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FROM CELLS TO ECOSYSTEMS: EXPLORING LIFE SCIENCE RESEARCH VOLUME II

Editors:
Dr. Surendra S. Kadam
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Editors

Dr. Surendra S. Kadam

Department of Zoology, Gokhale Education Society's Arts, Commerce and Science College, Jawahar, Dist. Palghar, M.S.

Dr. Alok Ranjan Sahu

Department of Botany,
Vikash Degree College,
Bargarh, Odisha

Mr. Bhuvaneshwaran T

Department of Fish Nutrition and Feed Technology, ICAR - Central Institute of Fisheries Education, Mumbai

Dr. Shrikant Verma

Department of Personalized and Molecular Medicine,
Era University, Lucknow, U.P.

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PREFACE

The vast tapestry of life, from the smallest cells to the most complex ecosystems, is a subject of endless fascination and critical importance. It is a domain where every discovery, no matter how small, can have profound implications for our understanding of the natural world and our place within it. "From Cells to Ecosystems: Exploring Life Science Research" is a celebration of this exploration, capturing the essence of scientific inquiry across the diverse and interconnected fields of life science.

This book brings together a collection of research and insights that span the full spectrum of life sciences. Each chapter delves into a different aspect of the biological world, offering readers a comprehensive overview of the latest advancements and enduring questions that drive this field forward. From molecular biology and genetics to ecology and environmental science, the breadth of topics covered reflects the intricate and multifaceted nature of life itself.

The creation of "From Cells to Ecosystems" has been a journey marked by collaboration, discovery, and a shared commitment to advancing our understanding of life. We have had the honor of working with leading scientists, researchers, and educators whose contributions are at the forefront of their respective fields. Their work not only expands our knowledge but also inspires new questions and avenues for future research.

Our aim with this book is to provide a resource that is both informative and inspiring. We seek to highlight the connections between different areas of life science research, emphasizing the importance of a holistic understanding of biological systems. By showcasing the diversity of life science studies, we hope to foster a deeper appreciation for the complexity and beauty of the natural world.

"From Cells to Ecosystems" is dedicated to the scientists and researchers who dedicate their lives to exploring the mysteries of life. Your passion, perseverance, and curiosity are the driving forces behind the advancements we celebrate in these pages. We also extend our gratitude to the educators who inspire the next generation of life scientists, ensuring that the pursuit of knowledge continues to thrive.

Editors

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REVIEW ON POTENTIAL UTILIZATION OF LACTIC ACID BACTERIA AS PROBIOTICS TO ENHANCE FISH HEALTH IN THE CONTEMPORARY AQUACULTURE SYSTEM

Madhuri Y. Bhande*[1,2] and Savita Bondhare[1]

[1]Department of Zoology, Hutatma Jayvantrao Patil Mahavidylya, Himayatnagar, M.S.

[2]Adarsh College, Hingoli, M.S.

Corresponding author E-mail: bhandemadhu@gmail.com

Abstract:

A dynamic field capable of addressing issues with secure food supply and a healthy diet is aquaculture. Serious issues with fish farming include the growth of organic pollution, the abundance of opportunistic microorganisms in the aquatic environment of fish farms, and the worldwide contamination of feed by mycotoxigenic fungus. The effects are weakening of the general condition of fish, immunosuppression, the formation of numerous diseases aggravated by drug resistance, the buildup of antibiotics and chemical substances in tissues. Antibiotics may be substituted with probiotics. One biological strategy for keeping fish in a normal physiological state and boosting their production is the application of probiotics. The objective of this review is to provide a scientific rationale for the safest microorganisms—lactic acid bacteria—to be used in the production of probiotics for aquaculture. The review that is being provided offers standards for choosing potential strains for successful probiotic production. The advantages of lactic acid bacteria for the prevention or control of infectious illnesses in cultured fish are considered. Members of the fish microbiome, lactic acid bacteria exhibit antagonistic action against opportunistic pathogens, fungi, and viruses that contaminate waterways, microbiologically ruin feed, and infect aquatic animals. The review offers details on numerous studies that have evaluated the potential of lactic acid bacteria or products derived from them in aquaculture.

Keywords: Probiotic, Lactic Acid Bacteria, Aquaculture, Fish Health.

Introduction:

In fermented foods, lactic acid bacteria (LAB) are important probiotic organisms that are usually regarded as harmless. LAB improve plant health, detoxify dangerous pollutants, and control soil organic matter and the biochemical cycle. Decomposing plants,

traditional fermented milk products, and the natural flora in the human gastrointestinal tract and vagina are all sources of them. Investigating LAB found in unidentified niches could result in the isolation of rare species. They are acclimated to acidic conditions and high sugar concentrations, although their classification is rather complicated. LAB strains improve soil fertility and health, making them attractive options for sustainable agriculture. As a result, they have drawn a lot of interest in sustainable agriculture. Plant growth is stimulated and shoot and root growth is boosted by LAB metabolites. LAB can be used as fertilizers to increase soil organic matter, speed up biodegradation, and produce metabolites of bacteriocin and organic acid. However, LAB show an antagonistic effect against phytopathogens, suppressing fungal and bacterial populations in the rhizosphere and phyllosphere. The effectiveness of LAB bioremediation and the detoxification of mycotoxins and heavy metals have been suggested by numerous research. On the other hand, metabolically tailored tools and LAB genetic manipulation offer effective cell factories specifically designed to generate advantageous industrial and agricultural products.

It is anticipated that the consumption of fish and seafood will rise by over one third in the next years due to population growth, the development of low-middle-income nations, and shifting dietary preferences (1). Global aquaculture will become a more significant part of fish production worldwide as a means of satisfying consumer demand for safe fish products. The breeding and raising of aquatic organisms (fish, crabs, shellfish, and algae) in both constructed and natural reservoirs, as well as on specially designed marine plantations, is known as aquaculture. Approximately 600 different species of aquatic animals are raised through aquaculture worldwide. among which the present expansion of species production includes shrimp, bivalve shellfish, salmon, tilapia, carp, and catfish. One of the food industries with the quickest rate of growth in the world is aquaculture, whose output has increased annually by 7.5% since 1970. In 2018, this sector of fish-breeding was a substantial source of fish eaten − 52%. By 2030, aquaculture production is predicted to reach 109 million tons, with low- and middle-income nations accounting for over 90% of this expansion (2). Better integration into production and supply networks, enhanced control over production processes, and other factors have contributed to aquaculture's domination over fisheries.

The FAO estimates that in order for this industry to flourish at all, it will need to overcome significant environmental obstacles, necessitating the establishment of a new

sustainable aquaculture development plan.Emergence of novel pathogens leading to unknown diseases that spread quickly, even across national borders, and result in significant production losses roughly every three to five years is the global trend in aquaculture.The sustainability of aquaculture production in many nations has already been impacted by the rapid global expansion of intensive aquaculture, which has increased the prevalence of transboundary viral, bacterial, parasitic, and fungal illnesses in cultured aquatic animals.Aquatic animal diseases in the US can result in up to $6 billion in annual economic losses, making it one of the major major preventive factors for the growth of the aquaculture trade. High planting densities and highly nutritious feeds used in commercial fish farming can raise the amount of organic pollutants and opportunistic bacteria in the aquatic environment of fish farms as well as in the organs and tissues of the fish. Due to a decline in the fish's overall resistance caused by a number of variables, opportunistic autochthonous microbes start to exhibit pathogenic properties and cause acute illnesses that develop into chronic ones, which ultimately result in the fish's death.

The effective utilization of probiotics in aquaculture

Probiotics have the potential to reduce dependency on antibiotics, vaccinations, and other drugs as a substitute antimicrobial agent, as numerous studies have shown. In this field of fish farming, interest in them has been continuously rising because they can also improve fish health in aquaculture. Probiotics are utilized as defense mechanisms to halt the transmission of disease and improve the composition of the microbiota. Probiotics improve output and feed conversion efficiency while also having a positive impact on digestion. It is feasible to enhance the reservoir's water quality by using them. In this case, probiotics work in water by either functioning as a probiotic biofilter to assist the water develop microbiologically and eliminate opportunistic microorganisms, or by directly suppressing the pathogen in culture water (biocontrol). Probiotics enhance resistance to disease and innate immunity. Reduce the amount of stress caused by sudden dietary changes, missing feeding times, using electronics too much, and other issues. Basic research has shown that probiotics' interactions with aquatic animal bodies and gut microbiota go much beyond just "squeezing out" dangerous bacteria. Supplemental probiotic strains from food or medicine interact with the host's microbiome (3).

The fermentation activity (amylolytic, proteolytic, cellulolytic, etc.) of probiotics allows them to generate a wide range of physiologically active molecules, including lipids, organic acids, alcohols, vitamins (particularly group B), and compounds with a tetrapyrrol

structure. Many of them actively participate in vitamin and energy exchanges after being absorbed into the bloodstream, which is crucial for the host organism's ability to survive. Organic acids increase the intestine's peristalsis and secretion, which facilitates feed digestion and increases the resorption of calcium and iron. Bacterial polyphosphates contribute to the uptake of sugars into the cell. carrying out hexokinase functions Probiotics can also produce metabolites with antitoxic properties that decrease the buildup of heavy metals in fish tissues and water, offering direct defense against A probiotic's efficacy is mostly determined by the candidate strain that is selected correctly, which serves as its foundation. There are no special restrictions for the source of release of probiotic microorganisms when using probiotics in fish aquaculture.

Important components of the fish mucosa, the skin, gills, and gut make up a major portion of the first line of defense against infections; also, the microbiota of these organs is what gives rise to host immunity. A team of researchers lead by Miao Wang (4) demonstrated, using tilapia as an example, that probiotics added to water can increase the amount of beneficial host microbiota and the activity of immune enzymes in the immune tissues of the fish mucosa.

The intestinal wall is covered in a biofilm by the intestinal microbiota, which is a separate "organ" that develops during the organism's growth.The intestinal biofilm's collective immunity is a potent defense mechanism that keeps foreign strains out and limits the amount of dysbiosis that can be fully corrected with live probiotic culture preparations. These preparations cannot replenish the transient bacterial pool inside the biofilm because of biological incompatibility.

However, there may be a justification for using probiotic supplements in this situation. First, the principle of competitive exclusion explains the efficiency of utilizing probiotic microbes that are not yet prominent in the regular gut microbiota of larvae or growing fish. Probiotics' capacity for adhesion or colonization makes them competitors for resources and mucosal attachment sites.

Second, the intestinal contents contain a variety of symbionts and parasites, including helminths, protozoa, and transitory bacteria, all of which play an important part in the regular operation of aquatic animal organisms. Even though they are temporary, probiotic strains that are given to a hydrobiont's body along with food or water secrete biologically active metabolites, signaling molecules, antibiotics, and bacteriocins. They also interact with the microbiota, protozoa, and parasites and improve the host organism's

physiological systems. Stability, high enzymatic activity, and rapid multiplication are the most crucial characteristics for transitory probiotic bacteria (5).

To maximize the level of immune responses and disease resistance of aquatic animals against targeted pathogens, preliminary research on the frequency and duration of probiotics administration (e.g., daily, daily interval, weekly, or weekly interval) is crucial when using probiotics as a tool to combat fish diseases in the aquaculture sector. Understanding the LD50/LC50 of the target pathogen in the target fish or shellfish is another crucial requirement for the successful use of probiotics as an alternative to conventional antibiotics. This information enables the probiotic's effective dosage to be determined.

Lactic acid bacteria that are probiotics in aquaculture

Lactic acid bacteria (LAB) are highly promising microorganisms for use in aquaculture because they possess several useful features that are necessary for probiotic candidates, as demonstrated by several scientific research. Microorganisms belonging to the genera Lactobacillus, Pediococcus, Enterococcus, Streptococcus, Lactococcus, Vagococcus, Leuconostoc, Oenococcus, Weissella, Carnobacterium, and Tetragenococcus are classified as LAB. They are gomo- and hetero-fermentative, optionally anaerobic, and do not generate spores. Microorganisms known as LAB are safe for both humans and animal

However, other scientists point out that bacterial illnesses may be caused by some of this wide group of bacteria (Lactococcus lactis, Lc. garvieae, Enterococcus sp., Lacticaseibacillus casei, and Lacticaseibacillus rhamnosus) (7). Because humans are the last in this food chain, it is imperative that strains of LAB be carefully evaluated for safety (pathogenicity, virulence, invasive properties, etc.) before adding them to feed probiotics, water supplements, or probiotics for fish disease control in aquaculture (7).

