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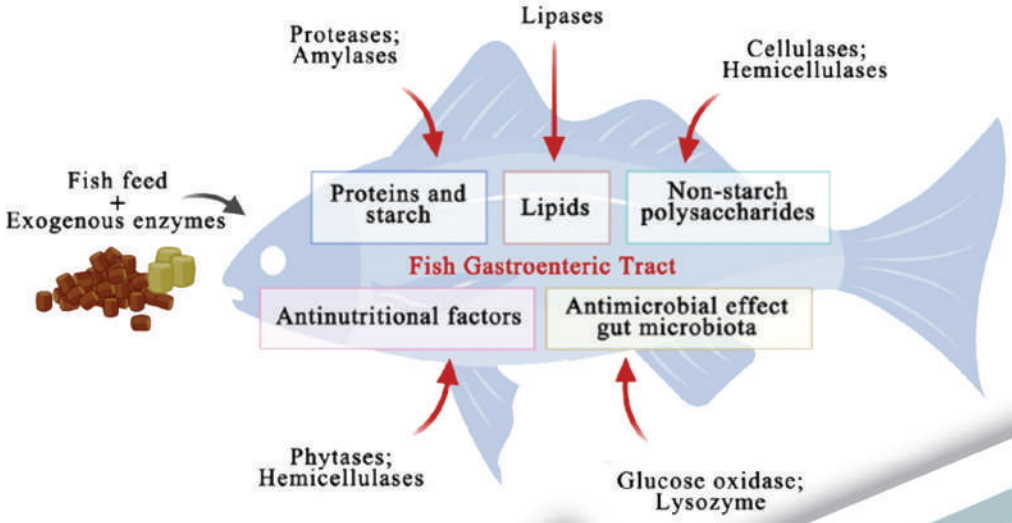

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AQUAFOCUS

Dedicated to Aquaculture Research & Development

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EDITOR'S LETTER

Dear Readers,

It gives me great pleasure to welcome you to this special edition of AQUAFOCUS, where science meets sustainability in redefining the future of aquaculture. This issue captures the transformative intersection of biotechnology, marine resources, and food innovation that are driving a new wave of progress from lab to lagoon.

We begin with "Biomanufacturing of Aquaculture Enzymes," a feature exploring how enzyme innovation is enhancing digestion, nutrient absorption, and pond health reshaping feed efficiency and profitability. The biotechnology thread continues in "Revolutionizing Larval Nutrition: Biotechnology in Aquaculture Live Feed," which highlights the breakthroughs turning microalgae, probiotics, and precision nutrition into key tools for hatchery success.

The article When the sea follows the sky: Lunar Illumination and Spawning Cycles in fish reminds us that aquaculture and fisheries science are not just about productivity but about understanding and respecting the natural rhythms that sustain aquatic life. Meanwhile, "From Shore to Plate: Why Domestic Seafood Consumption Matters More Than Ever" makes a compelling case for strengthening local seafood value chains and empowering coastal livelihoods through consumer awareness and policy support.

We also explore the blue-green revolution in "Spirulina as a Food Source," presenting how this microalga continues to bridge human nutrition, wellness, and sustainability. Finally, our cover story "The Science of Formulated Feed is Unlocking a Profitable and Sustainable Blue Future for Tamil Nadu's Aquaculture" delves into regional innovation, showcasing how feed technology and biotech integration are propelling Tamil Nadu to the forefront of India's blue economy.

Each story in this issue reflects a shared vision to merge innovation with ecological balance, to empower farmers with knowledge, and to shape an aquaculture future that is profitable, inclusive, and sustainable.

With Regards,
Dr. Jesu Arockia Raj. A
Editor-in-Chief
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Biomanufacturing of Aquaculture Enzymes

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Introduction

Aquaculture has always contributed a lot in meeting our needs and demands. These demands include various purposes starting from the basic needs of human beings to the needs of the environment. As the population keeps increasing rapidly, the mouths to be fed also keeps increasing simultaneously and seafood plays a major role in contributing to our daily meals. Fish and seafood are generally healthier than red meats. It acts as a major source of protein necessary for our body's wellbeing especially in Asia and coastal regions. The amount of fishes found generally in nature are depleting because of overfishing. Hence, aquaculture comes into the picture to assist the problem by replacing the wild-caught fishes and easing pressure on oceans. This aquaculture seafood is found to be completely environmental friendly than other land-based farming. Also, introduction of this method of development has paved way in creating a new field of study and has opened our minds to think out of the box. They have also promised in eradicating the problems of unemployment and have given a lot of job opportunities to many.

Aquaculture Enzymes

A study has been carried out for many years based on replacing different seafood items with different plant protein components. Plant proteins generally possess various anti-nutritional substances and this becomes one of the negative points when we study relating this with fish feed. Hence, it is clearly understood that, for using plant protein components as a replacement in fish feed, it is essential to remove or at least reduce their anti-nutritional quality.

Enzymes are generally protein structures that assist the biochemical processes such as breaking down food, building of new molecules, or any other essential life process. They are also sometimes referred to as biological catalysts. Likewise, enzymes that assist the biochemical processes in fishes and other marine organisms are termed as aquaculture enzymes. Figure 1 shows the types of aquaculture enzymes used in aquaculture sector. Recent researches on exoenzymes that act as feed additives are attracting researcher's interests into this aquaculture industry. This aims in increasing the nutrient quality of plant protein components and creates a new way of providing nutrient enriched seafood or fish feed, increasing the profits for the aquaculture industries.

Assisting in better food digestion in fish, making more quantity of nutrients available, increasing the feed efficiency, and strengthening of immune system are some of the important roles of aquaculture enzymes. All these enzymes must be manufactured, altered and inserted in the fish feed production units appropriately for their assistance in improving the yield. These aquaculture enzymes can be extracted from plant based protein components. As already mentioned, plant based protein components have to be processed by feed processing to reduce its anti-nutritional factors (ANFs). Introduction of these processed exoenzymes into aquaculture fields has created a lot of developments like reduction in the impacts of anti-nutritional factors (ANFs), improvement in the health and immune response of the fish, increase in the availability of nutrients, increase in the quality of water, thereby increasing the possibilities of incorporating high levels of plant proteins to enhance the fish productivity and economy.

Major Aquaculture Enzymes

Proteases:

These enzymes are generally called the proteolytic enzymes, required to breakdown proteins into amino acids. Recently, these enzymes have claimed to be one of the common and important enzymes in aquaculture. Their roles in the development of fish feed have been enormous. Plant derived proteases, animal derived proteases, and microorganisms derived proteases are the three different sources of the enzyme protease. In these sources, microorganisms contribute the most in providing with the protease enzymes for fish feed. Hence, pH and temperature are the most influencing factors of the enzyme activity. The protease enzymes help in modifying the plant proteins that assists fish feed by interrupting the cell content, develops the contact between protease enzyme and the cell content, thereby decreasing the anti-nutritional factors (ANFs) and increases the quality of the protein in all aspects. Endogenous protease activity is stimulated by the incorporation of these protease enzymes that lead to the utilization of amino acids. Recent researches also state that protease enzymes have the capability in assisting the immune response and growth of the organisms. Hence, this simultaneously increases the aquaculture population.

