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Heavy Metal Toxicity in Fishes Health: A Review

Insights into Aquafeed Extrusion Technology

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Blue Economy Advancing India's Aquaculture

India's aquaculture sector is witnessing a paradigm shift as it adapts to evolving consumer preferences, technological advancements, and sustainable practices. While India has cemented its place as one of the largest shrimp exporters, the domestic market for shrimp is emerging as an untapped opportunity. Rising disposable incomes, increasing urban demand, and a growing health-conscious population are driving local shrimp consumption. Bridging the gap between production and domestic distribution will require infrastructural advancements, cold chain logistics, and greater consumer awareness to make shrimp an affordable and regular protein source on Indian plates.

Another critical component shaping modern aquaculture is 'insights into aquafeed extrusion technology', This innovative process enhances nutrient bioavailability, feed efficiency, and water stability, leading to healthier aquatic species and reduced environmental impact. The shift from traditional pelletized feed to extruded feed ensures uniformity in nutritional composition, fostering better growth rates in farmed shrimp and fish. As India's aquafeed industry expands, investments in cutting-edge extrusion technology will be pivotal in meeting the growing demand for high-performance feed. Beyond aquaculture, India's rich coastal traditions continue to captivate visitors. In Goa, the traditional Kholis fishing community enthralls visitors with their vibrant cultural heritage. Tourists are not only drawn to the scenic coastal landscapes but also to the age-old sustainable fishing practices of the Kholis, whose techniques have been passed down through generations. Their deep-rooted connection to the sea offers an insightful perspective on balancing tradition with modernity in fisheries and marine conservation.

On the scientific front, the 'emerging concept of Eubiotics opportunities and challenges for aquafeed' is gaining significant attention. Eubiotics—comprising probiotics, prebiotics, organic acids, and essential oils—play a crucial role in maintaining gut health, improving nutrient absorption, and enhancing disease resistance in aquatic species. As antibiotic-free aquaculture gains momentum, eubiotics present a sustainable and eco-friendly alternative to ensure optimal health and productivity in farmed fish and shrimp.

Apart from these topics, this edition covers a wide range of news articles to give glimpse of the developments in the fisheries sector last month.

The future of India's aquaculture lies in embracing innovation while preserving cultural legacies. Whether through strengthening domestic shrimp markets, advancing feed technology, celebrating traditional fishing communities, or adopting sustainable health solutions like eubiotics, the industry is poised for remarkable growth. By fostering collaborations between stakeholders, India can truly harness its aquatic potential and redefine its blue economy for a sustainable and prosperous future. ◆◆◆

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Farming the Shrimp for the Domestic Market

Dr. P.E.Cheran

Senior Consultant, Shrimp Farming

Our seafood export reported to be 17,81,602 MT valued at 60,523 cores of rupees and in the US $ it is 7.4 Billion. Farmed shrimp was the major item with 40.19 % volume and 66.12 % value.

Shrimp is the top most seafood traded globally. Farmed shrimp contributed more than 20 % annual growth since vannamei introduced in India from 2010 to 2020. Shrimp farming is significant in supporting the rural livelihoods and alleviating poverty in rural India. Our seafood export reported to be 17,81,602 MT valued at 60,523 cores of rupees and in the US $ it is 7.4 Billion. Farmed shrimp was the major item with 40.19 % volume and 66.12 % value. The quantity of vannamei exported was 6,25,475 MT. Maximum production is coming from small farmers and more than 1,00,000 farmers are contributing in shrimp farming.

Why Shrimp Farming?

Plenty of saline land which are not suitable for any agriculture activities available all along the coast is estimated to be 1.2 million hectares is ready for shrimp farming and also the saline land available in the three land locked states such as Rajasthan 3.75 Lakh Ha, Punjab 1.51 Lakh Ha and in Haryana2.32 lakh Ha are also suitable for shrimp farming. Shrimp farming gives at least 80,000 Rs/acre/annum as profit and also gives lot of employment opportunities among the rural population.

Globally, 1200 liter of fresh water

required to produce 1 kg offood grain in the animal feed concentrate. To produce 1 kg of cattle meat 7 kg of feed concentrate required similarly 1 kg pig meat requires 4 kg feed concentrate, 1kg chicken meat requires 2 kg feed concentrate. But for fish and shrimp to produce 1 kg meat only 1.2 to 1.5 kg feed concentrate is required and the fish and shrimp are most efficient biomass production in terms of feed associated water usage and that is the future of water starving world.

Freshwater Shrimp Farming

Shrimp farming is done in many different inland districts in fresh water very successfully. Mostly river water, rain water and some saline ground water are used in such farming. Small farmers doing shrimp farming on 0.5 to 1.0 acre ponds with a density of 25 to 30 pieces and produce 40 C (25g) in 90 days with 1.2 to 1.5 FCR. By doing this they are recharging the ground water and also the shrimp farm waste water is utilized in their own agriculture fields in paddy, coconut, Black gram, Green gram sesame, mango and all vegetable crops. Shrimp pond waste water enhances the productivity of paddy from 25 bags to 40 bags, Black and green gram from 2 to 4 quintal , coconut yield from 100 to 200 in 50 days without any additional fertilizers or manure. By seeing this benefit of shrimp pond waste water all adjacent farmers are also buying this water by paying some money to the shrimp farmers.

Public Awareness on Shrimp

The nutritional benefits of shrimp as a food, is not known by the general public due to non-availability of quality shrimp in the domestic market. Nutritional importance and health benefits of shrimp studied very well and the facts are established by International Agencies like NOAA (National Oceanic Atmospheric Administration) USA, FDA(Food and Drug Administration) USA, Irish Fisheries Development Board, Australian Prawn Farmers Association and Thai Frozen Food Association etc.,

Shrimp is a highly nutritive and very healthy food, rich source of protein, iron, copper, antioxidants, phosphorous, magnesium and vitamin B12

Shrimp as a Food

Shrimp is a highly nutritive and very healthy food, rich source of protein, iron, copper, antioxidants, phosphorous, magnesium and vitamin B12. Shrimp is also rich in cancer preventing selenium, omega 3 fatty acids good for heart health, vitamin E for skin protection. Shrimp is low in fat and virtually no saturated fat, high in good cholesterol and also reduces the impact of bad cholesterol. Shrimp also supports weight loss, fights aging, improves bone health, eases menstrual pain in women and

Lipids in Non-veg food in %	
Shrimp	1 – 1.5
Egg	11
Chicken	18
Mutton	13
Beef	16
Pork	35
Shrimp	26.25
Egg	36.20
Chicken with skin	31.11
Chicken	36.90
Pork	36.85
Mutton	43.91
Beef	41.10

also stems cardiovascular diseases.

Shrimp as a food decreases blood

Saturated Fatty Acids (%)

Mono unsaturated fatty acids mg in 100 gm portion	
Shrimp	18.38
Egg	48.10
Chicken with skin	44.13
Chicken	33.30
Pork	35.51
Mutton	39.39
Beef	43.39

Poly Unsaturated Fatty Acids mg in 100 gm portion	
Shrimp	24.13
Egg	0.3
Chicken with skin	1.4
Chicken	4.5
Pork	2.39
Mutton	2.49
Beef	1.77

glyceride levels, improves vision, contributes to brain development in infants and children, increases gestation period in pregnancy and also help build muscles.

FDA Advisory for US Citizen

Women who might become pregnant, who are pregnant, nursing mothers and young children should eat seafood as a regular part of their diet. Today shrimp stands as the most popular seafood in the US with an average 5.9 Pounds Percapita Consumption (NOAA 2022) followed by Salmon 3.22 P, Canned Tuna 2.2 P and Tilapia 1.01 P.

Domestic Marketing of Shrimp

Six gm shrimp sold in local market for not less than 250 Rs and the maximum price is 400-450 Rs per kg for any big size shrimp. Domestic market is ready for 6 gm to 15 gm sizes. Shrimp farming is slowly transforming into smaller pods and many partial harvests will be profitable and sustainable. Huge quantity and consistent supply is required in the domestic market. Nursery and batch culture is the key for success. There is huge domestic market is in the development in a couple of years and the shrimp exports will be gradually reduced. The unorganized shrimp market is steadily growing and the fresh shrimp is available all along the coast. Recent, market is extended from Haryana, Punjab and Rajasthan to Delhi and Gurgaon, Bengal shrimp to North eastern states up to Sikkim. Every day almost 30 MT of small shrimp vannamei travelling to each cities like Bangalore, Bombay, Hyderabad and Chennai etc. Frozen market is unable to compete with fresh market and lot of awareness is required here. Transporting huge quantity small size shrimp is very difficult and need good cold chain facilities. Value added shrimp like shrimp nugget, butterfly, shrimp crumps, shrimp popcorn etc is in high demand among kids and children. Sustainable Shrimp Farming for Domestic Market

Land (pond) lease should be below 40,000 to 50,000 Rs per acre depends on the facilities. Stocking density should be below 25-30 pieces to grow 40 C (25gm) in 3 months period. Shrimp farmer can get higher density of 70 C (14gm) in 70

Women who might become pregnant, who are pregnant, nursing mothers and young children should eat seafood as a regular part of their diet. Today shrimp stands as the most popular seafood in the US with an average 5.9 Pounds Percapita Consumption (NOAA 2022) followed by Salmon 3.22 P, Canned Tuna 2.2 P and Tilapia 1.01 P.

days for domestic market, with batch culture and continuous cropping pattern to cater the growing domestic demand.

Changing the Farming Style to Meet the Local Demand

On site shrimp nurseries with small ponds with a size of 2500 sqm or less than that is recommended, with 1.5 meter depth, central drain facility and full biosecurity is must. Such ponds should be stocked with 60 SD (2.0 Lakh seeds) and the first partial harvest@ 8 gm size 200 Kg, next harvest@ 10 gm 200 kg, next harvest @ 12 gm 200 kg, next harvest @ 14 gm 200 kg and final harvest at 16gm around 600 kg, so the total harvest 1400 kg per pond and if a farmer could do in 5 ponds in a crop he can harvest easily 7000 kg and in a year 3 crop is possible. And such a system is already developed and followed by few farmers in Tamil nadu and Andhra pradesh and this is going to be the game changer. ◆◆◆

(Views expressed are personal. References can be availed on request.)

North East Region Meet 2025 on development of fisheries sector in Northeast held in Guwahati

The Department of Fisheries, under the Ministry of Fisheries, Animal Husbandry, and Dairying, organized the 'Northeast Region States Meet 2025' in Guwahati, Assam. Rajiv Ranjan Singh, the Union Minister for Fisheries, Animal Husbandry, and Dairying, along with the Ministry of Panchayati Raj, chaired the meeting.

The event was honored by the presence of George Kurian, Minister of State for Fisheries, Animal Husbandry, and Dairying, as well as the Ministry of Minority Affairs, and Professor S.P. Singh Baghel, Minister of State for Fisheries, Animal Husbandry, and Dairying, and the Ministry of Panchayati Raj.

During the event, the Union Minister inaugurated and laid the foundation for key projects worth approximately Rs 50 crores under the Pradhan MantriMatsyaSampadaYojana (PMMSY). This initiative emphasizes the government's commitment to developing a self-sufficient fisheries sector in the Northeastern Region, which is expected to generate 4,530 direct and indirect employment opportunities within the sector. The Minister also distributed certificates to fisheries beneficiaries, including NFDP registration certificates, KCC cards, and awards for the Best Fish Farmers Producer Organizations (FFPOs) and fisheries start-ups. To sustain growth in the sector, the Department of Fisheries has notified an Organic Fisheries Cluster in the Soreng District of Sikkim, aimed at developing organic fisheries and aquaculture in the state. Singh stated the immense potential of the fisheries sector and urged states to take proactive measures to advance fisheries activities and optimize resource utilization.

