrow 5\text{SO}_4^{2-} + 4\text{N}_2 + 4\text{H}_2\text{O} + 2\text{H}^+$).

How to prevent it? It is easy to minimise the risk considerably.

First, we should build these facilities in units with separated water flow ensuring that for example, that H₂S released from the filters does not affect the entire stock.

Second, the maintenance protocols must be kept within a strict frame of operational procedures. As much as possible should be automated digitally to prevent human errors.

In the end, mass die-offs are a management problem - not caused by bad management, but by lack of both practical and theoretical experience in the sector and by immature



management protocols. RAS units are highly technological and complex production facilities, possibly too complex to run without modern digitalisation tools and automation of procedures.

We strongly believe the mass die-offs will become history only, in a very short timespan.

2: Off-flavour caused by Geosmin and MIBs

As the technology matures, so does our knowledge on water quality and the water matrix development over a production period.

The first step towards removing the challenges with off-flavours is to gain complete control over the

water matrix. Part of the challenge can be overcome simply by optimising the cleaning capacity for the recirculation water. This removes part of the challenge.

The next step is to implement new technology in the water treatment systems.

Today off-flavours can be removed with ozone and within the near future it might be possible to do biodegradation of the substances using selected bacterial strains of *Chryseobacterium* sp., *Sinorhizobium* sp. and *Stenotrophomonas* sp.

The final solution to the off-flavour challenge will probably be a mixture of water treatment using ozone, filters, skimmers and increased control over the bacterial communities both within the water and the filters.

3: Early maturation – a multifactorial challenge

Numerous factors are influencing the time of maturation for and solving the challenge with early maturation which will take a multi-factorial effort.

The growth conditions in RAS must be optimised for late maturation.

First of all water quality and water matrix should be optimised and this takes sensors, monitoring systems and digitalisation. As we say in OxyGuard – do not spend billions on concrete and save a buck on the technology that will determine the operational success of your farm.

We need to access data on all the parameters of influence – their correlation of feedback systems. This knowledge must be collated into management procedures. With the introduction of digitalisation and strong algorithms such as AI and machine learning, it will soon be possible to draw information across all these factors and develop guidelines for production based on this.

Choose your digitalisation tools with care! Besides improving production methodology, both sex and genetics play a large role. Some subspecies are genetically better in these production systems than others.

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4: Energy consuming factories – when it cost a billion to make a million

Yes, RAS comes with steep energy costs affecting the environmental footprint of the production. To make RAS feasible both economically and environmentally this must be addressed.

Small improvements can be done through facility design, for example not keeping equipment that produces heat in water that must be kept cold, and optimising water flow.

However, the long-term solution will be to introduce renewable energy. This will take RAS high up on the ladder of environment-friendly protein production.

On a general note, RAS could become one of the world's most efficient ways to produce good healthy protein. By bringing fish on land and growing them in enclosed enclosures we gain full control over all inputs and outputs. We could, in theory, reuse every single molecule from these facilities, thereby creating an almost perfect food production system, seen from an environmental point-of-view.

5: RAS – a business in the red

Closely tied to the above challenges are the economical disadvantages of RAS. Often economy is the ultimate argument when critiques explain why RAS will never be a success.

As for today, they seem to be right.

RAS facilities are struggling with establishing profitable production. The expenses are high and often the amount of produced fish is low – giving a high per kg price. But this is not a law of nature. The economy is struggling for many reasons; reasons that have solutions as pointed to in the above challenges.

Solving these challenges will make RAS a good business option both for the economy and for nature.

We have our heads deep in the task of trying to deliver the needed technological innovation that will solve current and upcoming challenges. We strongly believe in land-based RAS until someone gives us a significant reason not to! We do not expect everything to be in place and perfect at this point. It wouldn't make sense. and as Aristotle said, We have to learn by doing.



About the Author

Mette Cristine Schou Frandsen (1976) holds a Masters Degree in Biology and a PhD degree in environmental science from the University of Copenhagen, Denmark. Prior to her academic career, she was educated as a farmer on Ladelund Academy of Agricultural Business. She is the founder of the Danish innovation platform Future Foods (now part of the national organisation World's Best Food) and have been working with food security and sustainable food production for more than five years. Currently she is employed as a communications adviser for OxyGuard International.



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Fish mortality

Preventing springtime fish deaths on your aqua farm

by Kristin Elliott, Aquasend, USA

Each year as spring approaches, it is important to be prepared for springtime diseases and dissolved oxygen loss on your aqua farm. That said, if you do see a few dead fish floating in your ponds, there is no cause to panic.

Fish deaths are the result of many different causes including changes in temperature and dissolved oxygen levels, stress, pollution, disease, toxic substances, and more. However, there are a few specific factors that you should keep your eye on come spring.

Specifically, abrupt temperature changes, decreased dissolved oxygen levels, and bacteria are the most prevalent factors leading to springtime fish deaths. Luckily, they can often be prevented or alleviated with a little preparation.

Why your fish are dying

Springtime fish kills are unfortunately fairly common and can be the result of several different challenges that fish can face coming out of wintertime. In many climates, spring can mean extreme weather conditions or sudden temperature increases, both of which are detrimental to the well-being of your fish.

These conditions can contribute to low dissolved oxygen levels along with additional sources of stress that make the fish more vulnerable to diseases.

Fish have decreased appetites during the winter. Their metabolisms naturally slow down, so they don't need to eat as much to stay healthy when there are fewer nutrients readily available due to a reduced number of important compounds being produced by phytoplankton and other microorganisms.

During this time, fish immune systems are suppressed, which is detrimental when temperatures start to increase. In springtime, when temperatures begin to rise again, bacteria that are present in fishponds, which are able to recover from winter hardships much faster than fish can, will attack the vulnerable fish, resulting in diseases and potentially mass fish deaths.

Another factor in disease susceptibility is stress. Stress in fish, like humans, can result in lower immune system functions. One major stress that occurs for fish in the springtime is reproduction.