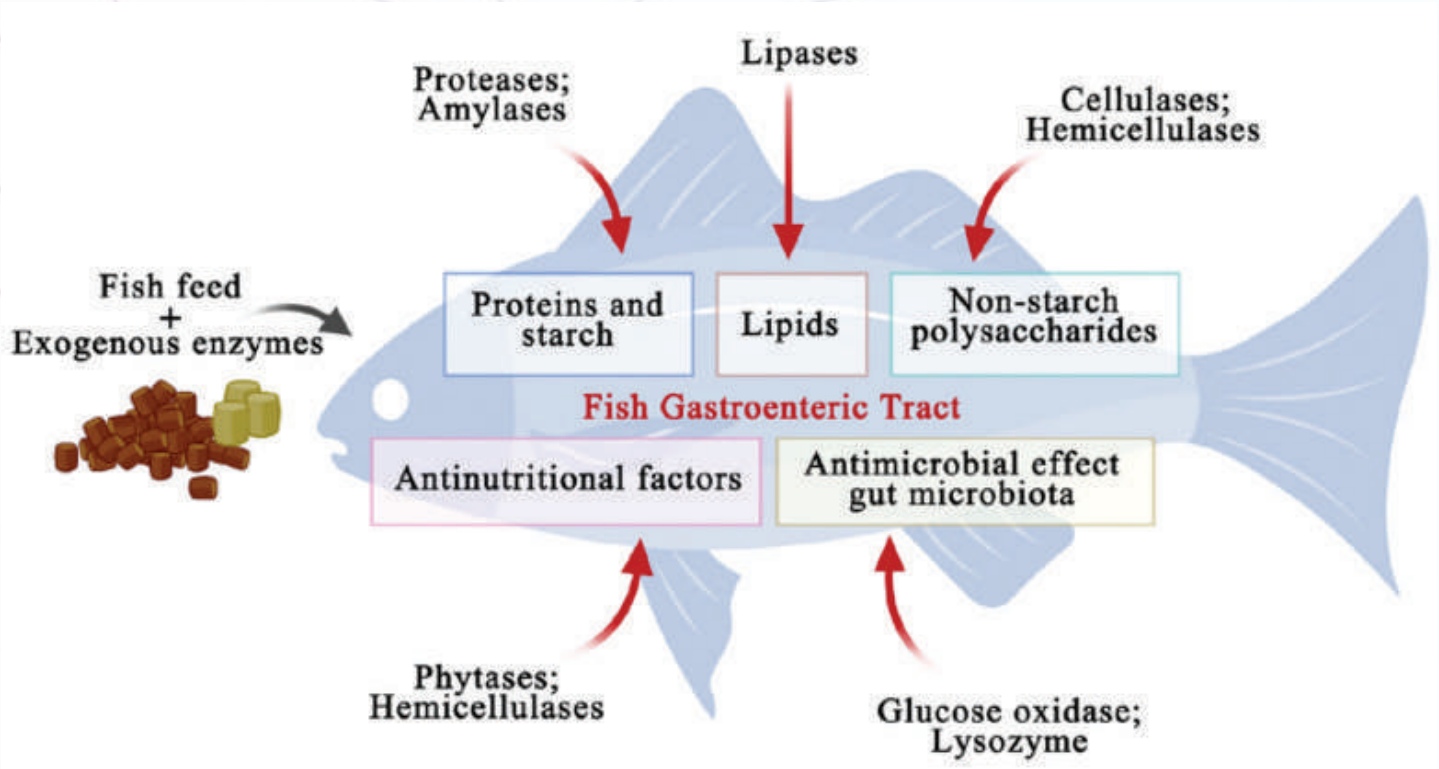

Figure 1: Types of Aquaculture enzymes used in aquaculture sector

Carbohydrase:

The main cause for the importance of utilization of this enzyme in fish feed is to reduce the non-starch polysaccharides (NSPs). This is because they play a vital role in reducing the availability of nutrients for fish feed. They are one of the most common anti-nutritional factors. Generally, fishes lack the capacity to produce the necessary enzymes to reduce these non-starch polysaccharides and thereby, carbohydrases become needy as NSPs causes viscidness in the digestive tract of fishes leading to negative growth rates. This helps in a developed gut health. CHO digestion enzymes increase nutrient digestibility and availability. Implementation of these enzymes in fish feed increases its growth, health, feed conversion ratio, and its gut microbiome. Factors influencing the incorporation of these enzymes are the amount of plant protein in the diet of the fish, size and age of the species, and type and quantity of the enzymes according to the species.

Phytase:

Phytate is a naturally occurring substance in the plants especially in grains, beans, and oilseeds. It is the main storage form of phosphorous in plants. Fishes and animals lack the phytase enzyme that degrades the phytate. Therefore, all the phosphorous stored in the phytate molecule gets trapped and the fishes find it harder to utilize the particular nutrient. These phytate molecules also bind to certain micronutrients and macronutrients like calcium, iron, and zinc leading to unavailability of these nutrients too. Hence, incorporation of the phytase enzymes in the food source of fish feed leads to more utilization of phosphorous, nitrogen, and unbind phosphorous from phytate acid which can be used by the fishes for their development. They also contribute to reduction in the environmental impact by releasing a lot of phosphorous unutilized. This methodology has lead to improved growth, weight gain and feed efficiency of the fish feed. The factors influencing the use of this methodology are fish physiology, nutrition and environmental conditions.

Other Aquaculture enzymes:

Other aquaculture enzymes include lipases for breaking down fats, cellulase for breaking down plant fibers like cellulose, xylanase for decomposing hemicelluloses fibers, glucanase for degrading beta-glucans, chitinase for breaking down chitin from crustaceans, pectinase for degrading pectin cell walls and many more.

Conclusion and future perspectives:

Aquaculture exogenous enzymes have successfully proved to contribute to the development of aquaculture feeds. They have increased the growth rate, health, immune responses, gut microbiome, production of antioxidants, feed utilization etc. Their strategic use not only boosts the overall efficiency and sustainability of aquaculture production but also supports healthier and faster-growing aquatic species. Future researches can be based on improving the causes of influential factors that have been mentioned above for each enzyme. Providing optimum growth conditions like temperature, pH and other required factors for the growth of organisms from which these enzymes are extracted can contribute a lot to the development of aquaculture industry. Further researches can be done on creating more stable enzymes for better efficiency. They can be tested to work under different environmental conditions. Also production of genetically modified microorganisms to produce even more efficient species specific and condition specific enzymes can lead to even more advancements.

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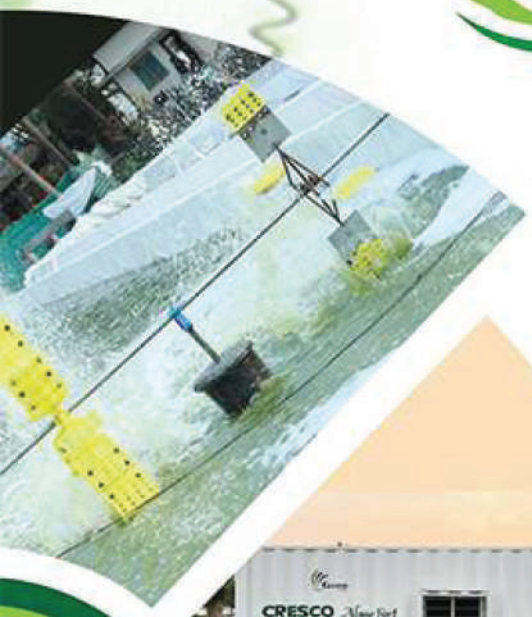
Cresco
Live Goods



CRESCO Objectives

CRESCO aims to cultivate and produce huge quantitative of Algae for Aquaculture Industry for use as Feed and Nutrition agent It aims for Mass production of Spirulina and value added products with an initial Target of 1Ton per month. Gradually it aims to develop large scale Algae ponds and be one of the largest producer of Spirulina – both for domestic consumption and also for International exports.