He emphasized the importance of species diversification, aiming for a growth target of 20-25% in fish production, and bridging the production-consumption gap to ensure food security and create employment opportunities. He directed the National Fisheries Development Board (NFDB) to visit Northeastern states at the district level to identify gaps and support holistic regional development. Additionally, he called on ICAR institutes to provide technical training to fish farmers and fishers to improve efficiency.

States were encouraged to develop specific plans that address regional gaps. Key initiatives discussed included leveraging the Fisheries and Infrastructure Development Fund (FIDF), fostering innovation through NFDB regional centers, formalizing the unorganized sector, developing brood banks, and training progressive farmers at the Central Institute of Freshwater Aquaculture (CIFA) and the Central Institute of Fisheries Research Institute (CIFRI). The adoption of new technologies and a shift from traditional practices were highlighted as

vital for promoting sustainable growth. Baghel remarked that doubling farmers' income can only be achieved through the integration of agriculture with allied sectors, particularly fisheries. He stressed that achieving self-sufficiency in the Northeastern Region (NER) is a key priority, focusing on innovative aquaculture practices such as Biofloc and Recirculatory Aquaculture Systems (RAS) to address land and resource constraints.

Kurian noted the significance of traditional integrated fish farming practices in the Northeastern Region and Kerala, including systems like Tapioca-cum-fish farming and pig-cum-fish farming. These methods have been enhanced with modern techniques to improve efficiency. He further emphasized increasing fish production and adopting new technologies to grow the region's fisheries sector.

(Source: https://www.pib.gov.in/PressReleasePage)

FY25 seafood exports cross Rs 60,000 cr, govt eyes duty cuts in Budget 2025

The government has proposed reducing the Basic Customs Duty on several key inputs for shrimp and fish feed production to 5%

New Delhi: India's seafood industry exports surpassed Rs 60,000 crore so far in financial year 2024-25 (FY25), the Ministry of Finance announced on Friday, adding proposals to cut customs duties, among other measures to enhance the sector's global competitiveness.

This announcement comes in the run-up to the Union Budget 2025, poised for February 1, 2025. Frozen shrimp emerged as the star performer, accounting for nearly two-thirds of the total seafood exports, the ministry said.

India shipped 1.78 million metric tonnes of seafood in the last financial year FY24, valued at Rs 60,523.89 crore, despite facing challenges in major export markets. This represented a 2.67 per cent increase in volume at the end of FY24 compared to the previous year.

In order to increase India's seafood exports, the government has proposed reducing the Basic Customs Duty (BCD) on several key inputs for shrimp and fish feed production to just 5 per cent. This move includes reductions in broodstock, polychaete worms, and various feed components.

Additionally, customs duty exemptions will apply to several inputs used in manufacturing shrimp and fish feed.

Mission Navshakti 2.0: ICAR-NBFGR Empowers Rural Women in Uttar Pradesh through Ornamental Fish Farming

Mission Navshakti 2.0, launched by ICAR-NBFGR, empowers rural women through training in ornamental fish farming and aquarium fabrication.
The initiative promotes economic independence and social upliftment for Scheduled Caste women in Uttar Pradesh. ICAR-National Bureau of Fish Genetic Resources (ICAR-NBFGR) has launched Mission Navshakti 2.0, an initiative under its Scheduled Caste Sub Plan (SCSP) project, to empower rural women through ornamental fish culture and aquarium fabrication.
This transformative project is creating entrepreneurial opportunities for Scheduled Caste (SC) women in Barabanki, Sitapur, and Unnao districts of Uttar Pradesh.
Mission Navshakti 2.0 began as a pilot project in Dhankutti village, Barabanki, in February 2024. Encouraged by its success, the initiative expanded to KVK Katia in Sitapur and KVK Unnao.
An interactive session held on January 10, 2025, in Unnao brought together local women to discuss challenges and aspirations, followed by hands-on training in aquarium fabrication and fish farming on January 16-17. Women from Dhankutti shared inspiring success stories, showcasing how backyard ornamental fish farming has become a source of economic independence and community pride.
The project's innovative hub-and-spoke model, supported by partners like Aquaworld and Hi-Tech Fish Farming, localizes production and reduces reliance on external markets.
Participants received startup kits, including solar lights and aquarium accessories, to kickstart their entrepreneurial ventures. This grassroots initiative has already trained 325 women, fostering leadership, resilience, and economic independence in rural communities.
In Unnao, 51 women from 13 self-help groups (SHGs) across eight villages, including Dohra, Chiraiya, and Mithepur, have participated in the program. SHGs such as Nari Shakti and Jai Ambe are becoming vibrant centers of entrepreneurial activity, promoting local development and strengthening community bonds. Director of ICAR-NBFGR, Dr. U.K. Sarkar, highlighted the transformative power of grassroots interventions. By integrating traditional knowledge with modern techniques, Mission Navshakti 2.0 is not just creating income opportunities but also fostering social empowerment.
(Source: https://krishijagran.com/news/mission-navshakti-20-icar-nbfgr-empowers-rural-women-in-uttar-pradesh-through-ornamental-fish-farming/)

New coordinators supporting the Energy Transition Partnership for EU fisheries and aquaculture

The Energy Transition Partnership for EU Fisheries and Aquaculture has announced the appointment of 10 support group coordinators to help drive progress towards a more sustainable and low-carbon fishing and aquaculture sector.

The support group coordinators will play a critical role infacilitating the exchange of inputs, recommendations, and best practices within the sector, through working groups; and providing recommendations to develop a roadmap for climate neutrality in the sector by 2050.

The support group is an advisory and consultative body addressing key challenges across the fisheries and aquaculture sectors impacted by the energy transition. To ensure all voices and concerns are heard, the coordinators represent various industries from fisheries to ports.

The coordinators for fisheries include Small-Scale Coastal Fisheries (SSCF): Marta Cavallé and Executive Secretary of the Low Impact Fishers of Europe (LIFE).

While the Large-Scale Fisheries coordinators is Jules Danto, policy officer at European Association of Fish Producers Organisations (EAPO), Distant Water Fleet (DWF) coordinator is MatiSarevet, Member of the Management Board at Reyktal Ltd.

Eva Kovacs, Senior Project Manager at Eurofish International Organisation; Giulio Brizzi, senior aquaculture expert; Carlos Botana Lagaron, President of the Port Authority of Vigo; Alexandra Phillipe, Fisheries and Maritime Affairs Advisor at the European Bureau for

Conservation and Development; GorkaGabiña, AZTI Research Centre and Katarina Sipic, Secretary General at AIPCE and CEP arethe coordinators for Inland Aquaculture, Offshore Aquaculture, Ports, NGOs, Research Organisations, Academia and Processing Industry respectively:.
Vincent Guerre, Director for Trade and Competitiveness at the Shipyards' and Maritime Equipment Association of Europe (SEA Europe) will be coordinator for Fishing Shipbuilding Industry.
The work of the support group will be crucial in supporting the sectors to reduce greenhouse gas emissions (GHG) and transition to a more sustainable and low-carbon economy. The Energy Transition Partnership for Fisheries and Aquaculture is an initiative of the European Commission that was presented in 2023 in the oceans and fisheries package and aimed at addressing the GHG emissions and energy challenges facing the fisheries and aquaculture sector. The partnership brings together industry stakeholders, national and regional public authorities, and international organisations to share knowledge, best practices, and innovative solutions to reduce greenhouse gas emissions and improve energy efficiency in the fishing and aquaculture sector.

ICAR-CIBA organizes Shrimp Farmers Conclave in Balasore, outlines a road-map for the development of shrimp aquaculture in Odisha

More than 500 shrimp and fish farmers, state administration, scientists, and industry stakeholders participated at the 'Shrimp Farmers Conclave 2025' held in Balasore. The ICAR-Central Institute of Brackishwater Aquaculture (CIBA),

in association with the Department of Fisheries, Odisha and P2C Communications organized the Conclave.

In a message for the participants, Shri Gokulananda Mallik, Minister for Fisheries & Animal Resources Development, MSME, Government of Odisha highlighted the importance of the conclave for the state.

Inaugurating the national conference, Dr J K Jena, Deputy Director General-Fisheries, ICAR urged the farmers to produce suitable size shrimps and fishes for the domestic market to get assured income for the farmers and break the myth of shrimps are produced for the foreign consumers. He emphasized that the State Department of Fisheries and the shrimp farmers association with the help of processors should prepare a 'shrimp production and marketing plan' suggesting the phase and zone wise shrimp farming plan, what to produce for the domestic market and what to produce for export and connect the potential domestic markets and processors with farmer groups.

"Farmers are the fulcrum in any farming sector around whom the technology, inputs, services and market revolve. With regions being unique in terms of resources and production systems, region specific aquaculture planning is necessary", said Dr Kuldeep Kumar Lal, Director, ICAR-CIBA. He also laid emphasis on the best resource management practices and production systems in brackishwater aquaculture, offering CIBA's technological solutions for the development of the sector in the state of Odisha.

Dr. A. Panigrahi, Principal Scientist CIBA and coordinator of the conclave in his welcome note underlined that CIBA has developed several technologies to ensure farmers' profitability and farmers should select appropriate production system and their farm-business plan rather than just emulating fellow farmers whose resources, infrastructure and capacity are entirely different.

"The shrimp farming has undergone a tremendous change over the years with technological interventions. However, it is very important to ensure the financial security of the shrimp farmers. The sessions on insurance and market linkage will help farmers understand the future trends of the shrimp aquaculture," said Pravash Pradhan, Chief Editor, Aqua Post, sharing his thoughts on the conference.

Shrimp aquaculture is an important agri-business farming system practiced with entrepreneurship approach in the coastal districts. Odisha state has a huge potential of 4.18 lakh hectare suitable for shrimp farming but utilized hardly 4% of that at present with a production of 45000 metric tonnes of shrimp due to many reasons.

Heavy Metal Toxicity in Fishes Health: A Review

Siddharth Kumar Jatav, Ravikant, Domendra Dhruve, Priya Singh, Shivam Pandey and Nidhi Dhansukhbhai Pate

Toxic heavy metals are known to alter the external organs of fish, resulting in loss of equilibrium, increased Opercular movement, aberrant vertical motions, and, eventually, death.

Abstract

Environmental pollution is a worldwide issue, and the most significant pollutants are heavy metals in aquatic networks due to their toxicity, accumulation, and bio-magnification by marine animals. Heavy metals are derived from both natural and manmade sources. Heavy metal contamination in aquatic settings is caused by direct air deposition, geologic weathering, or the discharge of agricultural, municipal, residential, or industrial waste products, as well as wastewater treatment facilities (WWTPs). Cadmium, lead, mercury, zinc, copper, nickel, cobalt, molybdenum, chromium, and tin are the heavy metals most typically discovered in fish organisms. Heavy metal toxicity can alter individual development rates, physiological processes, mortality, and reproduction in fish. It can enter fish bodies through three routes: the

gills, the digestive tract and the body surface and interfere with numerous developmental processes throughout the embryonic phase, resulting in a decrease in offspring quantity and quality. Heavy metals' influence on human includes gastrointestinal and kidney dysfunction, neurological system diseases, skin lesions, vascular damage, immune system malfunction, birth defects, and cancer.

