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Reducing the Environmental Footprint of the Aquaculture Industry in the Mekong Delta

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Vietnamese tuna available in 80 markets worldwide

Vietnamese tuna products have been exported to more than 80 markets around the world during the opening three months of the year, 10 more markets compared to the same period last year. Most notably, tuna exports to the members of the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) have witnessed vigorous growth. February 2024 alone saw tuna exports to Canada and Chile skyrocket by 146% and 116%, respectively. Meanwhile, after experiencing a strong increase in January, tuna exports to major markets such as the United States and the EU in February dropped of 8% and 16%, respectively. Industry insiders point out that Vietnamese tuna will continue to face a number of challenges in the time ahead due to the European Commission's yellow card warning against Vietnamese seafood. Furthermore, local businesses are short of both domestic raw materials and imported materials. However, as a number of major international seafood fairs are scheduled to take place in the US and Spain in March and April, there will be a positive outlook ahead for Vietnamese tuna businesses, say experts.

Pangasius exports in Jan 2024 nearly doubled y-o-y

Pangasius frozen fillets remained as the main exported item in January 2024, with a value of over 131 million USD, up 87% from the same period in 2023, accounting for 80% of the total export value. As for markets, in the first month of 2024, China & Hong Kong continued to be the largest destinations of Vietnamese pangasius, with the total worth of 52 million USD, nearly quadrupling compared to January 2023 and increasing by 65% compared to January 2022. Such a value accounted for 32% of the total pangasius exports to all markets. Notably, in the first month, exports of frozen/dried pangasius products (code 03) (excluding code 0304) to China increased by 6.5 times compared to the same period last year. In January 2024, the US spent 18 million USD buying Vietnamese pangasius, up 83% compared to the same period last year. Also in this month, the US increased imports of almost all Vietnamese pangasius products. The export turnover of processed pangasius to the US increased 18 times compared to the same period last year, reaching 295 thousand USD. This market consumed over 17 million USD of frozen pangasius fillets in January 2024, up 81% compared to January 2023. The EU purchased nearly 13 million USD worth of Vietnamese pangasius, up 20% compared to the same period last year. The export turnover of pangasius in the first month of 2024 is evaluated as quite positive after consecutive declines in 2023.

Vinh Hoan Corporation achieves remarkable revenue from pangasius exports in January 2024

Vinh Hoan Corporation has made a significant mark at the beginning of the year by announcing its business results for January 2024 with revenue reaching 921 billion VND, a 102% increase compared to the same period last year. Notably, the Corporation saw a noticeable surge in the US, Europe, and particularly a breakthrough in China. Specifically, exports of the main pangasius products reached 448 billion VND, up 64% from the same period. Revenue from by-products reached 175 billion VND, an increase of 3.2 times compared to the same period last year. Additionally, VHC recorded revenue from C&G (Collagen and Gelatin) products of 74 billion VND, 3.4 times higher than the same period last year. Revenue from rice products (16 billion VND), puffed cakes (40 billion VND), and other products (160 billion VND), up 149%, 78%, and 142% respectively. According to VHC, in January 2024, pangasius exports to major markets recovered well, especially experiencing significant growth in China. Revenue in the Chinese market (117 billion VND), the US (185 billion VND), and Europe (154 billion VND) increased by 259%, 59%, and 33% respectively compared to the same period last year. Revenue in the domestic market reached 325 billion VND, also increasing by 137%.

Japan selects Vietnam as the location for scallop processing

At a business networking event in the seafood sector, including scallops, held in the afternoon of March 14 in Ho Chi Minh City, Toru Yoshimatsu, representative of the Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF), acknowledged that Vietnam is a potential market for Japanese seafood. More importantly, Vietnam has many experienced seafood processing factories, including scallop processing. Therefore, the Japanese government and businesses have chosen Vietnam as a processing location, aiming to export products to ASEAN countries and the United States.Vietnam is a promising destination due to its low labor costs, extensive experience in processing seafood products, and few barriers in the export processing sector.

Cooperation for the Development of Fisheries and Aquaculture with Indonesia

On March 2nd, a working delegation from the Ministry of Maritime Affairs and Fisheries of the Republic of Indonesia, led by Mr. Tubagus Haeru Rahayu, Director General of the Directorate of Aquaculture, held a meeting with the Provincial People's Committee to finalize a draft memorandum of understanding aiming to record the commitments for cooperation between the two parties in the sustainable development of fisheries and aquaculture. Phu Yen province has approximately 14,685 hectares of coastal waters, 4,225 hectares of lagoons, and about 2,000 hectares of tidal flats, estuaries, and tens of thousands of hectares of open sea, with over 2,000 fishing vessels. Given the potential, strengths, and current situation of the fisheries sector, to develop the province's fisheries industry, Phu Yen proposes cooperation in several areas: Development of sustainable exploitation and aquaculture, especially for lobster seed, tuna, and seaweed. Collaboration in processing, trade promotion, marketing, and investment in lobster, tuna, and seaweed production and business. Enhancing human resource capacity in harvesting, aquaculture, and processing for the export of lobster, tuna, and seaweed (including research, sharing of scientific and technological knowledge, study programs, and training). During the working session, both parties agreed on several issues regarding cooperation in the sustainable development of fisheries and aquaculture.

VFM

Ecuador, India, Vietnam shrimp industries facing higher US countervailing duties

The U.S. Department of Commerce (DOC) is planning to hit shrimp exporters in Ecuador, India, and Vietnam with higher countervailing duties once it posts its preliminary determinations to the Federal Register.

The DOC released its preliminary determinations on 26 March, finding the three countries, as well as individual companies in those countries, benefited from subsidies that gave them an unfair advantage in the U.S. market between 1 January and 31 December 2022. As a result of the findings, shrimp exports from the three countries to the U.S. will be hit with a minimum countervailing duty once the findings are posted to the Federal Register, and certain companies will face either higher or lower rates depending on the DOC's findings – which it will finalize in September.

Based on the preliminary determination, Ecuador is facing a 7.55 percent countervailing duty on all shrimp exports to the U.S. On a company level, Sociedad Nacional de Galapagos is facing a 1.69 percent rate, and Industrial Pesquera Santa Priscila is facing a duty of 13.41 percent. India is facing an overall countervailing duty rate of 4.36 percent. By company, Devi Sea Foods is facing a slightly higher 4.72 percent rate, and Sandhya Aqua Exports, Neeli Sea Foods, Vijay Aqua Processors, and Neeli Aqua Farms are facing a rate of 3.89 percent.

Vietnam was given the lowest duty rate of 2.84 percent, and Soc Trang Seafood Joint Stock Company in particular is also facing a rate of 2.84 percent. However, one company, Thong Thuan Company, is facing a countervailing duty of 196.4 percent, which the DOC said is "based on adverse facts available." The fourth country that was investigated, Indonesia, was found to have subsidy rates below the amount requiring countervailing duties, the DOC said.

The preliminary determination is not final, and the department will not make its final determination until 5 August 2024. Subsequently, the International Trade Commission (ITC) must make its own final determination on 19 September before an order may or may not be issued on 26 September. An order will only take place, the DOC said, if both the department and the ITC find that the shrimp industries of the three countries received subsidies from their governments.

(by VNA)

NUMBER AND FACTS

142,269 HA

Is the total number of shrimp farming area in Bac Lieu province, with a production volume of 278,500 tons in 2024

242 MILLION USD

Is the Vietnam's shrimp exports in January, up 71% compared to the same period in 2023

79 MILLION USD

Is the Vietnam's tuna exports in January, up 58% over the same period last year. The US is still the largest market for Vietnamese tuna with a turnover of $ 26 million.

45,246 HA

Is the total number of Quang Ninh's water surface, in nine coastal localities planned for marine farming and integrated into the province's planning

NEWS

- Vietnam's shrimp exports in January 2024 reached $242 million, up 71% compared to the same period in 2023. The prices of raw shrimp in some localities also rose in the first month of the year.

- The Ministry of Agriculture and Rural Development held a press conference on the afternoon of March 25 for the Sustainable Development Conference for Mariculture - Insights from Quang Ninh, under the theme "Mariculture: Sustaining Ocean Life for Future Generations."

- Vietnam Mariculture Association will contribute to and collaborate on developing standards and criteria for mariculture cages, thereby providing a basis for establishing suitable insurance mechanisms and policies. He emphasized that this task must be deployed immediately as mariculture is considered a high-risk investment.

- As of the end of February 2024, lobster exports reached nearly 30 million USD, up 1,746% from the 1.6 million USD in the same period last year. Of this, green lobster exports accounted for over 90% with 27.6 million USD worth, an 80-fold increase.

- The central government of Quang Nam Province is applying sustainable and environmentally-friendly solutions to restore Hoi An coastline to ensure safety for visitors, promote tourism development and maritime economy.

- On February 27, Beanstalk AgTech announced a bilateral cooperation strategy between Australian - Vietnamese businesses on climate-smart agriculture (CSA) in the shrimp and rice industries.

Reducing the Environmental Footprint of the Aquaculture Industry in the Mekong Delta

Sustainable aquaculture can provide healthy, high-quality food, minimize environmental impacts, create jobs, and contribute to economic development. Vietnam is one of the world's largest seafood producers and the second-largest supplier of seafood to Europe, with the Netherlands being the largest importer of Vietnamese seafood in Europe. However, Vietnamese aquaculture farmers currently lack incentives to produce in an environmentally friendly and sustainable manner. IDH cooperates with partners to develop a path to reduce 'carbon footprint' to protect the environment for shrimp and pangasius supply chains in the Mekong Delta.

Mr. Nguyen Ba Thong, Aquaculture Program Manager of IDH Vietnam

The Mekong Delta region, with an exclusive economic zone and a condition of interfering saltwater, brackish water, and freshwater, has created a particular ecoregion that is rarely seen in the world and is extremely favorable for the development of seafood production.

According to Decision No. 3550/QD-BNN-TT dated August 12, 2021 of the Ministry of Agriculture and Rural Development on the "Sustainable Aquaculture Development Plan in the Mekong Delta," by 2030, the entire Mekong Delta region strives to reach an aquaculture area of over 990,000 ha, in which brackish water shrimp of 720,000 ha, pangasius of 7,447 ha, giant freshwater prawn of 50,000 ha, and an aquaculture output of over 4,800,000 tons. However, according to experts, the Mekong Delta region has a lot of potential to restructure high-value natural shrimp production and supply chains. Strengthening linkage and cooperation between farmer households, cooperative groups, cooperatives, businesses, and local governments helps create branded product lines of organic shrimp and ecological shrimp in the Mekong Delta region. In addition, meeting requirements on traceability or reducing "carbon footprint" is also one of the solutions for the shrimp industry to develop sustainably in the future, meet the conditions of the domestic supply and consumption chain, and export to many demanding markets.

Especially when Vietnam participates in international commitments on climate change, such as committing to zero net emissions by 2050 and reducing methane emissions by 30% compared to 2020, reducing "carbon footprint" of the shrimp industry is a solution to improve export value, aiming for sustainable and responsible development. In order to provide solutions to support Vietnam in developing the Mekong Delta region, on March 21, the event "Vietnam-Netherlands: Mekong Delta Business Forum" took place, attracting over 300 domestic and international delegates. Of these, Dutch experts and businesses have proposed many solutions to help develop the supply chain in the seafood industry in the Mekong Delta.

On the sidelines of the event, Mr. Nguyen Ba Thong, Aquaculture Program Manager of IDH Vietnam, shared about initiatives aimed at reducing carbon emissions from the shrimp and pangasius supply chains in the Mekong Delta, as well as proposals for potential cooperation opportunities between the two countries. According to Mr. Nguyen Ba Thong, Vietnam is one of the world's largest seafood producers (ranking 1st in pangasius and giant tiger prawn production; 3rd in seafood export; 4th in aquaculture production). Vietnam is also the second-largest seafood supplier in Europe, of which the Netherlands is the largest European importing market for Vietnamese seafood. However, Vietnamese aquaculture farmers currently do not

On March 19, Minister of Agriculture and Rural Development Le Minh Hoan had a working session with Minister of Nature and Nitrogen Policy (Dutch Ministry of Agriculture, Nature, and Food Quality) Christianne van der Wal on solutions to turn the Mekong Delta into a center in the region while still ensuring issues on ecology, biodiversity, and environment.

receive incentives to produce in a beneficial, environmentally friendly way.

In Vietnam, supply chain linkage is a key factor in achieving feasible interventions for agents in the chain to change their production and business practices.The Sustainable Trade Initiative (IDH) organization cooperates with partners to develop a path to reduce environmental emissions and a Life Cycle Assessment (LCA) tool to calculate the environmental footprint of aquaculture products from input to retail link. On that basis, the supply chain can identify important hotspots of the environmental footprint, thereby implementing feasible intervention measures and promoting the establishment of partnerships between relevant parties. Currently, global aquaculture product supply chains are seeking ways to reduce environmental impacts and emissions, and IDH is promoting cooperation and supporting them in this transformation.