Because of the antimicrobial activity of their metabolites, which include organic acids (primarily lactic and acetic acid), biocides - carbon dioxide (CO2), hydrogen peroxide (H2O2), lysozyme, phenyl-lactic acid, fatty acids, antibiotics (reuterocyclin) or bacteriocins, LAB can be used as biological food preservatives. Lactic acid is the primary byproduct of LAB. During fermentation, equimolar amounts of lactic acid, acetic acid/ethanol, and carbon dioxide (CO2) are produced by heterofermentative lactic acid bacteria.

Lactic acid has a limited level of antibacterial action at low doses, particularly at neutral pH. When it comes to bacteria, mold, and yeast, acetic acid is a stronger inhibitor

than lactic acid. Because they are hydrophobic, un-dissociated forms of acids diffuse through the microbial cell wall before dissociating inside the pathogen cell. From the mixture of acids produced by LAB, acetic acid also interferes with the preservation of cell membrane potential, inhibits active transport, and destroys pathogens' cell membranes, whereas lactic acid primarily lowers intracellular pH and inhibits numerous metabolic functions (8).

Antimicrobial compounds including reuterine, bacteriocins, antifungal peptides, etc. are known to be produced by LAB. Among these, bacteriocins—extracellular peptides produced by ribosome synthesis or protein molecules—have a unique role because of their ability to function either bacteriocidally or bacteriostatically against certain kinds of microbes. Research has shown that bacteriocins produced by certain strains exhibit antibacterial activity against more phylogenetically distant Gram-positive and occasionally even Gram-negative bacteria. Previously, it was believed that these strains' bacteriocins were exclusively active against other closely related LAB species (9). Microorganisms that cause illnesses in fish and shellfish, such as Aeromonas salmonicida, A. hydrophila, Edwardsiella tarda, Pasteurella piscicida, and Vibrio anguillarm, are among those that are inhibited by the antibacterial compounds of LAB.

In addition to inhibiting the synthesis of mycotoxin and detoxifying mycotoxins in plant raw materials used to make fish feed, antifungal peptides of LAB have the potential to be antifungal against mycotoxigenic fungi of the genera Aspergillus, Fusarium, Penicillium, and Rhizopus, which is significant for the fish industry (10). The potential antiviral activity of Pediococcus acidilactici and Pediococcus pentosaceus against respiratory and gastrointestinal viruses, including rotaviruses, noroviruses, enteroviruses, and salmonid viruses, has been demonstrated by their antifungal activity and their capacity to inhibit the formation of zeralenone LAB in multiple in vitro and in vivo studies. Researchers led by Son V.M. have confirmed that feeding the probiotic Lactiplantibacillus plantarum through diet has improved the grouper Epinephelus coioides' innate immune responses and resistance to iridovirus (11).

Numerous researchers believe that direct interaction with the virus, the induction of antiviral gene expression, or the activation of host immune system processes are the mechanisms underlying LAB's antiviral activity. The body's total defense against infections is increased by lactobacteria, which also promote lysozyme secretion, phagocytosis activation, and humoral and cellular immunity (12). Furthermore, they are able to absorb

compounds that trigger hypersensitivity reactions and allergic reactions to food ingredients. They aid in the development of "oral tolerance" to food antigens, which helps the body cope with food allergies.

When it comes to the application of LAB in aquaculture, their antioxidant activity merits particular consideration. Studies by Castex *et al.,* have demonstrated how Pediococcus acidilactici, a dietary probiotic, increases antioxidant protection and lowers oxidative stress levels in shrimp. *Agathosplenia stylirostris*

Conclusions:

One of the fisheries sectors that is developing the fastest is aquaculture, which was created to supply the increasing demands for protein of the population. Infectious diseases of fish and shellfish, however, pose a significant obstacle to the expansion of production in this area of fish farming. In order to find a solution, it is imperative to look for novel, ecologically friendly antimicrobials that can replace chemicals and antibiotics. One such antimicrobial substitute is probiotics.

They are useful in lowering financial losses during feed changes or transportation, as well as in the prevention and treatment of gastrointestinal disorders with a bacterial etiology, after antibiotic medication and immunization courses. Probiotic strains known as LAB are widely utilized to fight diseases that are bacterial, fungal, and partially viral. Their actions are intended to improve digestion, immunity, defense against infections, and the growth and reproduction of fish and shellfish. As a result, probiotics based on lactic acid bacteria (LAB), whose advantageous qualities and safety in both vitro and vivo settings have been extensively studied, are highly efficient, eco-friendly, and appropriate for the whole aquaculture system (basic and supplemental nutrition, water purification, disease prevention and treatment), as well as having a positive impact on the well-being, productivity, and sustainability of hydrobionts as well as the health of consumers.

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FISHERIES KNOWLEDGE AND INFORMATION SYSTEM (FKIS)

Mani Selvam J*, Palsam Karthik Kumar Goud and Dinesh R

ICAR – Central Institute of Fisheries Education, Mumbai – 400 061

*Corresponding author E-mail: manishjagan1998@gmail.com

Abstract:

Fisheries Knowledge and Information System (FKIS) is pivotal in integrating fisheries development stakeholders—farmers, educators, researchers, and extensionists—through a collaborative knowledge triangle. This system facilitates the creation, sharing, and application of fisheries-related technology, knowledge, and information, enhancing farming practices and livelihoods. Central to FKIS are its educational programs, research initiatives, and extension services, which collectively empower farmers with essential skills and insights. FKIS promotes sustainable fisheries management through mutual learning among stakeholders and addresses the sector's diverse challenges. However, effective information dissemination faces challenges such as inadequate communication channels, varying literacy levels, and language barriers. Addressing these challenges requires leveraging modern ICT tools and enhancing stakeholder coordination to ensure farmers receive timely, relevant, and accessible information. FKIS is a transformative tool in fisheries, bridging the gap between technological advancements and practical application, supporting resilience and sustainable development in fisheries communities.

Keywords: Fisheries Knowledge and Information System; Extension Services; ICT tools

Introduction:

The Fisheries Knowledge and Information System (FKIS) serves as a crucial nexus between individuals and institutions, promoting mutual learning and creating, sharing, and applying fisheries-related technology, knowledge, and information. This system integrates farmers, fisheries educators, researchers, and extensionists, enabling them to draw upon various knowledge sources to enhance farming practices and improve livelihoods. This collaborative integration is often referred to as the knowledge triangle, placing farming communities at its center. The concept of the knowledge triangle emphasizes the interconnected roles of education, research, and extension services in fisheries development. At its core, the FKIS aims to ensure that these components work

synergistically to respond to the needs of farmers. By doing so, it facilitates the exchange of valuable information and practical solutions directly applicable to the farmers' unique circumstances (Sulaiman and Hall, 2004).

Components of Fisheries Knowledge Information System (FKIS)

i. Education: Educational programs within FKIS are designed to equip farmers with the latest knowledge and skills required for modern farming practices. These programs focus on various aspects of fisheries management, from basic aquaculture techniques to advanced biotechnology applications. The goal is to provide farmers with the necessary tools to increase productivity and adapt to changing environmental conditions (FAO, 2011).

ii. Research: Research is a critical component of FKIS, driving innovation and providing evidence-based solutions to complex challenges in the fisheries sector. Researchers within FKIS work on a range of topics, including sustainable fishing practices, disease management, and the development of resilient fish species. By continuously generating new knowledge, research ensures that the information disseminated to farmers is current and relevant (World Bank, 2006).

iii. Extension: Extension services act as the bridge between research and practical application. Extensionists within FKIS play a vital role in translating scientific research into accessible and actionable information for farmers. They conduct field visits, organize training sessions, and provide on-the-spot advice to help farmers implement new technologies and practices effectively. This hands-on support is crucial for fostering innovation at the grassroots level (Roling and Van de Fliert,1998).

iv. Role of farmers: The farmers are at the heart of the knowledge triangle. FKIS recognizes that farmers are not just passive recipients of information but active participants in the knowledge-generation process. By involving farmers in research and extension activities, FKIS ensures that the solutions developed directly apply to real-world conditions. This participatory approach enhances the relevance and effectiveness of the information provided, ultimately leading to improved productivity, income, and welfare for farming communities (Leeuwis and Aarts, 2011). Figure 1 illustrates the knowledge triangle, with research, education, and extension services forming the three corners and farmers positioned at the center of this collaborative framework.

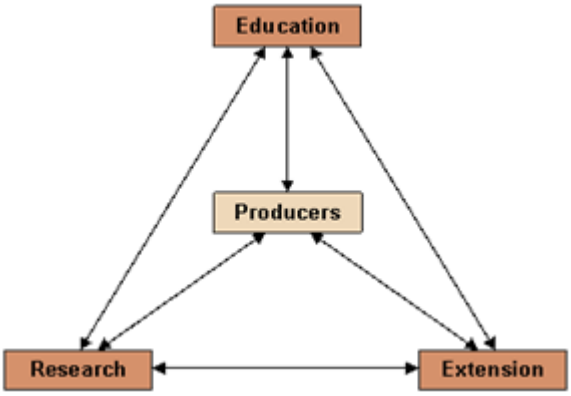

Figure 1: Knowledge Triangle of Fisheries Knowledge Information System

Principles of the Fisheries Knowledge and Information System (FKIS)

The Fisheries Knowledge and Information System (FKIS) is designed to serve as a robust platform for enhancing the capabilities of rural communities engaged in fisheries. The fundamental principles guiding FKIS are designed to promote a comprehensive and integrated approach to fisheries education, research, and extension. These principles are essential for addressing the sector's diverse needs and ensuring sustainable development. The principles of FKIS are outlined as follows:

i. Unified Vision for Integrated Fisheries Education, Research, and Extension

FKIS aims to establish a coherent and unified vision that integrates fisheries education, research, and extension services. This integrated approach is crucial for addressing the technology, knowledge, and information needs of millions of rural individuals involved in fisheries. FKIS enables these individuals to make informed decisions about managing their farms, households, and communities more effectively (FAO/World Bank, 2000). The establishment of a unified vision for FKIS involves bringing together various stakeholders to develop a shared understanding of the goals and objectives of the system. This process requires comprehensive planning and consultation to ensure that the needs and priorities of all stakeholders are considered. The unified vision serves as a roadmap for the development and implementation of FKIS initiatives, guiding the efforts of educators, researchers, and extensionists toward common objectives.

ii. Promoting dialogue with decision-makers

Effective implementation of FKIS requires strong support and commitment from decision-makers in government and development organizations. FKIS promotes an ongoing dialogue with these stakeholders to ensure that investment proposals are well-founded

and receive due consideration. This dialogue is essential for securing the necessary resources and support to sustain and expand FKIS initiatives. Dialogue with decision-makers is crucial for securing the necessary support and resources for FKIS. This involves engaging with government officials, policymakers, and representatives from development organizations to advocate for the importance of FKIS and its potential impact on rural communities. Through continuous engagement and communication, FKIS can ensure its initiatives align with national and international development goals, thereby enhancing the chances of securing funding and support.

iii. Equipping FAO and World Bank Staff with guiding principles

To ensure consistency and coherence in the application of FKIS, it is essential to equip FAO and World Bank staff, along with their counterparts in client countries, with a standard set of principles. These principles guide their work in fisheries education, research, and extension, ensuring that their efforts are aligned with the overarching goals of FKIS.

iv. Maximizing benefits from coordinated investments

FKIS emphasizes the importance of coordinated investments in education, research, and extension. FKIS aims to develop a more effective and efficient system by creating synergies between these components. Coordinated investments ensure that resources are utilized optimally, leading to improved outcomes in technology adoption, knowledge dissemination, and overall system efficiency, thus reducing duplication of efforts and maximizing the benefits for rural communities.

v. Sustainable resource management

A key objective of FKIS is to promote the sustainable management of natural resources. Fisheries, by their nature, rely heavily on healthy aquatic ecosystems. FKIS initiatives are therefore designed to help farmers adopt practices that conserve water quality, maintain biodiversity, and reduce environmental impact. Sustainable resource management not only supports long-term productivity but also ensures that the natural resources upon which farmers depend are preserved for future generations (Pretty *et al.,* 2010).