Heavy metals' influence on human includes gastrointestinal and kidney dysfunction, neurological system diseases, skin lesions, vascular damage, immune system malfunction, birth defects, and cancer.

Introduction

For many decades, there has been worry about the effects of pollutants, particularly heavy metals, in fish's aquatic ecosystems (lakes, rivers, and lagoons), which have a serious negative impact on the organisms. Fish are used to measure the health of the aquatic ecosystem because heavy metals bioaccumulate in the food chain and have negative consequences, including death. Metals are classified into two types: those required for life and those that are not. Non-essential metals such as aluminium (Al), cadmium (Cd), mercury (Hg), tin (Sn), and lead (Pb) becomes more poisonous with concentration, and none of their biological activities have been discovered. They're also referred to as xenobiotics or alien components. On the other hand, the toxic effects of important metals (such as copper (Cu), zinc (Zn), chromium (Cr), nickel (Ni), cobalt (Co), molybdenum (Mo), and iron (Fe)) occur either when there is a metabolic deficiency or when there is a high concentration. Metal concentrations in various fish tissues have increased dramatically due to a variety of factors, including seasonal changes, physical and chemical properties of water, and other factors. Because of higher metal concentrations in the water and sediments, there are substantial metal residual concerns with fish epithelium.The pattern of heavy metal uptake in fish varies by species and is influenced by a variety of factors such as the fish's age, developmental stage, and psychological makeup. This review has highlighted the widespread presence of heavy metals in aquatic environments, originating from both natural sources and human activities.

Sources of Heavy Metal

Heavy metals are produced through a variety of anthropogenic and natural processes. Heavy metal pollution in aquatic environments is caused by direct air deposition, geologic weathering, or the discharge of industrial, municipal, residential, or agricultural waste materials, including wastewater treatment facilities (WWTPs). Coal combustion is a substantial source of trace element emissions and a significant source of some metals. Heavy metals and metalloid contamination in water

and sediment constitute a serious threat at higher concentrations due to their toxicity, long persistence, bioaccumulation, and bio-magnification in the food chain.

Effect of Heavy Metal on Embryonic Development of Fish

Fish in their early stages of development are extremely vulnerable to water contamination. Heavy metals can disrupt a number of embryonic developmental processes, reducing the number and quality of offspring. Waterborne metals can accumulate in spawners' gonads, reducing gamete viability and output or directly harming developing embryos. Metals may accumulate in the egg because the eggshell may not fully protect the embryo from metal penetration, particularly during the swelling process. The effects might range from embryonic death to developmental issues, depending on the metal content. Metals inhibit and slow down specific developing processes in fish embryos. Waterborne metals can also induce bodily malformations and other developmental abnormalities during organogenesis. Heavy metals are frequently responsible for premature or delayed hatching, deformations, and mortality in newly hatched larvae. As a result of all of these changes, there are fewer larvae and they are of poor quality, with small bodies, frequent malformations, and low viability.

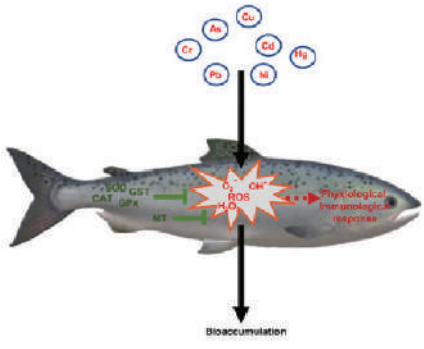
Effects of Heavy Metals on Fishes

Heavy metal toxicity can affect fish physiological systems, individual growth rates, mortality and reproduction. Fish can take heavy metals through their gills, digestive system, or body surface, among other possible entrance channels. The food source can also contribute to heavy metal accumulation, which may result in bio-magnification- the augmentation of toxins as they migrate up the food chain. Toxic

heavy metals are known to disrupt fish's external organs, resulting in loss of equilibrium, increased opercular movement, abnormal vertical motions, and ultimately death. According to Ali et al., cadmium, lead, mercury, and arsenic seriously harm fish's neurological and renal systems in addition to their gills. Toxic heavy metals are known to alter the external organs of fish, resulting in loss of equilibrium, increased Opercular movement, aberrant vertical motions, and, eventually, death.

Effects of Chromium on Fish

Fish swallowed either food from the environment or heavy metals from the water surrounding them. As a result of human activities, natural water is increasingly contaminated with this element. Despite the fact that the concentration of chromium in rivers and lakes is documented to range between 1 and 10 ug/L, the EPA recommends an acceptable



threshold of 50 to 100 ug Cr/L for the protection of aquatic life and human health. Several fish species demonstrate the chromium poisoning impact based on blood changes such as anaemia, eosinophilia, and lymphocytosis, as well as bronchial and renal illnesses. Although chromium is known for its modest accumulation in fish bodies, higher quantities of Cr injure fish swimming near the point of Cr disposal. Effect of Chromium on Humans by Fish Intake Fish, which are at the top of the food chain, acquire a lot of metals, and the amount depends on how much is consumed and how much is excreted by the body.

Effects of Cadmium on Fish

Cadmium, the non-essential and most dangerous heavy metal, is abundant in the marine environment and the earth's crust. Heavy metals such as lead, mercury, and cadmium are regarded to be hazardous to public health (Sastry and Gupta 1979). It is widely acknowledged that the major sources of cadmium discharge into the environment (such as coal or oil) are municipal rubbish burning and fossil fuels. Cadmium may also be released into the atmosphere when copper, lead, or zinc is melted. Waste from businesses and families can be disposed of, allowing new water to enter. Heavy metal exposure may also impede aquatic creature reproduction, leading to the slow extinction of

generations in contaminated settings. Cadmium is commonly found in fertilisers. Long term toxicity from Cd and mercury (Hg), for example, may appear as kidney damage, tumours, hypertension, and hepatic dysfunction, among other symptoms. The nutritional needs of different fish tissues are determined by their biochemical makeup, which includes the levels of minerals, amino acids, protein, and vitamins, among other things. At sub-lethal Cd doses, the electrophoretic structures of protein segments in O. mossambicus gills and muscle displayed abnormalities.

Effects of Zinc on Fish

Zinc may accumulate in the bodies of fish that live in zinccontaminated streams. The bodies of these fish absorb zinc, causing bio-magnification up the food chain. Toth and Brown (1997) found that as fish length rose, Zn concentrations in tissue decreased dramatically. One of the most common heavy metal pollutants is zinc, a vital element. Zinc and other heavy metals in natural streams can be traced back to geological rock weathering, human activities such as industrial and domestic wastewater discharges, and animal sources where it serves as a component function in cytoplasmic integrity. However, at higher concentrations, Zn caused structural damage in fish, affecting their growth, development, and survival. When zinc accumulates in fish gills, it impairs tissue respiration, resulting in hypoxia and death. Zinc pollution can also alter the physiology of the heart and ventilator. Zinc has a detrimental impact on fish hatchability, survival, and haematological limitations. Sub-acute effects of zinc on fish behaviours are possible. Because most of the fins in the affected fish remain fixed, these observed behaviours include imbalanced swimming, air guzzling, restless swimming, periods of dormancy, and death. Zn is particularly harmful due to its almost endless persistence in the environment and its inability to be eliminated biologically. It simply switches from one oxidation state to another or from one chemical complex to another. Zinc may be harmful to fish, since it interferes with their capacity to control their acid-base and ions, destroys their gill tissue, and promotes hypoxia.

Effects of Lead in Fish

When accumulation reaches an appreciably high level, heavy metals can become dangerous in aquatic animals' tissues. Aquatic animals may absorb considerable amounts of heavy metals if there is a rise in their concentration in the water. Fish is usually one of the biggest eaters. Pb is primarily consumed through food and is also breathed in by both fish and people. Lead accumulates in the blood, fat, muscles, and bones. Lead enters water systems through runoff, industrial waste, and sewage waste streams. Pb concentrations in the water can change the blood and nervous systems of other animals, fish, and other organisms, as well as injure some aquatic species.

Conclusion

The contamination of aquatic ecosystems with heavy metals represents a significant threat to both fish populations and human well-being. Fish, being essential components of aquatic food chains, play a crucial role in reflecting the overall health of the environment due to their capacity to accumulate these harmful substances. These adverse effects can ripple through the food chain, impacting humans who consume fish contaminated with these toxic elements. The detrimental consequences of heavy metal exposure on fish encompass damage to their nervous and renal systems, disruptions in their immune function, and various physiological irregularities. Heavy metals such as chromium, cadmium, and lead can impose severe health risks on humans when they consume fish tainted with these substances. These health hazards include digestive issues, impaired kidney function, neurological disorders, skin problems, damage to blood vessels, compromised immune responses, birth defects, and even the potential for cancer. Efforts to alleviate the problem of heavy metal pollution in aquatic ecosystems are of utmost importance to protect both aquatic life and human health. This involves enhancing monitoring techniques, imposing stricter regulations on the disposal of industrial and municipal waste, and encouraging sustainable practices in industries that release heavy metals into water bodies. Furthermore, it is essential to raise public awareness about the dangers associated with consuming fish that may be contaminated. ◆◆◆

(Views expressed are personal. References can be availed on request.)

Impact of climate change on aquatic ecosystem

Priyanka Rani*, Akansha Khati**, Divyanshu Kumar Upadhyay***

Fishermen may improve circumstances for their species by utilizing sensors and sophisticated monitoring systems to assess environmental characteristics such as oxygen levels, pH, and water temperature. This allows them to make modifications in real time.

Introduction

Climate change is defined as an alteration in the normal weather pattern across timescales ranging from months to several million years. It might be a change in the distribution pattern of weather-related events; it is either near the norm or has changed the typical weather patterns (Trenberth et al., 2002). It is possible for climate change to occur globally or locally. Many people's access to food and water is impacted by climate change's effects, such as severe droughts and floods. Climate change has a substantial impact on food supply and employment in a number of poor countries and small island states. In addition to affecting life processes and

shifting food chains, climate change is also affecting the profitability and quantity of freshwater and marine creatures. Therefore, it is necessary to include the potential effects of environmental changes on decadal and shorter timescale fluctuations when forecasting future climate effects on marine ecosystems and fisheries.