In Vietnam, IDH prioritizes supporting the reduction of environmental emissions for shrimp and pangasius supply chains in the Mekong Delta. "Hotspots of environmental emissions in the aquaculture chain with the highest-level negative environmental impact can now be identified by the Life Cycle Assessment (LCA) tool, providing the basis for developing priority impacts to reduce emissions for the entire chain. By jointly resolving this issue across the supply chain, we can not only minimize our impacts on the environment but also support the resilience and adaptation of aquaculture farmers to climate change," shared Mr. Nguyen Ba Thong, Aquaculture Program Manager of IDH Vietnam.

Currently, many Mekong Delta provinces, such as Ca Mau, Kien Giang, Ben Tre, etc., have many small and medium-scale business establishments and cooperatives with nature-based shrimp farming areas, producing shrimp-forest, shrimp-rice, and clean shrimp products. However, these products have not been centrally managed and certified with appropriate quality values.

Ca Mau has over 80,000 ha of mangrove forests, including 30,000 ha of shrimp farming under the forest canopy, but only 14,000 ha are certified for ecological shrimp farming.

The Aquaculture Programme lead by IDH

IDH is a co-founder of the Aquaculture Stewardship Council (ASC). With support for the shrimp and catfish supply chains in Vietnam to obtain ASC certification, and gain acceptance from high-end markets, the number of certifications and export volume of Vietnamese catfish and shrimp has seen significant growth over the past decade. Additionally, IDH co-chairs and actively participates in Public-Private Partnerships (PPP) within the framework of the Sustainable Agriculture Development Partnership (PSAV) in Vietnam, initiated by the Ministry of Agriculture and Rural Development, aiming to mobilize resources from relevant parties to address common issues in the supply chain.

As part of the PPP on Aquaculture, IDH, together with key partners such as D-Fish, VASEP, VINAFIS, and WWF Vietnam, has developed and implemented the project: "Promoting sustainable aquaculture development through enhanced public-private cooperation in the Mekong Delta." The project aims to strengthen environmental and disease management, improve production practices, and enhance traceability of export product supply chins.

VFM

A floating village on the Hau River in Vietnam, one of the country's key pangasius producing areas. Extreme weather events are putting aquaculture operations at risk

Six ways to make your aquaculture operations more climate-resilient

By Kyra Hoevenaars and Jonah van Beijnen

Sharing practical tips for small-scale aquaculture operators, particularly those based in the tropics, to adapt and become more resilient to the changing climate and extreme weather events.

Most fish and shrimp farms are heavily dependent on environmental conditions, especially the provision of clean water at a stable temperature, and this makes them especially vulnerable to the impacts of a changing climate.

The main climate stressors that affect aquaculture are temperature fluctuations, changes in rainfall patterns that cause floods or droughts, and increased storm variability and severity. Marine aquaculture is also affected by ocean acidification and the increased occurrence of harmful algal blooms (HABs). Impacts differ, depending on the farmed species, the farm environment, the type of farming system and the geographical location. Impacts can occur in a very short time (i.e. heavy rainfall), while other are long-term trends, with change happening gradually over time (i.e. ocean acidification). Ninety percent of aquaculture operations face risks from environmental change. Some of the countries with the highest climate risks – mostly in Asia, Latin America and Africa – have the lowest capacity to adapt to the changes in climate.

A good example is Myanmar. In May 2023, Cyclone Mocha hit the southern Bay of Bengal, with the centre of the storm near Sittwe City in Rakhine State. This was one of the most powerful storms to have ever been recorded in the region, with winds reaching 259 kilometres per hour, and an estimated 670,000 hectares of land were flooded, impacting livelihoods and food security of the already poverty-stricken regions. Over a million people from an estimated 237,000 households were impacted, including many fish and shrimp farmers. Stock was lost and infrastructure destroyed. The

UN estimated that two in every three farming households and more than one in every three fishing households in the area lost their productive assets. The total economic loss has been calculated at US$ 2.24 billion, which is the equivalent to 3.4 percent of Myanmar's GDP. Similarly in 2021, Indian shrimp famers were struck by Cyclone Yaas, losing around 12,000 tonnes of shrimp (valued at USD 130 million). It was hard for farmers to start again, since some had loans to pay off on top of the losses of shrimp and infrastructure.

Marine farms are also regularly hit by more severe storms that seem to have been increasing in recent years. In Scotland 50,000 salmon escaped after damage to the nets by storm Ellen in 2020 and in Chile between 500,000 and 800,000 fish escaped due to storm damages. Damage to floating cages in Thailand by the tsunami in 2005 amounted to USD 32.7 million, with over 40,000 cages destroyed. Effects of climate change are highly unpredictable and extremely localised, complicating things further. While some areas will experience more rainfall, others are impacted by more severe droughts or more frequent and bigger storms. Therefore, adaptation measures should be adjusted to suit local circumstances, as different threats need different adaptation options. In principle, the goal is that all adaptation measures should be designed to reduce vulnerability and effectively adapt to the climate impact. Selection of effective adaptation measures also depends on community acceptance, the urgency of implementation, technical feasibility, ease of implementation and the costs required to implement the measures.

In this article we provide general tips for small-scale farmers to follow when starting an aquaculture farm or when adapting their farm to the changing climate. Doris Soto, who has worked for the United Nation's Food and Agricultural Organization (FAO) for 12 years, leading the aquaculture team on environmental issues and climate change, adds her insights to our own expertise from working on small-scale aquaculture in Southeast Asia, the Middle East, and Africa for the past 20 years.

1. Implement best management practices

"Improving management practices is the first move towards climate adaptation, especially improving biosecurity, considering lower stocking densities and ensuring a good farm location," says Soto.

Implementing best management practices (BMPs) in all aspects of production will improve the overall resilience of the farm. Susceptibility to disease is particularly likely to increase with the changing climate, as the immune system of animals is compromised when they are stressed (from for example, by warmer water in and around the farm). Ensuring fish and shrimp health through the implementation of BMPs will reduce disease risks. Environmental measures that ensure the protecting of local ecosystems will also decrease the vulnerability of farms to climate change. BMPs also contribute to improved hygiene, feed efficiency and water quality. Guidelines on best management practices for aquaculture are provided by ASEAN, WorldFish and Sustainable Fisheries Partnership. WorldFish also published a series of videos on good aquaculture practices. Some guides are applicable to certain geographical areas or species, but much of the content can be transferred to other areas or similar species.

2. Perform a risk-based analysis

During site selection and farm planning for a new farm, a risk-based analysis should be performed in relation to climate change and extreme weather events. This can also be done for existing operators who want to adapt their farm. An assessment needs to examine the climate risks of an area in terms of exposure, potential impacts, and the risk mitigation capacity. The ultimate goal of a risk assessment is to come up with recommendations for measures that reduce climate-related risks: so-called adaptation measures. Based on the risk assessment, a disaster preparedness plan can be developed, with the aim to monitor risk mitigation actions such as adaptation measures. Usually, a risk assessment is carried out by organisations covering a whole country, region or project. However, risk assessments can also be done by a group of farmers (a farmers association or cooperative) or larger individual farmers. Guidelines on how to conduct risk assessments are available from Care, UN and GIZ.

If the risk assessment finds very high risks that cannot be mitigated, relocation to safer areas should be considered. Alternatively, short-cycle aquaculture projects can be implemented in areas that face longer and regular periods of drought or flooding. For example, a fast-growing fish species can be grown which can be harvested before the rainy or dry season starts. Stocking larger fingerlings also shortens the farming period and so reduces production risks too. Finally, culturing species with the capacity to breathe air such as catfish, pangasius and climbing perch, can be a viable option where water quantity and quality is restricted. Such species can also be moved more easily in case of emergency.

3. Diversify your production

Do not put all your eggs in one basket: diversification of products is a strategy commonly used to spread risks against losses. It can enable continued production if one crop fails. When selecting species that can benefit from each other, farm diversification also reduces waste and increases productivity by using byproducts from one species as inputs for other species. It also diversifies the income sources of farmers, stabilises production and increases resource efficiency.

However, as Soto observes: "Diversification only works if different species or products are not subject to the same hazard, for example extreme events such as the one that took place in Myanmar in 2023 can impact all aquaculture farming systems and species". The use of integrated agriculture-aquaculture and polyculture aquaculture systems should also be considered. This approach diversifies livelihoods further, provides extra food for the family and to sell, and uses scarce water more efficiently, making it an effective climate adaptation measure. Pond water can be used for the irrigation of crops, while crop waste can be used as feed for the fish. Nutrients in the pond water from fish excretion act as a natural fertiliser for the crops. Vegetation on pond dykes also strengthens them and reduces erosion.

Selecting local strains and varieties for both the fish and crops is key, as these are in most cases best adapted to the local climate and to local pathogens. For marine farms, integrated multi-trophic aquaculture (IMTA) can be implemented as a means to diversify.

Doris Soto (right) with one of her PhD students at a mussel farm in southern Chile
Photo: Doris Soto

Seaweeds can be cultured around the sea cages and filter feeders such as bivalves and sea cucumbers can be grown under or around the cages. IMTA or any diversified system cannot however solve issues resulting from a common hazard, such as an extreme storm event. Additionally, the market can be diversified between local, national, and international options. Supply to local markets has the advantage that transport requirements are limited, and it contributes to local food security.

4. Make use of early warning systems

Farmers should be familiar with reliable sources of information on climate change and climate variability. Timely information can enable farmers to respond quicker to climate risks. It is important to understand and interpret the meteorological predictions, such as weather forecasts, well. Make use of forecasts to prepare for extreme weather events. Daily online weather forecasts provide information on upcoming extreme weather events, like cyclones and extreme high tides. When changes in salinity, water availability and other important parameters are predicted in advance, farmers can prepare their farm to minimise losses and damage.

According to Soto, more and more farmers are already starting to use early warning systems. Most farmers now have a cell phone and early warning systems can be used with simple technology mostly coming from governments, so there is large potential for every village to be informed in case a severe cyclone is approaching, or to stay updated on the latest developments regarding an El Niño season. The main gap is understanding the forecast and improving preparedness and emergency response. Farmers can often access training through NGOs or government programmes. Technology used in early warning systems include artificial intelligence, remote sensing and satellite imaging, and the Internet of Things. Companies such as Scoot Science and Blue Lion Labs use tools to predict outbreaks of extreme ocean events and HABs.

Examples of emergency responses to hazards include early harvesting, strengthening farm infrastructure, increasing the rate of water exchange, and the provision of aeration. Some cage farms can be towed to safer places and ropes and nets should be checked to ensure everything is tied well.

5. Farm infrastructure improvement

For inland pond farms, higher and stronger dykes can protect against flooding and provide an opportunity to have deeper ponds in preparation for droughts and hot weather, since they have a more stable water temperature and a greater dissolved oxygen reserve. They are also less sensitive to environmental factors in dry periods. Dykes should be made as stable as possible to endure floods and storms. This can be done by using the correct ratios of dyke height and width and the correct angle of the slope. Nets can be placed on dykes around ponds to prevent escapes during flooding and heavy rains.

For areas with heavy rain or floods, it is important to ensure water can flow out of the pond. For this piping and sluices for water intake and outlets are important, as well as drainage canals. Canals should be wide and deep enough to uptake extra water in case of heavy rain and floods. In case the area suffers dry periods, an inlet canal can be useful to ensure water supply from the sea or river. Water reservoirs (or spare ponds) can also be constructed to buffer for dry spells. For marine farms, submersible sea cages can be deployed, but these are expensive and more difficult to manage, so are currently not suitable for small-scale farmers. Cage structures, mooring, and nets should be of sufficient quality to withstand the strongest storms. Farms should also have equipment to recapture escaped fish. As improving farm infrastructure is expensive, it is possible that governments, as part of their policy on climate change, provide micro-finance schemes, insurances and loans to invest in farm infrastructure. Farmers can inquire if these options are available in their respective countries.

6. Collaborate with other farmers

Most adaptation measures cannot be implemented by a single farmer alone. Therefore, farmer organisations and other community and government entities should play an important role in building resilient farms and communities. Farmers' organisations allow for collective pooling of resources and skills. Other than implementing adaptation measures together (for example disease prevention), they can also work together on receiving training, exchanging information, understanding their ecosystem, infrastructure development, buying inputs and marketing of products.

Where do we go from here?

Despite a number of encouraging projects in this field, there are still very few detailed, data-backed success stories relating to how the adaptation measures have worked, so it is important that more studies are conducted in this area.

"At the moment, we do not have very good monitoring systems or indicators in place to measure the success of adaptation measures," says Soto. She stresses that this is needed to select effective and feasible measures. Additionally, the implementation of adaptation measures often comes at a considerable cost. For small-scale farmers, who work tirelessly to put food on the table in communities worldwide, while often living in poverty themselves, implementing some of these changes will thus be challenging. Government support is needed through policies, legislation and financial support for the implementation of adaptation measures. Part of this cost should also be shouldered by consumers, through higher prices.

Food security is of critical importance to our still growing global population. By working together and taking collective responsibility, aquaculture operators can help to create a climate-resilient future-proof food system.