CRESCO and MICROALGAE Production

Cresco aims to produce large quantities of Algae and Microalgae. This would encompass production of economically important algal species like *Spirulina sp, Chlorella sp, Dunaliella sp, Hematococcus sp, Nanochloropsis sp, Diatoms, etc.* These are highly useful in the Aquaculture industry as Fish Nutrition.

CRESCO ALGAE FORT
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Kalla Mandal, West Godavari Dist,
Andhra Pradesh. PIN - 534 237.
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Revolutionizing Larval Nutrition: Biotechnology in aquaculture live feed

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ABSTRACT

The increase in demand for seafood and decline in feed resources has shifted the focus of researchers towards integration of potential technologies like biotechnology and nanotechnology in feed production. Larval rearing is one of the crucial phases in the culturing of aquatic animals due to its sole dependency on live feed for nutrition. Live feed has its own limitations such as an imbalanced nutrition profile, scalability, economic feasibility, and inadequate advancement in production technology. Hence, incorporating biotechnological approaches, such as strain improvement, bioencapsulation, gene editing, and metagenomics, will enhance the efficacy of live feed. This article emphasizes on recent breakthrough of biotechnological applications in live feed industry. The responsible and optimal use of this technology will help us to overcome the milestones in live feed production.

Keywords: Live feed, Biotechnology, Nutrition, Larvae, Insect, Supercharged microalgae.

Introduction:

Early life stages of fish and shellfish in aquaculture are especially vulnerable and need food that is high in nutrients and simple to digest in order to survive, grow, and develop normally. The larvae depend upon live feed for its nourishment. It provides essential nutrients such proteins (essential amino acids), lipids (essential fatty acids), vitamins, enzymes such as proteases, lipases and other bioactive substances.

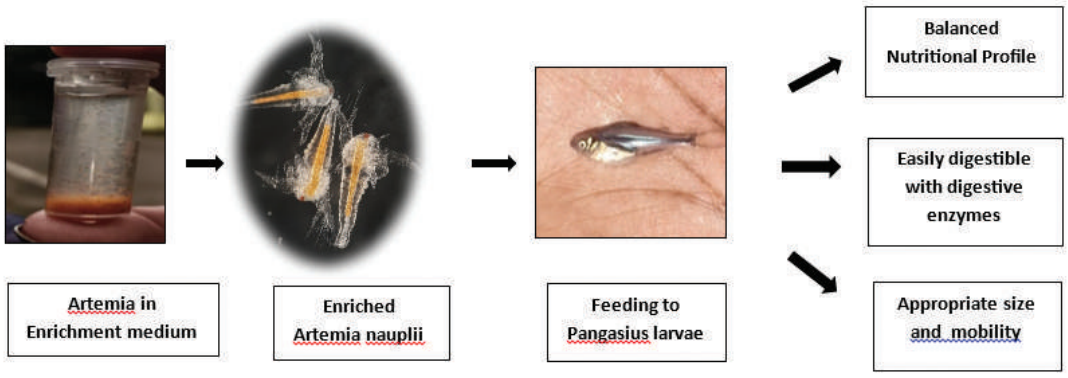
Biotechnology addresses these challenges such as inconsistent nutrition, difficulty in large-scale production, contamination, and environmental concerns. Thus, by increasing their nutritional value, advancing culture techniques, and maintaining biosecurity, it transforms live feed optimisation, enhancing growth potential, disease resistance and increasing survival rates of larvae (Khan & Rahman, 2025).

Importance of Live Feed in Aquaculture:

As the intensification in aquaculture proceeds, it demands the more seed supply from the hatchery. The hatchery depends upon on live feed for its production as it serves as a primary food from the hatched larvae till it able to digest artificial feed.

The early life stages have small mouths, undeveloped digestive systems, lack of digestive enzymes and requires high and balanced nutritional demands. Artificial diets are usually indigestible at this stage and fish larvae cannot survive or grow properly without it. (Faudzi, et al., 2024).

Live feed is critical in aquaculture because :



1. Digestibility and Behavioral Stimulation

• Live deed such as rotifers, artemia, and copepods are small in size , motile, and easy for larvae to ingest, their soft bodies and enzymes help larvae digest nutrients.

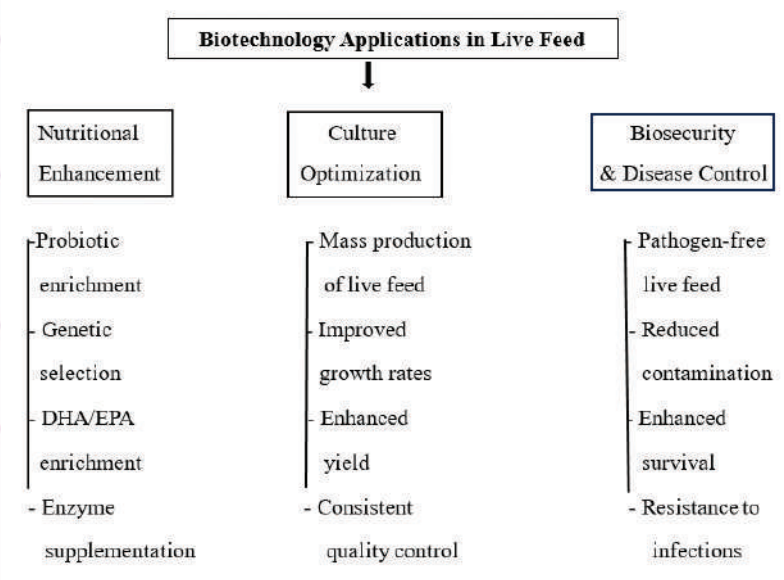
• It triggers feeding reflexes in larvae which inert feeds cannot replicate.

2. Nutrition and Survival

• It supply essential fatty acids (DHA, EPA), proteins, vitamins, and minerals. Proper nutrition ensures faster growth and successful transition to formulated feed.

• Larvae transition from endogenous to exogenous nutrition, requiring nutrient-rich live foods to support growth and development.

Biotechnology Applications in Live Feed



Role of Biotechnology in Live Feed

Various biotechnological tools are used to enhance the nutritional quality of live feed in several innovative ways:

1. Supercharged Microalgae

• These are nutritionally enhanced microalgae for creating a superior live feed for aquaculture in order to improve the growth, survival and overall health of the fish and shellfish larvae.

• They are specially cultured microalgae through optimization of culture media coupled with various biomolecule enrichment technique which results in efficient nutrient transfer.

• These supercharged microalgae serves as a more balanced and potent food source than a standard microalgae cultures.

Common super charged microalgae are:

• Chlorella vulgaris – high protein content and efficient assimilation of ammonia from water

• Nannochloropsis sp – rich in lipids, particularly poly unsaturated fatty acids

• Dunaliella sp – rich in carbohydrate and other bioactive compounds such as carotenoids.

Microalgae are the base of the aquatic food chain and are consumed by live feed organisms like rotifers and copepods. Genetically modified microalgae can be produced to:

• Boost Omega-3 Fatty Acids – Essential for fish growth and brain development.

• Enhance Vitamin Content – Microalgae rich in vitamins improve survival rates of fish larvae.

• Speed Up Growth – Faster-growing microalgae ensure a steady supply of nutritious feed.

2. The Rise of Probiotics

• The nutritional quality and disease resistance of the live feed can be enhanced with the help of probiotics by integrating beneficial microorganisms, such as bacteria and yeast into copepod, rotifer and artemia, which in turn promotes the health and growth of fish and shrimp larvae.

• This "probiotic enrichment" of live feeds also improves the environmental quality of the culture system by competing with harmful bacteria and assimilating nutrients.