Spring is the spawning season for most fish species. In order for fish to successfully reproduce after a harrowing winter, their bodies produce a hormone called cortisol, a stress management hormone that also exists in human bodies. While it alleviates the stress from winter, cortisol also suppresses the immune system.

Many aqua farms may also experience partial fish die-offs during the spring due to low dissolved oxygen levels. Algae

and phytoplankton, the main oxygen suppliers in most ponds, produce oxygen through the consumption of sunlight.

Cloudy weather conditions, and ice covers in certain climates, limit the amount of sunlight that the phytoplankton are able to consume which will also decrease dissolved oxygen production.

When pond water temperature increases too quickly, cold-water algae often die off suddenly and are then consumed by bacteria that feed on the dissolved oxygen and multiply rapidly, which in turn causes lower amounts of available dissolved oxygen for the fish in the pond for several days.

The aforementioned contributors to springtime fish kills are able to be visually detected in some cases, if you are paying attention. However, taking preventative measures and constant monitoring of your pond's water quality are the best ways to prevent or limit the impact of fish kills.

If you do see a concerning number of dead fish in your pond, ask yourself the following questions to determine the potential cause of fish deaths on your aqua farm:

Only the larger or smaller fish are dying

If big fish are dying but small fish are not, the problem is probably low dissolved oxygen. Another sign of low dissolved oxygen is an unusual number of fish gulping near the water's surface or pond edges and slow movements.

The upper layers of the pond tend to have a greater dissolved oxygen content than deeper waters, so if you see a large number of fish spending a lot of time near the surface, or near a waterfall or other source of new water, you should check on the dissolved oxygen levels.

If smaller fish die before larger ones of the same species, there could be a toxic substance such as livestock waste runoff, pesticides, pollution, etc. involved. Small fish are more vulnerable to toxins than larger fish.

All fish are dying regardless of size

In this case, you are probably dealing with a disease or parasite outbreak. Fish can contract bacterial, viral and parasitic diseases, just like any terrestrial animal. However, there are only a handful of drugs and vaccines available to treat fish diseases because of environmental concerns.

Sanitising your farm equipment and maintaining high water quality in your ponds are the best ways of minimising risk of disease. Signs of an outbreak include unusual discoloration or sores, erratic swimming, bulging eyes, external parasites clinging to their bodies and a singular species experiencing the symptoms.

Once you know the cause, or have an educated guess, as to why your fish are dying you can easily and quickly find a solution.

How to prevent fish deaths

Although knowing what to do when one of the aforementioned issues occurs is important, putting preventative measures in place will ultimately save you time and money. If you aren't sure what to do, don't panic! Here are a couple of ways you can prevent fish deaths and keep your fish happy and healthy in the springtime:

Don't over-fertilise your ponds

An excessive amount of fertiliser can be toxic and potentially fatal for fish. Nitrogen and phosphorus are the two most important minerals for promoting phytoplankton growth, which in turn promotes fish growth.

However, if there is an excessive quantity of phytoplankton (which can be determined by the turbidity level of the pond) there may not be enough available dissolved oxygen or other nutrients for the fish. There are several safe, effective ways to fertilise your pond depending on the size of your pond and the type of fertiliser you plan on using.

Avoid using excessive herbicide on or near your ponds

Herbicide, while helpful for killing off invasive plants, can go too far if used incorrectly. This can result in aquatic plants that normally produce oxygen for the fish dying off. One best practice is to treat no more than one third of your pond with herbicide at a time.

Don't overstock your fish

Overstocking creates resource scarcity; if more fish are fighting for the same oxygen and food, more will be unable to intake

a healthy amount. The ideal pond size to fish ratio depends on the species and size of fish you are raising. However, a general guideline is 6-10 gallons of water per every one pound of fish.

The largest risk of disease in fish, aside from suppressed immune systems from abrupt temperature shifts, is contracting a bacteria or parasite from another nearby fish, so you should only stock healthy fish and separate sick fish from your main stock.

Your fish feed supplier may be able to supply medicated fish feed that is designed to treat bacterial disease, which can also be useful in preventing bacterial disease outbreaks.

You should also make sure that your ponds are not at risk of receiving waste runoff from any livestock, crop fertiliser, pesticide or any other organics.

Use fish farm technology to your advantage

Making use of existing fish farm technology is a further method of avoiding mass die-offs. By installing real-time monitoring devices in your ponds, you will be notified immediately if a drop or change in temperature or dissolved oxygen levels is detected in your pond. This will help you to avoid potential fish kills from suffocation.

Considering an aerator for your farm is also good practice, this is because aerators create bubbles under the surface of the pond which allows more oxygen to be circulated and dissolved.

There are different types of aerators that are best for specific pond sizes; aerated well water systems (splashed or sprayed) are most effective for smaller ponds, for example.

Using some, or all, of the above suggestions, you can preemptively prepare your aqua farm to have the lowest risk of a spring kill. Taking preventative measures before you start experiencing fish deaths is the best way to prepare for springtime.

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- Electrical power panels and control panels



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Innovations this month

May 2021

This month, the International Aquafeed team examine some of the best innovations in sensor technology, pens, submersible ROVs and fish counters.

Yanmar Automated Fish Counter

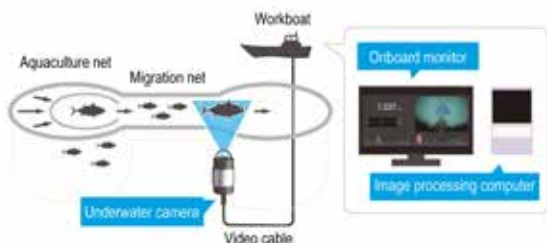
Designed specifically for the tuna farming industry, the Yanmar automated fish counter uses image recognition to count the number of fish.

Fishing vessels are now legally required accurately to report the number of young Pacific bluefin tuna caught in the wild. Many of these immature fish are handed over alive for breeding at fish farms.