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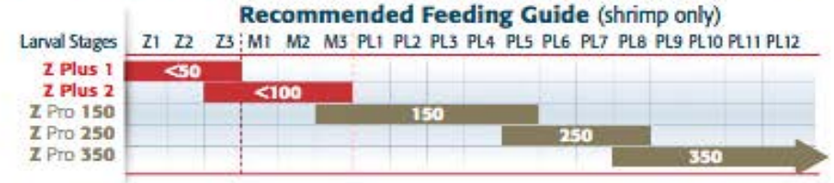

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Functional amino acids improve whiteleg shrimp resistance to water stress challenges

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World production of farmed shrimps reached almost 4 million tonnes in 2018, increased by 3 to 5% over 2018 (FAO 2019). Infectious diseases are considered as the main threat to shrimp farming expansion. Diseases such as acute hepatopancreatic necrosis disease (AHPND), of bacterial aetiology, and white spot syndrome virus (WSSV) viral disease, have induced billions of US$ of losses in the last decade (Shinn et al. 2018). The WSSV belongs to the genus Whispovirus, the only genus of the family Nimaviridae and is historically the most devastating pathogen affecting the shrimp industry since its apparition in 1992 (OIE 2019). The AHPND has emerged in 2010 and is sometimes referred to as early mortality syndrome (EMS). This disease is mainly caused by Vibrio parahaemolyticusstrains that carry a plasmid that encode homologues of the Photorhabdus insect-related (Pir) toxins, PirA and PirB, although other Vibrio species that contain this plasmid have also been shown to produce AHPND in shrimps (Devadas et al. 2018).

Economic losses are recurring problems in shrimp farming, and disease management requires a global approach including parameters such as feed. Strategies based on biosecurity and pathogen management only are generally not successful. In aquaculture, farming practices combined to variations of environmental conditions can induce stress for the animals. These factors of stress generally linked to pollution, temperature and water quality (oxygen, salinity, pH, ammonia and its by-products), but also handling during pond transfers can affect immune system performances and generate development of opportunistic infections (Tendencia and Verreth 2011; Chen and He 2019). Amino acids (AA) are essential in shrimp nutrition (NRC 2011). In formulator's toolbox, synthetic AA (Met, Lys) are generally applied in shrimp feed in order to reach shrimp essential AA requirements (Nunes et al. 2014). This practice is reinforced with the trend of novel diets development based on fishmeal replacement by plant proteins with less adapted amino acids profiles (Gatlin III et al. 2007; Suresh et al. 2011). In addition to their action in protein synthesis, AA play various functional roles in animal nutrition. Their effects have been underlined in different fields: attraction (Derby and Sorensen 2008), meat firmness (Østbye et al. 2018) and antioxidant defences (Wu 2010). In addition, AA can significantly improve the immune response in fish (Clark et al. 2020). In a previous study, a mix of 17 free amino acids (MFAA), in soluble form and with 92% of the composition under free form, obtained from poultry keratin extensive hydrolysis, demonstrated its ability to act as feeding stimulants and improve shrimp growth performances in tank and pond conditions (Le Reste et al. 2019). However, according to our knowledge, potential action of MFAA to induce a better immune response in case of infectious bacteriological and viral challenges has not been investigated before this study.

Another study has recently showed that the low molecular weight (lower than 800 Dalton) of these MFAA is linked to a very high in vivo digestibility of 96.8% (Duperray et al. 2018, unpublished data). This makes MFAA an interesting candidate to feed shrimp larvae that are equipped with immature digestive tracks (Navarrete del Toro and García-Carreño 2019). Feed supplementation can be one of the keys of success as it has a major impact on gut microbiota (Aasen et al. 2012) and can act as health booster of the immune system (Holt et al. 2020; Li et al. 2018). In addition, shrimp can be programmed by early nutritional stimulus (Lage et al. 2018), and the nutritional programming concept (Lucas 1998) shows that early nutritional events may have a persistent long-term effect either on metabolism and/or

physiology (Patel and Srinivasan 2002; Patel et al. 2009). In this context, MFAA supplementation during early development stages could be an efficient feeding strategy. Supplying animal devoid of specific immune system such as shrimp could provide them with easily digestible useful metabolites.

The interest of hydrolysates in aquaculture is underlined in many papers (see review by Martínez-Alvarez et al. 2015). Extensive hydrolysis of poultry keratin leads to a complete denaturation of the protein chain to reach the state of free amino acids (FAA). This industrial process was initially developed to extract cystine and tyrosine for pharmaceutical and nutraceutical applications. It also generates a mix containing free AA, short peptides and mineral salts. This MFAA is particularly rich in FAA with a typical amino acids profile resulting from combination of raw material and partial extraction and purification steps of single amino acids (composition available in Table 1 and Table 2).

In order to evaluate the potential effect of this MFAA on whiteleg shrimp Litopenaeus vannamei performance, two consecutive trials have been recently conducted in Incabiotec/ Concepto Azul Research Centre located in Tumbes, Peru. Each trial was designed to alternate a growth phase with an infectious challenge with AHPND or WSSV.

Experiments

Material and methods of experiments I and II

Feed preparation and feeding protocol

Two locally produced commercial feed for shrimp post larvae (PL) (Nicovita Origin 0.5 for PL11-20 and Nicovita Origin 0.8 for PL21-1g, 45% crude protein and 10% lipid) were used as a base feed (composition available in Table 3). The MFAA was obtained from BCF Life Sciences (Boisel, France). In order to identify a potential dose effect, three MFAA concentrations were tested: 10g/kg of feed, 50g/kg of feed and 100g/kg of feed (MFAA 10, MFAA 50 and MFAA 100, respectively) in comparison with a negative control feed. MFAA doses were selected in accordance with a previously published work (Le Reste et al. 2019). The MFAA was mixed with a fixed quantity of water (3/5 of MFAA and 2/5 of water). This solution was homogenized and mixed by coating with the feed for 3 min in a mixer. The control feed followed the same process and was sprayed with water only. After 12-h drying at room temperature, each feeds were coated with a 2:1 mix of fish oil and soy lecithin sprayed at 30 g/kg. After an additional 12-h drying at room temperature, batches of feeds were stored in individual sterile bags and stored in a clean and cool stocking room (4°C) for the whole trial duration.

Table 1 Proximate composition of the MFAA tested in experiments I and II

Items	Value
Dry matter	98.6%
Total amino acids (CE 152/2009)	88.7%
Free amino acids (CE 152/2009)	83.8%
Crude ashes	7.7%

Table 2 Amino acids contained in the MFAA with the proportion of each AA under free form

	Total amino acids	Proportion of free AA
Aspartic acid	6.87	99%
Threonine	4.55	100%
Serine	12.10	100%
Glutamic acid	10.33	96%
Glycine	7.84	98%
Alanine	4.64	98%
Valine	7.42	73%
Cystine	1.71	71%
Methionine	0.40	96%
Isoleucine	4.18	82%
Leucine	7.09	95%
Tyrosine	0.26	72%
Phenylalanine	2.33	97%
Lysine	1.80	93%
Histidine	0.58	89%
Arginine	5.69	94%
Proline	10.86	100%

Table 3 Proximate composition of feeds used in experiments I and II

Items	Control diet
Dry matter, %	> 90%
Crude protein, %	> 45%
Lipid, %	> 10%
Ash, %	< 10%
Fibre, %	< 2%

Animal husbandry and experimental protocol for the growing period

Shrimp PL were obtained from commercial broodstock (certified IHHNV, WSSV, NHP free) and were previously analysed by polymerase chain reaction (PCR) to confirm the absence of WSSV, infectious hypodermal and haematopoietic necrosis virus (IHHNV), necrotizing hepatopancreatitis (NHP) and AHPND (Dangtip et al. 2015; Tang et al. 2000; Nunan et al. 1998, 2008).

In addition, before the beginning of the trials, microbiological counting of Vibrio spp. and Pseudomonas spp. was performed in thiosulfate-citrate-bile salts-sucrose (TCBS) and cetrimide agar, respectively. The PCR analysis results in PL were negative for AHPND, IHHNV, NHP and WSSV. Bacterial counts indicate 320 cfu/PL by agar TCBS, and 0 cfu/ PL by cetrimide agar were obtained. Thirty-six glass tanks of 20-l capacity were filled each with 15 l of seawater (32ppt salinity). Each tank was stocked with 90 healthy L. vannamei post larvae, PL14 and PL21/22 (initial individual average weight of 0.005g and 0.028g, respectively, for trials I and II). All the glass tanks were randomly placed in the same room. Animals were maintained under natural photoperiod, and salinity was maintained at 32 ppt. Water was at room temperature. The tanks were divided into four groups of nine tanks. Each of these groups was fed with one of the previously described diets, respectively, for a period of 28 and 21 days for trials I and II. The PL were hand-fed five times per day according to the biomass evolution and table feeding provided by the feed manufacturer. Survival rate and biomass evolution were checked weekly during this period.

Animal husbandry and experimental protocol for the infectious challenge period

At the end of the growing period, 324 PL of each treatment were placed in 9 tanks of 15 l filled with the same brackish water described above. Animals were divided into three groups (noninfected control, AHPND group, WSSV group). The PL average initial body weights were respectively 0.26g and 0.091g for trials I and II at the beginning of infectious challenge phase. All the glass tanks were randomly placed in the same room. Animals

were maintained under natural photoperiod, and the salinity was maintained at 32 ppt. AHPND and WSSV infections were processed by dipping, following standard infection protocols for these two pathogens: Vibrio parahaemolyticus 106 cfu/ml and adding of infected WSSV tissues at 20% of initial biomass (Devadas et al. 2018; Domínguez-Borbor et al. 2019). Each of these groups was fed with one of the previously described diets, for a period of 28 days for trials I and II.

Survival rate and biomass evolution were followed weekly during this period to identify potential effects of MFAA in case of immune challenges. For biomass determination, all the larvae were harvested, gently dried through a net and weighted before individual count.

Water quality parameters

During growing and infection stages, ammonium, nitrite, nitrate and phosphate were checked and recorded twice a week during water renewal (50% of volume). Water temperature, pH and dissolved oxygen were checked and recorded twice a day, at 8 AM and 6PM (Table 4).

Data statistical analysis

Data were subjected to ANOVA, and in case of significance (P≤0.05), a Duncan test was performed. Statistical analyses were made with the SPSS software.

Results experiments I and II

Results for the growing period

Water quality parameters measured during these two experiments (Table 4) were in conformity with known requirements for L. vannamei shrimps (Alday-Sanz 2010). Survivals of the animals were above 81% and 87% for controls of trials I and II, respectively (Table 5). Survival was significantly improved of 8.08% for the animals fed.

MFAA 50 in trial I and of 3.39% MFAA 10 in trial II. In this latest group, biomass increase was also significantly improved of 13.11% for the animals fed MFAA 10.

Results for the infectious challenge period

The AHPND- and WSSV-infected control groups showed a significant decrease of survival and biomass increase (Table 7 and Table 8), while these parameters remained steady in noninfected groups (Table 6). Unlike control group, moribund shrimps were observed few days after experimental challenges. Affected animals showed lethargy, decreased or absent feed consumption with clinical symptoms such as pale white atrophied hepatopancreas and reddishwhitish bodies for AHPND and WSSV groups, respectively. In WSSV-infected groups of trials I and II and in AHPND-infected group of trial II, animals fed with MFAA treatments showed significantly higher survival rates from the second week to the end of the infection phase (Figs. 1 and 2 and Tables 7 and 8), in comparison with the animals fed with the control diet without MFAA.

Table 4 Water quality parameters measured in the glass tanks used for experiments I and II

	T° (°C)	DO (ppm)	pH	pH	NH3 (ppm)
Trial I	Average	26.9	7.53	7.61	1.62
	Min	26.0	6.16	7.45	0.50
	Max	28.3	8.57	7.75	4.00
Trial II	Average	27.8	6.37	7.30	0.50
	Min	27.6	6.06	7.00	0.50
	Max	28.5	6.92	7.99	0.50

Table 5 Survival and biomass of *Litopenaeus vannamei* PL shrimp fed feeds containing respectively 10g/kg, 50g/kg and 100g/kg of the mix of free amino acids (MFAA) at the end of the growth phase in 18 experiments I and II

		Control	MFAA 10	MFAA 50	MFAA 100	*P*-value
Trial I	Survival (%)	80.99 ± 2.96^{b}	81.11 ± 3.29^{b}	87.53 ± 3.72^{a}	79.63 ± 4.48^{b}	0.000 VHS
	Base 100	100	100.15	108.08	98.32	
	Biomass (g)	19.16 ± 2.34^{a}	19.89 ± 1.5^{a}	21.45 ± 3.44^{a}	12.72 ± 3.34^{b}	0.000 VHS
	Base 100	100	103.81	111.95	66.39	
Trial II	Survival (%)	87.29 ± 1.68^{b}	90.25 ± 1.9^{a}	88.03 ± 1.55^{ab}	88.4 ± 1.58^{ab}	0.006 VHS
	Base 100	100	103.39	100.85	101.27	
	Biomass (g)	7.17 ± 0.61^{b}	8.11 ± 0.76^{a}	7.52 ± 1.13^{ab}	6.43 ± 0.81^{b}	0.002 VHS
	Base 100	100	113.11	104.88	89.68	

Table 6 Survival and biomass of non-infected group of *Litopenaeus vannamei* PL fed with the control feed at the end of the infectious challenge phase in experiments I and II

		Control
Trial I	Survival (%)	85.17 ± 1.62
	Biomass (g)	41.6 ± 8.22
Trial II	Survival (%)	73.15 ± 1.6
	Biomass (g)	12.82 ± 0.98

Discussion

The present results underline the potential of MFAA extracted from poultry keratin after extensivehydrolysiswhenapplied on shrimp feed for early stages of development, particularly to face infectious challenges. During the first growing period, survival was significantly and positively influenced in the two experiments. Biomass increase was significantly improved in experiment II. The AHPND and WSSV challenged groups were followed during 4 weeks. Altogether the onset of symptoms and mortalities were in accordance with classic clinical signs observed in WSSV and AHPND diseased animals (OIE, 2019). Infected groups faced a strong drop of the PL population in comparison with the non-infected control groups for the two experiments. In these challenging conditions, it is noteworthy that animal fed with feeds supplemented with different levels of MFAA showed a significantly higher survival and biomass increase in case of AHPND infection for trial II and WSSV infection for trials I and II.