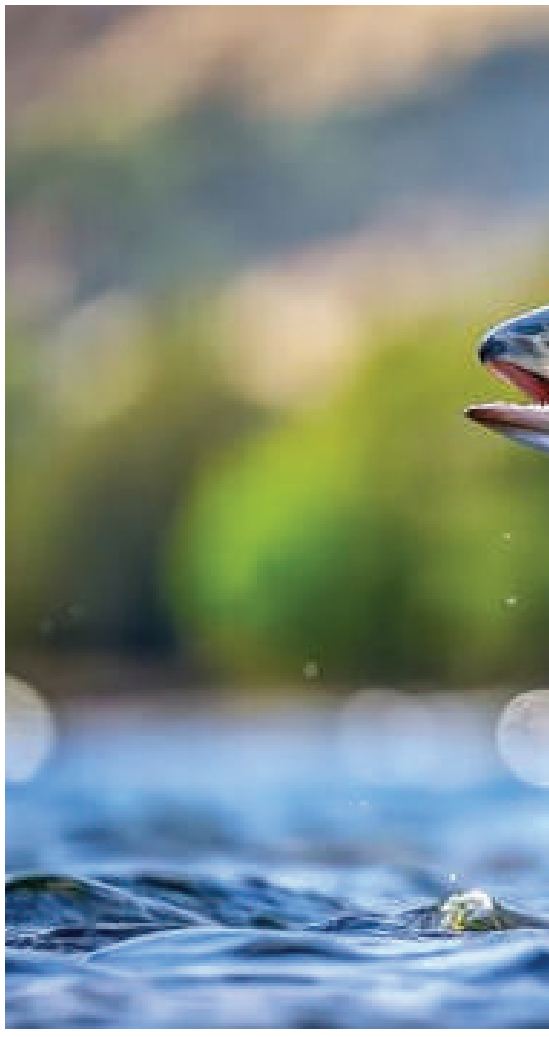
The profitability and efficiency of the fisheries and aquaculture industry are expected to be most significantly impacted by the manner that climate change affects the use of resources. The frequency, intensity, and location of significant climate events, as well as variations in freshwater and saltwater content, oxygen concentrations, carbon uptake and acidification, temperature and thermal stratification, sea levels, ocean circulation, surface wind, storm systems, and wave changes, can all be impacted by climate shifts (Guild et al., 2025). The geographic spread of marine life is also changing as a result of climate change. In order to adapt to the ideal natural area circumstances (such as oxygen levels), many species are moving to deeper seas and polar regions (Williamson & Guinder 2021). The migration processes change the patterns of relationships between species, ecological links, and food webs. In regions where migration is not feasible, many aquatic animals are predicted to undergo changes in their life spans, reproductive cycles, and physical traits. Both positive and negative effects will depend on latitude and location. It is anticipated that most tropical and subtropical marine ecosystems, lakes, and seas would become less ecologically sustainable, even though creatures that can tolerate rising temperatures and changes in the chemical makeup of coastal waters are encroaching.

The delivery of fish to local and national markets, post-harvest activities, and productivity-boosting processes may all be severely affected by climate change in the fisheries and aquaculture sector. There may be shifts in the supply's location and unpredictability, as well as adjustments to the accessibility of other crucial inputs like water and power for processing. All of these climate change-driven changes will occur concurrently with other national, regional, and global socioeconomic influences affecting natural resources. This will have a greater impact on housing, social stability, food security and nutrition.

Major climatic changes and their impact

◆ **Rise in temperature:** Aquatic species that are poikilothermic—that is, have internal temperatures that vary in relation to the water's surrounding temperature—include fish and aquatic invertebrates. Therefore, a key factor in their ability to survive is their heightened sensitivity to temperature fluctuations outside of their typical habitat. There is no denying that water body aquaculture suffers from rising temperatures and global warming. Heat-tolerant cyanobacteria in ponds can grow quickly as a result of global warming, causing extreme eutrophication from increased temperatures and pollution. Filter-feeding organisms may be highly susceptible to absorbing heavy metals and contaminants in freshwater aquaculture because of the faster metabolic rates caused by higher temperatures.

◆ **Harmful algal blooms (HABs):** Several scientific investigations have examined the consequences



of HABs on climate change, particularly warming. A range of temperatures lower than those that promote maximum growth is a requirement for the HAB to become more severe in a particular place, while warmer temperatures are a necessity for the HAB intensifying. As water temperatures get closer to the ideal range for their growth, HABs have been seen to become more intense. Another risk factor in coastal locations is eutrophication, which is the underlying because of many potential stressors. Excessive nutrient loading and extended Residence durations have been demonstrated to encourage the establishment of several HABs.

◆ **Rise in sea level:** Radiation from the sun is trapped in the environment by carbon dioxide and other greenhouse gases. The ocean warms as a result of absorbing a large portion of this heat. Sea level rise can also be attributed to warmer waters. Sea level rise might wipe out a number of coastal ecosystems, including salt marshes and mangroves, which are thought to be essential for preserving indigenous fish supplies and providing spawn for fish farming. Aquaculture reproduction initiatives and the industry's financial viability will suffer as a result. According to predictions, saltwater infiltration from rising sea levels will impact aquaculture production infrastructure, including ponds, cages, tanks, and pens, especially in lowland areas. Alteration in the diversity of species, organism density and allocation, ecological efficiency, and phenological variations brought on by sea level rise could also endanger the production of aquaculture both inland and offshore.

◆ **Changes in precipitation:** The two extreme effects of altered precipitation patterns on aquaculture output and future viability are seasons with low or no rainfall (drought) and enhanced rainfall (flooding) (Maulu et al., 2021). In the specific area, the hazards associated with severe droughts are probably higher with 2°C than with 1.5°C of global warming (IPCC, 2018), although It is hard to anticipate with precision the patterns of flooding episodes. In lowland areas, more rainfall will raise the dangers of production, especially if it happens during heavy events. Water stress from drought occurrences can result in shortages and decrease of quality, which can negatively impact aquaculture productivity.

◆ **Sea surface salinity changes:** A changeable dimension, salinity is thought to represent rainwater input from rain, melting glaciers, river discharge, water lost through evaporation, and the exchange and circulation of surface and subsurface ocean water. Sea Salinity fluctuations can be influenced directly by climate change or indirectly caused by higher evaporation brought on by warming temperatures and shifting ocean circulation (Reid et al., 2009). Any changes could result in mortality and reductions in productivity because most aquatic creatures remain alive at certain salinity levels.

The frequency, intensity, and location of significant climate events, as well as variations in freshwater and saltwater content, oxygen concentrations, carbon uptake and acidification, temperature and thermal stratification, sea levels, ocean circulation, surface wind, storm systems, and wave changes, can all be impacted by climate shifts.

The effects of climate change on aquaculture production system

Aquaculture is affected by changes in the climate both directly and indirectly, with both short-term and long-term effects on the industry. Some of the consequences of climate change on aquaculture include alterations that could show themselves as reduced yields, unexpected mortality, and adjustments to spawning seasons and numbers (Brander, 2010). Significant changes in many aspects of Earth's climate, oceans, coasts, and freshwater ecosystems have been brought about in the past few years by the buildup of greenhouse gases in the atmosphere. These include alterations to air and water temperatures, changes in rainfall patterns, variations in sea level, changes in ocean acidity, adjustments to wind patterns, and a rise in tropical cyclone severity. The Aquaculture and fisheries industries are affected by these changes. Aside from its effects on biological processes and shifting food chains, climate change is also altering the distribution and productivity of freshwater. Fisheries, Aquaculture, aquatic ecosystems, and the humans who rely on them are all under risk.

Measures to mitigate climate change in aquaculture

Aquaculture must adopt an array of approaches for handling climate change in order to minimize its effects and guarantee environmentally friendly procedures. Mixing technical

innovation Future generations' food security and environmental well-being can be guaranteed by aquaculture's improved environmental adaptation through sustainable practices and legislative adjustments. The following are a few measures:

- Aquaculture facilities must be supported by species that are more resilient to changes in salinity, temperature, or oxygen stress. And adapt to changes in the surroundings. For instance, shellfish like oysters and fish like tilapia are more able to adjust to climate change.
- Choose or cultivate species that can withstand harsh environments, such as increasing temperatures or ocean acidity.
- The feed industry, which significantly raises aquaculture's carbon footprint, might lessen its climate impact by substituting alternative protein sources like algae or insect meal for conventional fishmeal.
- Fisheries can reduce their environmental impact by switching to renewable energy sources like solar, wind, or tidal power.
- Fishermen may improve circumstances for their species by utilizing sensors and sophisticated monitoring systems to assess environmental characteristics such as oxygen levels, pH, and water temperature. This allows them to make modifications in real time.
- By using buffering agents, the detrimental impacts of ocean acidification on mussels and additional marine species can be mitigated.
- By employing sensors and advanced monitoring systems to evaluate environmental parameters like water temperature, pH, and oxygen levels, farmers may make real-time adjustments to optimize conditions for their species.
- By restoring damaged ecosystems and increasing their resilience to the adverse impacts of climate change, aquaculture and the surrounding communities can benefit.

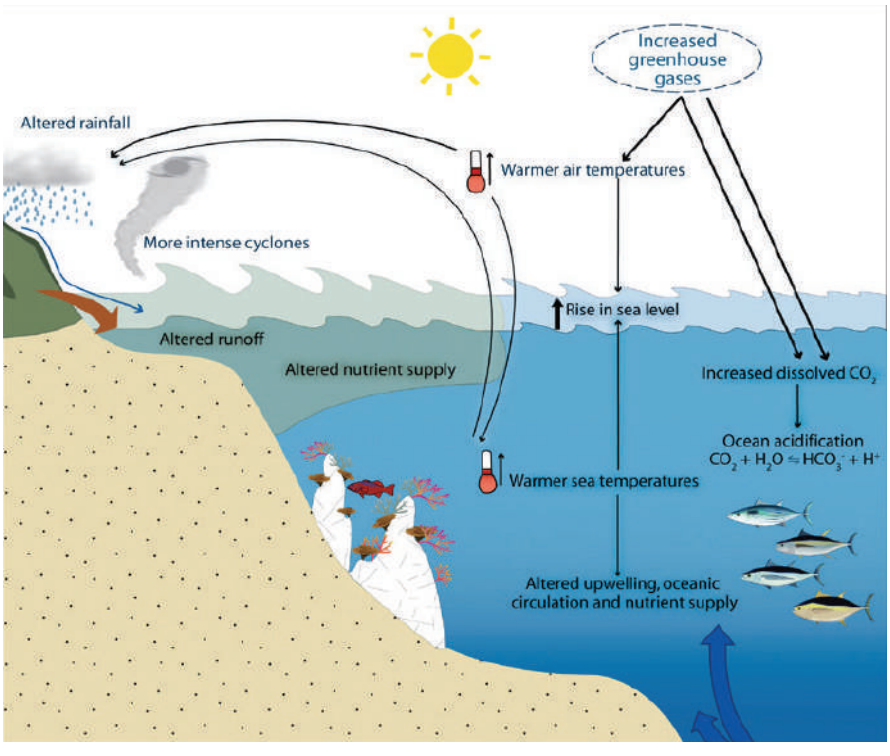
Development of strategies for climate-smart aquaculture

Climate-smart practices in this subject are linked with numerous of the primary crossing themes of sustainable growth. Like other professions, there are a number of challenges that need to be recognized and overcome in order to make climate-smart strategies the chosen advancement path. Climate-smart techniques include current practices, such as ecosystem-based management (Ahmed & Solomon 2016). Further research into Climate-smart Advancement's potential to mitigate climate change through pollution reduction and/or improved carbon storage could potentially be beneficial. It takes innovative mechanisms that link and integrate climate finance with financing specific to a sector's needs to establish and implement climate-smart fisheries and aquaculture. Finding suitable climate-

smart methods can be aided by the farming and fishing communities' participation in regional efforts. Climate-smart initiatives must be recognizable and implementable by policymakers in order to effectively engage producers and consumers at every stage.

Conclusion

The ecological diversity of an area is greatly impacted by modifications to climatic variables. Numerous species have become extinct as a result of factors like rising sea levels and temperatures that have had a significant influence on both ocean and land ecosystems. Regions providing ideal environmental factors for freshwater and marine aquaculture are becoming less widely distributed due to climate change. Challenges are also raised by the increased occurrence of disease transmission and species invasion. As the fisheries sector grows, the consequences of climate change gradually become apparent. A comprehensive strategy must be taken to deal with the consequences. ◆◆◆



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((Views expressed are personal. References can be availed on request.)