Evolution of information systems in fisheries

The Fisheries Knowledge and Information System (FKIS) has evolved significantly over the years, shaped by technological advancements and the changing needs of the

fisheries sector. The evolution of information systems in fisheries can be traced back to the early efforts to document and disseminate knowledge related to fishing practices, aquatic biology, and resource management. Initially, information was shared through traditional means such as printed publications, face-to-face training sessions, and extension services. These early systems were primarily localized and could not often reach a broader audience efficiently. With the advent of the digital age, significant transformations began to occur. The introduction of computers and the internet revolutionized how information was collected, stored, and shared. Digital databases and online repositories became increasingly common, providing a centralized platform for storing vast amounts of data related to fisheries. These systems enabled researchers, educators, and extensionists to access and share information more readily, enhancing the overall efficiency of knowledge dissemination. The 1990s marked a significant turning point with the advent of Information and Communication Technology (ICT) in agriculture and fisheries. ICT tools such as Geographic Information Systems (GIS), remote sensing, and mobile technologies started to play a crucial role in fisheries management. These technologies allowed for more precise monitoring of fish stocks, improved data collection methods, and better communication channels between stakeholders (Sulaiman, 2003).

Modern ways for dissemination of information

Information has been crucial to societies since the dawn of civilization. Today, we are experiencing an Information Communication Technology (ICT) revolution with profound socio-economic implications for both developed and developing countries. ICTs are vital for advancing agriculture and related fields in our country. Recent ICT innovations in the fisheries sector have significantly transformed the lives of fish farmers. Various ICT initiatives have been launched to expand and develop fisheries technologies, making them more accessible to farmers and enhancing their productivity and sustainability.

Initiatives in the fisheries sector

i. Agricultural Technology Information Centres (ATIC)

Generating information alone is insufficient; ensuring that this information reaches end users promptly and with minimal dissemination loss is essential. The establishment of Agricultural Technology Information Centres (ATIC) enhances interaction between researchers and technology users. ATICs operate as single-window systems, aiming to assist farmers and other stakeholders by solving agriculture-related problems. They offer

technological information, along with technology inputs and products. This information is valuable for farmers, entrepreneurs, extension workers, NGOs, and private sector organizations (Lekshmi and Vipinkumar, 2013).

ii. AGRISNET

AGRISNET is an extensive web portal developed and funded by the Ministry of Agriculture, Government of India, to deliver pertinent information to farmers. This platform leverages Information & Communication Technology (ICT) to serve the farming community by disseminating information and offering various services. The goals of AGRISNET include providing farmers with information on the quality and availability of agricultural inputs, sharing details of various government schemes and recommending fertilizers based on soil testing results, and offering the latest technological information to enhance agricultural productivity (Ministry of Agriculture, 2000).

iii. AGMARKNET

The Agricultural Marketing Information Network (AGMARKNET) was launched in March 2000 by the Ministry of Agriculture, Government of India, to enhance farmers' decision-making capabilities regarding the sale of their produce. This portal aims to streamline the agricultural marketing system by providing transparent and rapid information on the influx of agricultural commodities and their prices to producers, consumers, traders, and policymakers (Mehta, 2009).

iv. Kisan Call Centre (KCC)

The Department of Agriculture & Cooperation (DAC), Ministry of Agriculture, Government of India, established Kisan Call Centres nationwide to provide extension services to the farming community. These centres comprise a network of telecommunication infrastructure, computer support, and human resources dedicated to addressing farmers' queries in their local languages (Lekshmi and Vipinkumar, 2013). Subject Matter Specialists (SMS), equipped with telephones and computers, interact directly with farmers to understand their problems and provide solutions. Each state has its call centres, capable of handling inquiries from any region across the country (Lekshmi and Vipinkumar, 2013).

v. SMS Portal/mKisan Portal

The SMS Portal/mKisan Portal is designed to serve farmers in three primary ways: disseminating information about various agricultural activities, providing a range of

services directly to farmers via SMS in their local languages, and integrating service delivery across different sectors, including Agriculture, Horticulture, Animal Husbandry, and Fisheries. This platform ensures that farmers receive timely and relevant information to support their agricultural endeavors (Ministry of Agriculture, 2000).

vi. Aqua Choupal

Aqua Choupal, a unique web-based initiative by ITC Ltd., provides farmers in Andhra Pradesh with comprehensive information, products, and services to boost productivity, improve farm gate price realization, and reduce transaction costs. Farmers can access information on weather, scientific farming practices, and market prices through this web portal. Additionally, Aqua Choupal facilitates the supply of high-quality farm inputs and the doorstep purchase of shrimp, making the entire process more efficient and beneficial for farmers (ITC, 2003).

vii. Aqua Service Centres

Many unemployed, educated youths have established aqua service centers similar to agri-clinics. These centres provide various services, including soil and water testing, feed analysis, seed quality testing (PCR tests), disease diagnosis, and market intelligence. Additionally, they sell inputs such as feed, fertilizers, pesticides, and other therapeutic products (FAO/World Bank, 2000).

viii. eSagu

Developed in 2004, the eSagu system provides customized solutions to farmers' problems, offering guidance from sowing to harvesting. Farmers send digital photographs and videos of their farm conditions, which are analyzed by agricultural scientists and experts. Based on this analysis, farmers receive timely and appropriate advice. Even small and marginal farmers benefit from this system. Expert advice is communicated to the concerned farmer swiftly. For illiterate farmers, educated coordinators at the village level assist in conveying farm situations or problems to the agricultural experts, who then transmit accurate information back to the farmers (Sulaiman, 2003).

ix. aAQUA (Almost All Questions Answered)

aAQUA is a multilingual online system designed to assist farmers by providing advice, solving their agricultural problems, and answering their questions. Farmers can register on the aAQUA platform either online or via telephone. Once registered, they can

submit their queries on the portal and receive prompt responses (Bhattacharjee and Raj, 2016).

x. One-Stop Aqua Shop

Under the DFID-funded project "Investigating Improved Policy on Aquaculture Service Provision to Poor People," a significant proposal was the establishment of a One-Stop Aqua Shop (OAS). The OAS aims to improve farmers' access to suitable aquaculture technology, government scheme information, rural banking, and microfinance services. Operating as a singular point of access, the OAS provides a comprehensive range of inputs necessary for fish cultivation, such as fish seed, fertilizers, and chemicals. Moreover, it disseminates crucial information on fish farming through brochures sourced from state departments and research institutes. This initiative aims to simplify the procurement process for essential resources and information for the success of fish farming enterprises (Haylor and Savage, 2001).

xi. Fisher Friend Programme (FFP)

Launched in 2009 by the M S Swaminathan Research Foundation, the Fisher Friend Programme (FFP) aims to safeguard fisherfolk from occupational risks and enhance their livelihoods. It delivers essential information in local languages to fishermen, including details on wave height, wind speed, fishing zones, news updates, government schemes, and market prices. The FFP serves marginalized coastal communities across Tamil Nadu, Puducherry, Andhra Pradesh, Kerala, and Odisha, operating in English, Tamil, Telugu, Malayalam, and Odia languages (MSSRF, 2009).

xii. Social media

Social media refers to web-based communication tools that enable users to interact personally with others, either individually or in groups, to exchange information, share opinions and thoughts, and influence decision-making. Users can create, store, retrieve, and exchange information in various formats, such as text, pictures, and videos across the virtual world (Bhattacharjee and Raj, 2016).

Types of Social Media platform in disseminating information

Type of information	Relevant tool	Description	Way to use for fisheries extension
Social networking sites	Facebook, google	Primarily utilized for establishing personal profiles and networks with friends, colleagues, and peers, these platforms are the most widely adopted form of social media due to their extensive personal connectivity.	Facebook facilitates connecting with targeted audiences and evaluating the reach and engagement of innovations and technologies. Farmers can regularly post pictures and videos of their farm operations. To address literacy challenges among fishermen, sharing more visuals such as pictures, videos, and audio on Facebook provides easier comprehension.
Microblogs	Instagram, Twitter	Microblogs, akin to blogs but with character limits (140 for Twitter), enable users to create and share content. They offer high media richness, similar to blogs. The use of hashtags (#) in microblogs enhances content visibility and searchability among users.	The fisheries department and other fisheries institutes can utilize their Instagram and Twitter accounts to share updates on new technological innovations and schemes. By tagging specific clients who would find the information particularly useful, they ensure targeted delivery while benefiting a wider audience.

Content communities	Video (YouTube, Vimeo, Vine) Photo (Instagram, Flickr, Tumbler) Audio (Soundcloud, Podcasts) MS Office docs, PDF, PPT (Slideshare)	These platforms are primarily designed to facilitate easy sharing of specific types of content among numerous users. They offer high media engagement for targeted content and provide an effective means to reach a global audience in an engaging manner.	Information on various farming methods, good management practices, and training can be disseminated through platforms that support video, audio, slides, and documents. These platforms enable sharing with individuals or groups, facilitating the widespread distribution of fisheries knowledge.
Forum, group discussion	Google hangout, Blackboard, Discussion groups (D groups)	Creating and sharing content among users with specific interests or activities is simplified. Media richness varies, as not all platforms support various content formats.	Extension workers can generate content on new innovations, technology, pond management, and disease management, sharing it with users to enhance understanding.
Social integrated messaging platform	Whatsapp, Facebook, snapchat, messenger	These platforms are widely favored for their group messaging capabilities and rich media features, allowing users to create and share various types of content with groups or individuals.	Fisheries extension personnel can establish groups tailored for specific groups of farmers or fishermen, through which they can distribute pertinent information in video, audio, document formats, and more.

Advantages of Fisheries Knowledge Information System

The Fisheries Knowledge and Information System (FKIS) is a transformative tool for farmers, addressing their critical needs in technology, knowledge, and information to enhance decision-making and management of agricultural practices (Hashemi, 2011). This integrated system leverages Information and Communication Technology (ICT) to provide farmers with timely, customized information on agricultural innovations, market dynamics, weather patterns, and sustainable farming practices. One of FKIS's primary benefits is its ability to empower farmers with a diverse range of options tailored to their specific contexts. By disseminating information on cutting-edge technologies and best practices, FKIS enables farmers to adopt strategies that optimize productivity and resilience to environmental challenges (Hashemi, 2011). This personalized approach ensures that farmers can make informed decisions that align with their operational goals and local conditions. FKIS bridges the gap between technological advancements and their practical application in fisheries. Often, new technologies fail to reach their potential due to barriers in information dissemination and adoption. FKIS addresses this by facilitating the transfer of knowledge from researchers to farmers through extension services, training programs, and digital platforms (Teno, 2014). This collaborative approach enhances farmers' ability to adopt innovative practices and fosters a culture of continuous learning and adaptation within the fishers' community. FKIS promotes collaboration and knowledge-sharing among stakeholders, including farmers, researchers, extension workers, and policymakers. By creating platforms for dialogue and exchange, FKIS strengthens the collective capacity to address challenges and seize opportunities in agriculture (Teno, 2014). This inclusive approach enhances the resilience of farming communities and contributes to sustainable fisheries development.

Challenges in information dissemination

Effective dissemination of information faces challenges such as inadequate use of appropriate communication channels, varying literacy levels, reliance on foreign languages, and a preference for oral communication over printed materials. The language used to convey agricultural research information significantly impacts how farmers utilize the information (Mubofu and Elia, 2017). Utilizing local languages enables farmers to effectively apply the information received. Challenges include farmers' limited knowledge of using information from extension officers and researchers and insufficient access to credit for purchasing inputs like improved seeds and fertilizers. Institutions need to be more responsive in addressing these issues and

opportunities. Weak connections between farmers, extension workers, and researchers contribute to poor dissemination of agricultural research findings. Many developing countries need access to accurate and relevant agricultural information.

Conclusion:

The fisheries sector is rapidly advancing, highlighting an increasing demand for effective dissemination of information, technologies, and farming techniques. Limited communication facilities in communities hinder the social, political, and economic empowerment of the majority. Today, fisheries extension services must fulfill diverse roles: providing information on technologies, market prices, and policies, organizing farmers for knowledge exchange, facilitating experiential learning, and offering problem-solving consultancy to support the farming community (De *et al.,* 2008). Farmers now require high-quality information on technological advancements in fisheries to enhance production and navigate market participation effectively. Understanding market price trends is crucial for cultivation planning. To enhance information transfer, modern information technology and improved communication channels between researchers, extension workers, and farmers must be leveraged more extensively.

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EXPLORING THE EFFICACY OF MEDICINAL HERBS IN AQUACULTURE: A REVIEW

Hiba Siddiqui* and Nandita Singh

Department of Zoology,

G.M. Momin Women's College, University of Mumbai

*Corresponding author E-mail: hibasiddiqui108@gmail.com

Introduction:

The aquaculture industry is experiencing rapid growth within the food sector, as it supplies fish for human consumption, serving as a valuable source of protein and fatty acids. (Anderson, *et al.,* 2017). It is a crucial area for the production of fish food. To optimize the production of commercially valuable fish in aquaculture, it is necessary to enhance the weight of each individual fish (Verreth, 1991; Schuchardt, *et al.,* 2008). Multiple studies have demonstrated that incorporating medicinal herbs into the diet of fish has a beneficial impact on their growth and ability to fight diseases (Fig. 1). The inclusion of medicinal herbs in diet enhances its flavor, modifies eating habits, and promotes digestion in fishes by stimulating the production of saliva and other digestive enzymes (Platel *et al.,* 2002; Lee and Gao, 2012). This review presents a examination of the utilization of a few medicinal herbs used in aquaculture.