MFAA applied on shrimp PL feed in present study is composed of both essential and nonessential amino acids for shrimp (NRC 2011). It appears that these two categories of amino acids can act by different specific actions on immune-health improvement status. Between non-essential amino acids, glutamine, present in high proportion in glutamic-acid form in evaluated MFAA.

(11.6% of total AA), is one of the most abundant free AA in fish plasma and muscle and is crucial to the immune response in fish (Buentello and Gatlin 1999; Li et al. 2007). Dietary glutamine supplementation also enhances weight gain, feed intake and improve feed ratio, intestinal development and digestive enzyme activities in Jian carp (Lin and Zhou 2006). Arginine is present in high proportion in evaluated MFAA (6.42% of total AA), and fish have particularly high requirements for dietary arginine because it is abundant in protein as a peptide bound AA (Mommsen et al. 2001). Arginine also generates growth and health effect for some fish species. For example, Buentello and Gatlin (2001) showed that the survival of channel catfish in response to challenge with Edwardsiella ictaluri critically depends upon

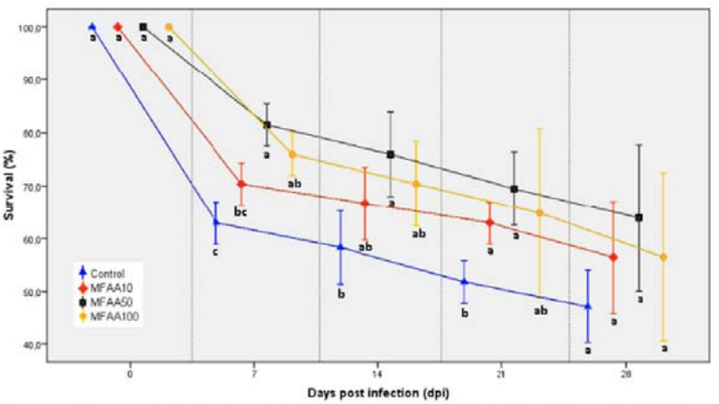

Fig. 2 Evolution of survival week by week after AHPND infection in trial II (95% CI of averages and 15 Duncan test by week)

dietary arginine levels. Proline is also present in high proportion in evaluated MFAA (12.25% of total AA), and its supplementation improves amino acid constituent, anti-oxidative capacity, immune response and NH3 stress tolerance of juvenile Litopenaeus vannamei (Xie et al. 2015). Lysine is present in smaller proportion (2.03% of total AA) in evaluated MFAA but considered as one of the most limiting amino acid in aquafeed formulations, and fishmeal replacement by plant protein sources particularly reinforce this point (Mai et al. 2006a). In addition, dietary lysine supplementation is effective in improvement of growth and enhancement of intestinal and hepatopancreatic enzyme activities of sub-adult grass carp and could promote the antioxidant defence in fish intestine (Li et al. 2014). Phenylalanine can be converted to tyrosine that acts as a common precursor for important hormones and neurotransmitters. Dietary levels of phenylalanine and tyrosine could profoundly influence pigmentation development, feed intake, growth performance but also immunity and survival of fish and shrimp in natural environment (Chang et al. 2007; Yoo et al. 2000).

MFFA have already demonstrate their ability to generate significant gains on zootechnical performances by positively influencing feed intake and growth when applied on shrimp feed at low incorporation rates (5 to 10g/kg). During the two studies presented in this synthesis, it appears that MFAA also give a positive influence on shrimp survival in case of bacteriological and viral challenges. Mechanisms of action are probably multiple as each amino acid acts at different levels of different metabolic pathways, perhaps in relation with the immune response. We can hypothesize that these actions could have synergetic effects. Regarding immune response improvement through nutritional approach and amino acids supplementation, it is probably preferable to have a holistic approach. In the present case, evaluated MFAA is composed of 17 amino acids with some of them already identified to generate positive actions on immune response of aqua species. In evaluated MFAA, a more important bioavailability of free amino acids than native protein chains is directly in relation with a high level of assimilation (96.8% in vivo digestibility measured on cockerel) (Larbier Zuprizal and Chagneau 1991). This characteristic is particularly important for young animal with immature digestive tracts if we consider that a fast absorption after feed ingestion can contribute to improve general metabolic pathways (Rønnestad et al. 2003; Zambonino-Infante et al. 2008).

Another point to take into account is also the highly soluble form of these amino acids mix in comparison with crystalline amino acids mainly used for feed supplementation and generally individually extracted at their isoelectric point, which corresponds to their lower water solubility. This particularity could also accelerate this MFAA assimilation by the animal. To our knowledge, there is no previous available scientific work in shrimp nutrition underlining effect of a MFAA inducing a better immune response in case of bacteriological or viral challenge. In general, research studies mainly focus on single amino acids and their individual effects in feed supplementation. For example, methionine is usually the first limiting AA in formulations containing high levels of plant protein sources (Mai et al. 2006b).

More investigations are available in field of fish nutrition where amino acids role is studied in relation with the development of functional and environmentally oriented aquafeeds inducing specific requirements. Amino acids and their metabolites are important regulators of key metabolic pathways that are necessary for maintenance, growth, feed intake, nutrient utilization, immunity, behaviour, larval metamorphosis, reproduction as well as resistance to environmental stress and pathogenic organisms in various fishes (Li et al. 2009). Considering these several points, we can hypothesize that a combination of different amino acids available in free form provides a synergetic effect on immune response of juvenile aqua species. In addition, a positive influence of MFAA on microbiota composition generating a better immune response should also be one interesting hypothesis to evaluate deeply in order to explain the better survival rates obtained with experimental treatments.

Conclusions and perspectives

Those two experiments have demonstrated that MFAA obtained from extensive poultry keratin hydrolysis have an interesting potential as feeding ingredient for shrimp feed with positive effect on L. vannamei PL survival in case of AHPND and WSSV infection challenges. The infection protocols generated a strong drop of the population excepted for treatments including MFAA supplementation at 10, 50 and 100 g/kg.

In a context of marine ingredients substitution, AA supplementation is commonly applied to reach nutritional requirements. Present results are opening new possibilities for AA Aquaculture International utilization in aquafeed formulations. Further research is needed to better understand the mode of action of each AA, considered individually or in synergy. In conclusion, MFAA obtained from extensive poultry keratin hydrolysis offers a sustainable valorisation of a non-digestible protein source converted into an efficient functional ingredient to improve survival of white shrimp, L. vannamei, in case of bacteriological and viral challenges.

VietShrimp 2024

Measures sought to recover shrimp industry

The fifth VietShrimp Aquaculture International Fair 2024 (Vietshrimp 2024) officially opened in the southernmost province of Ca Mau on March 20. Vietshrimp 2024 is jointly organised by the Directorate of Fisheries, Vietnam Fisheries Association (VINAFIS), Vietnam Fisheries Magazine and the Department of Agriculture and Rural Development of Ca Mau Province.

Over the past decades, Vietnam's shrimp industry has played a crucial role in seafood exportation worldwide, accounting for about 40-45% of the total export value, equivalent to 3.5 – 4 billion USD. Currently, Vietnamese shrimp has been exported to 100 countries, with the top 5 markets being Europe, the United States, Japan, China, and South Korea. With relentless efforts, Vietnam has become the world's second-largest shrimp supplier, accounting for 13-14% of the total global shrimp export value.

VietShrimp is an international fair focusing on Vietnamese shrimp technology. Throughout its editions, the event has left significant impressions on both domestic and international seafood communities. Each edition attracts thousands of registrations, millions of visitors to official event information platforms, and sees hundreds of significant contracts signed. It draws a diverse audience from seafood-related entities and individuals nationwide, fostering knowledge exchange and contributing to sustainable development. The VietShrimp fair is highly regarded by industry experts for its quality content and organizational efforts. Particularly, the program serves as the most authentic forum for networking, exchanging ideas, sharing experiences, and contributing to enhancing quality, promoting effective and sustainable development.

The exhibition took place from March 20th to 22nd, 2024, at the Ca Mau Convention Center with 200 exhibition booths showcasing products and services of seafood enterprises from both domestic and foreign markets. Additionally, the VietShrimp 2024 International Seminar will be held on March 20th and 21st with the participation of the Directorate of Fisheries, associations, and leading seafood experts from Vietnam and around the world.

In his speech at the opening ceremony, Mr. Nguyễn Việt Thắng, Chairman of the Vietnam Fisheries Association and Head of the VietShrimp 2024 Organizing Committee, shared that VietShrimp has successfully organized four editions, leaving a significant mark on Vietnam's shrimp industry and

deeply impressing the aquaculture sector in Southeast Asia and Asia. The organizing committee hopes that this event will serve as a large forum for managers, scientists, businesses, and farmers to collaborate on finding the most effective solutions to bring Vietnam's shrimp industry back to a path of growth and realize sustainable development goals for Vietnamese shrimp.

Mr. Phung Duc Tien, Deputy Minister of Agriculture and Rural Development, expressed that Vietnam's economy is increasingly integrating into the world, with Vietnamese agricultural products present in over 200 countries and territories, especially seafood products in nearly 170 countries and territories, including shrimp dominating over 100 markets. He emphasized that this event will facilitate trade connections, exchange of information, and discussions on Vietnam's seafood industry and particularly shrimp. It provides an opportunity for collective efforts to find solutions for the efficient and sustainable development of the shrimp industry, maintaining Vietnam's position in the global market and learning from the experiences and advancements of advanced countries to elevate Vietnam's shrimp industry. The Ministry of Agriculture and Rural Development acknowledges and highly appreciates the efforts of the VietShrimp Organizing Committee, as well as the businesses and sponsors who have accompanied the program. He hopes that the program will serve as a practical bridge between businesses and shrimp farmers to promote the sustainable development of the seafood industry and shrimp farming sector.

In 2023, the province had about 278,000 ha of shrimp farming area, producing 231,000 tonnes, and earning over 1 billion USD from shrimp export, accounting for 40% of the total shrimp farming area in Vietnam, 22% of the country's output and nearly 30% of the country's shrimp export value.

Su acknowledged the difficulties and limitations that the province's shrimp industry is facing, noting that the Vietshrimp 2024 will bring opportunities for local authorities and farmers to learn and improve shrimp production, processing and exports in the coming time.

VFM

"Vietshrimp not only contributes to promoting and introducing the brand of Vietnamese shrimp but was also an opportunity for authorities from central to the local level, experts, scientists, businesses, cooperatives and farmers to exchange and update the situation and new and advanced scientific and technical advances; connect production and consumption along the value chain and at the same time, discuss measures to overcome limitations and shortcomings of the shrimp industry."

Antimicrobial photodynamic therapy, or aPDT, for potential management of pathogenic bacteria in aquaculture

By Edith Dube, Ph.D.

Antimicrobial photodynamic therapy (aPDT) using natural and synthetic photosensitizers has shown antimicrobial activity against fish pathogenic bacteria, including multidrug-resistant ones. aPDT can inactivate fish pathogenic bacteria (especially Gram-negative bacteria) and has the potential for use in disinfection of surfaces, equipment and aquaculture water. Photo by Darryl Jory.

Promising aquaculture technology can help in the treatment and prevention of fish infections caused by microbial pathogens.

Alternative technologies are needed for controlling pathogenic infections in cultured fish, and Antimicrobial Photodynamic Therapy (aPDT) has recently emerged as one of the technologies that can be successfully applied for the treatment of bacterial diseases and for the prevention of antibiotic resistance. This therapy involves the use of various chemicals called photosensitizing agents, together with light, in an oxygen-rich environment to kill pathogenic bacteria. aPDT applies a photosensitizer – such as methylene blue, riboflavin, curcumin and several others – which, after cellular uptake by bacteria, is irradiated with light (of appropriate wavelength) promoting chemical changes in the photosensitizer inside the bacterial cells, eventually producing reactive oxygen species (ROS) such as hydrogen peroxide and others which cause pathogen cell damage and death.