Insights into Aquafeed Extrusion Technology

Bandi Sumanth Kumar Reddy1, Gayatree Behera1, Qurat Ul Ain1, Chiranjiv Pradhan*,Kedar Nath Mohanta2

During the extrusion process protein molecules loses their functionality after temperature is >60°C and also the water solubility, durability and expansion decreases.

Introduction

Aquaculture is a sun rising sector and aquafeed is a critical input to support the growth of this industry. According to the Alltech Agri-Food Outlook 2023 report, aquafeeds now constitute approximately 4.2% of the global compound feed production, which amounted to 1.266 billion metric tons in 2022 of worth US $155.3 billion and expected to reach US $260.5 billion by 2028, exhibiting a growth rate (CAGR) of 8.90% during 2023-2028. The utilization of extrusion technology has completely transformed modern aquafeed manufacturing, despite its origins dating back to 1948. The resulting feeds from this method boast exceptional durability, water resistance, and digestibility, crucial

for promoting the growth and well-being of farmed fish. Studies have evidenced that extruded fish feed enhances feed conversion rates and accelerates growth in various species such as carp, tilapia, and catfish (Sarker et al., 2018; Gao et al., 2019). Extrusion technology has emerged as a superior method in the production of fish feeds, allowing for the creation of feeds with precise nutritional profiles that can maximize fish growth and development.

Principles of Extrusion Process

Extrusion is a process of pushing and shaping a material by forcing it through a die. Fish feed preparation involves a range of extrusion processes, varying from simple to complex. The creation of compressed sinking pellets constitutes a straight forward extrusion method with the help of screw and die, whereas the production of floating feed involves a more intricate process involving adequate moisture, temperature and pressure along with different types of screw and dies. In floating feed preparation process, raw materials are introduced into a heated extruder barrel, where screws drive the material convert them into a semi-solid and plasticized mass then compact the ingredients through a die. This process involves high temperatures and pressures, ideally exceeding 100°C, facilitated by heaters installed at top the barrel. The heater and frictional heat rapidly elevates the temperature within a brief duration, preserving the nutrient properties of the feed mass without denaturation. The feed mass experiences increased pressure and shearing in a barrel section with smaller flights before being forced through restricted openings (dies) at the discharge end. The sudden decrease in pressure at the die end facilitates the release of trapped vapour, generating air pockets within the pellets. This action lowers the bulk density of the pellets, enabling them to float on water while maintaining stability in water.

Types of Extruders and Working Principle

Two main types of extruders exist: single screw and twin screw

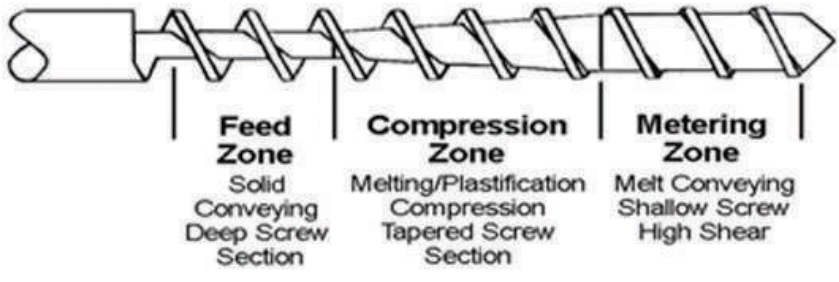


Fig 1. Sections of single screw (www.globalseafood.org)

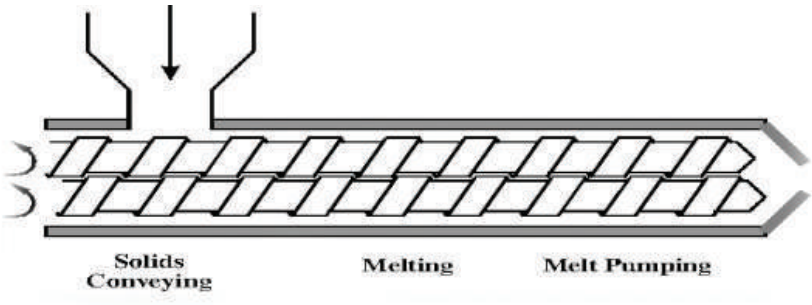


Fig 2. Twin Screw

Table1. Difference between single screw and twin-screw extruder

Feature	Single Screw Extruder	Twin Screw Extruder
Mixing Capability	Moderate mixing due to single screw	Excellent mixing due to intermeshing twin screws
Throughput	Lower throughput	Higher throughput
Residence Time	Longer residence time	Shorter residence time
Energy Consumption	Lower energy consumption	Higher energy consumption
Flexibility	Less flexibility in processing different materials	More flexibility in processing different materials
Extrusion Pressure	Higher extrusion pressure	Lower extrusion pressure
Product Quality	Good product quality	Excellent product quality
Maintenance	Simplified maintenance	Complex maintenance
Intial cost	Lower initial cost	Higher initial cost

Die Types and Die Design

Proper shape and design of the extrusion die are very important to achieve the desired shape and uniform cross-section of the extruded product. The pellet density, durability, uniformity, and texture are influenced by the design, orientation, shape, and size of the hole whether they are angled or perpendicular to the die face. Smaller holes can create denser and harder pellets, while larger holes produce softer and less dense pellets. The required properties of the material for the die are wearing resistance and good hardness. Alloy steel, stainless steel, and tungsten are often used for the fabrication of the die. Die passage is also important to maintain proper velocity and regulate the flow of material to avoid abrupt changes like stagnation. Otherwise, it would lead to thermal degradation of material when exposed to high heat for long periods.

Different Types of Dies for Extrusion Processes

The main types of dies are flat die, ring die and round die, each having their advantage and disadvantages. Flat dies were introduced around of 20th century with a purpose to make animal feed. Ring die was not developed until the 1950s. The purpose of all dies is to give perfect shape to the feed that is allowed to pass through it.

Nutrients and Extruder Condition

In aquafeed production, various types of ingredients are used based on their nutritional content, availability, and usefulness. Commonly used materials include animal byproducts,

Fig 3. Flat die

Fig 4. Ring die

Fig 5. Round die

Fig 6. Flat die with roller

Table 1: Comparison between dies

Table 1: Comparison between dies		
Ring Die	**Flat Die**	**Round Die**
I. The Shape of the die is circular having a hole in the center. II. It is ideal for large-scale production. III. Providing consistent quality and density for efficient feeding.	I. The shape of the die is flat and rectangular. II. It has a simpler design and is cost-effective. III. It is suitable for small-scale production.	I. The shape of the die is circular like a ring die but without a central hole. II. It offers good pressure distribution i.e., its main function. III. It is suitable for materials having low friction. It is used for small to medium-sized farms.

oil cakes, cereal by-products like de-oiled rice bran (DORB) and vitamin-mineral mixture. These ingredients show changes in their properties when subjected to the extrusion process.

During the extrusion process protein molecules loses their functionality after temperature is >60°C and also the water solubility, durability and expansion decreases. However, the nutritional properties remain intact up to 130°C. The exposure to temperature reduces the size and value of the protein and that increases their digestibility by fish. Lipids act as lubricants and influence the quality of products.

High lipid content, typically ranging from 5-6%, contributes to suboptimal product expansion during the extrusion process. Excessive lipids play a dual role by decreasing melt viscosity and impeding starch hydration. Fat is second most important nutrient in fish feed and it included to balance the protein: energy ratio, enhances palatability, provide essential fatty acids and fat-soluble vitamins, and control dust. Typically, lipids in feed are primarily applied through top dressing to prevent them from causing die lubrication and to preserve their quality by avoiding exposure to high temperatures during the extrusion process. However, extrusion process reduces oxygenation of lipids as the enzymes like lipases and lipoxidases get inactivated at high temperatures.

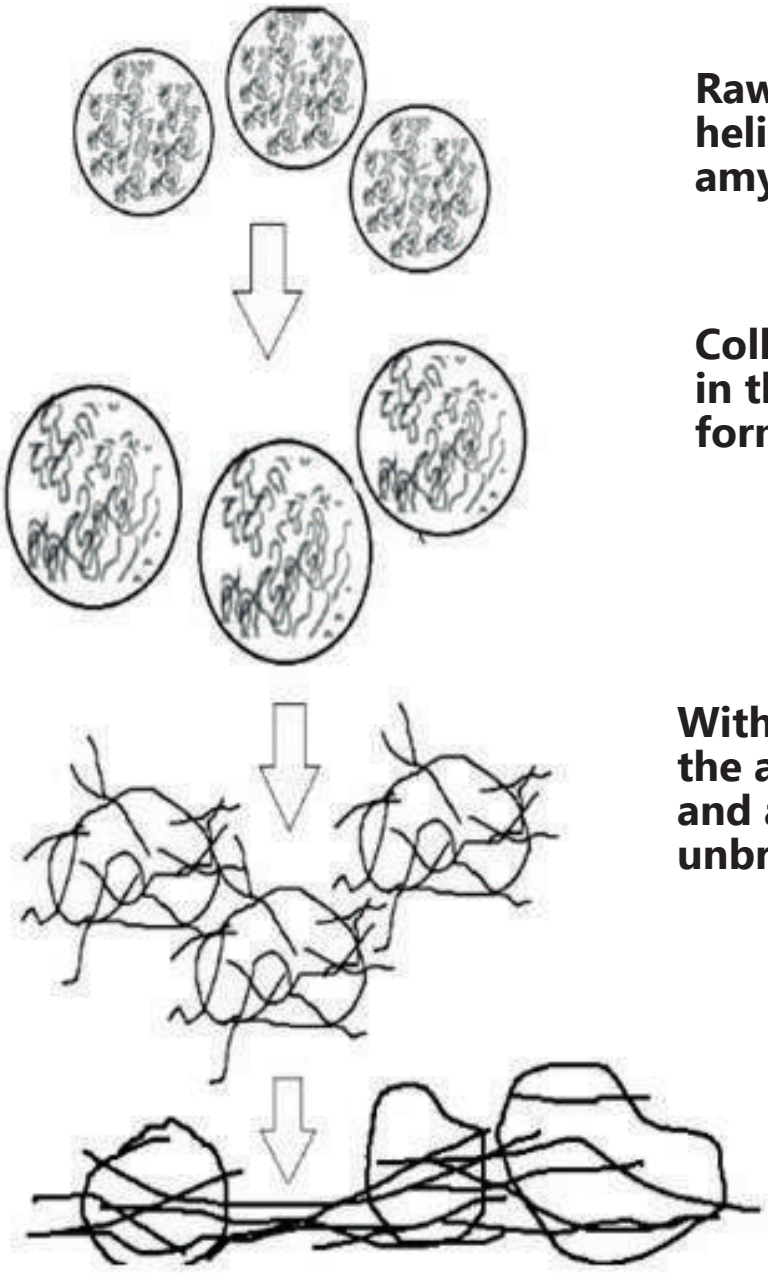


Fig 7. Gelatinisation of starch

According to the Alltech Agri-Food Outlook 2023 report, aquafeeds now constitute approximately 4.2% of the global compound feed production, which amounted to 1.266 billion metric tons in 2022 of worth US $155.3 billion and expected to reach US $260.5 billion by 2028, exhibiting a growth rate (CAGR) of 8.90% during 2023-2028

Carbohydrates act as binding agents, suspending agents, and emulsifiers. Digestible carbohydrates like starch first swell and then hydrate, more in the compression zone. This results in the gelatinization of starch and thus improves its digestibility, it is important for floating feed preparation (Fig 7). Under severe heat dietary fibre content increases due to enzyme-resistant starch function.