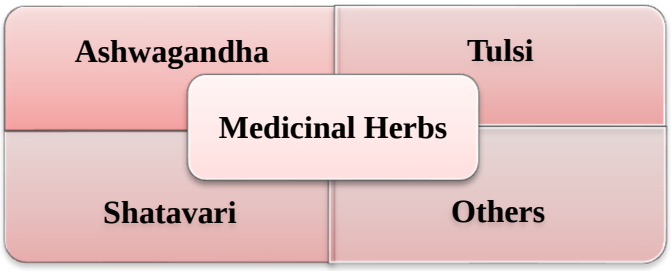

Figure 1: Medicinal Herbs Used in Aquaculture

Ashwagandha (*Withania somnifera)*

Ashwagandha is a rasayana of Ayurvedic system of medicines. It is also called *Withania somnifera* (Latin name), Winter cherry, and Indian Gingseng (Chandrasekhar, *et al.,* 2012; Milner 2016) and belongs to the Family *Solanaceae* (Gupta, *et al.,* 2021). Ashwagandha, in Sanskrit, literally translates to "smell of a horse." This name not only refers to the scent emitted by the plant's fresh roots, but also symbolizes the plant's renowned ability to enhance strength and stamina in individuals who consume it. The bioactive compounds present in Ashwagandha is shown in Fig. 2. It is an exceptional

potent regenerative tonic possessing various pharmacological properties like anti-stress, anti-arthritic, antitumor, neuro-protective, analgesic and anti-inflammatory. (Ray, *et al.,* 2016).

Ashwagandha has been used as a dietary supplement in aquaculture (Table 1).

Table 1: Ashwagandha used as a supplement in diet

Sr.No.	Species	Parameters	Reference
1	Fingerlings of *Oreochromis niloticus*	Growth Performance, Diet Utilization Efficiency, Hematological Indices	Ashraf and Goda, 2008
2	*Carassius auratus*	Growth Performance, Disease Resistance	Ahilan and Nithiya Priyatharshini A., 2015
3	Nile Tilapia (*Oreochromis niloticus*)	Growth Performance, Non-Specific Immune Response, Antioxidant Status, Diseases Resistance to Aeromonas hydrophila	Engy, *et al.,* 2017
4	*Labeo rohita*	Growth Performance, Haemato-Biochemical Response, Disease Resistance to Aeromonas hydrophila	Sharma, *et al.,* 2017
5	*Cyprinus carpio haematopterus*	Growth Parameters (Net Weight Gain, Specific Growth Rate (SGR), Feed Conversion Ratio, Gross Conversion Efficiency (GCE), Protein Efficiency Ratio)	Nazir and Chauhan, 2018
6	*Labeo rohita*	Survival, Growth, Flesh Quality	Srivastava, *et al.,* 2020
7	*Labeo rohita*	Growth Rate, Feed Conversion Ratio, Condition Factor, Protein Efficiency Ratio, Gross Protein Retention	Rana and Kumar, 2020
8	*Litopenaeus vannamei*	Growth Performance, Digestive Enzymes, Intestinal Histo-Morphometry, Antioxidant Biomarkers and Antioxidant-Related Genes, Immune Response, Resistance against V. harveyi Infection	Abdel-Tawwab, *et al.,* 2022
9	*Channa punctatus*	Hematological Index, Total Protein, Lysozyme Enzyme Activity	Trivedi, *et al.,* 2023

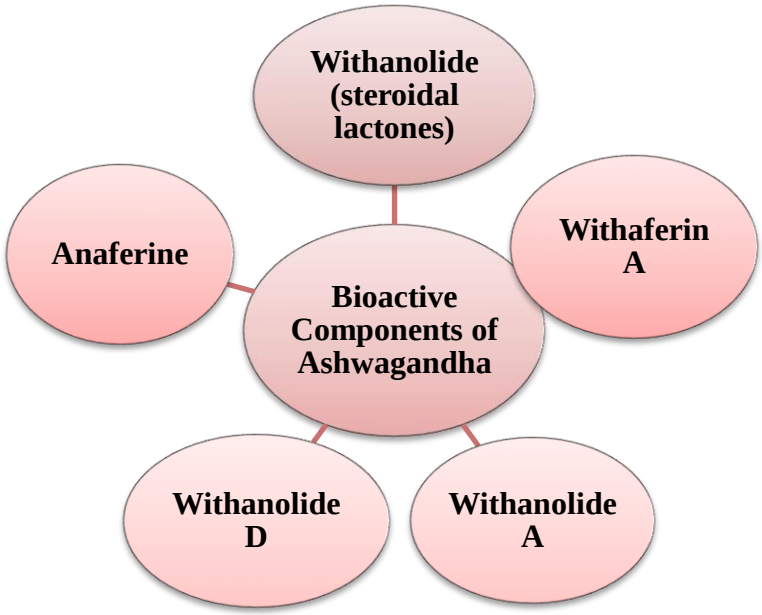

Figure 2: Bioactive Constituents of Ashwagandha

Shatavari (*Asparagus racemosus*)

Table 2: Shatavari used in diets in Aqauculture

Sr.No.	Species	Parameters	References
1.	*Channa punctatus*	Average Body Weight	Borkar, *et al.,* 2014
2.	*Labeo rohita*	Cellular Immune Reaction	Sharma, *et al.,* 2018
3.	*Labeo rajasthanicus*	Growth Performance, Nutrient Utilization, Feed Conversion, Survival	Keer, *et al.,* 2020
4.	Genetically Improved Farmed Tilapia (GIFT) Fry	Growth Performance	Parmar, *et al.,* 2020
5.	*Channa punctatus*	Hematological Index, Total Protein, Lysozyme Enzyme Activity	Trivedi, *et al.,* 2023
6.	*Clarias gariepinus*	Growth Performance, Haematological Parameters, Carcass Composition	Oladipupo, 2023

It is commonly referred to as Asparagus, Wild Asparagus, Asparagus Root, and Satavar. The roots of this plant exhibit both fibrous and tuberous characteristics (Alok *et al.,* 2013). The plant is a valuable flowering medicinal plant found in tropical and subtropical regions such as Bangladesh and India. It has been documented to possess

anti-aging properties, increase longevity, and boost immunity. Shatavari leaf and root contain a range of bio-active substances, including polyphenols, polysaccharides, steroidal saponins, flavonoids, and oligosaccharides (Chawla *et al.,* 2011; Fuentes-Alventosa, *et al.,* 2013), which stimulate fish growth by enhancing cellular metabolic activities (Table 2).

Tulsi (*Ocimum tenuiflorum*)

Ocimum sanctum, a member of the *Lamiaceae* family, is commonly called 'Tulsi', 'queen ofplants', 'holy basil', and 'the mother medicine of nature' (Sikotariya, *et al.,* 2019). It is a Southeast Asian Ayurveda plant with a long practice of traditional usage (Parveen, *et al.,* 2023). Eugenol (l-hydroxy-2-methoxy-4-allylbenzene), which is the active component found in *Ocimum sanctum* L., is primarily responsible for the therapeutic properties of Tulsi. Scientific evidences are available on various medicinal aspects i.e. antimicrobial, antidiabetic, hepatoprotective, anti-inflammatory, radioprotective, immunomodulatory, neuroprotective, anti-carcinogenic, cardio-protective, etc. Consequently, *Ocimum sanctum* is readily consumable and contains numerous bioactive compounds that may contribute to health benefits and serve as a preventative measure against potential deficiencies. (Ekta, *et al.,* 2021). Due to its immense benefits it has also been used in dietary studies with number of aquatic organisms (Table 3).

Table 3: Tulsi used in diets in Aquaculture

Sr.No.	Species	Parameters	References
1.	*Macrobrachium rosenbergii*	Growth Performance (nutritional indices, energy utilization, and concentrations of biochemical constituents)	Anne Rebecca, A., 2011
2.	*Labeo rohita*	Immune Response and Disease Resistance against Aeromonas hydrophila	Das, *et al.,* 2015
3.	Nile tilapia (*Oreochromis niloticus*)	Growth Performance, Immune Response and Disease Resistance against Streptococcus agalactiae	Panprommin, *et al.,* 2016
4.	*Cirrhinus mrigala*	Growth Performance, Survival Rate	Sikotariya and Yusufzai, 2019
5.	*Cirrhinus mrigala*	Growth Parameters	Jetithor and Nalle, 2021
6.	*Cirrhinus mrigala*	Growth Performance, Hematological and Immunological Parameters	Bhatnagar and Mann, 2023

Other medicinal herbs

Following are the few of other medicinal herbs used in the field of Aquaculture:

Neem (*Azadirachta indica*)

Neem (*Azadirachta indica*), usually called Margosa or Indian Lilac, is a member of the family *Meliaceae*, subfamily *Meloideae*, and tribe *Melieae*. In the Indian subcontinent, neem has been referred to as a panacea, life-giving tree, divine tree, sacrosanct tree, village pharmacy, and omnipotent tree. It has been widely mentioned in Ayurvedic, Unani, and Chinese medicines. (Kumar, *et al.,* 2018). Moreover, every part of *A. indica* tree contains an extensive range of pharmacological properties against certain bacterial, fungal, and viral infections and enhance antioxidant properties (Talpur and Ikhwanuddin, 2013, Adamu, *et al.,* 2018). It can be used as a pesticides, natural insecticide, and molluscicide to kill or control aquatic parasites (El-Badawi, *et al.,* 2015). The plant contains a variety of active compounds like antioxidants, azadirachtin, nimbolinin, nimbidin, nimbin, nimbidol, salannin, and quercetin extracted from distinct plant parts. (Gupta, A., *et al.,* 2019).

Amla *(Phyllanthus emblica)*

Emblica officinalis Gaertn. or *Phyllanthus emblica Linn*, also called Indian gooseberry or Amla, is the most vital medicinal plant in the Indian traditional system of medicine, the Ayurveda (Bhandari and Kamdod, 2012). It is a highly nutritive and richest source of ascorbic acid/vitamin C among all fruits after Barbados cherry. It contains very important phytochemicals like phyllaemblic compounds, alkaloids (*Phyllantidine* and*phyllantine*), gallic acid, ellagic acid, flavonoids (kaempferol), hydrolysable tannins (Emblicanin A and B), pectin, quercetin, vitamin C and various polyphenolic compounds, which are responsible for its antioxidant, immunostimulatory, anticarcinogenic, antitumour, antigenotoxic and anti-inflammatory activities. (Srivastava, *et al.,* 2019)

Peppermint (*Mentha piperita)*

Mentha piperita (also known as peppermint) is a perennial herb belonging to the *Lamiaceae* family and it is a cultivated natural hybrid plant being result of a cross between Spearmint (*Mentha spicata*) and Watermint (*Mentha aquatica*). (Lin, *et al.,* 2008) Peppermint is one of the world's oldest medicinal herbs and it has been used in both eastern and western traditions. It possesses flavonoids, lutolin, volatile oils, hesperidins etc. The primary constituents of the volatile oil are methanol and methone. Peppermint exhibits effectiveness as an antineoplastic, antimicrobial, anti-radiation,

antiviral, antioxidant, and anti-inflammatory agent. (Chakraborty, *et al.,* 2022) It is an aromatic and medicinal plant extensively used besides of in traditional medicine in the food and beverage industry, perfumery and cosmetic and pharmacy (Adel, *et al.,* 2015).