This article – summarized from the original publication (Dube, E. and G.E. Okuthe. 2024. Applications of Antimicrobial Photodynamic Therapy in Aquaculture: Effect on Fish Pathogenic Bacteria. *Fishes* 2024, 9(3), 99) – provides an overview of the use of aPDT against fish pathogenic bacteria and its potential of innovative designs towards the development of sustainable aquaculture. For detailed information on this technology, the various

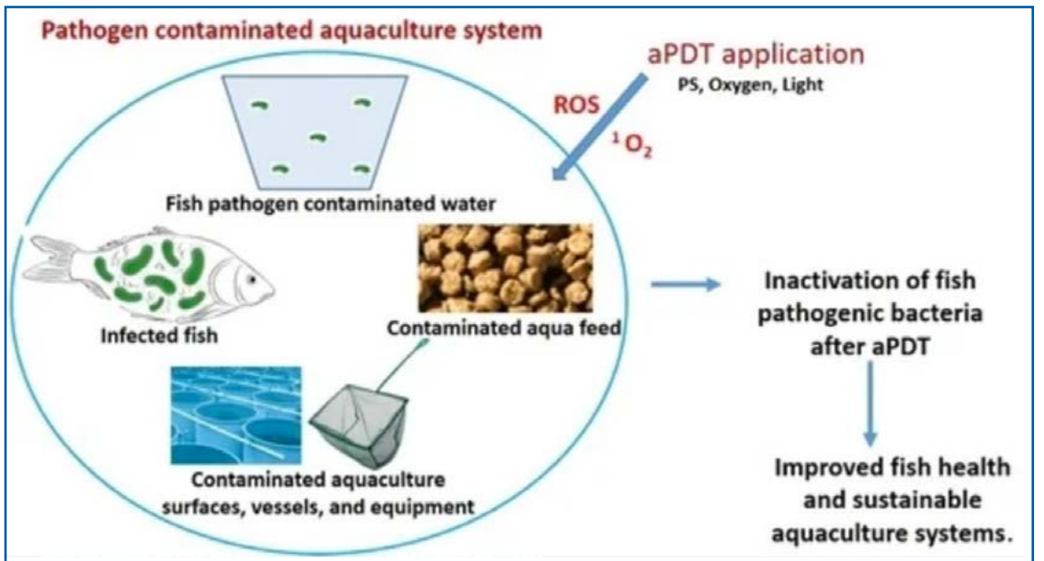

Fig. 1: Summary of the potential applications of antimicrobial photodynamic therapy in aquaculture. Adapted from the original

photosensitizers utilized for aPDT against fish pathogens, potential applications of aPDT in aquaculture, and other relevant information, refer to the original publication.

Application of aPDT in aquaculture

The application of aPDT for addressing deep tissue infections is constrained, with only a few documented attempts involving animal models like mice. However, there is a noticeable lack of scientific research attention on the treatment of fish diseases through aPDT, which may be attributed to the localized delivery of visible light. Researchers have proposed that fish with superficial infections, ulcers or lesions can be incubated in the dark and in water with dissolved photosensitizer. Subsequent irradiation with light should result in total recovery, as illustrated in Fig. 2. However, this area of research still needs to be thoroughly investigated, considering the sensitivity of fish to changing environmental conditions, especially sudden changes in water conditions.

Water quality is of importance in fish farms as it impacts the growth and health of fish. Fish not only live but feed and excrete waste in water. The residual feed, defecated waste and other water pollutants afford microorganisms favorable habitats. The water must be regularly cleaned and disinfected to reduce microbial infections. aPDT has been utilized for the disinfection of aquaculture water by adding the photosensitizer to water or embedding the photosensitizer in a solid membrane before irradiation with light of an appropriate wavelength. The irradiated light should be able to penetrate into the water (thus, water should be free of suspended matter) for the activation of the photosensitizer, and the water should be sufficiently oxygenated.

Magnetic nanoparticles have been linked to photosensitizers for easy recovery of the photosensitizers from the water matrix using a magnet, allowing for recycling and reuse. Fig. 3 illustrates the use of a magnetic photosensitizer in disinfecting aquaculture water, together with the recovery of the photosensitizer after disinfection using a magnet.

Researchers have demonstrated the photoinactivation of bacteria like *Staphylococcus aureus* and *Escherichia coli* using a magnetic photosensitizer (phthalocyanine linked to iron oxide nanoparticles), together with the recyclability of the photosensitizer. Photosensitizers have also been immobilized on multi-walled carbon nanotubes for enhanced antibacterial activity (through photodynamic and photothermal therapy) while allowing for recovery and reuse in water and surface disinfection, making them cost-effective and environmentally friendly. For sustainability, natural light from the sun can be considered as it can penetrate deep and be utilized for large ponds.

Disinfection of surfaces and equipment is a preventive measure to avoid opportunistic pathogens, including their transmission within the aquaculture facilities. After cleaning, surfaces, vessels, and equipment can be exposed to the photosensitizer and light for bacterial inactivation through aPDT, and self-disinfecting surfaces that utilize aPDT have been reported. For instance, researchers have utilized a phenoxy-substituted zinc phthalocyanine as a photosensitizer to

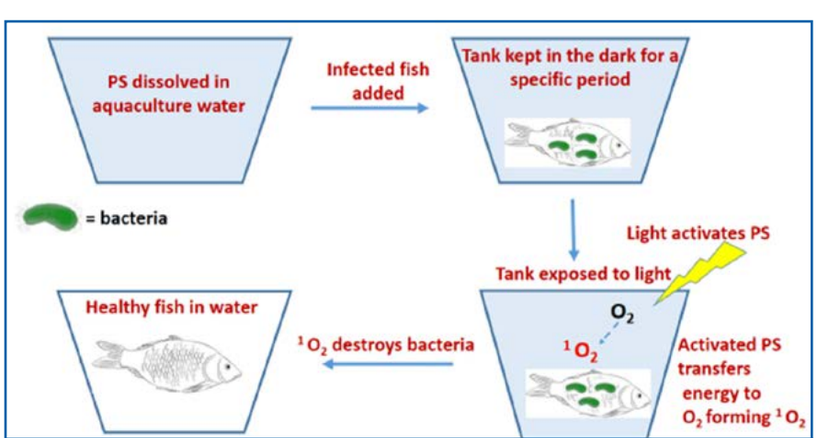

Fig. 2: Illustration of the proposed treatment of localized fish infections using aPDT in aquaculture.

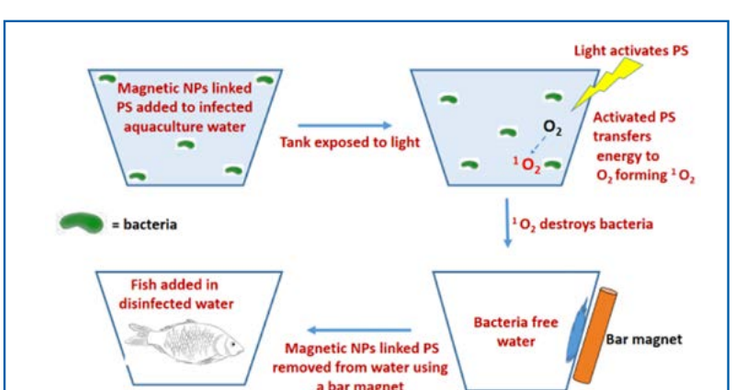

Fig. 3: Illustration of the disinfection of aquaculture water using magnetic photosensitizer and recovery of the photosensitizer after disinfection using a magnet.

fabricate cellulose acetate self-disinfecting films, which continuously generated singlet oxygen ($^1O_2$; the lowest excited state of the diatomic oxygen molecule) for over six months under continuous exposure to room light. Self-disinfecting aPDT coatings can, thus, be applied on aquaculture surfaces for natural light activation.

Aquafeed is formulated from plants and animal sources, including seaweed and microalgae. These can be contaminated with bacteria before harvesting, during drying, processing, packaging, storage and transportation. To avoid the introduction of bacterial pathogens into the aquaculture production systems, the fish feed needs to be disinfected, and researchers have shown aPDT to have potential for the disinfection of fish feed.

Researchers have also demonstrated the ability of aPDT to disinfect microalgal aquafeed contaminated with the bacterium Vibrio *campbellii.* Other authors confirmed the ability of aPDT to destroy *V. splendidus* in both microalgal feed and tank water of oysters fed with the aPDT-treated microalgae, compared to those of oysters fed with an untreated diet.

Advantages of aPDT

aPDT, being a non-antibiotic strategy for the treatment and prevention of infectious diseases, has several advantages over the use of antibiotics, because antibiotics can result in increased antibiotic-resistant bacteria together with the presence of residual antibiotics in food products. aPDT has proven effective due to its broad spectrum of action since it can prevent infections caused by diverse organisms such as protozoa, viruses, fungi, parasites, and bacteria. This is because aPDT generates highly reactive oxygen species (ROS) that oxidize cellular components, rapidly inactivating the cells of these infectious organisms. aPDT can thus be used to control not only bacterial infection but a range of microbial infections. aPDT has been shown to be effective against dangerous antibiotic-resistant bacteria. Additionally, there are no reports of the development of resistance against the photosensitizer, even after multiple therapy sessions. This could probably be because, unlike antibiotic therapy, aPDT treatment is too short for resistance to develop. Additionally, the generated ROS species can oxidize numerous targets on the bacterial cell structure and components, unlike antibiotics, which work on a specific target.

For the treatment of infections in fish, aPDT can be designed to have minimal effects and damage to the host tissue through photosensitizer and light dosage control, as well as the targeting of infected areas, ensuring that only pathogens are destroyed. Due to the short lifetime and high reactivity of singlet oxygen, photo-oxidative damage is restricted to the exposed infected parts.

Since the photosensitizer can also be embedded into polymers, aquaculture production systems that can kill microbes on their surfaces when activated by visible light can be designed. The self-disinfecting systems can reduce the spread of disease-causing microbes during production and processing. Additionally, natural light can be utilized for photosensitizer activation, making aPDT technology cost-effective. Embedding the photosensitizer onto polymeric materials prevents the release of the PS into the environment and promotes the reuse of the embedded photosensitizer. aPDT can be combined with other technologies for enhanced efficiency. Combination therapy involving aPDT and antibiotics can be utilized, as aPDT therapy has been shown to induce damage to bacterial cell membranes, making the bacteria more susceptible to antibiotic treatment. Combining aPDT with nanomaterials not only enhances uptake by bacteria but can also lead to the synergistic effect of aPDT and photothermal therapy (PTT), as specific nanomaterials generate localized high temperatures upon light absorption.

Limitations of aPDT

The application of aPDT for treating fish infections is restricted to infected fish parts where light can reach, such as the skin. It will not work for systemic infections due to poor light accessibility. Light penetrability is important for aPDT; hence, in aquaculture, the technique can only work in water that can allow light through (water should be clear and free of debris).

Considering that both faecal matter and uneaten food make the water in ponds murky, the material should be trapped and removed from the system for this technique to be effective. Thus, recirculating aquaculture systems might be required to continuously clean and disinfect aquaculture water. aPDT is meant to target infectious microorganisms. However, it also damages unintended targets, such as fish tissue and beneficial microorganisms, due to its non-selectivity, which could manifest as side effects such as redness, swelling, and other allergic reactions.

Perspectives

aPDT can inactivate fish pathogenic bacteria, especially Gram-negative bacteria, one of the most important pathogens in aquaculture. Although there are no reports yet of its application in the treatment of fish infections, this technology has the potential for use in aquaculture, especially for surfaces, equipment and aquaculture water disinfection, as it has shown advantages compared to traditional antibiotics. This technology can be effective in water if utilized under recirculating aquaculture systems. This will enable the continuous removal of sludge, allowing for aPDT treatment of water and, ultimately, water reuse. Though not reported yet in aquaculture, self-disinfecting surfaces utilizing aPDT can go a long way in managing bacterial pathogens. Photosensitizers can be embedded in surface coating materials for activation by light, including sunlight. The possibility of using sunlight and natural photosensitizers could make the technology cheaper. Additionally, the technology can reduce photosensitizer release to the environment and allow for the re-use of the photosensitizer.

Though some limitations of aPDT, especially when using natural photosensitizers, have been reported, ways to overcome these limitations can be designed. For instance, the use of several photosensitizers simultaneously can enhance antimicrobial effects. The combined photosensitizer may exhibit different photophysical and photochemical characteristics that complement each other. Additionally, aPDT has been combined with other antimicrobial therapies. The application of aPDT in the aquaculture industry still requires significant research and development efforts to ensure its efficacy, safety and scalability. ■

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SHRIMP PERFORMANCES WITH FERMENTED CORN PROTEIN (MOTIV)

Nguyen Duy Hoa, PhD.
Technical Director.
Empyreal & Motiv products, Cargill Inc.