The vitamins sensitive to the extrusion process are Vitamins A, E, C, B1, and Folic acid while the vitamins stable are Vitamin B2, B6, B12, Niacin, Biotin and Ca-pentatonic. There is a slight loss of Vitamin D, Vitamin E acetate, B12, choline chloride, and ascorbyl phosphate in the extruder. Vitamins lose 20% of their activity at the lowest expander temperature and shortest residency time. At the highest residency and longest time, it reduces to 65% of the original activity. Minerals do not change during the extrusion process. A mineral increases the surface area results in good penetration of oil and reduces the migration of oil from feed to packaging material. Vitamins are also preferred to be given as top dressing on the pellets. Water is needed for the gelatinization of starch. When given directly into a barrel or steam process more than 10% of biopolymer hydrate and move freely. At higher content, water acts as a lubricant which decreases the mechanical energy input and exhibits elastic recoil as it leaves the die. At more than 30% moisture the product has high density and an overall smaller dimension (expansion coefficient) than a product made with low water addition.

Determination of Product Parameters

The extruder system processes ingredients using mechanical energy, resulting in changes to product properties like moisture content, bulk density, dimension and mass expansion ratio, water stability index, water absorption ratio, hardness, surface area and volume and texture.

Bulk Density: Bulk density is a measure of how much expansion has

occurred as a result of extrusion. It was observed that higher barrel temperature, screw speed, and moisture level reduce bulk density. A high bulk density indicates a uniform protein matrix with parallel layers, no air pockets, and non-spongy hydration (Taranto et al., 1978). Bulk density is the ratio of mass to volume of the product. It is expressed as gm/m3.

$$BD = \frac{4 \times m}{\Pi \times d2 \times L}$$

Where, m is the mass of the extrudate in g; d is the diameter of the extrudate in cm; L is the length of the extrudate in cm.

Dimension and mass: The mean weight of the fish feed pellets increases with increasing the pellet sizes and protein ratio. The dimensions of the pellet i.e. length and diameter can be measured by vernier calliper. The mass can be measured by electric digital balance.

Area and volume: For the surface area average diameter is required and it is calculated by formula 4πr^2. The volume can be calculated using the formula 4/3πr3.

Expansion ratio: It is the swelling of extrudate immediately beyond the die, followed by bubble growth and collapse. Raising the barrel temperature leads to extrudate with greater expansion, while increasing screw speed correlates with higher expansion. The diameter of the extruder is measured using vernier callipers (Chandrahas Sahu et al, 2022). The expansion ratio of the extruded product is given by the ratio between the diameter of the extruded product and the diameter of the die.

$$\text{Expansion Ratio} = \frac{\text{Extruded Product Diameter}}{\text{Die Diameter}}$$

Water Absorption Index (WAI): The water absorption index with screw speed may be attributed to high mechanical shear and higher expansion due to gelatinization. An increase in screw speed decreases WAI. It increases with the increase in temperature probably due to increased dextrinization or starch degradation at higher temperatures. WAI can be measured using the method given by Anderson et al.

$$\frac{\text{Weight of gel after removing supernatant}}{\text{Weight of original dry solids}}$$

Water Solubility Index (WSI): The WSI increases with an increase in screw speed and barrel temperature and decreases with an increase in moisture (Pathania et al., 2013). The direct relation of the WSI of extrudate with screw speed may be related to increasing specific mechanical energy with screw speed. A positive relationship between temperature and WSI is due to an increase in the degree of starch gelatinization which increases the amount of soluble starch.

$$\text{Water Solubility Index} = \frac{\text{Weight of sediment after filtration}}{\text{Weight of dry solids}} 100$$

Hardness: It is measure of physical integrity of the feed. An increase in barrel temperature resulted in higher hardness due to the expansion that occurs at elevated temperatures. While increasing screw speed and increasing level of moisture resulted in lower hardness. It may be observed that hardness decreased with the increase in screw speed due to lower melt density was observed by Ding et al. Hardness of the extruded feed can be measured manually. Various hardness testers such as those from Stokes, Pfizer, and Acme Penetrometer can be utilized, with the Kahl Hardness tester being the most commonly used according to Thomas Winowiski.

Water stability: To achieve water stability the first rule is to extrude the pellet. The starch content gets dextrinized and due to this process product will dissolve fairly in water. Wheat gluten is a unique denatured protein that acts as a good binder but gets denatured in the machine which loses its binding property before the pellet is formed. So, it is best to extrude wet and cool and then it is kept for post-conditioning in the drier. All these steps will lead to the formation of water stable pellet. The stability of the feed can be checked by oven dry all the pellets at 105°C for 24h, then keeping 3-4g of feed in a mashed wire and keeping it immersed for 20 minutes. The feed maintaining its integrity for more duration can be considered as water stable.

Extrusion troubleshooting

Troubleshooting in extrusion is crucial for maintaining product quality and nutritional profile. Continuous vigilance on extruder operation is necessary to identify and resolve any issues promptly. Problems with the extruder can impact the economy and lead to downtime or off-quality products. Proper instrumentation is essential for accurate problem detection and resolution.

Pelleting stopped suddenly: It can be caused due to the following reasons mechanical, electrical, feed, and operational problems. Mechanical problems may occur due to worn or damaged parts of the pellet mill, improper maintenance, lubrication, or adjustment of the pellet mill. Electrical problems may occur due to power failure, voltage fluctuation, and short circuits. Feed problems occur due

to poor quality or inconsistent feed ingredients, and improper mixing of the feed. Operational problems include improper setting or operation of the pellet mill, such as the die speed, roller pressure, and feed rate.

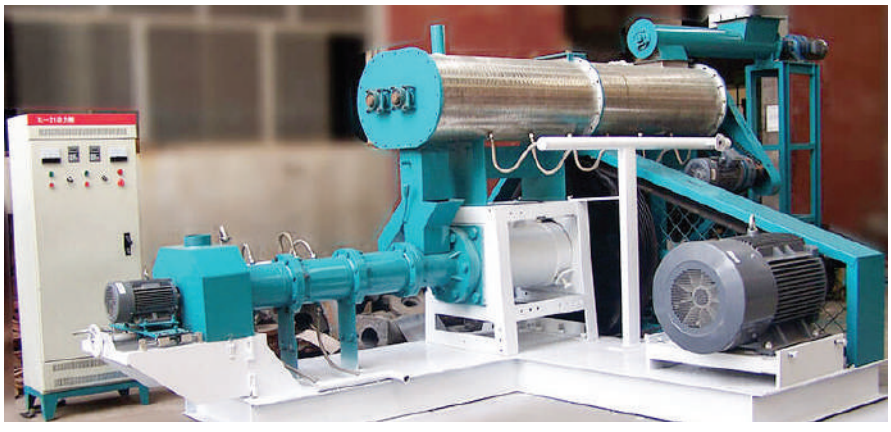
Production declined: It may be due to the raw material quality and availability and extruder performance and maintenance problems. For eg: poor quality of feed can cause problems in grinding and mixing leading to low output

Pellets are not uniform: It is due to inadequate grinding or mixing of the feed ingredients or due to faulty extruder or die focus on thorough grinding and mixing of feed ingredients for homogeneity.

The pellet is too long or short: it is because of improper knife speed or feed rate, faulty cutter or die that can result in mechanical or electrical failure which would affect the cutting efficiency and accuracy.

Motor load: Motor load issues can arise due to factors such as high or low motor load, feed rate, feed moisture, and die opening size..

Hard pellet: This occurs due to low moisture or steam addition, high die speed, high fat or protein content,



and inadequate cooling and drying of pellets.

Conclusion

Improving our understanding of feed mill components, the nutritional needs of fish, and ingredient processing techniques is crucial for enhancing pellet quality and optimizing feed preparation. By delving deeper into these aspects, we can refine our knowledge and skills in feed manufacturing, leading to the creation of superior-quality feeds that meet the specific nutritional requirements of fish. This comprehensive understanding empowers us to make informed decisions throughout the feed production process, ultimately contributing to the overall health and growth of aquatic species. ◆◆◆

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(Views expressed are personal. References can be availed on request.)

Kholis Enthrall Visitors with Fish Festival

Versova Fishing Village, situated in Andheri West, Mumbai, Maharashtra, proudly hosts the Kholi Fish Festival every January, showcasing the rich culture and traditions of the local fishing community.

Versova Fishing Village, situated in Andheri West, Mumbai, Maharashtra, proudly hosts the Kholi Fish Festival every January, showcasing the rich culture and traditions of the local fishing community. Established in 2006 by the Kholi Association, this festival has since become a vibrant annual celebration that draws thousands of eager visitors. The Kholi Seafood Festival is renowned for its array of freshly caught fish and prawns, prepared in authentic local styles. Attendees can indulge in an impressive selection of fish, including Pomfret, Surmai, Bombil, Bangda, Ghol, and Mandeli, along with delectable shellfish such as prawns, crab, and lobster (crayfish), all expertly cooked and sold by the local fishermen. This festival is not just an event; it's a celebration of culinary tradition and community spirit that everyone should experience.

The Kholiwadas are a prominent fishing community in Maharashtra, with a rich tradition spanning many generations. However, over time, they have faced several challenges, including shifting fishing grounds, rising expenses, and

a decline in fish catches. Meanwhile, the selling price of fish has remained largely unchanged, and since fish is a perishable product, it requires immediate sale, making the trade increasingly unviable for boat owners and fishermen. As a result of these circumstances, the Kholi community has been seeking alternate sources of income.

In response to these challenges, the Kholi community organized the Kholi Seafood Festival in 2006. The festival aims to promote fish consumption, showcase authentic Koli recipes, and celebrate the community's culture and traditions, while also generating income for the fishermen. The catchy slogan "Macchi sehat ke liye acchi" (Fish is beneficial for health) embodies the spirit of the Mumbai Koli Seafood Festival.

The festival consists of three main parts: cultural events and performances, Koli cuisine, and the showcasing of goods, ideas, and products by various organizations and sponsors. Originally started locally at a minimal cost, it has since grown into one of the most famous festivals in Maharashtra, receiving support through donations and sponsorships. In 2024, the Versova Koli Seafood Festival received financial assistance of Rs 500,000 from the National Fisheries Development Board (NFDB) for the first time.

The traditional attire and jewelry of Koli men and women are major attractions for visitors at the festival. Many stall owners dress in similar patterns and colors. The stall owners prepare their dishes while also enjoying dancing and singing throughout the event. The seafood festival has introduced the Koli fishing community to a new opportunity for selling Koli cuisine. It has showcased the entrepreneurial skills of Koli women. Despite a rocky start, the festival has become a must-visit for seafood lovers.

Exotic Species: A Big Threat to Native Species

Ishita mehta

Farmers are introducing different kinds of exotic species into their ponds to achieve their target.Unfortunately, the introduction of invasive species had a great impact on the indigenous fish species; itcauseda loss of biodiversity and ecosystem destruction.