The standard configuration of the automated fish counter includes an underwater camera, which includes a video cable with a high IP rating, onboard monitor, image processing computer and dedicated software.

The counting system enables users to analyse and check results during or immediately after video capture, whilst the underwater camera's angle of sight can be adjusted by remote control even after the camera is installed underwater. This reduces the time required to install and adjust the camera. The fully adjustable screen display and correction functionality also enable easy manual counting and correction after automated analysis, even for images affected by environmental disturbances.

www.yanmar.com



Faivre Pescasight 100 fish counter

Featuring the very latest camera technology, the Faivre Pescasight 100 fish counter is designed to cover the counting needs of fish that range from 0.2g to 50g, with a maximum hourly flow of 600,000 bass, bream, trout or salmon.

Faivre's counting technology allows for the average weight of fish to be calculated during the counting process, with both the counting report and video then exportable via a USB port for verification purposes.

Other key features include a high counting accuracy 99 to 100 percent, whilst its light weight of 72 kg makes it both compact and maneuverable, with its large touch screen interface also ensuring ease of use.

Designed to be placed at the fish pump outlet for loading trucks or fish transfer, its quick on-site installation also vastly reduces the time and costs required between purchase and installation.

aqfeed.info/e/1129

www.faivre.fr



The Blueye Pioneer underwater drone

The Blueye Pioneer underwater drone offers exceptional user experience and performance, with groundbreaking technology that gets your eyes below the surface.

The full HD-camera allows you to record your dive with a wide angle camera (1080p/30fps), whilst the 3300 Lumen LED light configuration allows you to dive in the dark.

The robust vehicle has been pressure tested and found to be able to handle frequent dives of up to 150 metres, whilst the two hour battery life means that the dives that you stream direct to MS Teams via the app remain uninterrupted.

Whether you are performing inspections in deep and dark oceans or clear waters, the camera is optimised to perform in different and challenging conditions. The Blueye app allows you to control light exposure and camera hue settings.

Blueye provide you with the tools to capture high-quality images and videos.

www.blueyerobotics.com



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The Meercat M14

The M range of workboats from Meercat offer increased cargo carrying capability and superb performance at an affordable price. The New Range M14 is the most compact of the Meercat range and a popular choice for those working in a confined environment. Standard vessel sizes range from 14 to 18 metres as standard but can be custom built up to 24 meters at their purpose built workshops in Southampton, UK.

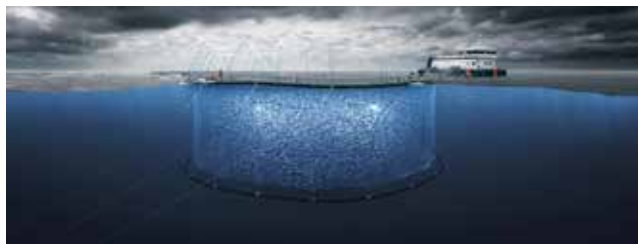
A highly manoeuvrable vessel with a shallow draft, the M14 is capable of working in tighter spaces than most workboats of a similar size. Its impressive load carrying capability and forward mounted crane will be a popular choice amongst vessel owners.

The new design allows for a greater bollard pull, improved visibility from the wheelhouse and is coded to MCA Workboat practice Category 3 as standard.

www.meercatboats.com



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The ScaleAQ Midgard® System is the result of several years of hard work to find new, improved solutions within net cage technology – including cages, sinker tubes and nets.

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The Midgard system provides stable, predictable cage net volume, even under the most extreme environmental conditions.

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www.scaleaq.com



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Aquaculture in Brazil

- The US\$1 billion industry

by Dr Patricia Moraes-Valenti

The article entitled Aquaculture in Brazil: past, present and future¹ is published in the journal Aquaculture Reports, which is available on open access, so it is open to everyone who wants to view it.

By combining the data yielded from five official databases with a wealth of information contributed by 77 stakeholders located across Brazil and employed throughout all stages of the production chain, this article provides an in-depth examination of Brazil's aquaculture sector.

Not only serving as an invaluable resource for academics, this journal article also provides very useful insights for those in a wide variety of occupations including public sector managers and the business leaders.

The article discusses all areas of the aquaculture sector in Brazil, from its humble beginnings in the middle of the 17th century in the country's Northeast region, right up to its recent emergence as a serious contender on the global aquaculture production stage.

However, as a professional activity, Brazilian aquaculture is only half a century old and started with the culture of carps in rural areas and ornamental fish species in urban areas.

In fact, it was only during the second half of the 20th century, that the culture of edible aquatic organisms such as fishes, molluscs, marine and freshwater shrimps, had attracted the attention of Brazil's policy-makers, water-reservoir managers, hydropower companies, researchers and farmers.

These initial experiences leveraged aquaculture in Brazil, with the activity experiencing great development and diversification throughout the 1990s and 2000s. During this period, thousands of aquaculture farms have been installed across Brazil. In fact, of the 5570 Brazilian municipalities, 4198 report some form of aquaculture production.

As the aquaculture industry has continued to expand throughout the country, it has also diversified and there are currently more than 60 species of fish and shellfish produced for food, whilst more than 250 varieties of ornamental fish and invertebrates are also widely farmed. The annual production figure currently sits at approximately 0.8 million tons, which amounts to in excess of US\$1 billion in trade.

The market for small native fish species for use as bait is also significant. Lambari (*Astyanax lacustris*) is the main species that is produced in order to cater for this market. Although it is grown throughout the country, production is concentrated in the southern and southeastern regions, mainly in the state of São Paulo.

Lambari is farmed in small ponds in small farms, although two large farms are currently operating. Production is estimated above 1,000 tonnes per year and is mostly traded as baitfish, although it is also be found in restaurants as an appetiser.

Their market size ranges from six to eight centimetres, but some sport fishermen prefer smaller lambaris that are between three and five centimetres.