Unlike fermented soy protein or soy protein concentrates with low protein (55-56% protein) and very high carbohydrates (23-24% carbohydrates) and high antinutrients, MOTIV® is a value-added feed ingredient developed by Cargill Inc. which consists of high-quality & concentrated protein (69% protein) and low carbohydrates (1.7% carbohydrate), and rich in health nutrients (7.2% organic acid, 3.1% biopeptides, and 285 ppm carotenoids). In addition, the fermented biomass of MOTIV also serves as prebiotics that is excellent for shrimp's gut health.

Several indoor and outdoor studies and trials with MOTIV in replacing fishmeal have demonstrated that MOTIV is an excellent fishmeal alternative for shrimp performances both in growth and health performances when using minimum 7.5% MOTIV in shrimp diets. But the effects of fermentation make Motiv more than just a protein alternative.

Growth performances

Shrimp postlarvaes were nursed for 32 days and then transferred to 500-m^2 tanks to stock at 250 shrimp/m2 for continuously feeding with the commercial shrimp feed added with 50 ppm astaxanthin (the control diet) to compare with the shrimp fed with the MOTIV feed (the control diet replaced 7.5% of fishmeal by 7.5% of MOTIV and added with 25 ppm astaxanthin) for another 80 days (total 112 days of culture - DOC). Average daily growth (ADG), Feed Conversion Rate (FCR), Survival rate, harvest biomass, and shrimp color were measured at the end.

In another trial, shrimp (1g) was organized at density of 150 shrimp/m^2 and 10 replicates for a trial duration of 60 days. 9% of the Peru fishmeal in the control diet was replaced by 7.5% MOTIV and 1.5% Krill meal (MOTIV diet).

Shrimp color enhancement

In the above trial, shrimp fed the MOTIV diet consisting of 7.5% MOTIV and 25 ppm astaxanthin resulted in better red color scores (Table 1) than the shrimp fed the control diet (commercial diet added 50 ppm astaxanthin).

Parameters	Control diet (50 ppm astaxanthin)	MOTIV diet (25 ppm astaxanthin)
DOC (day)	112	112
ADG (g/day)	0.235	0.265
FCR	1.66	1.57
Survival rate (%)	88.60	93.36
Harvest biomass (kg)	2,916	3,468
Shrimp color scores	22.70 ± 0.95	24.50 ± 0.71

Table 1. Shrimp performances under the control and MOTIV diets in commercial ponds

Parameters	Control diet	MOTIV diet
DOC (day)	60	60
Initial weight (g)	1.0	1.0
Final weight (g)	12.13[a]	13.88[b]
Survival rate (%)	95.83	96.67
FCR	1.80[c]	1.55[d]

Table 2. Shrimp performances under the control and MOTIV diets in indoor facilities

Shrimp responses to stress tests

Using 7.5% MOTIV and 12.5% MOTIV to replace 7.5% fishmeal & 12.5% fishmeal in the control diet, respectively have indicated mortality of shrimp fed on 7.5% MOTIV diet and 12.5% MOTIV diet was significantly lower than shrimp fed on the fishmeal-based control diet recorded at 6 hours and 12 hours during the test.

In conclusion, several indoor and outdoor trials, MOTIV is an excellent fishmeal alternative and it has proved several benefits for both shrimp feed mills and shrimp farmers as it helps to reduce astaxanthin costs per metric ton of feed (estimated 31.25 $/mt) while significantly increases shrimp weight again (11%) and reduces feed conversion rate (8%) as well as increases shrimp survival rates (4%). ■

Control diet
(added 50 ppm astaxanthin)

7.5% MOTIV diet
(added 25 ppm astaxanthin)

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Capturing carbon from land-based algal blooms

Brilliant Planet's unique idea to capture carbon by creating - and then burying - algal blooms in coastal deserts shows great promise, but it will take hundreds millions of dollars of investment before it can fully achieve its ambitious goals.

Brilliant Planet's pilot farm in Morocco

Photo: Brilliant Planet

In a nutshell, the business revolves around filling ponds in coastal deserts with nutrient-rich seawater and then seeding them with local algae. While Brilliant Planet initially aimed to convert these algae into aquafeed ingredients, they have since pivoted to drying and burying them, as a form of carbon capture.

It's a truly unique idea, but the startup's quietly charismatic founder, Raffael Jovine, makes a strong case for its potential, supported by research gleaned from eight years of field trials in Morocco, Oman and South Africa. "We're in a very different place than we were before – we knew that the concept would work in terms of the volumes, but as well as getting much better on the technical and engineering side we now know more from a social and environmental point of view. And, having done a thorough life cycle analysis, we have identified further hotspots for improvement before we scale up," Jovine explains.

▶ The startup plans to bury the resulting biomass as a means of carbon capture and sequestration © Brilliant Planet

The evolution of a unique concept

A molecular biochemist and biophysicist by training, with a depth of experience in biological engineering – gained at Yale, MIT, UCSB and Woods Hole – Jovine's path to founding a startup was inspired by field trip to one of the most remote regions of the ocean. "I ended up at Woods Hole Oceanographic looking at the environmental triggers behind harmful algal blooms and why some organisms respond more than others. At the time the goal was to stop blooms and reduce them," he recalls. However, it also made him consider that doing the opposite – creating algal blooms – could potentially help provide a solution to climate change. "When on assignment in the Central Pacific Gyre, I realised that the organisms in the middle of the gyre, despite the lack of nutrients, were photosynthetically much more effective than anything I could engineer in the lab," he recalls.

The discovery inspired Jovine to formulate a concept that was good enough to reach the longlist for the – later-to-be-cancelled – Virgin Earth Challenge, so he decided to patent it, in 2008. Since then the idea has evolved considerably. "There was no carbon

market at the time, so we looked at using the algae for livestock and aquaculture feed. We did lots of feed trials and got fantastic results – the algae were rich in protein and omega-3s. But it was always going to take a long time to fit into the big feed producers' schemes: to get to a size where we could fill a silo at an attractive price point. However, the carbon market has since developed, and we realised that if we cut out a lot of the post-harvest processing needed to get the algae into fish feed, we could be low enough cost for carbon," he explains.

According to Jovine, this has allowed them to concentrate almost purely on the production – rather than processing – of the algae, and they've identified areas for further improvements. One such area relates to finding the most efficient species of algae, following extensive trials in their London lab. While they plan to concentrate on producing a single species per location, they are considering changing their species according to the season – for example, using one for the summer and another for the winter. However, they are not able to use genetically engineered algae, as they farm in open systems. Pond management is another area where progress is being made. Equally, they have discovered that the shape of the ponds and the rate of water intake can significantly impact productivity. And the team have also been delving deep into the photo and nutrient physiologies of algae.

"We look at the fundamental cell physiology – what is it that's limiting the growth – and we're uniquely strong on measuring instant growth. At any moment I can tell you exactly how fast the algae are growing – and so we can measure the impact of, for example, a cloud passing over the pond," he explains. As for the nutrient physiology, even though we work in areas with nutrient-rich sea water there's never enough nutrients around, never enough carbon around. But we are much better than nature, because we manipulate the system – by optimising the conditions in the ponds we're taking as much as 10 times more CO_2 out of the seawater than would happen with a natural algal bloom offshore.

▲ Raffael Jovine, founder of Brilliant Planet

While Brilliant Planet do add nutrients to the ponds, this is done carefully, and on a seasonal basis. The main source of their nutrients currently comes from a local phosphate facility, which Jovine says has a "very green" method for producing phosphate or ammonia.

Potential locations

While Jovine says that the government of Morocco has been very supportive, the project has also been making waves further afield and has attracted the attention of the UN, which has made it one of their blue belt initiative reference projects. Brilliant Planet are now looking to expand into a range of coastal desert locations that are close to the world's strongest nutrient upwelling systems – including Chile, Peru and Namibia – essentially making it a platform technology, according to Jovine. While the ocean currents in these areas provide a steady source of nutrient-rich water, the startup is also determined that its facilities are only located on land that is otherwise largely unproductive and yet is blessed with high levels of sunlight – providing a win-win-win for resource efficiency.

Looking ahead

As well as upscaling production and expanding into multiple countries, Jovine is looking to share infrastructure with other industries – in order to reduce costs and increase income streams. A 1,000 hectare site at 100 m elevation could store 1.9 GW hours of electricity every day. So, from a grid-balancing point of view, we would be the ultimate pump-hydro solution. At peak demand in the evening hours we could discharge and recapture 85 percent of that energy. We're still a small company, so developing these things is not something we can do by ourselves, but that would be another milestone.

While Jovine's ultimate ambition is for an international network of algae-producing facilities that cover thousands of hectares, in the shorter term he is currently looking to build a semi-commercial-scale facility. And he believes that raising £20 million will allow him to prove his unique concept and pave the way for an industry that could not only revolutionise carbon capture and promote biodiversity, but also create flourishing communities in some of the planet's most marginal zones.

Rob Fletcher

NOURISHING SUSTAINABLE FUTURES

Skretting is known as a global corporation providing innovative and sustainable nutrition solutions for the aquaculture industry. Skretting Vietnam's top priority is research and development of new products to enhance efficiency for farmers. Let's listen to the insights of Mr. Eric De Vaan, General Manager of Nutreco Vietnam and South Asia, about the company's strategic direction in the Vietnamese market.

SKRETTING VIETNAM

Could you please introduce Skretting Vietnam?

Skretting is a leading global corporation in providing innovative and sustainable nutrition solutions for the aquaculture industry, headquartered in Stavanger, Norway. Skretting began operations in Vietnam in 2012. Since then, we have constructed 2 feed factories for shrimp and fish. Currently, we take pride in being one of the top enterprises in the aquaculture sector.

Every year, Skretting supplies approximately 100,000 tons of high-quality feed for shrimp and fish to the Vietnamese market. For fish feed, we focus solely on producing feeds with high commercial value, meeting stringent nutritional requirements. Typical examples include feeds for fingerlings, scaled fish, catfish, pond carp, snakehead fish, marine fish, and sturgeon.

Skretting, with its talented and passionate team, continuously develops superior solutions, aiming to build a stronger and more sustainable global aquaculture industry.

Due to the local impact, the food market is facing numerous difficulties and challenges in 2023. Could you share more about this and how your company has overcome these challenges?

There are a couple of challenges that the shrimp industry is currently facing. One of them is that production costs are too high, especially given the current low shrimp prices. To address this issue, we aim to assist our customers in achieving more successful crops and reducing feeding costs. We are doing this by providing them with different options within our product range.

Specifically, to tackle this challenge, we're launching a new product range called Titan. This range offers optimal protein at a much lower cost compared to what we've previously offered. I believe this is a concrete measure to help farmers reduce their production costs. Additionally, we're also working through our technical team to help farmers increase their success rates.

In Vietnam, especially in the Mekong Delta provinces, disease outbreaks pose a significant challenge to the shrimp industry. This issue becomes increasingly severe when existing diseases remain unresolved while new ones emerge, causing many difficulties for farmers. What are your thoughts on this matter?

I think all diseases don't disappear; the old diseases persist, and new ones continue to emerge. Vietnam faces a significant presence of almost all shrimp diseases. We must confront this reality. Diseases emerge from various sources such as post-larvae (PL), water, and biosecurity issues on farms. Therefore, we need to ensure that farmers in Vietnam are resilient. They must be capable of farming despite the risks posed by diseases, able to monitor the emergence of diseases, and know how to handle them, including in 2024.

Participating in the 5th VietShrimp, what advanced technologies or products will Skretting introduce to visitors?

As I mentioned earlier, at VietShrimp 2024, Skretting is introducing Titan, a new shrimp feed product. This

product provides an optimal level of protein, helping shrimp to be healthier, eat more, digest better, and grow faster to achieve good productivity. Additionally, Titan contributes to a more stable farming environment, requiring fewer water changes and facilitating easier water quality management, thus reducing water treatment costs and leading to an abundant harvest with optimal expenses.

Another product we'd like to introduce is Galea, which helps control and limit the negative impact of various disease-causing parasites, including combating EHP (Enterocytozoon hepatopenaei), while stimulating the growth of shrimp and fish. These products have actually achieved very positive results not only in Vietnam but also in other markets across Southeast Asia.

In the future, what new directions does Skretting have to aim towards the goal of sustainable development of the aquaculture industry in Vietnam?

Sustainable aquaculture in Vietnam is a priority for us in the near future. We are actively promoting the transition to net-zero shrimp farming. Our efforts focus on reducing the environmental footprint of our feeds, utilizing life cycle assessment tools to minimize the impact of soy and marine ingredients, as well as optimizing our own production operations.

Additionally, we assist farmers by providing access to technology, farming protocols, and recommendations aimed at reducing the use of harmful inputs. We advocate for the adoption of sustainable energy sources for on-farm power generation and emphasize the importance of mangrove reforestation. This is a powerful strategy for enhancing the overall environmental footprint of shrimp farming areas.

Skretting hopes that the shrimp farming industry in Vietnam will further develop in this direction. Currently, shrimp farms in Vietnam face significant challenges regarding production costs and environmental impact. Therefore, I believe it is time to unlock the potential of this industry, ensuring efficiency, cost optimization, and sustainability. If we do not accelerate now, we will not be able to compete with other countries.