• Probiotics can be added directly to the live feed culture tanks to enrich it before being fed to the target aquatic species.

Fish can benefit from probiotic-enriched feed through special bacterial strains that:

• Improve digestion in fish larvae.

• Strengthen immunity, reducing the need for antibiotics.

• Enhance nutrient absorption, leading to faster growth and better survival rates.

3. Insect Power: The Future of Live Feed

• Efficient conversion of waste into valuable products can be achieved by integration of insects into food and feeding systems.

• Insects are a rich source of high-value protein, vitamins, minerals, and essential fatty acids like omega-3 and omega-6.

• They often exhibit high protein and amino acid digestibility, which is comparable or even superior to some conventional animal proteins.

• Challenges remain in achieving price competitiveness, chitin digestibility and consistent quality due to varying processing methods and nutritional profiles.

Using biotechnology, scientists can modify insect feed to create larvae with:

• Higher protein content (better growth for fish).

• Balanced amino acids for improved digestion.

• Optimized production methods for cheaper and eco-friendly farming.

This approach reduces the industry's reliance on wild-caught feed sources and provides a sustainable alternative.

4. Genetically Enhanced Artemia & Rotifers

Artemia (brine shrimp) and rotifers are staple live feeds, but they often lack essential nutrients. They can be genetically modified to:

• Increase DHA and EPA levels (crucial for fish development).

• Improve resistance to disease, making them easier to farm.

• Enhance survival rates, reducing waste in aquaculture systems.

• Enhancement of traits like stress tolerance, nutritional quality, or the production of specific proteins can be done by genetic modification.

• These modifications, which involve integrating foreign genes, create "transgenic Artemia" that can improve sustainable aquaculture practices, serve as bioreactor materials, and contribute to bioengineering and environmental monitoring.

Genetic enhancement can be achieved through:

Genetic Engineering: Foreign genes are integrated into the organism's genome to produce desired traits.

Gene Expression: The genetically modified organisms can then express these foreign genes, for example, to produce specific proteins like growth hormone (ypGH)

5. Artificial Plankton & Lab-Grown Feed

• Artificial Planktons are composed of a variety of inert microparticles that simulate the nutritional and physical features of live zooplankton for early larvae, even though in some cases, live prey may still offer a superior level of nutrition for some species.

• The purpose of these artificial diets is to help reduce costs and labor of producing live feeds, however, they still need to be carefully formulated to account for the nutritional requirements, particle size and digestive capabilities of the larvae cultured.

Scientists are already working on:

• Encapsulation technology – Tiny nutrient-packed capsules that slowly release essential compounds.

• Bioengineered yeast & bacteria – Lab-grown microorganisms designed to provide custom nutrition for fish larvae.

These developments could redefine aquaculture by providing a stable, predictable, and eco-friendly alternative to traditional live feed.

Challenges and Strategic Analysis of Biotechnology-Based Live Feed

1. Regulatory Issues:

• Biotechnological approaches includes genetic engineered live food organism (GMOs) which face strict regulations in many countries like USA due to environmental concerns and genetic pollution.

2. High Costs and Economic Viability:

• A substantial research and development requires huge investment for the development and application of biotechnological solutions, ranging from probiotic enrichment to genetic selection.

• Also, scaling up to meet commercial aquaculture demands adds financial strain and may hinder acceptance in hatcheries and industries, even though lab-scale production may be possible.

3. Technical Challenges in Scaling Up:

• During mass manufacturing, processes that have been optimised in controlled laboratory settings can run into problems.

• It is difficult to maintain consistent quality, nutritional profiles, and biosecurity standards on a wide scale (Sandeep et al., 2025; Marleen & Annelies, 2024).

Emerging biotechnological approach in Aquaculture

• CRISPR Gene Editing : A powerful tool to modify live feed organisms with pinpoint accuracy.

• AI & Big Data : Artificial intelligence can analyze nutrient compositions to optimize feed formulations.

• Metagenomics : Studying fish microbiomes to create personalized probiotic solutions.

SWOT analysis:

Strengths	Weakness
Enrichment of live feed	High R&D and production costs
Improved disease resistance in larvae through probiotic and microbial enrichment.	Regulatory hurdles and approvals
Sustainable, controlled production.	Technical challenges in scaling up.
Opportunities	**Threats**
Growing global demand for aquaculture products	Consumer skepticism to GMOs and biotech feeds
Integration with precision aquaculture and monitoring	Competition from conventional feed alternatives
Development of functional feeds with added health benefits such as phtyobiotics, immunostim.	Risk of unintended environmental impact from biotech organisms.

Future prospects

The exploration and development of different live feed cultures (including novel micro-sized copepod and rotifer species) is energizing research ranges, to industrial applications. The design, development and production of dormant live feed (e.g., copepod resting eggs) has been included in new research programs, and is likely to be a future development for the marine larviculture industry.

Future programs should explore both indoor and outdoor aquaculture systems integrating appropriate RAS technologies with artificial intelligence (AI) technology to optimize performance of both prey and larval culture in complex aquaculture systems. Developing technologies and management for virus free live feed and bacterial free live feed use in larviculture.

Scientists and farmers can work closely together to make sure pilot studies are up scaled and to have the feedback cycle needed to maintain required interaction between industry needs - science research challenges. As biotech innovations continue to evolve and improve, the aquaculture industry will become more sustainable, efficient, and resilient.

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When the sea follows the sky: Lunar Illumination and Spawning Cycles in Fish

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ABSTRACT

Because it affects tidal movements and nighttime illumination, the lunar cycle has a remarkable effect on fish reproduction. In order to provide the best conditions for fertilization, larval dispersal, and survival, many species time their spawning activities with particular phases of the moon. Fish use specialized photoreceptors and neuroendocrine systems that involve gonadotropic hormones and melatonin to sense these lunar cues. Because this synchronization improves larval transport and decreases predation, evolution has favoured it. These natural cycles are threatened by human activities like artificial light at night (ALAN) and overfishing during the lunar spawning peaks. The conservation of coastal ecosystems and sustainable fisheries management depend on an understanding of how moonlight coordinates reproductive cycles.

KEYWORDS: Lunar light, fish, melatonin, spawning

INTRODUCTION

For centuries, fishermen have observed that fish "bite bitter around the full moon." There is a solid scientific foundation for this traditional knowledge. For many marine creatures, the moon serves as a natural clock due to its gravitational pull and light. Its phases affect biological functions like migration, feeding, and reproduction, in addition to controlling tides. Fish use the lunar cycle as a crucial cue to time their spawning activities. Lunar-synchronized spawning is a phenomenon where entire populations release gametes simultaneously around particular moon phases. Scientists have now begun to unravel how this celestial rhythm governs reproductive physiology and behavior, revealing a fascinating link between the moon's glow and life beneath the waves (Ikegami, 2014).

LUNAR RHYTHMS AND SPAWNING PATTERNS

The moon affects two major environmental factors: moonlight intensity and tidal amplitude. Both are essential to the timing of reproduction. During full or new moons, coral reef fishes, including groupers, snappers, and rabbitfish, congregate in dense spawning aggregations. Larval survival and fertilization efficiency are improved by these coordinated events (Sponaugle et al., 2004). Breeders in the intertidal zone: In order to ensure that their eggs are transported to safer nursery grounds, fish that live in mangrove zones and coastal flats frequently spawn during spring tides, which are marked by new and full moons (Ikegami, 2014). Models of comparison: Corals and marine worms exhibit similar lunar-linked spawning patterns, indicating that tidal and moonlight cues are ingrained evolutionary signals in marine taxa (Lin et al., 2021).