Regardless of size, the farm gate price is about US\$50 per thousand, whilst the authors state that a dedicated processing plant pays about US\$ 3.00/kg and sells frozen gutted and scaled lambari for human consumption.

Given its tolerance to saline waters, the Atlantic forest lambari

(*Deuterodon iguape*) is being considered for use as bait for tuna fishery, state the authors, who also believe that its production may be an important tool for the sustainable development of rural populations and an alternative income source for communities who reside within forest conservation areas.



Brazil's different aquaculture systems

The article also shines a spotlight on Brazil's various different aquaculture systems, as well as examining the different cultivated species and production methods.

Traditionally, aquaculture farms in Brazil are classified according to the impounded area, with much of it depending on small-scale units, with 95 percent of them considered to be very small, whilst only 0.1 percent are large.

The few large farms produce marine shrimp, tambaqui/ tambatinga or tilapia, with a similar structure used by small farms also found in the leading aquaculture producing countries in Asia.

This criterion may be suitable for pond production systems, which correspond to most Brazilian production systems, but not for other culture systems, such as net-cage culture, widely used to produce tilapia.

Net cage and other open water farms may be classified according to the effective volume used to raise the organisms or include the water volume to dilute wastes.

Still, as the authors point out that, although aquaculture is strengthened as an economic activity for several producers, subsistence aquaculture is still maintained in the country, mainly based on carp, a fish group that makes little or no use of inputs.

This production is not always included in the statistics and, therefore, can be "invisible" to the eyes of academia, industry, and decision-makers responsible for public policies in the country.



Brazilian aquaculture is predominantly freshwater

Currently, aquaculture in Brazil is predominantly based in fresh water, with more than 200 thousand fish farms; there are also three thousand marine shrimp production facilities located throughout the South American nation, whilst somewhere in the region of 100 aquaculture Research & Development institutions also operate in the country.

Because of the existence of such a wealth of resources, the authors believe that Brazil possesses excellent potential for developing mariculture, which they believe is still only marginally explored at present.

They also claim that this is at least partly due to the questionable accuracy of fisheries and aquaculture statistics, that were very poor in Brazil until recently, due to what the authors describe as being an inefficient data collection system. The information on marine fisheries' production was fragmented and outdated, while the figures on inland catches were also widely underestimated.

Since 2016 however, the Brazilian Institute of Geography and Statistics (IBGE) has provided official statistical data on aquaculture, which the authors consider to be much more consistent and accurate than past data.

In parallel to this initiative, the Shrimp Farmers' Association (ABCC, Associação Brasileira de Criadores de Camarões, 2019) and the Brazilian Association of Fish Farming (Peixe BR, 2020) have also begun to present estimates of their specific sectors, although figures differ slightly from the official IBGE data.

Considering data provided by producer associations and interviews with various stakeholders, the authors estimate that production in 2019 was over 800,000 tonnes, with almost half of the country's aquaculture production coming from the southern and southeastern regions, despite the prevailing colder temperatures. Brazilian aquaculture's two most commonly produced groups are freshwater fish species, followed by marine shrimp and mussels.



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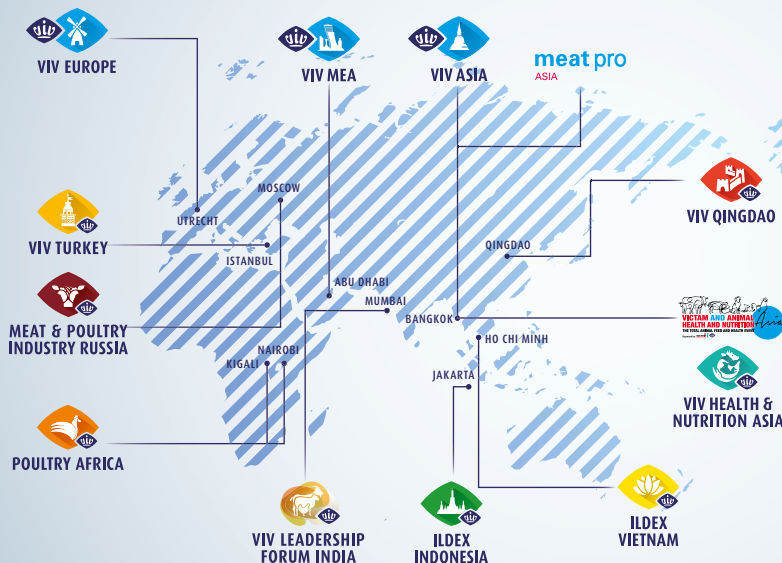


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VIV ASIA 2022

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BANGKOK | JANUARY 12-14

VICTAM AND ANIMAL HEALTH AND NUTRITION ASIA 2022

BANGKOK | JANUARY 18-20

VIV EUROPE 2022

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Aquaculture production of freshwater fish for human consumption totalled around 760,000 tonnes in 2019, while the official data (IBGE - Instituto Brasileiro de Geografia e Estatística, 2020) indicates that it was approximately 530,000 tonnes.

In the past five years, the estimated increase in Brazil's freshwater fish production was around 25 percent, whilst the freshwater fish sector represents almost 90 percent of the country's aquaculture production and 95 percent of the total number of farmed fish.

With producers that number in excess of three thousand, the farming of penaeid shrimp is a well-organised sector in Brazil. The production is based on the monoculture of the Pacific white leg shrimp, *L. vannamei*, normally farmed in intensively fed monoculture systems in large ponds, with the majority produced on farms in the estuarine regions in the Northeast, mainly in Rio Grande do Norte and Ceará, where semi-intensive systems are commonly used.

Several inland farms have low salinity waters and obtain a survival rate of 60–80 percent and attempts to produce shrimp mainly in monoculture, but also integrated with Nile tilapia. Pilot projects to produce shrimp integrated to algae and filtering mollusks have also yielded promising results.

In recent years, there has also been a growing interest in intensification, using biofloc technology which has run in parallel with a trend towards the production in inland areas, which is widely hoped will minimise environmental impact.