At VietShrimp 2024, Skretting Vietnam was honored to be awarded the Most Impressive Booth of over 200 booths at the event. This is the motivation for Skretting Vietnam to constantly innovate at the next Vietshrimp edition.

As a company participating in VietShrimp 2024, how do you evaluate this exhibition?

Well, regarding VietShrimp 2024, I must say that the venue is very impressive, even better than in previous years. The program is quite interesting, and it's great to see the participation of numerous companies. Although yesterday wasn't as busy as expected, I hope to see more visitors next time. Despite being a bit further away from the city center, I believe the fair itself has been well organized, especially thanks to the efforts of your marketing team. Overall, I think it's been a good experience.

Anh Thu

APPLYING FOR A MARINE FARMING LICENSE - A PERENNIAL CHALLENGE

By Hoang Anh - Kien Trung

Marine farming in Van Don district, Quang Ninh province Photo: Kien Trung

Great aspirations, high determination; however, policy and mechanism barriers are like a golden bracelet tightening our mariculture dream,' expressed Hai Binh.

In the era of seas and oceans, Vietnam aspires to emerge as a maritime powerhouse, leveraging the wealth of its expansive aquatic resources. To materialize this ambition, central strategies and projects have underscored mariculture as a pivotal strategy, solution, and inevitable trend to harness the national advantage of golden forests and silver seas.

Nonetheless, the practicality of marine farming in localities today confronts myriad legal barriers, overlapping planning, and policy mechanisms, hindering the realization of maritime endeavors.

This series of articles from the Vietnam Fisheries Magazine presents genuine records and reflections from Quang Ninh, Binh Thuan, Ninh Thuan, Phu Yen, Khanh Hoa, Kien Giang, and other coastal provinces—the nation's marine farming hubs—with the aim of alleviating bottlenecks and elevating Vietnam's marine farming into a high-value economic industry.

7 years of struggle to obtain a marine farming license

Seven years ago, Ms. Nguyen Thi Hai Binh, General Director of STP Group (Super Truong Phat Plastic Group Joint Stock Company), reminisced about the time spent on a motorboat navigating the marine farming area around Phat Island, Ha Long commune, Van Don district, Quang Ninh province.

Despite her petite stature, Hai Binh's resolute voice resonated amidst the vast ocean waves, leaving few to ponder her determination amidst the sea's expanse.

Furthermore, Phat Co Island in the heart of Bai Tu Long Bay, lies a fishing area that has served generations. However, as fish and shrimp stocks dwindled in the sea, with escalating costs of marine expeditions, local inhabitants gradually transitioned towards sea farming. In vast aquaculture areas, residents phased out the cultivation of geoducks and snails in favor of groupers and clams. As if it had become a norm: when prices surged, individuals rushed to rear their stock, leveraging their homes and securing bank loans for their ventures. Plummeting prices, insurmountable debts, lost homes,

and at times, abandoned boats followed initial successes. In recent years, however, oyster farming has witnessed significant growth.

While production processes, linkages, and market structures have become more organized compared to the past, they remain susceptible to fluctuations. In the heart of Bai Tu Long Bay, hundreds of oyster farms dot the water, resembling thousands of warships often depicted in historical films. Quang Ninh province has designated numerous sea areas in Ban Sen, Ha Long, Thang Loi, Minh Chau, and other locales in Van Don district as pivotal marine farming zones. The district has over 23.8 thousand hectares of water surface area earmarked for marine farming potential, with over 11 thousand hectares within 3 nautical miles and more than 3 thousand hectares beyond 6 nautical miles. The marine farming strategy prioritizes two primary species: mollusks and marine fish. Despite positioning marine farming as a key economic sector, particularly in advantageous locales like Van Don, Quang Ninh province, legal quandaries, and barriers persist, hindering the realization of the sea-farming dream.

Responding to the clarion call from various levels and branches of Quang Ninh province, Nguyen Thi Hai Binh and STP Group ventured into the waters of Van Don in 2017. Concurrently, the Phat Co Aquaculture Cooperative was established that same year. United by shared aspirations and objectives, they have collaborated to implement a sustainable marine farming model. Thanks to the support of technology, capital, and technical processes from STP, Phat Co Cooperative emerged as the first unit in Quang Ninh to transition from traditional aquaculture platforms, rafts, and floats made of bamboo and foam to eco-friendly HDPE material. Furthermore, it pioneered the establishment of an expansive floating farm spanning 8 hectares, featuring operational facilities, visitor-serving cages, and spaces for intercropping and multi-cropping aquaculture.

Transitioning from precarious sea farming conditions, perpetually fraught with legal, disease, environmental, and market risks, the members of Phat Co Cooperative, in collaboration with STP, successfully constructed a thriving model of seaweed cultivation intercropped with Pacific oysters. Director Nguyen Sy Binh and Phat Co Cooperative members revealed they cultivate three seaweed crops annually, yielding 70-100 tons per hectare. STP provides farmers with material, substrate, and seed support, along with post-harvest product consumption incentives. Additionally, should market prices exceed commitments by 10%, members have the liberty to engage in free trade. Consequently, each cooperative member accrues over 1 billion VND annually, offsetting interest costs exceeding 300 million VND.

Phat Co pioneered a model integrating aquaculture with community tourism, swiftly garnering recognition as a model cooperative in Quang Ninh province. Since 2020, it has successfully established a closed chain of operations encompassing farming, processing, and market sales of milk oysters. In 2022, a venture into intercropping milk oysters with seaweed further solidified its economic prowess. Despite the promising outlook, Nguyen Thi Hai Binh cautions against Phat Co becoming a "flagship" due to the litany of challenges and obstacles it encounters.

Implementing marine aquaculture planning and policies to stimulate investment in marine aquaculture within Quang Ninh province, STP Group stands as a pioneering enterprise in crafting project documents for submission to all levels, seeking licenses to utilize marine resources within the designated planning areas of Van Don, Cam Pha, and Ha Long. Building on the successes achieved with the intercropping model of cartilage seaweed and milk oysters, and the fish farming model in Bai Tu Long Bay, Nguyen Thi Hai Binh harbors ambitions to replicate interconnected

▼ Intercropping seaweed and Pacific oysters generates high economic value.

Photo: Kien Trung

▲ After 7 years of staying at Van Don beach, they still need a marine farming license

Photo: Kien Trung

chains and upscale marine farming to an industrial level. With proposed expansions across 318 hectares in Cam Pha, 120 hectares in Ha Long, and 96 hectares in Van Don, this determined entrepreneur believes firmly in the potential, advantages, resources, and technological capabilities of STP. However, despite seven years of persistent efforts, the elusive license remains out of reach due to many persistent obstacles.

"Quang Ninh province's zoning plan delineates each sea farming area and allocates sea usage authority from districts and provinces to ministries and branches. We have diligently compiled documents and solicited feedback from every relevant agency in accordance with regulations, yet regrettably, we remain ensnared in bureaucratic limbo," lamented the General Director of STP.

It's worth noting that Quang Ninh has implemented Decree 11/2021/ND-CP, which governs the allocation of specific sea areas to organizations and individuals for the exploitation and utilization of marine resources. Complementing this initiative is a series of policies designed to attract investment, along with establishing steering committees and dedicated working groups to bolster support for the business community, cooperatives, and individuals, thereby unlocking the vast potential of marine farming. However, issuing marine farming licenses remains excessively challenging, particularly in designated farming areas, underscoring the persistence of bureaucratic hurdles. In our ongoing STP projects, even though the authority to grant licenses lies with the Provincial People's Committee, it necessitates soliciting opinions from multiple ministries and branches, including the Ministry of Natural Resources and Environment, Ministry of Agriculture and Rural Development, Ministry of Transport, Ministry of Foreign Affairs, Ministry of National Defense, and Ministry of Public Security.

"The most arduous aspect is that obtaining approval from the Ministry of Agriculture and Rural Development requires endorsement from the Ministry of Natural Resources and Environment. Conversely, gaining approval from the Ministry of Natural Resources and Environment necessitates permits and endorsements from other ministries and branches. Furthermore, in certain areas designated for project implementation lying beyond 6 nautical miles, within the buffer zone of the World Natural Heritage, authority must be sought from the Prime Minister. Consequently, investors face formidable challenges," lamented the General Director of STP, expressing deep frustration.

Challenges persist

In tandem with implementing marine farming projects in Quang Ninh, STP Group concurrently prepares documentation to apply for marine farming projects in Khanh Hoa and Ninh Thuan provinces. General Director Nguyen Thi Hai Binh remarked, "Marine aquaculture is a distinctive domain. While we perceive significant opportunities and potential, they are accompanied by many challenges, including substantial investment, adherence to environmental standards and regulations, considerations of density and productivity, and structural aspects of cages. These challenges, compounded by the complexity and overlap of regulations, deter investors from realizing their aspirations of venturing into marine farming. "Without a marine farming license, both businesses, cooperatives, and individuals lack a legal foundation for investment," emphasized Ms. Binh. "Investments in marine farming entail substantial financial support aimed at facilitating the transition of marine farming materials, breeds, and technological advancements, alongside environmental enhancements, to ensure successful implementation."

The entire Van Don district now has more than 65 seafood cooperatives, many of which are affiliated with businesses to produce according to orders from the export market jointly. Size, type, output, season, farming area code... all have significant advantages. However, the legal basis is still precarious, the need for a marine farming license is like a tight grip on the marine farming community in Van Don.

For the whole Quang Ninh province, with a 250 km long coastline running from Mong Cai to Quang Yen, the area of marine farming is more than 45,000 hectares, and the mining land identifies marine farming as a key economic sector. The project to develop marine aquaculture until 2030, with a vision to 2045, approved by the Prime Minister, also identifies Quang Ninh as the national marine aquaculture center. The Department of Agriculture and Rural Development of Quang Ninh province has also published documents to attract investment in marine farming. Mong Cai, Hai Ha, Dam Ha to Van Don, Co To, Quang Yen... The total area of attraction is about 13.4 thousand hectares, but up to now, not a single investor has been granted a license. ■

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From Rice To Shrimp

Can Vietnam's Rice Farms and Aquaculture Survive Climate Change?

Article written by Jillian Wong - RYNAN Technologies

The Mekong River is saltier than ever. As saltwater intrusion worsens in the Mekong Delta region and paddy fields give way to shrimp farms, will shrimps survive the impacts of climate change in the long run? Can we have our bowl of rice with shrimp and eat it too?

Flowing almost 3,000 miles from the Tibetan plateau down to the South China Sea, the Mekong River boosts a rich biodiversity comparable to that of the Amazon. It is also one of the most intensively cultivated areas in Asia, supporting the livelihoods of tens of millions of people.

Rice farming plays an important role in Vietnam's economy, with the Mekong Delta producing more than half of Vietnam's total rice production. As the world's third-largest rice exporter, Vietnam's rice farming has come a long way, until recent years when saltwater intrusion is threatening rice crops. The Mekong Delta, known as the "rice bowl of the nation", now seems to be in danger of depleting.

An Appetite for More Diverse Diets

Back in the 1970s, the Vietnamese government invested heavily in reclamation, irrigation, and soil improvement to promote the intensification of rice production. Their efforts paid off, as the paddy fields that sprawled Mekong Delta's agricultural land increased from 2 to 4.3 million hectares in 2016, catapulting Vietnam into a key rice exporter. The exponential growth enabled the nation to be self-sufficient in food production, but rice farmers were locked into producing low-quality rice with poor returns as they sold their harvest to the state at meager prices.

As consumer tastes gradually shift to favor higher-quality rice and more diverse diets, many rice farmers are turning to fruits, fish, or shrimp farming which offer better income.

The Mekong is Entering Uncharted Waters & Rice Crops are Withering

Few places on Earth face the wrath of climate change as much as the Mekong delta.

During the dry season, seawater flows into the Mekong River yearly as part of the natural cycle. Then in the wet season, monsoon rains carry nutrients and silt from upstream to nourish vast paddy fields. As the Mekong floods, salt is flushed through the delta and back into the sea. This annual flooding helps reset the delta's natural balance and limits saline intrusion.

However, as sea levels rise, salt-laden water encroaches deeper inland and into the estuaries during the dry season. The Mekong Delta lies on average a meter above sea level, thus a sea-level rise of 0.7 to 1.0 meters could flood approximately 40% of the delta. Rice crops, in particular, are extremely salt-intolerant, and flooded fields can hamper rice planting efforts. With seawater levels increasing along the delta's shores causing the river to become saltier each year, many

rice fields have been destroyed. This climate crisis is also pushing rice farmers away from rice production.

The construction of several hydropower dams upstream is also causing further stress to the river by reducing freshwater flow and transporting lesser nutrients and sediment during the monsoon floods. If sea levels continue to rise, more devastating floods will follow, with increasingly salty waters that not only damage crops but harm the biodiversity of the Mekong and the livelihoods of those who depend on it. It is estimated that up to 70% of the Mekong's agricultural land is at the mercy of saline intrusion this century.