HOW IS THE MOON DETECTED BY FISH?

Fish use both light-based and tidal mechanisms to detect changes in the moon.

1. Moonlight as a clear indicator: Fish have extraocular photoreceptors in their brains and pineal glands that are able to pick up on minute variations in nighttime light. Melatonin secretion, which controls gonadal maturation and spawning timing, is influenced by variations in moonlight intensity (Takemura et al., 2010). According to experiments, fish exposed to artificial moonlight continuously may experience irregularities in their natural reproductive cycles (Fukunaga et al., 2022).

2. Hydrodynamic and tidal cues: Another reproductive signal is the water movement that results from the tides being driven by the moon's gravitational pull. The likelihood that eggs and larvae will be carried to appropriate nursery habitats is increased when spawning is timed to coincide with spring tides. For coastal and intertidal spawners, this is especially crucial (Ikegami, 2014).

3. Clock and Harmonic Systems: According to endocrine research, fish might have biological clocks that run on the moon in addition to their circadian cycles. Lunar illumina-

tion modulates dopamine, melatonin, and gonadotropin-releasing hormones (GnRH), connecting environmental cues to reproductive readiness (Takemura et al., 2010).

LUNAR SPAWNING'S ADAPTIVE SIGNIFICANCE

There are various benefits to aligning reproduction with lunar cycles from an evolutionary perspective. Avoiding predators: It is possible to lessen visual predation on eggs and larvae by spawning during darker new moons. On the other hand, brighter nights might facilitate orientation and feeding for larvae (Shima et al., 2019).

Larval survival and dispersal: Eggs and larvae are transported to favorable habitats or retained close to reefs when spawning is timed to coincide with tidal cycles (Sponaugle et al., 2004).

Predator-swamping effect: Groupers and rabbitfish use this tactic to increase overall reproductive success when numerous individuals spawn at the same time, overwhelming predators (Ikegami, 2014).

LUNAR IMPACTS ON SEX DETERMINATION AND GROWTH

Recent studies suggest that lunar cues could affect offspring development in addition to spawning. Faster growth rates and, occasionally, different sex ratios are observed in larvae hatched during specific moon phases (Shima et al., 2020). Analysis of the otolith (ear bone) shows growth rings that correspond with lunar periodicity, indicating that the lunar cycle has been physiologically imprinted for a long time.

IMPACTS ON HUMANITY: NIGHT ARTIFICIAL LIGHT (ALAN)

Artificial light pollution is one of the most urgent contemporary threats to lunar synchronization. Natural moonlight is obscured by the continuous nocturnal lighting created by offshore industries, harbors, and coastal development.

Studies show that artificial illumination disrupts melatonin rhythms and delays or suppresses spawning in several marine species (Fukunaga et al., 2022). Fish populations may consequently lose reproductive synchrony, which would result in poorer recruitment and population decline.

IMPLICATIONS FOR FISHERIES AND CONSERVATION

The repopulation of numerous commercially significant fish stocks depends on lunar-linked spawning aggregations. They are susceptible to targeted overfishing during aggregation periods, however, because these events are predictable. Lunar calendar-based management techniques, such as temporal fishing prohibitions or marine protected areas, can aid in the protection of spawning peaks. In order to maintain natural lunar cues, conservationists also stress the importance of lowering light pollution in coastal areas (NOAA, 2023).

CONCLUSION

By coordinating the timing of reproduction through its light and tides, the moon serves as a cosmic metronome for marine ecosystems. Fish populations rely on these evolutionarily-fine-tuned lunar rhythms for survival and ecological balance. However, this natural symphony is in danger of being muffled by human activity, especially uncontrolled fishing and artificial lighting. Sustainable fisheries management and biodiversity conservation both depend on the identification and preservation of moon-driven reproductive cycles. Knowing how moonlight controls life beneath the sea becomes not only a scientific endeavor but also a conservation necessity as we light up coastlines and change natural rhythms.

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From Shore to Plate: Why Domestic Seafood Consumption Matters More Than Ever

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The Indian Seafood Paradox

India's relationship with seafood is centuries old. With a coastline of over 7,500 kilometres, countless rivers, lakes, and ponds, the sea has always been more than a geographical feature. It has been a provider of food, culture, and livelihoods. Fishing villages and bustling harbours tell stories of dawn markets, steaming pots of fish curry, and nets heavy with the day's catch. Yet, despite this abundance, India faces a paradox. We are one of the largest seafood producers and exporters in the world, but our domestic consumption remains surprisingly low. Much of our catch travels thousands of kilometres to Europe, North America, and East Asia, while our own households often treat seafood as an occasional delicacy rather than a regular staple.

To put numbers behind this paradox: the total fish production in India during FY 2023-24 was about 18.40 million metric tonnes (MMT), with the inland sector contributing ~13.91 MMT and the marine (including capture and marine aquaculture) ~4.49 MMT. Despite this high production, per capita consumption has been modest. In 2021, India's per capita annual fish consumption was approximately 8.89 kg per person, up from around 4.9 kg in 2005. Among only those who eat fish, the figure is higher (around 12.33 kg/year), but large parts of the population either consume very little fish or none.

Seafood as Nature's Superfood

Few foods offer as rich a nutrient profile as fish. Apart from high-quality protein, essential amino acids, and healthy fats, fish delivers micronutrients often lacking in many Indian diets. Considering rising health challenges such as diabetes, heart disease, obesity, and childhood malnutrition, seafood holds tremendous promise. The increased awareness of these benefits in recent years is reflected in rising demand for fish in diets. Though precise state-wise health outcome statistics directly tied to rising fish consumption are limited, national nutrition surveys show that regions with higher fish intake tend to have better protein and micronutrient status among women and children.

Economic Ripple Effects

Every time a fish is sold in a domestic market, it sustains far more than one livelihood. The fisheries sector in India supports over 2.8 crore fishers and fish farmers at the primary level, plus many more along the value chain. Within this total, about 23.1 million are engaged in inland fisheries and around 4.9 million in marine fisheries. This huge workforce is vulnerable to fluctuations in demand and export pressures.

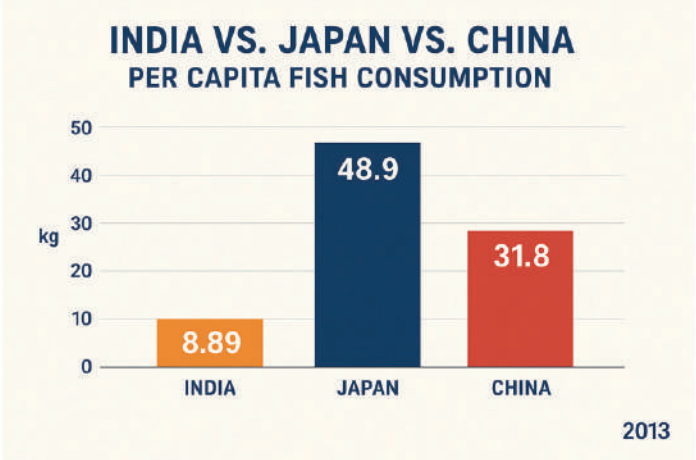

Figure 1: The infographics of per capita fish consumption.

In terms of production growth, fish production has more than doubled over the past couple of decades. For example, in 2005-06, annual fish production was about 5.66 MMT. By 2023-24, it reached 18.40 MMT. The sector's annual average growth in recent years has been around 6.30%. Andhra Pradesh is the leading state in the fishing and aquaculture sector, holding about 40.9% share of India's total fishing & aquaculture output. The value of output in that sector rose from around ₹80,000 crore in 2011-12 to about ₹1,95,000 crore in 2022-23. The domestic consumption of fish has increased too: from about 5.428 million tonnes in 2005 to nearly 11.924 million tonnes in more recent years, indicating over 100%

growth in tonnage consumed domestically.