Prawn aquaculture initiatives

A further species considered by the authors to have a minimal environmental impact are freshwater prawns. Freshwater prawns are believed to possess great potential because they dwell in the bottom of ponds and may feed on the wastes of other cultured species.

This means that no supplementary feeding is required, with the only additional costs being those related to the acquisition, harvest management and pre-processing.

The farming of freshwater prawns started in Brazil in the 1980s, with a few traditional farmers active to this day, with the state of Espírito Santo widely considered to be the main centre of freshwater prawn farming.

The production relies on small farms scattered across the country that primarily produce the giant river prawn, *M. rosenbergii*, an Asian species. In Brazil, this species is popularly known as Malaysian prawn.

However, after years of severe droughts, production decreased drastically. Nowadays, Brazil has at least ten commercial hatcheries that distribute PL all over the country, with grow-out performed in 0.1 to 0.5 ha earthen ponds.

The total overall production is estimated to be around 150 tonnes, which is sold to wholesalers, retailers, or directly to the final consumer. Some farmers even sell their harvests at the farm gate, whilst others deliver directly to restaurants or households in different parts of the country.

According to the authors, Brazil has always had a tradition in R & D initiatives that relate to freshwater prawn aquaculture. The large group of experts has provided the necessary support to establish a solid base that has allowed the production of freshwater prawns in all farming phases.

The hatcheries are also small but are widely considered to be highly profitable and they operate in recirculating systems.

Facing an uncertain future

However, the authors suggest that these small hatcheries do face an uncertain future as the market has fluctuated wildly over the past



year. This turbulence has not only been caused by the disconnection of the production chain, but also by the climatic limitations brought about by the South and Southeast during winter.


The article also mentions that approximately 20 percent of all fish consumed in Brazil is imported, generating a commercial deficit of about US\$ 1.2 million. Most of the imported fish are marine fish.

That said, Brazil also has a vast consumer market for fish used for food and live bait for fishing, juveniles for restocking natural environments and ornamental organisms.

To get a more complete picture of aquaculture in Brazil, we recommend reading the full article, which is available at: <https://www.sciencedirect.com/science/article/pii/S2352513421000272> to prospect about the possibilities of interaction with Brazilian researchers, farms and other stakeholders of the sector.

Industry Events

Status updates for industry events amidst global effects of COVID-19

2021	May
	Starting May 4 OMS Aquafeed Production School www.onlinemillingschool.com

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Zone 2: Every Wednesday at 10:00 CST USA

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12 weekly 2-hour Sessions

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	25-27 Alltech ONE Ideas Conference Online https://one.alltech.com
	26-28 Livestock Philippines 2021 Pasay City, Philippines www.livestockphilippines.com POSTPONED TO 11-13 NOVEMBER, 2022
2021	June
	10-12 VIV Turkey 2021 Istanbul, Turkey www.viv.net POSTPONED UNTIL 2023
	23-25 Indo Livestock 2021 Jakarta, Indonesia www.indolivestock.com POSTPONED TO 2-8 JULY, 2022
2021	July
	21-23 ILDEX Vietnam 2021 Vietnam www.ildex-vietnam.com
2021	August
	2-7 Indo Livestock 2021 Virtual event online www.indolivestock.com
	11-14 Aquaculture America 2021 San Antonio, Texas, USA www.was.org
	24-26 Livestock Malaysia 2021 Malacca, Malaysia www.livestockmalaysia.com

	24-27 Aqua Nor 2021 Trondheim, Norway www.aquanor.no
	26-28 Hanoi Livestock 2021 Hanoi, Vietnam www.hanoilivestock.com
2021	September
	TBA Taiwan International Fisheries and Seafood Show 2021 Taiwan www.taiwanfishery.com
	7-10 Asian Pacific Aquaculture 2021 Surabaya, Indonesia www.was-apc.org
	14-17 SPACE 2021 Rennes, France http://uk.space.fr
	15-17 VIV Qingdao 2021 Qingdao, China www.vivchina.nl
	22-23 Aquaculture New Zealand Conference 2021 Blenheim, New Zealand www.aquaculture.org.nz
	22-24 VIV Asia 2021 Bangkok, Thailand www.vivasia.nl
	26-29 WAS North America & Aquaculture Canada 2021 St John's, Newfoundland, Canada www.was.org

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2021	October
	5-8 Aquaculture Europe 2021 Madeira, Portugal www.aquaeas.org
	OCEANS OF OPPORTUNITY Madeira, Portugal Oct. 4-7 2021 
	13-15 Vietstock 2021 Ho Chi Minh, Vietnam www.vietstock.org
	20-22 Lanka Livestock 2021 Colombo, Sri Lanka www.lankalivestock.com
2021	November
	11-13 Livestock Taiwan 2021 Taipei, Taiwan www.livestocktaiwan.com
	7-9 AlgaEurope 2021 Europe www.algaeurope.org
2021	December
	5-8 World Aquaculture 2020 Singapore www.was.org
	11-14 Aquaculture Africa 2021 Alexandria, Egypt www.was.org
	

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As a result of innovation and continuous improvement, Dibag Aquaculture takes advantage of the arrival of summer to announce a new product line:

Dibag AquaSafe®, in which we have been actively working in recent months. It is an internal quality seal to differentiate our high-value products.

Dibag Aquaculture brand has always been of a valuable company, specialized in the manufacture of special and differentiated products, using high quality raw materials, micronutrients and functional components. However, as a result of the innovation and needs of our global market, we have managed to go further and improve the quality of our nutrients, additives and formulas in our products with this new seal that aims to provide value and differentiation to our clients and achieve them the maximum performance in their production.

Why have we called it AquaSafe?

This concept includes the sustainability and safety of water and Planet Earth, as well as the health and safety of fish fed with our products, stimulating the immune system, protecting them against internal and external parasites and improving productive performance. Therefore, it is a global concept that offers and focuses on the safety of the planet and fishes.