Table 4: Other Medicinal Herbs used in diets of aquatic organisms

Herb	Sr.No.	Species	Parameters	References
Neem (*Azadirachta indica*)	1.	*Clarias gariepinus*	Antibacterial, Biochemical, and Heamatologicalparameters of fish against infection with *Aeromonas hydrophila*	Abou-Talb, *et al.,* 2019
	2.	*Cyprinus carpio*	Growth Performance, Feeding Efficacy, Immunological Parameters and Gonadal Reproductive Parameters	Kaur, *et al.,* 2020
	3.	*Oncorhynchus mykiss*	Growth Performance and Survival	Abidin, *et al.,* 2022
Amla (*Phyllanthus emblica*)	1.	*Ctenopharyngodon idella*	Haematological and Serum Biochemical Parameters	Tamta, and Saxena, 2018
	2.	*Labeo rohita*	Growth Performance, Survival, and Flesh Quality	Srivastava, *et al.,* 2019
	3.	*Oreochromis niloticus*	Growth, Skin Mucosal and Serum Immunity, and Disease Resistance against *Streptococcus agalactiae*	Van Doan, *et al.,* 2022
Peppermint (*Mentha piperita)*	1.	*Cyprinus carpio*	Growth Performance and Survival	Sial, *et al.,* 2019
	2.	*Rutilus caspicus*	Growth Performance, Hematological Parameters, Protein Profile of Skin Mucus, Immune Parameters, Growth Hormone (GH), Insulin-Like Growth Factor (IGF), and 70 kDa Heat Shock Protein (HSP70) Gene Expression	Paknejad, *et al.,* 2020
	3	*Labeo rohita*	Growth Performance, Survival, Haematologyand Disease Resistance against *Aeromonas hydrophila*	Padala, *et al.,* 2021

Conclusion:

Medicinal herbs are major dietary supplements being used for various health benefits which includes improved immunity and increased growth. These herbal supplements have been shown to increase the growth and boost immunity in fishes. Hence these medicinal herbs can play a vital role in aquaculture and boost its economy.

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PRELIMINARY PHYTOCHEMICALS ANALYSIS OF *ANDROGRAPHIS PANICULATA* (BURM.F.) WALL

Abhijeet R. Kasarkar*, Shweta V. Jadhav and Shrihari G. Kulkarni

Department of Botany & Department of Biotechnology,

Vivekanand College, Kolhapur (Empowered Autonomous)- 416 003

*Corresponding author E-mail: kasarkarabhi@gmail.com

Abstract:

The phytochemicals present in plants act as potential source of useful drugs to improve the health status of humans. Phytochemicals analysis is the first step towards discovery of useful drugs. Plants are the richest resources of drugs and useful for the various biological activity. The present investigation includes the phytochemical screening of *Andrographis paniculata* (Burm.f.) Wall. was one of the highly used medicinal plants. Phytochemical tests were carried out specially for screening secondary metabolites of this plants. In our study we have investigated different phytochemicals from leaf of this plant by using different solvents for extraction. The plant shows the phytochemicals like saponins, tannins, terpenoid and steroids.

Keywords: *Andrographis paniculata* (Burm. f.) Wall, Phytochemicals, Saponins, Tannins, Terpenoid, Steroids.

Introduction:

Phytochemicals are produced by plants through primary or secondary metaboilsm. Generally they have biologically activity in the plant host and contribute to its development or protection by activating defence mechanisms and giving the plants colour, odour and flavor (Molyneux *et al.,* 2007).

All the secondary metabolites are unique and complex structure. Many of these have been found to possess interesting biological activities and find applications such as pharmaceuticals, insecticides, dyes, flavors and fragrances. They can be used to treat chronic and infectious disease (Duraipandiyan *et al.,* 2006).

Andrographis paniculata (Burm.f.) Wall belonging to family acanthaceae. Erect, branched, annual herb, branches quadrangular, glabrous. Flowers solitary, distant in lax, terminal and axillary recemes or panicles. Corolla white with rose or pink throat, pubescent outside. Filaments hairs in upper part, anthers bearded at base. Capsules acute at both ends, glabrous. Seeds many, pitted, pale brown, glabrous. Flowering and

fruiting in between August to February (Yadav and Sardesai, 2002). It is commonly known as "King of Bitter".

Andrographis paniculata (Burm.f.) Wall was one of the highly used potential medicinal plants and it has been used to treat various illness conditions all over the world especially in Asia, Europe and Africa (Mishra, 2007).

This plant shows a variety of biological properties such as antibacterial, antiviral, cold and fever, anticancer, urinary tract infection, anti-diabetic, cardiovascular, immune- modulater (Bharatanatyam, 2023).

In traditional Indian medicine, this plant has been used for the treatments of dysentery and diabetic problems, skin and worm infections and against various ulcers. (Hossain *et al.,* 2014)

Phytochemicals such as tannins shows strong activity against several plant pathogens and pest (Pawar, 2010). Saponin has insecticidal activity like repellent and deterrent activity. The use of plant compounds like essential oils, flavonoids, alkaloids, glycosides, esters and fatty acids having repellent effects.

Materials and Methods:

Plant collection and identification

Collection of plant material like *Andrographis paniculata* (Burm.f.) Wall. These samples were free from disease. Plant materials were identified with stranded literature. Plant part like leaf was used for further studies.

Extraction of plant material:

Preparation of aqueous extracts:

Samples were weighed using an electronic balance and 10 gm of plant material were crushed in 100 ml of distilled water and filter through muscline cloth. These samples are used for phytochemical analysis (Harbone, 1973).

Preliminary phytochemical analysis:

The individual extracts were used for the qualitative phytochemical screening for the presence of some chemical constituents. Phytochemical test was carried out adopting standard procedure.

Test for Alkaloids

A quantity (3 ml) of concentrated extract was taken into testtube, cooled and filter, the filtrate was used for following test.

Dragen Droff's Test:

2 drops of Dragendroff's reagent were added to 1ml of the extract. The development of a creamy ppt was indicates that presence of alkaloids.

Test for Saponin

5 ml extract was mixed with 20 ml of distilled water then agitated in the graduated cylinder; 15 min formation of foam indicates Saponin present.

Test for Tannin

4ml of extract was treated with 4 ml $FeCl_3$ formation of green colour indicates that presence of condensed tannin.

Test for Proteins

Xanthoproteic Test: Extract was treated with few drops of concentrated HNO_3 formation of yellow colour indicates the presence of Proteins.

Test for Amino Acid

NinhydrinTest: Take the 2 ml of extract and 2 ml on the Ninhydrin reangent was added and boil for few minutes, formation of blue colour indicates the presence of the Amino Acid.

Test for Flavonoids

Alkaline Reagent Test: Extract was treated with 10 % of NaOH solution, formation of intense yellow colour indicates the presence of the Flavonoids.

Test for Phytosterol

Salkowski's Test: Extract was treated with chloroform and filtered. The filtered was treated with few drops of concentrated H_2SO_4 and shake, allow the standing appearance of golden red indicates the positive test.

Test for Phenol

Ferric chloride Test: Test extract were treated with 4 drops of Alcoholic $FeCl_3$ solution. Formation of bluish black colour indicates the presence of Phenols.

Test for Phlobatannins

Deposition of red ppt when aqueous extract of each plant sample is boiled with 10 % aqueous HCl was taken evidence of presence of the Phlobatannins.

Test for Cardial Glycosides

Killer-Killani Test: Plant extract treated with glacial acetic acid containing a drop of $FeCl_3$. A brown coloured ring indicates the presence of the positive test.

Test for Carbohydrates

Iodine Test: Take 2 ml of extract were treated with 5 drops of Iodine solution, gives blue colour, indicates the positive test.

Test for Reducing Sugar

Benedict's Test: Filtrate were treated with the Benedict's reagent and heated gently, orange red ppt indicates the presence of reducing sugar.

Test for Terpenoid

1ml. of freshly prepared extract was firstly treated with 2 ml. of chloroform then with 3ml. of concentrated sulphuric acid to form a layer reddish brown coloration of interface shows presence of terpenoid.

Test for Steroid

2 ml. of plant extract was dissolved in 5 ml. Chloroform and then 5 m. of concentrated sulphuric acid was added. Formation of 2 phases (upper red and lower yellow with green fluorescence) indicates the presence of steroid.

Results and Discussion:

Table 1: Phytochemical analysis of *Andrographis paniculata* (Burm.f.) Wall.

Sr. No.	Phytochemicals	Aqueous Extract	Methanol Extract	Chloroform Extract
1.	Alkaloids	+	-	-
2.	Carbohydrates	+	-	-
3.	Reducing Sugar	-	+	-
4.	Phytosterol	+	+	-
5.	Saponin	+	+	+
6.	Phenolic compounds	+	+	-
7.	Tannin	+	+	+
8.	Flavonoid	+	-	-
9.	Proteins	+	-	+
10.	Terpenoid	+	+	+
11.	Cardial Glycosides	+	+	-
12.	Steroids	+	+	+

Note: [(+)= Positive, (-)=Negative, (#) = Doubtful]

The present study was carried out to investigate the phytochemical profile present in leaf of *Andrographis paniculata* (Burm.f.) Wall. The results of the various phytochemical screening tests obtained during the experiment are shown in table No.1. The phytochemicals like saponins, tannins, terpenoid and steroids are present in all the extracts and shown potent biological activity and medicinal property.

Aqueous extarct revealed the presence of maximum phytochemicals such as alkaloids, carbohydrates, phytosterol, saponins, phenolic compounds, tannins, flavonoids, proteins, cardiac glycosides and steroids.

Methanol extract revealed the presence of phytochemical such as reducing sugar, phytosterol, saponins, phenolic compounds, tannins, terpenoid, cardic glycosides and steroids.

Chloroform extract revealed the presence of phytochemical such as saponins, tannins, proteins, terpenoid and steroids.

The presence of secondary metabolites in plants is influenced by several environmental factors. The presence of saponins is responsible for the bitter taste and a well known for their hemolytic effect on red blood cells (Prohp *et al.,* 2012). The saponins content of plants also helps in fighting pathogens and boosting the immune system. Additionally cytotoxic qualities, anti-bacterial, anti-viral properties are posses dut to the presence of saponin. (Bailly and Vergoten 2020)

Tannin possesses an anticancer property (Mazni *et al.,* 2016). The presence of terpenoids and steroid have a great importance in synthesizing sex hormones synthetic compounds (Okwu *et al.,* 2001).

Conclusion:

The phytochemicals observed in this study shows these plants have a potency for use in producing pharmaceutical bioactive compounds for therapeutic drugs. Further studies should be carried out on these in order to isolate, identify the bioactive compounds and determine their mechanism in action. The presence of phytochemicals makes the plant useful for treating different disease and have a potential for providing a drug for human use.

Phytochemicals analysis showed rich contain of bioactive molecules in *Andrographis paniculata* (Burm.f.) Wall. Due to the presence of saponin, tannin, terpenoid and steroid. Aqueous extract showed more bioactive constituents followed by methanol and chloroform. Thus this plant may be used for the production of herbal drugs.

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PUMPKIN SEEDS: NUTRITIONAL AND HEALTH BENEFITS

Gangubai P Abbihal* and Savita Hulamani

Department of Food Processing and Nutrition,

Karnataka State Akkamahadevi Women's University, Vijayapura, Karnataka, India

*Corresponding author E-mail: gangaabbihal1034@gmail.com

Abstract:

The pumpkin seeds are one of the underutilized crops. Generally it is considered as an agro waste. Pumpkin seeds are rich in macro and micro nutrients such as protein, fat, iron, zinc, magnesium and calcium. Pumpkin belonging to the family Cucurbitaceae, is a perennial plant and is consumed traditionally in a variety of foods such as fresh or cooked vegetables, as well as being stored frozen or canned. Throughout the world, pumpkin has been grown for the purpose of consumption as vegetable or as medicine. Pumpkin seeds are in great demand for their pharmacological effects. Pumpkin seed oil also confers many health benefits. Undoubtedly, pumpkin seeds are quite beneficial but still the untapped potential of these seeds is yet to be explored. The present review article aims at summarizing the various health benefits of pumpkin seeds along with their nutritional composition.

Introduction:

Pumpkin (Cucurbita) belongs to the family Cucurbitaceae generally grown in the regions of the globe as a vegetable. These are grown-up in the tropical and sub-tropical regions and including the cucumbers and squash. Worldwide there are three types of the pumpkins are present name as "*Cucurbita pepo*", "*Cucurbita maxima*" and *"Cucurbita moschata*" (Lee *et al.,* 2003) The pumpkin seeds are utilized for the cure of different diseases the herbal remedies separately or combine with medicines are used for the medical treatment. The pumpkin is the one of the famous edible plant that is utilized as the cure of many disorders due to the occurrence of many edible components and phytochemicals (Yadav *et al.,* 2010). Seeds and nuts are receiving more attention in recent years due to the significant medicinal and nutraceutical benefits of their bioactive compounds (Abd El-Aziz AB *et al.,* 2011). Although there are many different types of pumpkin seeds around the world, Cucurbita pepo L. is the species that is most important for commercialization (François G *et al.,* 2006).