Cultural Heritage on the Plate

Seafood is more than nutrition, it is memory and identity. Each region of India has its signature fish dishes: Bengal's prized hilsa, Kerala's meen curry, Andhra Pradesh's spicy prawn masala, Goa's aromatic fish thali, and Tamil Nadu's soulful meen kuzhambu. These dishes carry centuries of tradition, shaping festivals, rituals, and everyday meals. In many communities, fish is not just food but a symbol of prosperity and continuity.

Even culturally, statistics show strong participation by women: in the marine sector, about 47% of the marine fisherfolk (people involved in marine fishing) are women; in inland fisheries, about 44% are women. Most women are involved in post-harvest activities cleaning, curing, processing, marketing etc. These roles are essential for preserving and passing on local fishing/cooking traditions.

Sustainability and the Blue Future

India's aquaculture market is growing rapidly, partly driven by the need for sustainable food sources. In 2024, the aquaculture market size in India was 14.4 million tons, and it is projected to reach 28.8 million tons by 2033, showing a compounded annual growth rate (CAGR) of about 7.57% during 2025-2033. In the national fish production figures of FY 2023-24, the inland sector (aquaculture & inland fisheries) contributed ~13.91 MMT, constituting a large share of the total 18.40 MMT. Export figures also illustrate the scale of operations: seafood exports in FY 2023-24 were about 1.78 million tonnes, valued at approximately INR 60,523.89 crore (around USD 7.38 billion). Shrimp, particularly Penaeus vannamei, dominates in terms of value.

Barriers That Hold Us Back

Statistical data helps highlight how far India has come, but also what obstacles remain. For example, though per capita fish consumption rose from ~4.9 kg in 2005 to ~8.89 kg in 2021, that's still far below many Asian countries. In 2013, India's per capita consumption was ~6.1 kg, while in the same year China had ~38 kg, Indonesia ~31.8 kg, and Japan ~48.9 kg. Figure 1 shows the infographics of per capita fish consumption.

Another barrier is infrastructure: though exact numbers vary by region, many fisherfolk operate without adequate cold storage or hygienic handling, which limits the reach and desirability of seafood in inland markets. Also, price volatility: for example, a shift from shrimp farming to murrel fish in Andhra Pradesh was attempted after losses in shrimp, but oversupply caused prices for murrel to drop sharply, hurting farmers again.

The Way Forward

The statistics make the case: India is producing more, consuming more domestically, and employing millions via fisheries & aquaculture. But large gaps remain in per capita consumption, infrastructure, affordability, and cultural acceptance in non-coastal regions.

Policy initiatives like the Pradhan Mantri Matsya Sampada Yojana (PMMSY), schemes under the "Blue Revolution", investments in cold chains, better market infrastructure, and traceability can amplify the gains. Encouraging domestic consumption through public institutions (schools, hospitals) and awareness campaigns can help shift dietary norms.

Brands and communities can set targets: for example, raising national per capita fish consumption to 15-20 kg, or ensuring that every coastal household access affordable clean fish at least twice a week. Regions like Andhra Pradesh, with 40.9% share in the sector and strong growth in value of output, can serve as role models.

Conclusion: Bringing the Catch Home

The numbers are persuasive. India now produces over 18 million tonnes of fish annually; millions depend on this sector; domestic consumption has more than doubled in tonnage over two decades; aquaculture markets are growing at ~7-8% annually; Andhra Pradesh alone contributes nearly ₹2 lakh crore worth of output. Yet per-person consumption is still well below many of our neighbours.

If Indians collectively decide to bring seafood back onto everyday plates, the benefits multiply: healthier diets, stronger rural economies, preserved cultural heritage, and a more sustainable future for our water bodies. Seafood is not just export material, it is national treasure. From shore to plate, the journey awaits. Let's make every meal count.

Spirulina as a Food Source: The Blue-Green Revolution in Nutrition

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Introduction

In an age where the global population continues to rise and sustainable food systems are urgently needed, Spirulina has emerged as one of the most promising solutions to combat malnutrition, environmental degradation, and food insecurity. Often referred to as "green gold" or the "superfood of the future," spirulina is a type of microscopic, filamentous cyanobacterium that thrives in alkaline waters. Its unique nutritional composition, environmental resilience, and wide-ranging applications make it a sustainable and highly efficient source of protein and nutrients for both human and animal consumption. This article explores the biological characteristics, nutritional value, health benefits, production techniques, and socio-economic potential of spirulina as a sustainable food source for the future.

1. Understanding Spirulina: Nature's Microalgae

Spirulina belongs to the genus Arthrospira, with Arthrospira platensis and Arthrospira maxima being the most commonly cultivated species. Despite being classified as cyanobacteria (blue-green algae), spirulina functions photosynthetically like plants—converting sunlight, water, and carbon dioxide into biomass while releasing oxygen. It grows naturally in alkaline lakes in regions such as Africa, Mexico, and South America. Its ability to survive in extreme conditions and its simple growth requirements make it an ideal candidate for cultivation in diverse environments, including deserts, saline water bodies, and even space missions. Spirulina cells are spiral-shaped filaments composed of photosynthetic pigments such as chlorophyll-a, phycocyanin (a blue pigment), and carotenoids that contribute to its vibrant blue-green color and potent antioxidant properties.

2. Nutritional Composition: A Complete Superfood

One of the most significant reasons for spirulina's global recognition is its exceptional nutritional density. It contains almost every essential nutrient required for human health in a concentrated form.

2.1 Protein Powerhouse

Spirulina is composed of up to 60–70% protein by dry weight, making it one of the richest plant-based protein sources known. Unlike most plant proteins, spirulina provides all nine essential amino acids required by humans, making it a complete protein comparable to eggs or soybeans. The protein is easily digestible due to the absence of cellulose in its cell walls.

2.2 Vitamins and Minerals

Spirulina is a rich source of vitamins such as Vitamin B12 (although in an analogue form), Vitamin A (as beta-carotene), Vitamin K, Vitamin E, and B-complex vitamins (B1, B2, B3, B6). Mineral content includes iron, calcium, magnesium, potassium, and zinc, which are crucial for various metabolic and immune functions. The bioavailability of iron in spirulina is remarkably high, making it especially valuable for addressing anaemia and iron-deficiency conditions.

2.3 Essential Fatty Acids

Spirulina provides important omega-3 and omega-6 fatty acids, including γ-linolenic acid (GLA), which is rare in plant sources. These fatty acids contribute to cardiovascular health, hormonal balance, and anti-inflammatory effects.

2.4 Pigments and Antioxidants

Phycocyanin, the pigment responsible for its blue colour, is a potent antioxidant and anti-inflammatory compound. In addition, carotenoids and chlorophyll enhance immune response, protect cells from oxidative stress, and promote detoxification.

3. Health Benefits of Spirulina Consumption

3.1 Combatting Malnutrition

Spirulina has been recognized by the World Health Organization (WHO) and the United Nations (UN) as a valu-

able food supplement to fight malnutrition, especially in developing countries. It requires minimal resources to produce and provides dense nutrition, making it suitable for children and adults with limited access to diverse diets. Programs in countries such as Chad, India, and Bangladesh have shown success in improving nutritional status among malnourished populations using spirulina supplements.