Exotic fish specieswere introduced in India, for recreational Indian fishing, during the British period. Its greater efficiency of reproduction and easy adaptability to climate changes make it more popular among Indian farmers. In current years, the Fisheries and aquaculture sector have been rapidly growing in India, to meet the food demand of a growing population; farmers are trying to increase the production of fish and fish products, to earn more profit. Farmers are introducing different kinds of exotic species into their ponds to achieve their target. Unfortunately, the introduction of invasive species had a great impact on the indigenous fish species; itcauseda loss of biodiversity and ecosystem destruction. These species can establish, invade, and compete with native fishes leading to high abundance in the new environments and thus affectingthe biological diversity of Indian water. As per NBFGR, Lucknow, 2,508 species of native finfish have been recorded, of which 1,518 species are from the marine environment, 113 from brackish waters and 877 are from freshwater habitats. Other than this, 291 exotic fish species are also found in India's water.Exotic species have high reproduction rate and once the exotic species start propagating, it's hard to eradicate them from the water resource. In this article, we will

focus on how these exotic species are affecting the growth and population of the indigenous fish species.

Impact of Exotic Fishes on Ecosystem:

The introduction of Non-Indigenousfishspecies has now become the second most responsible reason for the extinction of native fish diversity.Invasive fish species are voracious feeders and can adapt to any adverse condition as well as they have very high rate of reproduction. These species can occupy the large water body in a short time. Non-native species give tough competition to native species of the water body for food, shelter, and other resources. This results in biodiversity loss, reduction of native species, and extinction of local diversity due to changes in hydrology and ecosystem functioning. The introduction of exotic fishes induces more stress on aquatic ecosystems and harms the indigenous fishes has been reported earlier in response to ecological, biological, diversity, and fish health. This also brings with them novel parasites and pathogens into the invaded area. Exotic fishes were intentionally introduced and cultured because of their fast growth rate, adaptation ability to tolerate environmental changes, and disease resistance ability (Chen et al. 2007,Lin et al. 2015). But accidentally,theseinvasive fishes may escape from the aquaculture ponds and increase their population

in the open natural ecosystems (Xu et al. 2006). Other than this, exotic species breed with the native species, whicherodes or dilutes local genetic diversity by hybridizing with the indigenous species. The rearing of exotic species can alter habitat in ways that render it unsuitable for the local species.

Furthermore, the introduction of non-native or exotic fishes induce adverse impacts on the ecosystem via decreasing native species, suppressing growth rate, and reduction of food availability by modification in the food web in the aquatic ecosystem (Britton et al. 2010). The introduction of alien fish causes, approximately 80% loss of endangered species in the world due to habitat or food competition or predation (Pimentel et al. 2005).

The introduction of Tilapia in India seems to have caused a surprising impact on both freshwater and brackish water fisheries (Trewavas, 1983). In India the introduction of Cyprinuscarpio into Dal Lake and Loktak Lake has been reported to affect the population of indigenous Schizothorax&Osteobramabelangeri respectively. The populations of native Catla and Mahseer were depleted considerably in GovindSagar Reservoir after introduction of Silver carp.

Socio –Economic Impact of Invasive fishes

The exotic fishes causes enormous economical as well as ecological loss (Xu et al. 2006). Recently, with the invasion of exotic fishes and their high capability of breeding and adapting new environment, this diverted and focused on exotic fishes rearing and cultivation because of their high growth rate, disease resistance, high reproduction rate, and better adaptation. Thus, large amounts of fish meat can be produced in a short time and space. The alien fishes may not be preferred as good quality food and thus have low commercial value. The exotic species enhance fishing and result in a decrease in fishermen's income because of the low price of exotic fishes (Xia et al. 2019).Therefore, the fisherman has to catch more fishes to increase their income. Recently, ornamental and aquarium fishes import trade and their introduction into the ecosystem become serious issues to the native aquatic biodiversity. During aquaculture practice, the requirement of eradication of exotic fish may cause economic loss and increase maintenance costs. Exotic fishes not only affect the ecosystem's health but directly or indirectly affect human health. The bacteria cause adverse diseases in the fishes and also cause health problem in human (Shotts 1987) that results in the loss of human health. Therefore, it

has to be undertaken that the alien species directly or indirectly affect the economics of the people.

History

In India, the introduction of alien species of fish goes back a time, during the period 19th century under British rule, 9 species of exotic fish were introduced. They were temperate food carps, Tinca tinca, Carassius carassius, Cyprinus carpio (European strain), the tropical osphronemid, Osphronemus goramy salmonid game fishes, the brown trout and the rainbow trout and larvicidal Gambusia affinis and Lebistes reticulatus. The post-independence India witnessed introductions of 8 exotic species. They were the cyprinids, Cyprinus carpio, (chinese strain), Ctenopharyngodon idella, Hypophthalmicthys molitrix, Puntius javanicus, and the cichlid, Tilapia mossambica, all of food species and the salmonids, Salvelinusfontinalis, Onchorhyncus nerka, and Salmo salar. Unauthorized introductions were: Aristicthys nobilis, Tilapia nilotica and red tilapia. Sir, Francis Day, the author of the classical work on the Fish fauna of Indian region, was probably the first person who tried to introduce the brown trout, Salmo trutta fario in the Nilgiri waters in the year 1863, but his attempt was unsuccessful (Jhingran, 1975). This was followed by introduction of several exotic fish species from various parts of the world to different regions of India for augmenting fish production through aquaculture, for sport fishery, for mosquito / weed control, for ornamental purpose etc with successes and failures. The larvicidal fishes, such as, Poecilia retiuculta and Gambusia affinis were introduced in the year 1908 and 1928 respectively, to contain mosquito larvae in confined waters. But the larvicidal value of these species is not well established. There are hundreds of ornamental fish species being imported to our country since the aquarium trade is in progressive growth stage/ insecticidal value of these species is not well established.

Management of exotic species:

Management and prevention of introduction of invasive species is very importantand most cost-effective measure against invasive alien species because once an introduced species has become established it can be extremely difficult or more often impossible to eradicate. If the

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invasion has spread to a point that eradication is not possible, then the species may be subject to control and management efforts. Regardless of whether the goal is eradication or control/ management, there are different options to consider. These include mechanical/physical, chemical and biological control methods. These methods can be used alone or in combination in order to increase efficiency. Physical/ Mechanical control involves directly removing individuals of the invasive alien species either by hand or using machinery (i.e., fishing, pulling weeds) or draining of the water body that has become infested.

In general, fishing catches decrease in the winter because most native species, with the exception of some migratory fish, hide in deep water to escape the low temperatures, making it difficult to catch these species. However, the relative biomass of exotic species was high in the winter due to their biological traits, including tolerance to wide ranges temperature (Das et al. 2005; Russell et al. 2012). This feature makes it convenient to remove exotic species in the winter. Prevention, early detection and rapid response and eradication are the most common management strategies of introduced species.

Aristicthys nobilis, Tilapia nilotica and red tilapia. Sir, Francis Day, the author of the classical work on the Fish fauna of Indian region, was probably the first person who tried to introduce the brown trout, Salmo trutta fario in the Nilgiri waters in the year 1863, but his attempt was unsuccessful (Jhingran, 1975).

Conclusion

The non-native fish species invasion in the freshwater body is a one of the serious issue of Indian fisheries. The invasion of alien species in water body not only cause habitat loss and competition but also causing genetic variation among the native species of the water body. There is an accidental escape of fishes into theopen water body results in their easy establishment andadaptation. It may be because of their hardy, strong,omnivorous nature, modification in feeding habitat, faster-growing ability, high breeding rate, easy coping with thechange of environment, etc. This attributes to the changein aquatic ecosystem biotic and genetic structure. Exotic fishes exertnot only a deleterious effect on native species but also,affect the ecological, genetic, economic, and health.Therefore, it is an alarming stage and needs to takesimmediate action to prevent their import and escape. Exotic fish introduction for aquaculture have impacted on the fish biodiversity and have provided serious warnings of the various effects. Exotic fish introduction for aquaculture have impacted on the fish biodiversity and have provided serious warnings of the various effects. ◆◆◆

Ishita mehta

Seaweed Culture

A Future Nutritional Alternative

Carbohydrate 16-45 percent, Amino acid 9-20 percent, Protein 10-35 percent, Lipid 8-34 percent and Ash content 0.4-14 percent on fresh weight basis

Introduction

Seaweeds are macroscopic aquatic plant algae, which can be found in both marine and freshwater ecosystem. They grow in the in the rocky intertidal as well as in the sub-tidal regions up to a certain depth where very little sun light is reachable. Seaweed is one of the food sources of aquatic ecosystem but, with the growing technologies, advancement and knowledge about the nutritional value of seaweed; it is now used as food for humans and plays a vital role in chemical and pharmaceutical industries. Presently, seaweed is consumed across all over the globe mainly in east and south Asia.

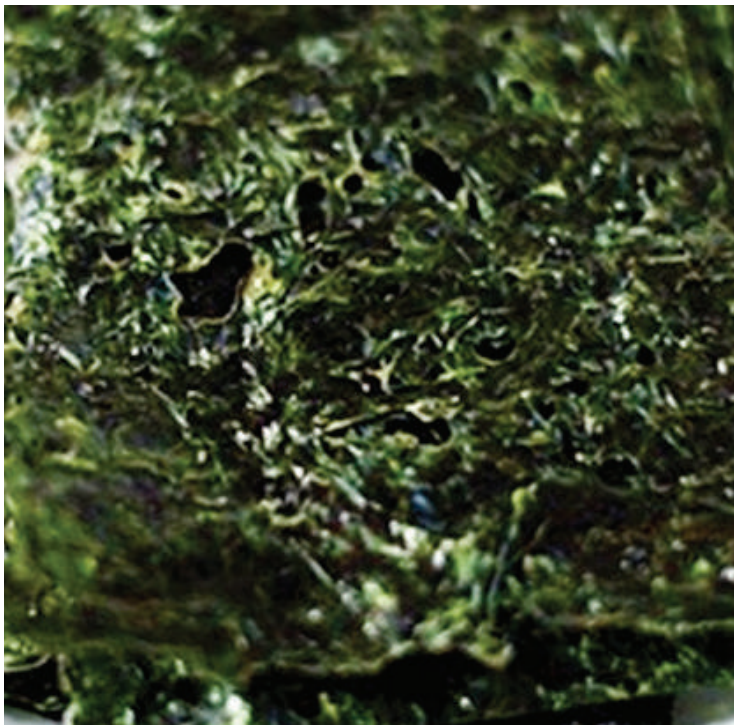
With the passing time, human being is more concerned about their heath and diet. Seaweed are the organisms capable of providing bioactive compounds for producing novel medicinal and as a source of food and a number of pharmaceutical and industrial products for humans. Presently, they are widely researched for human nutritional purpose and correspondingly utilized as functional foods.

Nutritional Value of Seaweed

Seaweed is one of the good sources

of nutrition. It is the complete and balanced diet that contains all the nutritive value, necessary for human consumption that can help to build and sustain the broad nutritional balance of vitamins, minerals and vital nutrition likes: - carbohydrates, protein, essential amino acid, dietary fibers. Biochemical constituents of eighteen species of marine macroalgae belonging to Chlorophyta, Phaeophyta and Rhodophyta collected from Okha coast, Gulf of Kutch, India and compared their biochemical composition are Carbohydrate 16-45 percent, Amino acid 9-20 percent, Protein 10-35 percent, Lipid 8-34 percent and Ash content 0.4-14 percent on fresh weight basis (Nirmal et al. (2010). In general, the red and green species contain relatively high protein levels, with an average value of 4-50% (w/w) dry weight, compared to brown species, which contain between 1 and 29% (w/w) dry weight (Harnedy & Fitz Gerald, 2011). Seaweeds contain relatively low levels of lipids (1-5%) when compared to other plant seeds such as soy and sunflower, but majority of those lipids are polyunsaturated fatty acids (PUFAs) (MacArtain, Gill, Brooks, Campbell, & Rowland, 2007; Makkar, et al., 2016).