Farmers Find A Sliver of Hope in Shrimps

As saltwater intrusion threatens to get more severe in many areas of the Mekong, the environment becomes increasingly unsuitable for growing rice crops. Farmers are switching to products that have a greater tolerance for saline conditions, and shrimps seem an obvious choice. The two most commonly farmed shrimp, *L. vannamei*, and *P. monodon* can survive salinities of up to 40 ppt. Besides, raising shrimp fetches a profit potential that is 12 times higher than farming rice. Revenue from shrimp exports has surpassed that of rice in Vietnam and has been growing expeditiously since 2013. To further boost the country's seafood industry, the government has set a goal to double shrimp exports to US$10 billion by 2025 and rolled out training and soft financing to farmers. Caught between rice crops dying from salt intrusion and a glimmer of 'shrimp hope' that might extricate them from poverty, rice farmers are making a dive for shrimp rearing.

Shrimp Business: A Boon or A Bane?

As farmers ditch rice farming for the more lucrative business of shrimp rearing, paddy fields are either abandoned or converted into shrimp farms. Intensification of aquaculture development has also led to the destruction of mangroves, rendering the forests defenseless against flooding, erosion, and salt intrusion. At present, shrimp aquaculture is posing a host of other environmental problems. Antibiotics, chemicals, and contaminated wastewater from shrimp farms are released directly into surrounding waters, further polluting an already ailing river and seriously damaging its biodiversity. When the Mekong reaches a state of irreversible contamination, farmed shrimps that were meant to save the day will eventually meet the same fate as the rice crops.

Reviving The Rice Fields and Saving The Shrimps

It seems a feat to reverse the catastrophic impacts of climate change on the Mekong. Furthermore, the compounded effects from agricultural activities on the Mekong and the consequences from hydropower development will have a serious impact on global food security for those depending on the river for sustenance and livelihoods.

Climate change isn't going away, and the only way to guarantee a full rice bowl is to develop sustainably in both aspects of shrimp and rice - the two main products that will bring high turnover export and food security.

Mixed rice-shrimp aquaculture ponds look promising as a solution to mitigate the effects of climate change and promote the sustainable production of both rice and shrimp. Traditional methods cultivate rice and shrimp separately, and we've seen its

dire consequences. With mixed rice-shrimp aquaculture, these ponds produce rice and fresh-water shrimps in rainy seasons and rear brackish-water shrimps during dry seasons and in periods of saltwater intrusion. Ponds are fertilized naturally by shrimp manure and nutrient-rich sediment from flood waters during the monsoon season. This method restores the natural sedimentation process and minimizes chemical use in pond treatment. Clean river water will be supplied through intake channels, while wastewater will be discharged through other channels.

Mixed rice-shrimp aquaculture not only brings economic value and increased productivity to the table, but it also contributes to the preservation of the natural environment.

After all, for farmers in the Mekong, a meal is never complete without rice. Even better when it is accompanied by succulent shrimps that are farmed sustainably. ■

Born and Bred

The Rise of Shrimp Aquaculture in a Changing Climate

By Jillian Wong
RYNAN Technologies

A relatively young entrant to the animal husbandry industry, shrimp aquaculture is emerging as a popular source of animal protein for the world. But first, it needs to overcome challenges from climate change and infectious diseases to produce for the future.

With the world population expected to reach 9.8 billion in 2050, we are running out of natural resources to sustain our food system. From depleting arable land and over-exploiting oceans for food, we are now turning to aquaculture to solve our food crisis.

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How Shrimp Farming Began

Although shrimp has been harvested for centuries, it began as an incidental catch when wild shrimp fry entered into coastal enclosures that were meant for milkfish, mullet, and other finned fishes. In the process of harvesting milkfish and mullet, shrimp was collected as a by-product without any extra effort by the farmers.

It was only in the 1930s that modern shrimp farming evolved, thanks to a Japanese ichthyologist named Motosaku Fujinaga. The shrimp that was successfully spawned and cultivated for the first time was the Kuruma shrimp *(Penaeus japonicus)*. Kuruma prawns are delicacies in Japan, usually kept alive until they make it to the dining table as raw sushi or deep-fried tempura. High demand for shrimp had quickly diminished its supply, with the shortage escalating into a culinary crisis.

In 1934, Motosaku Fujinaga's success in spawning and growing Kuruma larvae in captivity earned him the moniker "The Father of Shrimp Farming." With his remarkable first breakthrough in shrimp farming technology, the supply of postlarvae grew exponentially and commercial shrimp farming soon took off in other countries with different shrimp species by the 1970s.

Farmed shrimp production grew rapidly from the 1980s into the 1990s, and has evolved into a profitable trade attracting investments over the past two to three decades. The most common species of farmed shrimp are Penaeus vannamei (Pacific white shrimp) and Penaeus monodon (giant tiger prawn). Today, farmed shrimp accounts for 55 percent of the shrimp produced globally. Yet, this business comes at a cost, one that is fraught with numerous challenges.

Climate Risk To Shrimp Aquaculture

One of the most imminent risks to aquaculture is climate change. Climate change impacts aquaculture through changes in sea levels from extreme climatic events, causing fluctuations in rainfall, droughts, tidal floods, and algal blooms. Rainfall, for instance, has a huge impact on shrimp culture. Water variables such as salinity, temperature, pH levels, and nutrients can affect the presence of Vibrio, which can cause disease outbreaks that affect the growth and survival of penaeid shrimp.

Environmental Impacts From Shrimp Aquaculture

While shrimp aquaculture has to fend against the effects of climate change, it has also caused detrimental effects on the environment. Many shrimp farms discharge effluent directly into the environment. The discharge containing feed, antibiotics, hormones, pesticides, and fecal waste pollutes water and the health of ecosystems and coastal habitats. Farmers also pump out groundwater to fill their ponds to maintain water quality and salinity levels, resulting in seawater intrusion. Furthermore, the unplanned expansion of shrimp farming has led to the massive destruction of mangroves and other wetland habitats.

Mangroves play a critical role in mitigating climate change. They form the foundation of productive ecosystems on our planet, providing homes, nursing, and feeding grounds for biodiversity. These forests are also capable of removing discharges from shrimp ponds. Their dense roots stabilize coastlines, forging a natural fortress against floods, storm surges, and sea-level rise while mangrove peat takes in water during heavy rains and reduces coastal flooding. With the rapid loss of mangroves, shrimp ponds are exposed to storm surges and flooding. Water quality for shrimp farming deteriorates and shrimp culture becomes even more vulnerable to diseases.

Vulnerability To Diseases

Diseases are a primary culprit of the boom-and-bust production cycles in shrimp aquaculture and may increase with global warming, as thermally stressed farmed shrimps can develop weakened immune systems and become more susceptible to diseases. Common diseases include white spot disease, yellow head disease, and Early Mortality Syndrome (Acute Hepatopancreatic Necrosis).

When farmers release contaminated wastewater and sediment from their ponds into receiving waters without proper wastewater treatment, the pathogens spread easily into neighboring ponds. Effluents high in organic matter can also result in oxygen depletion in receiving waters and cause further harm.

As lower-yield extensive aquaculture systems are being gradually replaced by semi-intensive or intensive systems which promise higher yields, disease risks increase with culture intensity and high stocking densities. Expansion and intensification of aquaculture systems face risks of concentrated wastes in the effluent. When such wastes accumulate too quickly, farmers may resort to increased use of antibiotics and chemicals to control and treat polluted water, which can result in antibiotic-resistant pathogens with devastating consequences.

Shrimp Farming In A Changing Climate: Can We Do Better?

While aquaculture already makes notable contributions to global food security, reaching aquaculture's full sustainable potential will require every stakeholder in the value chain to play its part, from suppliers to farmers, governments, and the consumer.

For example, government intervention may be needed to curb unplanned shrimp farms or limit the area of planned shrimp farms to prevent further mangrove destruction. Intensification of existing shrimp farms can be considered over developing new farms. Legislation may be required on designs of shrimp ponds to ensure better water supply, wastewater treatment and discharge systems, and improved pond infrastructure. The 20th century saw a massive transformation of shrimp aquaculture through intensification and technology. The road ahead may require a digital transformation with complete traceability to drive shrimp farming toward a future of sustainability. Incentives, regulations, taxations, grants, certifications, and education schemes are just some of the ways that the government can collaborate with shrimp suppliers and producers, feed manufacturers, and middlemen.

As for us, the shrimp-loving consumer, we can create a demand for sustainable shrimps. Only by demanding sustainable shrimps, shrimp producers will be economically motivated to take responsible steps towards sustainable and environmentally-friendly shrimp farming. ■

Discover New Products and Solutions at SEAFOOD EXPO EURASIA

New global fishery industry event will be held in Istanbul on May 15-17. SEAFOOD EXPO EURASIA provides attendees with access to a variety array of fish and seafood suppliers from China, Vietnam, Indonesia, South Korea, Russia, Turkey, Japan, Morocco, Ecuador, Peru, Chile, and various countries across Europe, Asia, Africa, and Latin America. However, the event involves more than just catching and processing section.

What makes the new fair truly beneficial for fishery industry professionals?

SEAFOOD EXPO EURASIA provides a unique opportunity to connect with both small and large fishery companies in one place. This presents attendees with a chance to discover hidden industry gems and expand their business network. Designed with a business-focused approach in mind, the event understands the unique challenges faced by the fishery industry today and creates an experience that meets the diverse needs of its participants. Find new buyers, run into new distribution channels and choose technologies and solutions for your business. Let's see what else our exhibitors may offer?

If you are wondering how to benefit from fish processing waste you would be introduced to **NOBI**, which will present variety of fish feeds, as well as its other innovations from fishmeal and fish oil. Ready-made solutions for construction and maintenance of various types of fishmeal plants will be presented by **A & S Thai Works**, which has more than 30 years of rich experience.

The visitors who are looking for insights on sustainability in aquaculture will be introduced to **Valpak's** special antifouling coatings for nets and plastics, along with **Steen-Hansen's** solutions to the global biofouling issue. On top of that attendees will gain an overview on innovations in management software, IoT and business intelligence solutions from **AquaManager**. All the equipment tailored to support the entire lifecycle of aquatic farm animals, from larvae hatcheries to grow-out tank RAS filtration systems they will find at **Mat-Kuling's** stand.

Wide range of deep-sea and mid-water trawls, as well as codends, fishing nets, ropes, twines and other fishing gears will be showcased by **IWILL** and **Fishering Service.**

Polarplas will bring to exhibition fish bins, ice box, pallets, plastic body refrigerated products and industrial crates. Modern freezing and cooling solutions, including an ice machine and an installation for cooling seawater will be showcased by **Termodizayn**. **FESCO Transportation Group** will share insights on relevant seafood logistic routes and present their own infrastructure schemes.

Pregol Yard will introduce participants to its comprehensive ship repair and modernization services, as well as the restoration of mechanical and electrical equipment, automatics, and radio navigation. Systems of emergency control and other equipment for safer fishing will be demonstrated by **Bulutlu Marine**.

In addition, SEAFOOD EXPO EURASIA will feature digital tools for monitoring the transportation and tracking of fish products, new solutions for the use of refrigerants, veterinary drugs to improve survival rate of fish during cultivation, as well as alternative products – such as plant-based seafood.

An important part of the event will be a rich **business program**. To provide participants with effective tools for entering new markets, it will address not only global issues of industry development, but also the specifics of various regions. South and South-East Asia, Latin Amerika, the Middle East, Türkiye, and Eurasia at all, as well as African countries will be the focus of the experts, government officials, key decision makers and researchers sharing marketing success cases and regional markets insights.

Attending SEAFOOD EXPO EURASIA and its business program is free and available for all registered visitors.

Mark your calendars for **May 15-17** and meet us at Tüyap Fair Convention and Congress Center in Istanbul, where innovation meets opportunity. ■

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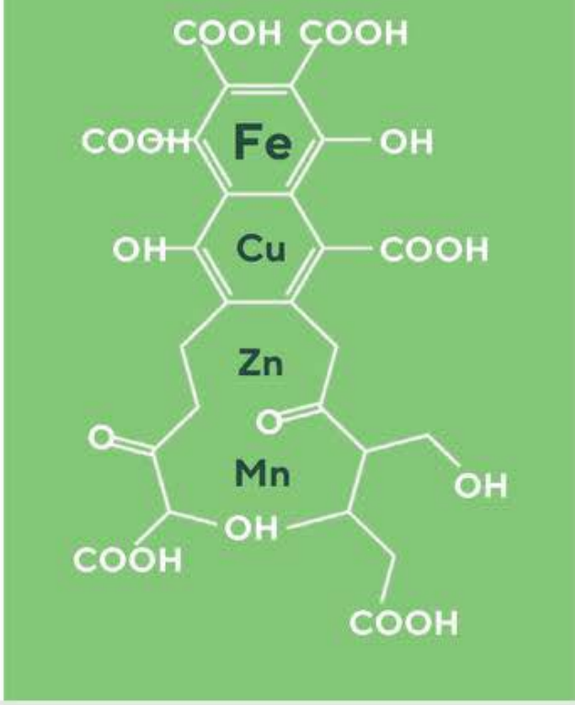

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