New updates for Aquaculture events in 2021

As our industry continues to experience disruption from the ongoing Covid-19 pandemic, countless aquaculture events and functions continue to suffer either cancellation or postponement.

To give us all something to look forward to, the following article contains a list of updates from the World Aquaculture Society (WAS) that relates to events that will be taking place over the coming months.

America & Europe

Aquaculture America 2021, which was rescheduled to be held August 11-14, 2021 will go ahead on these dates with an in-person conference and trade show. The event will be held at the San Antonio Marriott River centre, in the US state of Texas.

For more information visit: www.was.org/Meeting/code/AA2021

Although Aquaculture Europe 2020 (AE2020) has already taken place, all presentations, including videos of speeches and E-posters, are available online until June 1 for attendees to consult and watch.

Access to the AE2020 e-market is also free for everyone and will remain online until June 1, 2021. For more information, visit: www.aquaeas.eu

Africa & Asia

World Aquaculture 2020 Singapore has updated its dates to December 5-8, 2021 New Dates. There is still time to submit

your abstract and to book a booth in the exhibition, which can be achieved at: www.was.org/meeting/code/WA2020

Aquaculture Africa 2021 Alexandria, Egypt will instead be held December 11-14. There is still time to submit your abstracts and book booths, which can be achieved at: www.was.org/meeting/code/AFRAQ20

AE2020 headline vendor announced

The organisers of Aquaculture Europe also announce IMPAQT as a headline vendor. IMPAQT is a H2020 project developing an intelligent multi-purpose, multi-sensing and multi-functional management platform for sustainable Integrated Multi-Trophic Aquaculture (IMTA) production.

Coordinated by the Marine Institute (Ireland), the project brought together 21 multidisciplinary partners to progress towards a more sustainable and efficient aquaculture processes and practices.

Aligned with the EU's drive to progress IMTA, the project team tested and assessed the efficiency, sustainability and circularity attributes of IMTA on six different coastal, offshore and inland pilot sites.

To allow a reliable and real-time monitoring of the IMTA system, different novel technologies were developed and integrated in an intelligent management platform, boosting the precision Aquaculture framework, which improves production in Aquaculture sites.

Other upcoming IMPAQT outputs include policy documents, handbook of the Intelligent Management System for IMTA, on-line training in MOOC format and on-line events.

Registration opens for AFIA's Purchasing & Ingredient Suppliers Conference

Registration has opened for the American Feed Industry Association (AFIA) Purchasing and Ingredient Suppliers Conference (PISC), happening in-person on August 17-19, in Orlando, Florida.

This three-day program includes education and networking events for hundreds of feed ingredient buyers and sellers across the animal food manufacturing industry.

"We are thrilled to once again offer the feed industry the opportunity to make new connections and learn strategies that drive business," says Veronica Rovelli, AFIA's senior director of meetings and events.

"PISC provides a perfect venue for industry members to foster and deepen relationships with their suppliers and clients, many of whom have been unable to travel over the past year due to Covid-19.

"We look forward to safely being back on the road seeing our members and making new acquaintances."

In addition to the networking events, conference attendees will hear presentations on myriad topics, which include tips on how to navigate the plant-based product trend, communicating with consumers using 'advocacy,' managing the threat of foreign animal diseases - such as African swine fever, understanding the current trade and political landscape, forecasting the grain and economic outlook.

The conference will also host a Suppliers Showcase where AFIA member suppliers will have the opportunity to highlight their products and services.

Although PISC will take place in-person at the Hyatt Regency Grand Cypress in the US city of Orlando, it may look different than in years past due to the AFIA's commitment to providing a safe environment for attendees in light of the ongoing coronavirus pandemic.

Those who are unable to travel may have an option to participate virtually by contacting register@afia.org

LACQUA 20 Virtual

A webinar for the LATAM Aquaculture sector

Organised by the Latin American and Caribbean Chapter of the World Aquaculture Society, the Latin American and Caribbean Aquaculture 2020 Webinar (LACQUA2020) took place online from March 23-25, 2021.

Each day of the webinar was divided into a session in the morning and another in the afternoon, as well as at the end of each session a space for questions and answers with the experts.

Each session focused a specific topic, with day one addressing economy, markets and shrimp, whilst day two examining macrobrachium and tilapia. The third and final day shone a spotlight on native species and marine fish, management of the health and production systems.

Sponsoring companies were also provided with a virtual space, granting them the opportunity to present their products and services in a special session.

Sharing valuable information

"We appreciate the participation of our sponsors USSEC (US Soybean Export Council), Cargill, Kemira, Brabender. Your support is of great value for the successful development of our events and aquaculture in the region.

"Likewise, we want to thank all the media such as Aquaculture Industry, Aquaculture Panorama, International Aquafeed, among others for helping us with the dissemination of the event," comments an WAS spokesperson.

"A special thanks to all the attendees who accompanied us the three days of the virtual event. From the south of the continent to the north we had entry records. There were more than 200 people in total."



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The market place

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the interview

Dr Patricia Moraes-Valenti PhD

Dr Patricia Moraes-Valenti PhD is a professor in the graduate program of Aquaculture, at São Paulo State University Aquaculture Center - UNESP (CAUNESP).

She currently sits on the communication and media relations committees of the Brazilian Society of Aquaculture and Aquatic Biology (AQUABIO) the Regional Council of Biology of the first Region in Brazil.

Having formerly held the positions of Director of the World Aquaculture Society and international Liaison AQUABIO, Dr Patricia Moraes-Valenti is also a researcher for the AquaVitae Consortium and is involved with various Sustainable Aquaculture Network projects that use indicators of sustainability to assess aquaculture systems.

How long have you been working in aquaculture and what encouraged you to enter aquaculture as a career in the first place?

I have worked in aquaculture for 23 years. As a biologist, the possibility of working with applied biology was the major factor that encouraged me to work in this field. I saw in aquaculture the possibility of using the knowledge of biology to produce food for the consumption of the human population.