Seaweeds have great variability of nutritional composition. Many dieticians suggest them as a good alternative as it has low caloric food and rich in protein, vitamins (A, B1, B12, C, D and E, riboflavin, niacin, pantothanic acid and folic acid), minerals and important bioactive compounds. The majority of those lipids in seaweeds are long chain polyunsaturated ω-3 and ω-6 fatty acids. Different seafood has different nutritional properties. It has been found that brown algae are richer in soluble fiber and iodine, while, red and green algae are richer in carbohydrate content. The highest iodine content is found in brown seaweed with dry Laminaria having 1500 to 8000 ppm and Fucus having 500 to 1000 ppm (Dharmananda, 2002). Seaweeds are also a good source of bioactive compounds, which are characterized by ICAR-Central Institute of Fisheries Technology, having broad spectrum of biological activities



Seaweed used as Food

Recently the popularity of using seaweed as a food supplement is increasing day by day. The admiration of sushi and Asian cuisine in Western countries has stimulated the seaweed economy. The migration of Asian population across the world has promoted the discovery of new ingredients from seaweeds and has fuelled the creation of new dishes by chefs in restaurants. Among the macroalgae traditionally consumed by Asian population, Ulva,

Seaweed is one of the good sources of nutrition. It is the complete and balanced diet that contains all the nutritive value, necessary for human consumption that can help to build and sustain the broad nutritional balance of vitamins, minerals and vital nutrition likes: - carbohydrates, protein, essential amino acid, dietary fibers.

Laminaria and Porphyra (Atlas & Bartha, 1998) are well known. Emad (2011) noted that marine algae have been used as a novel food with potential nutritional benefits in food and pharmaceutical industry. The mean intake of seaweeds in Japanese diet has been reported to be approximately 7 gram per person per day (Center for Food Safety and Applied Nutrition, 2013). The seaweed species used in Asian cuisine and their common uses as found in the literature. These are grouped under three seaweed phylum: Chlorophyta (green), Ochrophyta (brown) and Rhodophyta (red) based on their pigmentation. Species such as Wakame or Kombu requires cooking to overcome their chewy texture while others can be eaten raw (Nori and sea lettuce) (Mouritsen, 2009). The valorization of seaweed as sea vegetables generally involves drying or salting processing treatments. Seaweed drying is one of the primary steps to allow transportation. They are either sun dried, air dried or dehydrated by salt addition (Fleurence, 2016; Venugopal, 2011). Seaweed can also be macerated with specific enzymes to improve protein bio-accessibility through hydrolysis of dietary fibers resistant to human digestion but this process hasn't reach any commercial application yet (Fleurence, 1999a).

The dried sheet of Porphyra commonly known as Gim in Korea, nori in Japan and zincai in China is used in soups, sushi or onigiri (rice balls). Dried sheet of Pyropia, is used as a flavouring ingredient in salads, omelettes and soups in Philippines. Chondrus crispus ('Irish moss' or carrageenan moss) is used in food additives, along with Kappaphycus and Gigartinoid seaweed. Porphyra is used in Wales to make laverbread (sometimes with oat flour). In northern Belize, seaweed is mixed with milk, nutmeg, cinnamon and vanilla to make "dulce" ("sweet").

Around 844 species of seaweeds have been reported from Indian seas, their standing stock is estimated to be about 58,715 tonne (wet weight). Out of the 844 seaweed species, India possesses around 434 species of Red Algae, 194 species of Brown Algae, and 216 species of Green Algae.

Types of Seaweed:

Seaweed is of 3 types: Brown (Phaeophyceae), Green (Chlorophyceae) and Red algae (Rhodophyceae). Brown seaweeds are usually large, and range from the giant kelp that is often 20 m long, to thick, leather-like seaweeds from 2-4 m long, to smaller species 30-60 cm long. For example: Alaria esculenta (dabber locks, wing kelps, Murlins). Red seaweeds are usually smaller, generally ranging from a few centimetres to about a metre in length; however, red seaweeds are not always red. For example: Acrosorium venulosum, Chondria capillaries (carrageen moss, irish moss) Green seaweeds are also small, with a similar size range to the red seaweeds. For example: Ulva rigida(sea lettuce), Prasiola calophylla.

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Seaweed in India:

Seaweeds are abundant along the Tamil Nadu and Gujarat coasts and around Lakshadweep and Andaman & Nicobar Islands. Rich seaweed beds occur around Mumbai, Ratnagiri, Goa, Karwar, Varkala, Vizhinjam and Pulicat in Tamil Nadu, Andhra Pradesh and Chilka in Orissa.

Other uses of Seaweed

Other than food seaweed is also very beneficial for medicinal,

climate change mitigation, biofuel and so on. The cultivation of seaweed in the open water body can act as a form of carbon sequestration to mitigate climate change. Studies have reported that near shore seaweed forests constitute a source of blue carbon, as seaweed detritus is carried into the middle and deep ocean thereby sequestering carbon. Seaweed also has medicinal use, for example alginates are used in wound dressings (see alginate dressing), and dental moulds. In microbiology, agar is used as a culture medium. Carrageenans, alginates and agaroses, with other macroalgal polysaccharides, have biomedicine applications. Delisea pulchra may interfere with bacterial colonization. Sulfated saccharides from red and green algae inhibit some DNA and RNA-enveloped viruses. Seaweed extract is used in some diet pills. Other seaweed pills exploit the same effect as gastric banding, expanding in the stomach to make the stomach feel full.

Conclusion

With the years the seaweed becomes very important source of nutrition for aquatic life as well as human being. The future prospects of seaweed are very positive, with significant potential for growth in various sectors due to its sustainability, nutritional value, and ability to combat climate change; experts predict a substantial market expansion, particularly in applications like food, pharmaceuticals, cosmetics, and carbon sequestration. A number of peoples and communities around the world have been using seaweeds as a food since time immemorial and recently these marine plants have been showcased as a food for future. Seaweed contains a various nutritional compounds also possessing several functional properties that may lead to many culinary innovations. The seaweeds may be used as a flavoring agent or as a texturizing agent. Edible seaweeds are rich in bioactive compounds such as soluble dietary fibers, proteins, peptides, minerals, vitamins, polyunsaturated fatty acids and antioxidants. Seaweeds have been shown to have therapeutic properties for health and disease management, such as anticancer, anti-obesity, antiviral, antifungal, antibacterial anti diabetic, anti-hypertensive, immuno- modulatory anti-hype lipidemic, antioxidant, anticoagulant, anti inflammatory, anti estrogenic, thyroid stimulating, neuro protective, and tissue healing properties. ◆◆◆

(Source: https://www.thepharmajournal.com/archives/2019/vol8issue8/PartB/8-5-67-445.pdf)

In an interview with Aqua Post, **Chef Sandeep Supkar,** a seasoned chef with 24 years of experience, works in renowned hotels. He belief in simple and precise cooking with sustainable products. With this he also suggested some seafood dishes which can be tried and brief us about his favorite recipe of seafood

Interview

Sandeep Supkar

◆ **Give us a brief about yourself and your profile**

- I am Chef Sandeep Supkar, a seasoned chef with 24 years of experience, ranging from world-class cruise lines to renowned luxury resorts. I have built a reputation for my exceptional skills in both traditional and contemporary cuisines, blending global flavors with a deep respect for authentic cooking techniques. My current designation is Director of Food & Beverage at Five Iron Golf, India.

◆ **When it comes to seafood, what is your view point on Seafood preparation?**

As a chef, my viewpoint on seafood preparation revolves around respecting the integrity of the ingredient while highlighting its natural flavors. Freshness is absolutely key when it comes to seafood—whether its fish, shellfish, or crustaceans—so sourcing the highest quality, sustainable products is essential. When preparing seafood, I believe in keeping the process simple yet precise. Overcooking seafood is a common mistake, as it can quickly lose its delicate texture and flavor. Light cooking methods, such as grilling, steaming, poaching, or pan-searing, help preserve the

freshness and enhance the natural taste. I also think that pairing seafood with complementary ingredients, such as citrus, herbs, or light broths, helps balance its flavors without overpowering them. Seasoning should be done thoughtfully and delicately, allowing the seafood to shine without masking its unique taste. Sustainability is a crucial aspect of my approach to seafood preparation. It's important to ensure that the seafood is ethically sourced and harvested responsibly to support the health of our oceans and marine life.

◆ **What are the best seafood items/ dishes you would like to suggest our reader?**

As a chef, there are numerous exquisite seafood dishes that I would recommend to your readers, each offering a unique taste experience. Here are some of the best seafood items and dishes I would suggest:

- ❍ Grilled Salmon with Herb Butter
- ❍ Pan-Seared Scallops with Lemon Garlic Sauce
- ❍ Lobster Thermidor Fish Tacos with Mango
- ❍ Salsa Chilean Sea Bass with Truffle Oil
- ❍ Seafood Paella
- ❍ Shrimp Scampi Pasta
- ❍ Mussels in White Wine and Garlic
- ❍ Grilled Oysters with Lemon and Parmesan
- ❍ Crispy Fried Calamari

◆ **Please give us a brief recipie of a seafood dish you would like to suggest for this edition and also tell us about its cultural significance (if there is any)**

Shrimp Scampi Pasta recipe

Ingredients:

- ❍ 400g (14 oz) spaghetti or your preferred pasta
- ❍ 500g (1 lb) large shrimp, peeled and deveined
- ❍ 4 tablespoons unsalted butter
- ❍ 2 tablespoons olive oil
- ❍ 4 garlic cloves, finely minced
- ❍ 1 teaspoon red pepper flakes (optional, for a little heat)
- ❍ 1/2 cup dry white wine (or chicken broth)
- ❍ 1 tablespoon lemon juice (freshly squeezed)
- ❍ Zest of 1 lemon
- ❍ Salt and freshly cracked black pepper, to taste
- ❍ 1/4 cup fresh parsley, chopped
- ❍ Grated Parmesan cheese (optional, for serving)

Instructions:

Cook the pasta:

- ❍ Bring a large pot of salted water to a boil.
- ❍ Cook the pasta according to the package directions, until al dente.
- ❍ Drain, reserving about 1/2 cup of pasta cooking water. Set aside.

Prepare the shrimp:

- ❍ While the pasta cooks, heat the olive oil and 2 tablespoons of butter in a large skillet over medium-high heat.
- ❍ Add the shrimp to the pan in a single layer.
- ❍ Cook for 1-2 minutes per side, until they turn pink and opaque.
- ❍ Remove the shrimp from the skillet and set aside.

Make the scampi sauce:

- ❍ In the same skillet, reduce the heat to medium.
- ❍ Add the minced garlic and red pepper flakes (if using), sautéing for about 30 seconds until fragrant, but be careful not to burn the garlic.
- ❍ Pour in the white wine (or chicken broth) and lemon juice, stirring to combine.
- ❍ Allow the sauce to simmer for 2-3 minutes, reducing slightly.
- ❍ Add the remaining 2 tablespoons of butter, stirring until the butter melts and the sauce is smooth.

Combine the pasta and shrimp:

- ❍ Add the cooked pasta to the skillet with the scampi sauce.
- ❍ Toss everything together, adding a bit of reserved pasta cooking water if needed to help the sauce coat the pasta evenly.
- ❍ Return the shrimp to the pan and toss again to combine.
- ❍ Season with salt, pepper, and lemon zest.
- ❍ Serve

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(Views expressed are personal. References can be availed on request.)

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