Today, salted and roasted pumpkin seeds are offered as a concentrated source of protein and are widely consumed as baked, roasted, and sprouted snacks. Pumpkin seeds are nutrient-dense foods that come in a variety of morphological forms, including hulled, semi-hulled and thin-layer seeds Meru G *et al.,* 2018) Since the flavonoid cucurbitacin is known for its anticancer activity, the presence of flavonoids and triterpenoids may be a contributing element in the anticancer action. Protein, vitamin E, carotenoids, saponin, phytosterol, provitamins, unsaturated fatty acids, flavonoids, phenolic substances, and their derivatives all are pervasive in pumpkin seeds (Chari KY *et al.,* 2018)

Pumpkin is available in many shapes, sizes and colors depending on the variety and climate. Because of the presence of nutritional and health protective polysaccharides in the fruit and protein and oil in the seeds, interest in pumpkin and pumpkin-based products, by food processing, agriculture, pharmaceutical and feed industry has been increased from last few years (Sojak & Glowacki, 2010).

Pumpkin seeds:

Pumpkin seeds, commonly known as 'pepitas', are flat, encased in yellow-white husk. Pumpkin seeds also contain phyto-compounds but which at certain critical levels have significant anti-nutritional effects. These compounds include oxalate, phytate, nitrate, cyanide, etc. In many cultures, pumpkin seeds are consumed directly as snack food. It was reported by Murkovic *et al.* 2003 that the nutritional value of seeds increases after roasting. Roasting basically increases the sterols and vitamin E content. Pumpkin seeds are rich in protein content (25-52%). It was reported by Nakiæ *et al.* (2006) that oil content is also high, ranging from 40 60%. Out of this, up to 60.8% is contributed from fatty acids oleic acid (up to 46.9%), linolenic acid (up to 40.5%), palmitic and stearic acid up to 17.4%, the ratio of monounsaturated to polyunsaturated acids from 0.60 to 0.75g. Approximately 1% each of phytosterols, squalene and chlorophyll pigment are present. Phytosterols are present in free and bound form. Minerals (including selenium, zinc, calcium, copper, iron, manganese, phosphorus and potassium) are present @ 4-5%. Pectin content is 30%.

Composition of pumpkin seeds:

Pumpkin seeds are nutritionally very good. They are rich source of proteins, fatty acids and minerals (Magnesium, Copper and Zinc). Pumpkin seeds are popular snack that can be found hulled/semi-hulled. Pumpkin seeds are fried and salted and are available in the market under the name of 'pepitos'. Fluted pumpkins seed flour has been used as a protein supplement in a variety of local foods (Giami and Bekebain, 1992).

Nutritional importance:

The physical properties, chemical composition and fatty acid proportion was determined by an investigator and his collogues they found that pumpkin seeds contained 41.59% oil, 25.4% protein, 5.2 % Moisture, 25.19% carbohydrates, 5.34% fiber, and 2.49% total ash. Total phenolic compounds, total sterols, waxes and total tocopherols were 66.25 (mg galic acid per kg oil), 1.86%, 1.56% and 882.65 (mg tocopherol per kg oil) respectively Ardabili [7] The studies on nutritional and antinutritional composition of pumpkin seeds by Elinge *et al.* (2012) reported mineral analysis profile of pumpkin seeds as potassium the most abundant mineral having value 273 mg/100 g and manganese was trace mineral having least value of 0.06 g/100 g. The antinutritional elements in pumpkin seeds were found as phytate 35.06 mg/100 g, oxalate 0.02 mg/100 g, hydrocyanic acid 0.22 mg/100 g and nitrate 2.27 mg/100 g. They reported that pumpkin seeds could be a good source of minerals if utilized properly.

Health benefits of pumpkin seeds:

Pumpkin seeds are usually discarded as waste products during the processing despite of having high amounts of protein, minerals, dietary fibre, monounsaturated fatty acids, vitamin E, zinc and phytonutrients Pumpkin seeds are renowned and relished over the world in direct and baking products for their unique greenish sweet and nutty flavor (Revathy MN *et al.,* 2013). The presence of health-protective qualities, high levels of pharmacological substances, and a good quantity of unsaturated fatty acids in pumpkin seeds oil is receiving more and more attention. Similarly, Rani *et al.,* 2021 reported that pumpkin seeds are rich in phosphorus, magnesium, zinc, and selenium, which improve their ability to prevent diseases including prostate cancer, arthritis, inflammation, and cardiovascular disease.

The various health benefits of pumpkin seeds are described below:

- **Bone protection effects**: Pumpkin seeds are used to make zinc-rich foods and are used to protect bones from fracture (Gold, 2009). Zinc boosts the immune system and aids in bone density support for the people at risk of osteoporosis. Eating pumpkin is particularly good for postmenopausal women.
- **Relief from anxiety effects**: Tryptophan present in pumpkin seeds helps to relieve a person from anxiety. Tryptophan gets converted into serotonin which is a neurotransmitter and that enhances mood and promotes well-being in the brain) (Shapiro, 2012). Tryptophan also promotes sleep and thus reduces anxiety (Zhang *et al.,* 1994).
- **Hypertensive and Heart Protective Effects**: The pumpkin seeds have essential role in blood pressure lowering and relaxing of blood vessels. It has been examined the role and effects of pumpkin seeds oil in rats that have high blood pressure induced by chemical. The oil served on daily basis for 6 weeks the oil range between 40 to 100mg per Kg. Consumption of the oil appreciably decreased elevated blood pressure resulting from the induction by chemical and electrocardiogram changes also became normal. It also maintains the decreased level of NO metabolites to normal range and increased MDA level to decrease. The overall outcome confirmed the protective effect of pumpkin seed oil towards pathological changes in the aorta and coronary heart. The NO production is indicated the amino acid L-arginine. Additionally, the high magnesium (mg) content in pumpkin seeds oil is credited to lessening the risks of coronary heart attack. The pumpkin seeds as dietary supplement has exposed the same effects to the calcium channel blocker as a drug amlodipine (El-Mosallamy *et al.,* 2012)
- **Anti-Carcinogenic Effects:** The rapidly prevailing health problem is the cancer. There is a biggest challenge for the investigators, professionals and researchers to select preventive and therapeutical strategies to prevent and cure the cancer. There are many fruits and vegetables have been found to minimize the risk factor of the cancer. The diet having high amount of pumpkin seeds have been identified as lowering the cancer risks. The pumpkin seeds oil has been found to reduce the risks of cancer as it contained the high amount of the various carotenoid's pigments (Jian *et al.,* 2005). The Gossell William and colleagues determine the role of oil of pumpkin seeds in chemical (testosterone) induced

hyperplasia rats. The rats were feed with pumpkin seeds oil and corn oil during the hyperplasia induction for the duration of twenty days. At the 21st day the prostate was weight after killed and analyzed. They were found that the increased prostate growth inhibition occurred in rats that were served with oil of pumpkin seeds (2mg per 100g). The protecting effects of the oil of pumpkin seeds were more considerable at high dose. The result of research study develops the hope for cancer management. (Gossell William et al).

- **Anti-hypertension effects**: A study conducted by Egyptian researchers showed antihypertensive properties of pumpkin seed oil (El-Mosallamy *et al.,* 2012). Researchers caused hypertension in rats by inhibiting nitric oxide synthase (an enzyme which is responsible for generating blood pressure regulating nitric oxide). These hypertensive rats were then administered with pumpkin seed oil or the antihypertensive medication amlodipine daily for 6 weeks. Results of the study showed that pumpkin seeds oil was as effective as amlodipine in reversing elevated blood pressure in rats by restoring nitric oxide levels close to normal (El-Mosallamy *et al.,* 2012). Pumpkin seeds contain tryptophan which might be responsible for exerting blood-pressure lowering effect but the mechanism by which it exerts the effect is not known (Vasdev and Stuckless, 2010).
- **Anti-inflammatory effects:** The beta-carotene in pumpkin seeds has anti-inflammatory properties and regular consumption of pumpkin seeds can protect against joint inflammation (McCaffrey, 2012). It has been concluded from animal studies that when pumpkin seeds are added to diet, they show an efficacy on par with anti inflammatory drugs in reducing anti-inflammatory symptoms of arthritis (Rhodes, 2008; Gold, 2009). They reduce inflammation without any side effect (Gold, 2009).
- **Anti-diabetic effects**: In most of the countries, pumpkin is used as an anti-diabetic. Pumpkin seeds have hypoglycemic action in normal animals and alloxan induced diabetic rats and rabbits. Pectin present in pumpkin is responsible for its hypoglycaemic action. Pumpkin also contains high level of polysaccharides which may be another reason for its hypoglycaemic action.According to a study by Li *et al.* (2001), oil from un-germinated pumpkin seeds and proteins from germinated pumpkin seeds possess hypoglycemic activity. They have also indicated that the protein components with molecular weight over 60 kDa and

below 3 kDa from pumpkin seeds after 4 days of germination increased the blood insulin level. Oil from un-germinated pumpkin seeds and protein components with molecular weights 3-60 kDa from germinated seeds improved blood glucose tolerance. However, proteins from un-germinated seeds did not possess any hypoglycemic action. Many researchers have indicated that the compounds in pumpkin may be useful in managing insulin levels and diabetes risk.

Conclusion:

The above research studies confirmed that the pumpkin seeds have nutritional and therapeutic properties as well as these are also served as delicious food in many regions of the globe. The pumpkin seeds are cultivated in tropical and subtropical areas. There are three main types are cultivated such as Cucurbita pepo, Cucurbita maxima and Cucurbita moschata. The nutrient composition analysis of pumpkin seeds showed that these are very nutritious and provide many essential nutrients for health. However, the pumpkin seeds have been used for medicinal purpose and these possess also nutritional and therapeutic importance. The pumpkin seeds play a significant role in providing of micronutrients and also used in treatment and management of diabetes, inflammation, hyperlipidaemia, hypertension, cancer management and protect heart etc. (Kalogropoulos, 2013).

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BIOFLOC TECHNOLOGY: A SUSTAINABLE APPROACH TO MODERN FISHERIES MANAGEMENT

Ramya Veena M, Umamaheshwari T and Rajan Dinesh*

ICAR- Central Institute of Fisheries Education, Mumbai

*Corresponding author E-mail: dineshcife1210@gmail.com

Abstract:

Biofloc Technology (BFT) represents a significant innovation in aquaculture, providing a sustainable and eco-friendly pathway to enhance fish production. This technology addresses critical environmental challenges by traditional aquaculture practices, including water quality deterioration, pollution, and disease outbreaks. By leveraging microbial interactions, BFT transforms waste products into valuable biomass, thereby improving water quality and reducing the need for water exchange. The implementation of BFT is cost-effective and relatively simple, making it accessible to fish farmers worldwide. This chapter explores the historical development of BFT, its underlying microbial mechanisms, nutritional benefits, and various system types. It also discusses the advantages and disadvantages of BFT, alongside its practical applications in fisheries. The future prospects for BFT are examined, highlighting its potential to revolutionize aquaculture by promoting higher productivity, enhanced survival rates, and improved disease resistance, ultimately contributing to the sustainability and eco-friendliness of fish production systems.

Keywords: Biofloc Technology, C:N ratio, Aquaculture system, Microorganisms and Sustainable fish production

Introduction:

The rapid intensification of aquaculture systems has led to significant environmental challenges, including water quality deterioration, pollution, and disease outbreaks. Consequently, an eco-friendly technique is essential to ensure better production with less environmental impact by minimizing effluent discharge from aquaculture practices. Biofloc technology represents such a breakthrough, being easy to implement with straightforward operation and establishment procedures at a relatively low cost, making it highly convenient for fish farmers. This technology enhances aquaculture by improving key characteristics such as biomass density, survival rates,

and disease resistance. The immunostimulatory effects of microbial flocs on the immune systems of cultured species further ensure biosecurity and sustainability.

The Biofloc technology (BFT) has emerged as an outstanding innovation capable of solving some of the environmental and economic challenges faced by traditional aquaculture production systems (Fig. 1). The term "biofloc" refers to a substance that is primarily composed of 60 to 70% organic matter, which includes a diverse mixture of microbes, such as algae, fungi, rotifers, and protozoa. Additionally, it contains 30 to 40% inorganic materials, such as organic polymers, colloids, and dead cells. Biofloc is the suspended growth in ponds or tanks, which consists of aggregates of living and dead particulate organic matter, phytoplankton, bacteria, and bacteria grazers (Brito *et al.,* 2014). This novel technology is exceptionally eco-friendly due to its reliance on the activities of microorganisms. These microorganisms' function in three primary ways: they control water quality through the immobilization of nitrogen, resulting in microbial protein; this microbial protein then serves as a source of nutrition for cultured species; and the microorganisms suppress the growth of pathogens through competition (Avnimelech, 2009). BFT is based on the cycling and recycling of nutrients and their reuse within the same system, which is designed as a zero-exchange or minimal-exchange (water) system (Emerenciano *et al.,* 2017). The technology is noted for its positive role in maintaining water quality, enhancing fish reproduction, providing an alternative source of nutrition, and promoting the overall welfare and growth of fish in the culture units (Azim & Little, 2008). Given these advantages, the success of the biofloc system is largely dependent on its ability to remove, recycle, or control harmful nitrogenous substances in the culture system.