Therefore, I decided to do a Master's, Doctorate and Post-Doctorate in Aquaculture. In addition, the multidisciplinary characteristic of Aquaculture fascinated me with the possibility to integrate different knowledges and interact with different professionals, so we learn from each other.

In what areas of aquaculture have you been involved throughout your career so far?

I have always worked on production systems. I started with freshwater prawn farming, developing technology for native candidate species for aquaculture. In this way, one important work was the development of technology for sustainable production of an Amazon river prawn, native from Brazil and this technology is now patented.

Ten years ago, I started to work with integrated multitrophic systems. This field enlarged my vision of productive systems and the future of aquaculture in a changing and limited world. In addition, our research group has developed, over the past 20 years, sustainability indicators to measure the sustainability of different aquaculture systems.

With these indicators, we can assess the sustainability of aquaculture systems in the economic, social and environmental dimensions and, also in governance. Recently, I have also worked in public policies using the Agenda 2030 and the Sustainable Development Goals – SDG's.

What were the main developments or changes that you saw in aquaculture over that time?

Indeed, aquaculture has been involved towards intensification and more responsible and sustainable systems. Some changes have enjoyed success, but others have not.

Most of the changes were only incremental technology. Nevertheless, I think that the sector needs more disruptive actions. We need changes paradigms to take more advantages of the biological and ecological characteristics of the aquatic organisms and the tridimensional and high-density fluid environment of the aquaculture systems. The sector really needs innovations to adapt to a new post Covid-19 world.

What are the biggest concerns you see facing the industry today?

I think that the industry needs to understand that the world is changing rapidly and what worked in the past may not work in the future. In the business plan should be considered new concepts, such as natural capital, ecosystem services and circular economy. Institutional innovations and governance are other important topics that should be faced.

Sometimes aquaculture sector is behind many other sectors in conceptual innovations. The new world certainly will be

different that the world before the pandemic. Aquaculture industry should be capable to face the new challenges.

There are many concerns in both industry and research. In some cases, the industry complains that scientific knowledge is not always carried out to meet the needs of the industry.

The industry, on the other hand, would need to understand better that in universities and research institutions, the sequence of knowledge generation occurs in the sense of teaching, research and extension until this knowledge reaches the industry. According to this sequence, the knowledge of the research sometimes takes a while for the results of the research to reach the industry.

Research and industry generally have no tradition of cooperative work in many countries. Frequently, actions to convert scientific knowledge into technology and extension products and services are still unsatisfactory. In this way, science would need to know better the needs of the industry and the industry needs to interact more with the university and research institutions to inform what are the needs which it demands.

For this reason, both sectors of scientific knowledge and industry would need to have a better synergy with each other to satisfy the need for both. When there is a better interaction between science and industry, a great development of the sector will be possible.

Are we doing enough to encourage consumers to accept fish as a significant part of their weekly diet?

I think we are still not doing enough for that acceptance. The acceptance of fish varies in different regions of the planet. The consumption of eastern populations is much higher when comparing western populations.

We would need to work these two markets together, but in different ways according to the culture of each of these markets. This is a very important work, in which it will be necessary to have the help of several actors among researchers, stakeholders from different areas, etc.

According to the United Nations Sustainable Development, 2018, the Global population is forecast to increase from 7.3 Billion to 8.5 Billion between 2015 and 2030, with the largest increase in developing countries and we will need to feed everyone, always worrying about the planet's carrying capacity.

Because it is from the environment that natural resources come from that society uses, generating the economy. Without the environment, there is no society and without society there is no economy.

How can we address these concerns as individuals or as an industry?

Difficult and subjective question, but I think we could in times of pandemic Covid-19, sharing experiences, ideas and working together for innovation in all fields. The future will depend on the ability of how to handle these subjects.

Some examples as simple paradigm changes, it could be more effective to reach important markets, especially in developed countries. The ecologically sound and socially considered technologies are essential.

The use of innovative processes and equipment to promote circularity in farms, through recycling and reuse of waste, can reduce costs, increase profitability and expand market opportunities. It has been shown in integrated multitrophic aquaculture that the inclusion of one or two species contributes to recycling waste and improves the FCR in several different aquaculture systems.

I think we also need try to put together the past with the present of aquaculture to build the future of this sector, trying to include the old experience and technologies together with the innovations technologies as Aquaculture 4.0 it is a period known as the Fourth Industrial Revolution. Means the use of updated technologies and innovations to improve the processes efficiency, product quality, and market efficiency and competitiveness.

The movement for Aquaculture 4.0 generally includes the use of technology of information solutions. In my opinion, the best technology is the one that adapts to each situation and scenario.



People

THE INDUSTRY FACES



Helene
Ziv-Douki

Cargill Aqua Nutrition names new company president

Helene Ziv-Douki has been named president for Cargill's Aqua Nutrition business, effective immediately. Ms Ziv-Douki, who joined Cargill in 2003, succeeds Pilar Cruz who was recently promoted to Chief Sustainability Officer, a new role for the company.

"Helene's success during her more than 20-year career reflects her approach as a builder of multicultural, diverse teams and talent, her customer focus, and her passion for excellence and innovation," says Ruth Kimmelshue, global lead for Cargill's animal nutrition and health enterprise.

"She brings a passion for sustainability and the aqua and seafood industry, with unique capabilities and perspectives that will help our aqua nutrition team advance its business objectives and deliver for our customers."

"It's an honour and dream come true to come back to our world-class aqua nutrition team," says Ms Ziv-Douki.



Dr Hadden
Graham

Ocean Harvest Technology appoints new Managing Director

Ocean Harvest Technology has announced the appointment of Dr Hadden Graham as Managing Director of their Animal Feed business, marking the beginning of the next stage of the company's growth path.

"I am excited about joining a fast-growing business such as OHT which is ideally positioned to support the animal feed industry's move to a more sustainable future," says Dr Graham, commenting on his appointment.