3.2 Immune System Enhancement

Spirulina stimulates the production of antibodies and infection-fighting proteins, helping the body ward off diseases. Phycocyanin and polysaccharides in spirulina enhance macrophage activity and promote immune balance.

3.3 Cardiovascular Health

Regular spirulina intake has been linked to lower cholesterol, reduced triglycerides, and improved blood lipid profiles. Studies suggest it can help reduce LDL (bad cholesterol) while raising HDL (good cholesterol), thus lowering the risk of heart disease.

3.4 Anti-inflammatory and Antioxidant Action

Spirulina neutralizes free radicals and protects cells from oxidative damage. Phycocyanin inhibits enzymes responsible for inflammation, providing natural relief for conditions like arthritis and asthma.

3.5 Blood Sugar Regulation

Clinical trials indicate that spirulina helps in reducing fasting blood sugar and improving insulin sensitivity, making it beneficial for people with type 2 diabetes or metabolic syndrome.

3.6 Detoxification and Liver Health

Spirulina binds with heavy metals such as arsenic, mercury, and lead, facilitating their excretion from the body. It also supports liver regeneration and protects against hepatic damage due to toxins.

3.7 Potential Anti-Cancer Properties

Preliminary studies suggest that spirulina extracts may inhibit the growth of certain cancer cells and reduce DNA damage, though more research is required to confirm these findings.

4. Spirulina as a Sustainable Food Source

4.1 Environmental Efficiency

Compared to traditional agriculture, spirulina production requires Less water (up to 90% less than livestock farming), No arable land, and Minimal energy input for cultivation. It converts solar energy into biomass with extraordinary efficiency and can be grown using non-potable or brackish water unsuitable for most crops.

Figure 1: The Spirulina powder and tablet form

4.2 High Yield and Productivity

Spirulina can yield up to 20 times more protein per acre than soybeans or corn. The rapid growth rate, doubling biomass in just 3–5 days makes it one of the most productive biological systems for food production.

4.3 Carbon Sequestration and Oxygen Production

As a photosynthetic organism, spirulina absorbs carbon dioxide during growth, contributing to climate change mitigation. Cultivation systems can help reduce greenhouse gas emissions and improve atmospheric oxygen

balance.

4.4 Integration with Circular Economy

Spirulina can be cultivated using wastewater rich in nutrients from agriculture or aquaculture, helping recycle nitrogen and phosphorus. This integration supports a zero-waste, circular bioeconomy model.

5. Production and Cultivation Techniques

5.1 Traditional and Modern Cultivation

Spirulina can be cultivated in open raceway ponds or closed photobioreactors.1. Open ponds are cost-effective and widely used in developing countries. 2. Photobioreactors, though more expensive, allow better control of light, temperature, and contamination, resulting in higher-quality biomass.

5.2 Growth Requirements

Optimal growth occurs in pH of 8.5–10, Temperature of 30–35°C, Light intensity of 1500–2000 lux and Nutrients of bicarbonates, nitrates, phosphates, and trace minerals.

5.3 Harvesting and Processing

Harvesting involves filtration or centrifugation of the algal biomass followed by drying (commonly spray-drying or sun-drying). The final product is processed into powder, tablets, flakes, or capsules. Figure 1 shows the spirulina powder and tablet form.

6. Spirulina in Human and Animal Nutrition

6.1 Human Food Applications

Spirulina is available in multiple forms like powder, capsules, and incorporated into food products like smoothies, pasta, biscuits, and snack bars. Its mild umami flavour and nutrient profile make it suitable for functional foods and nutraceuticals. Food industries are exploring spirulina-based meat alternatives, protein bars, and natural colorants (phycocyanin) for beverages and confectionery.

6.2 Animal Feed and Aquaculture

In aquaculture, spirulina is a valuable feed additive for fish and shrimp due to its role in Enhancing pigmentation, improving growth performance, boosting immunity, and supporting gut microbiota balance. Livestock and poultry feeds supplemented with spirulina show improved feed conversion ratios, fertility, and disease resistance.

7. Economic and Social Impacts

Spirulina cultivation can empower rural and coastal communities by providing Local employment opportunities, Nutritional supplements for local consumption, and Export potential in the health food market. Small-scale production units can be integrated with renewable energy sources, making spirulina farming a low-cost, eco-friendly enterprise for developing nations.

8. Challenges and Future Prospects

The challenges include high initial production costs for controlled systems, contamination risks from unwanted microorganisms in open ponds, public acceptance and taste barriers in certain regions and standardization issues regarding nutrient content and labelling. The global spirulina market is projected to grow exponentially, driven by rising demand for plant-based protein, increased interest in functional foods and nutraceuticals, and expanding applications in cosmetics, pharmaceuticals, and bioplastics.

Research into genetic improvement, bioengineering, and large-scale bioreactor design could further enhance yield and nutrient composition. NASA and ESA have already recognized spirulina as a potential space food due to its high nutritional density and oxygen production capacity.

Conclusion

Spirulina represents a convergence of nutrition, sustainability, and biotechnology. Its exceptional nutrient profile, environmental efficiency, and adaptability make it one of the most promising food sources for a world facing climate change and population growth. From alleviating malnutrition in underdeveloped regions to providing sustainable protein alternatives in developed countries, spirulina is not just a supplement. it is a symbol of the future of food security. With continued innovation, investment, and awareness, this humble microalga may very well redefine how humanity nourishes itself in the 21st century.

The science of formulated feed is unlocking a profitable and sustainable blue future for Tamil Nadu's Aquaculture

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From Overfished Seas to Structured Harvest

For centuries, Tamil Nadu's 1,076-kilometre coastline has sustained thriving fishing communities, shaping both culture and economy. Yet today, marine fish landings, once abundant, show signs of stagnation, as documented by the Central Marine Fisheries Research Institute (CMFRI). The crisis compels us not to look further into the deep sea, but to the overlooked expanse of 56,000 hectares of estuaries and backwaters stretching along the state.

Here lies a mystery of potential, waters neither fully fresh nor fully marine, but brackish, capable of sustaining a new frontier in aquaculture. The answer may well be found in brackish water cage culture which is a carefully engineered, science-driven approach that transforms these calm ecosystems into sites of thriving fish production. Unlike conventional fishing, this method is not an experiment in hope, but a rigorously tested, replicable blueprint for sustainable growth.

More than innovation this emerges as a shift in perspective. Tamil Nadu's future in fisheries may not rest in chasing dwindling catches offshore, but in harnessing the hidden productivity of its estuaries and crafting livelihoods. Success in cage culture is not accidental; it is the result of applying a standardized practices derived from extensive field trials. For example, the ICAR-Central Institute of Brackish water Aquaculture (CIBA) in Chennai dedicated years to developing a sustainable alternative. The result is 'Seabass Plus', a formulated, extruded floating pellet feed specifically designed for Asian Seabass. This innovation represents a paradigm shift in feed management.

The Scientific Blueprint: A Replicable Package of Practices

Field demonstrations in Tamil Nadu's estuaries have repeatedly shown that Seabass Plus achieves an FCR (Field Conversion Rate) between 1:1.6 and 1:1.8. This is a dramatic improvement, meaning less than 1.8 kilograms of formulated feed can produce the same 1 kilogram of seabass that once required 5 kilograms of trash fish. The key advantage lies on its scientifically proven efficiency.

Unlike the variability of trash fish, each pellet contains a precise, scientifically determined balance of proteins, lipids, vitamins, and minerals essential for the rapid and healthy growth of seabass. The feed is formulated for maximum absorption, meaning the fish convert more of the feed into body mass and produce less waste. The pellets float on the water's surface for an extended period, allowing fish to consume them entirely and enabling farmers to visually monitor feeding activity. This simple change drastically reduces the amount of uneaten feed sinking to the bottom, directly tackling the primary cause of cage pollution.