Figure 1: Biofloc Cultivation Pond (Source: Abidin, 2008)

History of biofloc technology:

The development of biofloc technology began in the early 1970s at Ifremer-COP (French Research Institute for Exploitation of the Sea, Oceanic Center of the Pacific), focusing on various penaeid species including *Penaeus monodon, Fenneropenaeus merguiensis, Litopenaeus vannamei, and L. stylirostris* (Aquacop, 1975; Sohier, 1986). Concurrently, Ralston Purina developed a system utilizing nitrifying bacteria and maintaining shrimp in total darkness. This system, in collaboration with Aquacop, was applied to *L. stylirostris* and *L. vannamei* in Crystal River (USA) and Tahiti, sparking considerations about the benefits of biofloc for shrimp culture. In 1980, Ifremer initiated the French scientific program 'Ecotron' to enhance understanding of this system. Several studies within this program took a comprehensive approach to BFT, elucidating the interrelationships among different compartments such as water, bacteria, and shrimp nutritional physiology. During the 1980s and early 1990s, Israel and the USA (Waddell Mariculture Center) also embarked on research and development in BFT with tilapia and white shrimp *L. vannamei*, driven by factors such as water limitations, environmental concerns, and land costs. Regarding the commercial application of BFT, Sopomer farm in Tahiti (French Polynesia) achieved a world record in production in 1988 using 1000m^2 concrete tanks and limited water exchange (20–25 tons/ha/year with two crops) (Garen and Aquacop, 1993; Rosenberry, 2012). Conversely, Belize Aquaculture farm (BAL) in Belize, Central America, is perhaps the most famous case of commercial BFT application worldwide, producing approximately 11-26 tons/ha/cycle using 1.6 ha lined grow-out ponds. Much of the operational knowledge for running commercial-scale BFT shrimp ponds globally is derived from BAL's experience. In small-scale BFT greenhouse-based farms, Marvesta farm in Maryland, USA, stands out as a successful indoor BFT shrimp farm, producing around 45 tons of fresh, never-frozen shrimp per year using approximately 570 m^3 indoor raceways (Rosenberry, 2011). Today, BFT has successfully expanded in large-scale shrimp farming across Asia, Latin and Central America, as well as in small-scale greenhouses in the USA, South Korea, Brazil, Italy, China, and other regions. Moreover, numerous research centres and universities are intensifying research and development in BFT, focusing primarily on key areas such as grow-out management, nutrition, BFT application in reproduction, microbial ecology, biotechnology, and economics.

Principle of biofloc technology:

The general mechanisms for the formation of biofloc in a culture system for fish and shrimp are illustrated in (Fig. 2). Ammonia and other nitrogenous substances are converted into bacterial protein biomass when the carbon-to-nitrogen (C/N) ratio is properly balanced in the bacterial substrate. Adjusting this ratio promotes the growth of heterotrophic microorganisms, enabling bacteria to assimilate ammonium waste and produce new biomass. This conversion serves as an additional sink for ammonia, facilitating efficient waste removal. Heterotrophic bacteria proliferate and produce microbial biomass at rates ten times higher per unit substrate compared to nitrifying bacteria, thereby accelerating the breakdown of inorganic nitrogenous substances in biofloc water (Hargreaves, 2006). This rapid nitrogen consumption through bacterial growth reduces ammonium concentrations more quickly than nitrification alone. Microbial aggregates produce approximately 0.5 grams of biomass carbon per gram of substrate carbon used. Crab *et al.,* (2012) further elaborate on the organic carbon required to process nitrogenous waste from unconsumed feed and excreta within biofloc systems. For instance, if fish are fed at 2% of their body weight per day (Craig and Helfrich, 2002), they would need 20 grams of feed per kilogram of fish. Assuming the feed contains 25% protein, this provides approximately 5 grams of protein to each fish daily, which converts to around 0.8 grams of nitrogen. According to Piedrahita (2003), about 75% of this nitrogen accumulates as inorganic nitrogen from uneaten feed and fish waste, amounting to roughly 0.6 grams. To optimize the microbial conversion of inorganic nitrogen, a carbon ratio of 10 is recommended, which would require approximately 6 grams of carbon per kilogram of fish per day for biofloc generation.

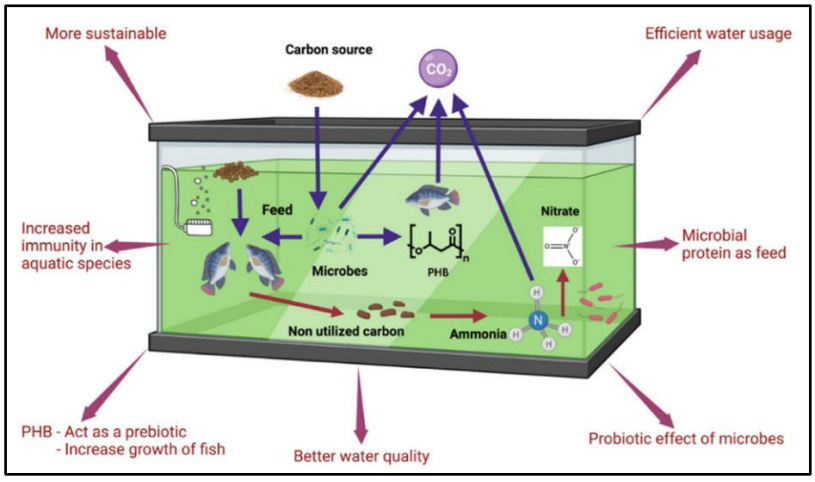

Figure 2: Mechanisms of Biofloc Formation and Maintenance in Cultured Ponds and Tanks (Source: Padeniya *et al.,* 2022)

Types of biofloc system:

Biofloc systems are classified into three main types based on their microbial composition and nutritional dynamics: Heterotrophic, Autotrophic, and Mixotrophic biofloc systems. Each type plays a distinct role in aquaculture, offering unique advantages and requiring specific management practices.

1. **Heterotrophic biofloc system**: The heterotrophic biofloc system promotes the growth of heterotrophic bacteria using added organic carbon sources such as starch or low-protein feed. These bacteria utilize organic carbon as their energy and carbon source, simultaneously assimilating ammonia or nitrate present in the water as nitrogen sources. This process not only enhances water quality by reducing nitrogenous compounds but also contributes to the formation of protein-rich microbial biomass within the system.
2. **Autotrophic biofloc system**: In contrast, the autotrophic biofloc system focuses on fostering the growth of autotrophic or nitrifying bacteria. This is achieved by providing suitable surface areas, maintaining ammonia levels, and ensuring adequate aeration. Nitrifying bacteria in this system convert ammonia to nitrite, and then to nitrate, using carbon dioxide as their primary carbon source. Unlike heterotrophic bacteria, they do not require organic carbon for growth and energy, relying instead on the oxidation of ammonia and other nitrogen compounds.
3. **Mixotrophic biofloc system**: The mixotrophic biofloc system integrates aspects of both heterotrophic and autotrophic systems. It evolves over time as both heterotrophic and nitrifying bacteria establish within the system. This can occur naturally as the system matures or can be induced by feeding practices that enhance the availability of organic carbon. By combining the advantages of both types, mixotrophic systems aim to optimize nutrient cycling and microbial biomass production.

Among these systems, the autotrophic biofloc system is often preferred in commercial aquaculture settings. This preference stems from its efficient control of ammonia and nitrite levels without the need for external additives like molasses or sugar. Maintaining higher ammonia levels, typically between 4-6 mg/L as total ammonia nitrogen (TAN), is advantageous as it accelerates microbial processes within the system, aiding in nutrient cycling and water quality management.

Composition of bioflocs as nutrient:

Fig. 3 Shows that Biofloc consists of aggregates (flocs) comprising algae, bacteria, protozoa, and other types of particulate organic matter like faeces and uneaten feed. These flocs are held together by a loose matrix of mucus secreted by bacteria, bound by filamentous microorganisms, or held via electrostatic attraction. The biofloc community also includes grazers such as certain zooplankton and nematodes. Heterotrophic bacteria like *Bacillus subtilis*, *Bacillus licheniformis*, *Bacillus coagulans*, along with Nitrobacter and Nitrosomonas, are present. While some bioflocs are visible to the naked eye, most are microscopic, with floc sizes ranging from 50 to 200 microns. In green water biofloc systems, algae dominate, whereas bacteria dominate in brown water biofloc systems. Floc species exhibit natural growth and succession, necessitating regular monitoring and management of floc quality and water colour. Biofloc is a protein-rich live feed created by converting unused feed and excreta into natural food within a culture system exposed to sunlight and vigorous aeration.

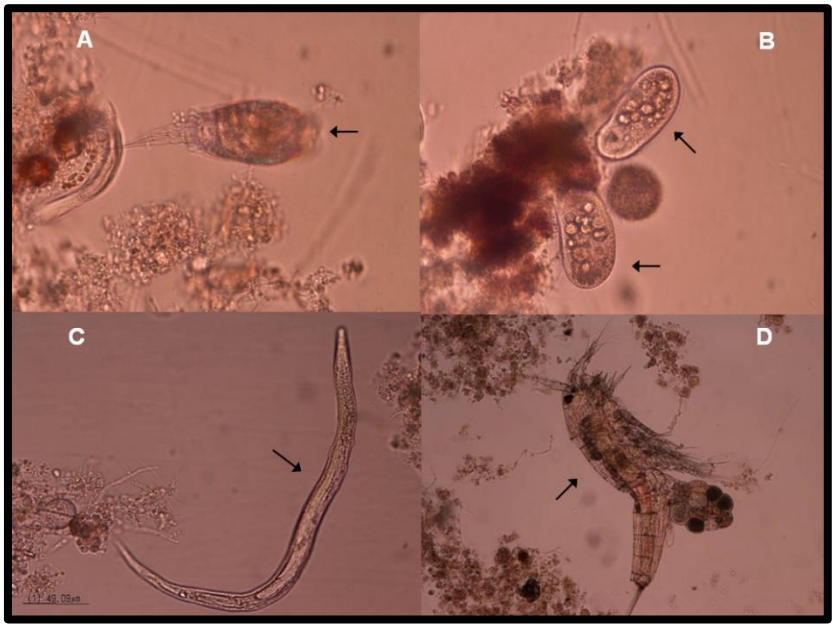

Figure 3: Grazers Often Observed in BFT, Including Flagellates, Protozoa (A), Ciliate Protozoa (B), Nematodes (C), and Copepods (D) (10x Magnification) (Source: Maurício Emerenciano, 2013).

Nutritional value of biofloc:

The nutritional quality of biofloc for cultured animals varies but is generally good. The dry-weight protein content ranges from 25 to 50 percent, with most estimates between 30 and 45 percent. Fat content ranges from 0.5 to 1.5 percent, with most estimates between 1 and 5 percent. It is also rich in vitamins and minerals,

particularly phosphorus (Ray and Mohanty, 2020). Dried biofloc is proposed as a feed ingredient to replace fishmeal or soybean in feed formulations. About 70% of the total feed energy is released into the system as waste. Therefore, in intensive culture operations, maintaining water quality becomes crucial, and reusing lost nutrients through floc development enhances feed efficiency and water quality maintenance.

Probiotic effect:

Biofloc exhibits a probiotic effect similar to organic acids internally synthesized by bacteria and their compounds. Regular addition of carbon in water selects for bacteria that accumulate polyhydroxyalkanoates (PHA), including poly-ß-hydroxybutyrate (PHB), a biodegradable polymer. PHB constitutes approximately 80% of bacteria cell dry matter and up to 16% of biofloc dry weight. These polymers, when degraded in the gut, exhibit antibacterial activity akin to short-chain fatty acids or organic acids (Sinha *et al.,* 2008).