"The team has recently been working on establishing conclusive evidence explaining and supporting the ability of their products to improve gut health and performance in ruminants, swine, poultry, equine and aquaculture".

"Over the past three years, OHT has built and proven solid prebiotic value propositions for our main swine, poultry, bovine, and companion animal OceanFeed products, and critically now has world scale customers in each of those segments" says Graham Ellis, Ocean Harvest CEO.



Lara
Moody

Lara Moody joins IFEEDER as new Executive Director

The Institute for Feed Education and Research (IFEEDER) has announced the addition of Lara Moody as its new executive director.

Ms Moody will provide visionary leadership to IFEEDER's activities including programme development, strategic partnerships and collaborative resourcing.

Working closely with IFEEDER's Board of Trustees and committee members, she will develop and support resources and related efforts to advance the public charity's research and education mission.

Collaborating with the American Feed Industry Association to pursue and communicate the institute's work, she will create opportunities to engage donors and further the dialogue on important issues impacting the feed industry.

"We need visionary leadership to ask the tough questions, provide reliable data and research and engage with stakeholders and the food chain to advance solutions and understand the issues that impact our business," says IFEEDER's President and AFIA's President and CEO Constance Cullman.



Glenn
David

Zoetis announces appointment of new Group President

Glenn David, current Executive Vice President and Chief Financial Officer (CFO) for Zoetis, has been named Executive Vice President and Group President effective June 1, 2021, a role that involves overseeing International Operations and other business units.

"Glenn's record of success at Zoetis, plus his deep knowledge of our operations and the animal health industry, make him the ideal leader to drive Zoetis' next phase of global growth in international markets, aquaculture, biodevices and pet insurance," says Chief Executive Officer Kristin Peck.

"As CFO for the last five years and a leader in animal health for a decade, Glenn has been a champion for building our business.

"He has played a pivotal role in supporting our recent product launches, scrutinising new business opportunities, and investing in global expansion initiatives.

"We are very excited by the strong leadership qualities and experience Glenn will bring to this role," she concludes.



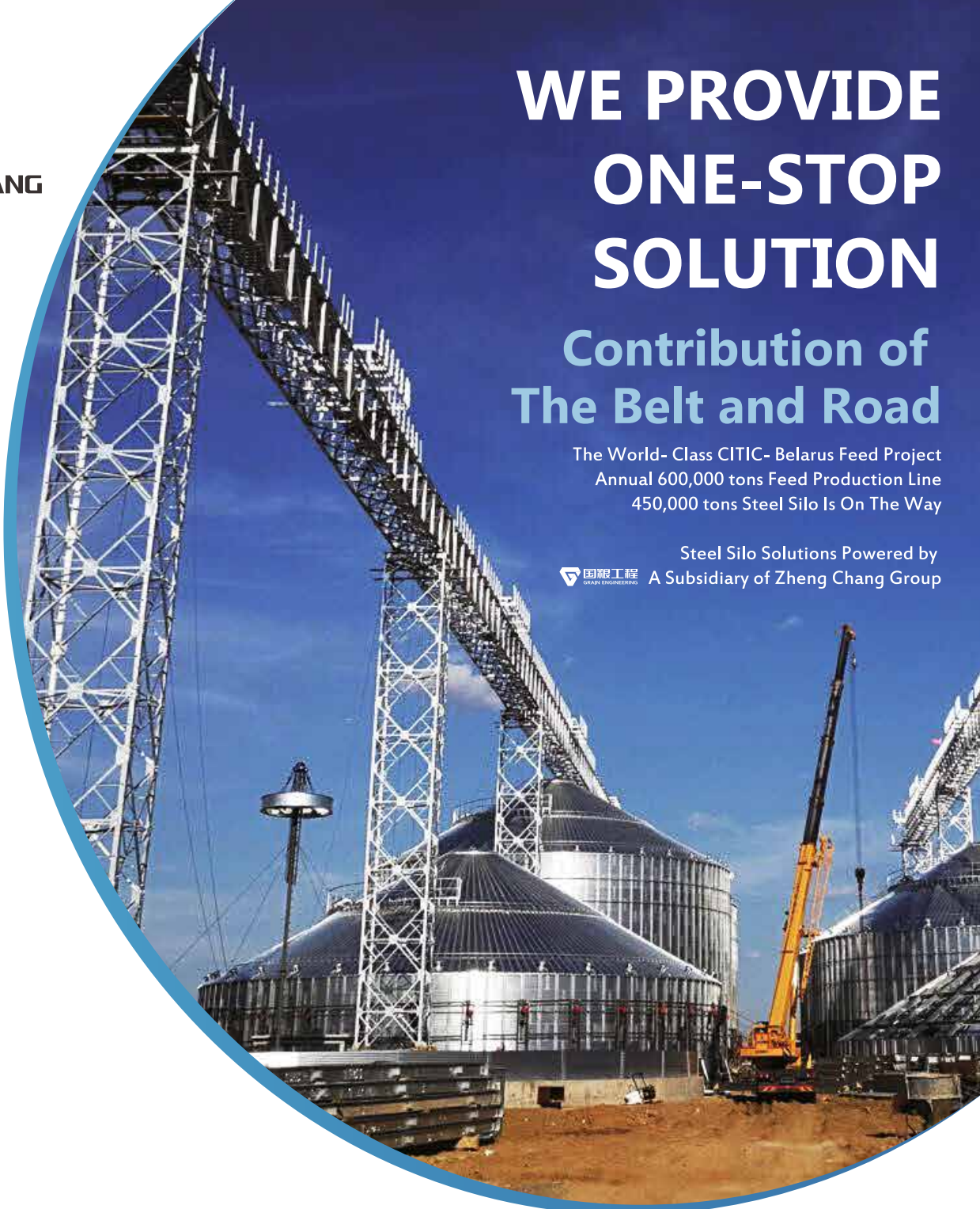
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