The Impact: A Win-Win for Profitability

The switch from trash fish to a formulated feed like Seabass Plus creates a powerful win-win scenario. Although the initial cost per kilogram of formulated feed may be higher than trash fish, Farmers buy less feed, achieve faster and more uniform growth, and can predict their harvest and profits with much greater accuracy. The reduction in feed required, combined with the minimal waste from floating pellets, significantly lessens the environmental load of each cage. This leads to cleaner water, a healthier ecosystem, and ensures the long-term sustainability of aquaculture in sensitive estuarine environments. It also decouples cage farming from the direct harvesting of wild fish stocks, making it a far more ecologically responsible practice. Regular monitoring of water is non-negotiable because fishes are a product of water quality. By adopting a standardized package of practices centered on the economically superior Asian Seabass, optimizing cage design and managing water quality meticulously, small-scale farmers can turn underutilized brackish water bodies into engines of economic growth. The success of this model depends on continued institutional support from bodies like CIBA, CMFRI and TNJFU, robust government policies to ensure seed and feed availability, and the empowerment of local fishing communities through training and cooperative models. This is Tamil Nadu's blue revolution in action for a sustainable, profitable, and scientifically validated blueprint for the future.

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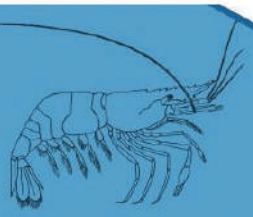

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OUR ACTIVITIES

We recently participated in the **Chennai Seafood Show & Prawn Fest 2025** on May 30, 31 & June 1 at Island Ground,Chennai.

Every Saturday and Sunday, we conduct a campaign across Chennai using our brand vehicle (Chitti) to create awareness about benefits of Seafood and encourage people to include it in their daily diet.

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AquaEx India 2025

AquaEx India, the premier trade event focused on the fisheries and aquaculture sector, was organized at Radha Krishna Conventions in Bhimavaram, India on September 11-13, 2025. As the largest integrated trade, technology, and knowledge platform, AquaEx India served as a vital hub for industry stakeholders, including farmers, researchers, exporters, policy-makers, and technology providers. The event aimed to accelerate knowledge exchange and support the adoption of sustainable practices within the aquaculture sector. With a visitor count of over 25,000 annually and participation from 120 exhibitors, AquaEx India established itself as a leading international showcase since its inception in 2017.

The event featured an array of opportunities for networking and collaboration, including buyer-seller meets that explored sourcing options and built supplier networks. Attendees engaged with qualified global buyers and industry leaders, fostering live business connections and partnerships. The agenda included hands-on workshops on best practices in hatchery management, disease control, feeding strategies, and water quality management. Additionally, the program incorporated high-level discussions on climate resilience, policy frameworks, digital transformation, and sectoral best practices, which drove actionable pathways for industry advancement. Eminent speakers and sector leaders shared insights into emerging trends and practices, illuminating the vast opportunities within the fisheries and aquaculture landscape.

AquaEx India also emphasized the importance of innovation and sustainability, aligning with national missions such as the Pradhan Mantri Matsya Sampada Yojana (PMMSY). The event highlighted advancements that transformed both pre- and post-harvest processes and offered unparalleled access to cutting-edge solutions and technologies. The venue included three indoor halls and outdoor spaces suitable for large displays, ensuring a comprehensive platform for exhibiting the latest industry innovations. Sponsorship packages provided brands with high visibility and the opportunity to connect with key players in the industry. Overall, AquaEx India played a pivotal role in advancing India's aquaculture sector on the global stage, contributing to enhanced productivity, increased farmer income, and expanded market access.

AQUA NORTHEAST SUMMIT

12 DEC 2025

10:00 AM - 5:00 PM

Hotel Taj Vivanta, Guwahati, Assam

Keynote Session:
10:50 – 11:30 AM
Envisioning Aquaculture Industry in the Northeast

Inaugural Session:
1:00 – 1:30 PM
AquaNE Expo Curtain Raiser

Registration:
10:00 – 10:45 AM
Informal Networking & Kit Distribution

Session 1:
11:35 – 12:15 PM
Sustainability in Diversified Aquaculture: Species, Culture, Nutrition & Health Management Aspects of NorthEast

Session 2:
12:20 – 1:00 PM
Smart Technology Integration (AI, IoT), to promote precision Aquaculture

Networking Lunch 1:30 – 2:30 PM

Session 3:
2:30 – 3:10 PM
Value added, Processing & Export potential of NorthEast

Session 4:
3:15 – 3:55 PM
Govt Schemes & Policies to boost Aquaculture in NorthEast

Session 5:
Showcasing of Innovative & Sustainable Aquaculture products for NorthEast

4:00 – 4:10 PM Vote of Thanks followed by High Tea & Networking

Organised by : Aqua Doctor Solutions

Media Partner : Fishery News

For More Details :

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Livestock Expo 2025

The 3rd Livestock Expo 2025, a significant international exhibition covering the poultry, dairy, and aquaculture sectors, was held from August 21st to August 23rd at the India Expo Mart in Greater Noida. This third edition of the event, orchestrated by Pixie Expomedia, served as a crucial business-to-business (B2B) platform, attracting thousands of industry stakeholders, including exhibitors, professionals, and policymakers, from various places. The expo's success underscored its role as a vital networking hub, showcasing the latest innovations and fostering business growth across the livestock industry.

The event's prestige was elevated by the attendance of VIPs, who represented a broad spectrum of the livestock industry's leadership. This included influential figures and seasoned experts, whose presence highlighted the expo's importance. Among the notable chief guest Padma Shri Mr. Sultan Singh, prominent industry leaders whose participation was featured in event promotions. Their insights and vision were central to the events conference and discussion panels, helping to shape the discourse on the future of the livestock industry. The VIP list also included top officials from various government departments related to agriculture and animal husbandry, key decision-makers from leading businesses, and representatives from industry. The Foundation for Aquaculture Innovations and Technology Transfer (FAITT) was the knowledge partner of the event. The high-level participation ensured that discussions and collaborations occurred at the forefront of the industry.

The expo's comprehensive nature was a significant draw, as it was structured around several specialized, co-located events, allowing for both focused and cross-sector networking. The Expo showcased state-of-the-art technologies and equipment for the poultry, dairy, and aquaculture industries from biosecurity to automation systems. Attendees, including farmers, feed manufacturers, and veterinarians, engaged with innovations driving efficiency and sustainability. Complementing the exhibition halls was an insightful conference program that facilitated knowledge exchange. The Aqua Conference on August 21st and the Poultry Conference on August 22nd featured expert-led discussions on market trends, challenges, and future growth strategies.

The expo successfully served as a bustling B2B hub, reinforcing Greater Noida's status as a major commercial center for agricultural exhibitions. The Livestock Expo 2025 effectively drove business growth, stimulated innovation, and facilitated crucial connections across the livestock industry, ultimately reinforcing its vital role in shaping the future of animal husbandry in India and neighbouring regions.

The 4th edition of Livestock Expo 2026 will be held in New Grain Market Karnal, Haryana on 26 to 28th February 2026.

FOUNDATION FOR AQUACULTURE
INNOVATIONS & TECHNOLOGY TRANSFER
FAITT
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Fibre (%)	0.4

Feed Sizes (Microns)	Larval Stages
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150 - 250	PL 1 to 6
250 - 350	PL 6 to 12
350 - 450	PL 12 & above

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