Role of microorganisms:

Microorganisms play a critical role in feeding and maintaining the health of cultured animals. Bacterial flocs (biofloc) provide a nutrient-rich source of proteins and lipids, serving as continuous food sources for fish. The water column facilitates complex interactions among living microbes, plankton, organic matter, substrates, and grazers such as rotifers, ciliates, protozoa, and copepods, acting as a secondary food source. This combination facilitates nutrient recycling and helps maintain water quality. Consumption of floc by cultured organisms has been shown to enhance growth rates, decrease feed conversion ratios, and reduce production costs. Biofloc stimulates immune responses in fish, making them more resistant to diseases compared to those in traditional culture systems (Naylor *et al.,* 2000).

Species compatibility:

In biofloc technology (BFT), there are specific norms regarding species compatibility for successful cultivation. To optimize growth performance, selected species must demonstrate resistance to high stocking densities and population densities, and be adaptable to fluctuations in dissolved oxygen levels (3–6 mg/L), settling solids (10–15 mL/L), and total ammonia compounds. Additionally, they should possess omnivorous habits or the ability to utilize microbial protein efficiently.

Major cultivable fish species in BFT:

Several species are well-suited for cultivation in biofloc technology (BFT), including:

- Air-breathing fish such as Singhi (*Heteropneustes fossilis*), Magur (*Clarias batrachus*), Pabda (*Ompok pabda*), Anabas/Koi (*Anabas testudineus*), and Pangasius (*Pangasianodon hypophthalmus*).
- Non-air-breathing fishes like Common Carp (*Cyprinus carpio*), Rohu (*Labeo rohita*), Tilapia (*Oreochromis niloticus*), and Milkfish (*Chanos chanos*).
- Shellfish such as Pacific white leg shrimp (*Litopenaeus vannamei*) and Tiger Shrimp (*Penaeus monodon*).

These species have been identified as suitable candidates for BFT due to their ability to thrive under the specific environmental conditions and management practices characteristic of biofloc systems.

Importance to obtain C: N ratio in biofloc:

A feed with 30 to 35 per cent protein concentration has a relatively low C: N ratio, about 9 to 10:1. Increasing the C:N ratio of inputs to 12 to 15:1 favours the heterotrophic pathway for ammonia control. The low C:N ratio of feed can be augmented by adding supplement materials with a high C: N ratio. Or the inputs C: N ratio can be increased by reducing feed protein content. Ammonia Control through the heterotrophic pathway is often, more stable and reliable than algal uptake or nitrification.

Table 1: Different carbon sources applied on BFT system (Source: Avnimelech, 1999)

Carbon source	**Culture species**
Acetate	*Macrobrachium rosenbergii*
Cassava meal	*Penaeus monodon*
Cellulose	Tilapia
Corn flour	Hybrid bass and hybrid tilapia
Dextrose	*Litopenaeus vannamei*
Glycerol and Glycerol+*Bacillus*	*M. rosenbergii*
Glucose	*M. rosenbergii*
Molasses	*L. vannamei and P. monodon*
Sorghum meal	Tilapia
Tapioca	*L. vannamei* and *M. rosenbergii*
Wheat flour	Tilapia (*O. niloticus*)
Wheat bran + molasses	*Farfantepenaeus brasiensis, F. paulensis and F. duorarum*
Starch	Tilapia *O. niloticus x O. aureus* and tilapia (Mozambique)

Advantages of biofloc technology:

Biofloc technology offers a range of advantages that contribute to its appeal as a sustainable and efficient culture system in aquaculture:

1. **Environmentally friendly culture system:** Biofloc technology is inherently environmentally friendly due to its ability to operate with minimal water exchange and reduced effluent discharge. This aspect significantly lowers the overall environmental impact compared to traditional aquaculture systems that rely on extensive water exchange, which can lead to habitat degradation and pollution of surrounding ecosystems.
2. **Reduces environmental impact:** By minimizing water exchange and effectively managing waste through microbial flocs, biofloc systems reduce the discharge of nutrients and organic matter into the environment. This helps maintain water quality and mitigates the risk of eutrophication in nearby water bodies, preserving natural ecosystems and biodiversity.
3. **Efficient use of land and water resources:** Biofloc systems are space-efficient and can be set up in various locations, including areas with limited access to freshwater. They optimize the use of land and water resources by allowing for higher stocking densities and production per unit area compared to traditional aquaculture methods.
4. **Operates with limited or zero water exchange:** Unlike conventional aquaculture systems that require regular water exchange to maintain water quality, biofloc technology operates with limited or even zero water exchange. This reduces the demand for freshwater inputs and minimizes the need for large volumes of water, making it suitable for regions facing water scarcity or high competition for water resources.
5. **Enhances productivity:** Biofloc technology enhances productivity in fish culture systems through several mechanisms:
    a) **Higher survival rates**: Improved water quality and reduced stress contribute to higher survival rates of cultured organisms.
    b) **Improved growth performance**: Optimal conditions within biofloc systems promote faster growth rates and better overall growth performance of fish and shrimp.

c) **Better Feed Conversion Ratio (FCR)**: The microbial flocs provide a natural source of nutrition, which supplements commercial feeds and improves the efficiency of nutrient utilization by the cultured organisms.

6. **Provides enhanced biosecurity measures:** Biofloc systems offer better biosecurity by creating a competitive environment for pathogens. The microbial communities within the flocs outcompete potential pathogens for nutrients and space, reducing the risk of diseases among cultured organisms. This decreases the reliance on antibiotics and other disease treatments, contributing to sustainable aquaculture practices.
7. **Reduces water pollution and pathogen spread:** By maintaining high water quality and minimizing effluent discharge, biofloc technology reduces the pollution of surrounding water bodies and mitigates the risk of introducing and spreading pathogens. This is crucial for maintaining the health of both farmed and wild aquatic populations, supporting ecosystem resilience and biodiversity conservation.
8. **Decreases reliance on protein-rich feeds:** Biofloc systems reduce the dependence on protein-rich feeds by utilizing microbial flocs as a supplementary feed source. This lowers the overall feed costs associated with aquaculture operations, making production more economically viable and sustainable in the long term.
9. **Cost-efficient feed management:** The integration of microbial flocs into the feeding regime improves feed efficiency and reduces the frequency and quantity of commercial feed required. This cost efficiency enhances the economic viability of biofloc systems and supports profitability for aquaculture producers.
10. **Alleviates pressure on wild fish stocks:** By increasing the efficiency and productivity of aquaculture operations, biofloc technology helps alleviate pressure on wild fish stocks from capture fisheries. This contributes to sustainable fisheries management practices and supports global efforts to conserve marine and freshwater resources.

The biofloc technology represents a significant advancement in aquaculture practices, offering a sustainable and efficient alternative to traditional methods. Its benefits include environmental sustainability, enhanced productivity, improved biosecurity, reduced operational costs, and support for global food security initiatives

Disadvantages of biofloc technology: While biofloc technology offers numerous advantages, it also presents several potential disadvantages that should be considered:

1. **Increased energy requirements for mixing and aeration:** Biofloc systems require continuous mixing and aeration to maintain optimal conditions for microbial floc formation and to ensure adequate oxygen levels for the cultured organisms. This increases energy consumption, which can lead to higher operational costs and dependency on reliable energy sources.
2. **Reduced response time due to higher rates of water respiration:** The dense microbial flocs in biofloc systems can lead to higher rates of water respiration, which may reduce the oxygen availability for cultured organisms, especially in densely stocked tanks. This necessitates careful management of oxygen levels and aeration, which adds to operational complexity.
3. **Initial start-up period required:** Establishing a biofloc system requires an initial start-up period during which microbial communities develop and stabilize. This process can take several weeks to months, depending on various factors such as water quality, stocking density, and management practices. The start-up phase may require additional monitoring and adjustments to optimize system performance.
4. **Supplementation of alkalinity required:** Biofloc systems often require supplementation of alkalinity to maintain stable pH levels and support microbial activity. This adds to operational costs and management efforts, as regular monitoring and adjustment of water chemistry are necessary to prevent fluctuations that can stress cultured organisms.
5. **Increased potential for pollution from nitrate accumulation:** While biofloc systems can effectively convert organic matter into microbial biomass, they may accumulate nitrate as a byproduct of microbial metabolism. High nitrate levels can pose a risk to water quality if not managed properly, potentially leading to eutrophication and impacting the health of both cultured organisms and surrounding ecosystems.
6. **Inconsistent and seasonal performance in sunlight-exposed systems:** Biofloc systems that rely on sunlight exposure for algae growth and photosynthesis may experience inconsistent performance, particularly in regions with seasonal variations in sunlight intensity or duration. Lack of sufficient

sunlight can suppress algae growth, affecting the stability and productivity of the system. This variability requires additional management strategies to optimize performance year-round.

7. **Unavailability of sunlight suppresses growth of algae in culture system:** In regions with limited sunlight availability, biofloc systems may struggle to maintain adequate levels of algae growth. Algae play a crucial role in nutrient cycling and providing food for certain organisms within the system. Insufficient algae growth can disrupt ecosystem balance and require alternative nutrient management strategies.

Applications of biofloc technology:

In the mid-1990s, the first commercial applications of Biofloc Technology (BFT) in shrimp aquaculture were documented in Belize. Initially, culture ponds covering approximately 1.6 hectares produced between 11 to 26 metric tons of shrimp per cycle. Since then, both large-scale commercial operations and smaller-scale enterprises utilizing BFT have expanded across various countries including Indonesia, Malaysia, Thailand, South Korea, China, and India (Prajith and Madhusoodana, 2011). Commercial biofloc ponds typically range from 0.1 to 2 hectares in size and are equipped with efficient aeration systems such as paddle-wheel aerators and aspirators, crucial for maintaining adequate oxygen levels and ensuring proper suspension of particles for effective mixing. This technology frequently leads to increased productivity without compromising environmental integrity. Production intensity in biofloc ponds often surpasses that of traditional systems; for instance, tilapia cultured in biofloc systems have shown superior growth rates and enhanced product quality. The adoption of BFT enhances output and productivity by facilitating the production of high-quality fish juveniles, a critical factor in aquaculture production processes. Studies indicate that biofloc systems contribute to approximately 45% higher production and individual weight gain compared to non-biofloc systems. In Indonesia alone, nearly 20-25% of aquaculture farmers utilize biofloc technology, typically managing ponds averaging 0.5 hectares in size, yielding more than 30 metric tons of output per cycle. High-density polyethylene (HDPE) liners are commonly used to line biofloc ponds, with aeration capacity typically set at 28 horsepower per hectare (Emerenciano *et al.,* 2012). For instance, fully HDPE-lined ponds in Malaysia yield an average of 17-23 metric tons per cycle, whereas ponds with linings in dikes yield approximately 12 metric tons per cycle.

Furthermore, biofloc systems can be integrated with other food production methods, creating more efficient integrated systems that maximize food and feed production from limited land with reduced inputs. By enhancing the reproductive performance and boosting the immunity of aquaculture species, biofloc technology plays a crucial role in sustaining the supply of high-quality seeds (Ekasari, 2014).

Future prospects of biofloc technology in aquaculture:

Biofloc technology emerges as a pivotal tool for sustainable aquaculture, presenting a multitude of benefits that simultaneously address environmental, social and economic challenges. This system is notably convenient, easy to implement and profitable, efficiently removing nitrogen even in conditions of high organic matter and biochemical oxygen demand within the system (Avnimelech, 2015). Despite these advantages, ongoing research is crucial to enhance technical advancements and ensure widespread acceptance and successful implementation of this technique. Future research directions include integrating biofloc techniques with existing systems like raceways and polyculture systems (Crab *et al.,* 2012), exploring microbial associations such as quorum sensing and microbial control of pathogenic species, characterizing microbes responsible for beneficial biofloc properties and developing sophisticated monitoring systems for floc composition and characteristics. These efforts will contribute to a deeper understanding of this innovative method, paving the way for future generations of scientists, farmers, and consumers to adopt it as a robust foundation for sustainable aquaculture worldwide.

Conclusion:

Biofloc technology offers a unique, eco-friendly alternative that helps mitigate the environmental impacts of intensified aquaculture while enhancing the disease resistance of cultured species by boosting their immune systems. This technology has proven effective in addressing fish farming challenges and can provide substantial benefits with relatively small investments. However, its success relies on sufficient knowledge and scientific application at the field level, including maintaining the carbon-to-nitrogen ratio, managing water quality, and monitoring floc formation during operations. Achieving sustainable aquaculture production through biofloc technology requires further research to optimize system parameters, particularly regarding nutrient recycling and immunological effects. The results of this research must be

communicated to farmers, who will need to upgrade their skills for successful implementation.

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STATUS OF FISH FARMING IN ASSAM

Liza Dutta*[1] and Biswajyoti Bordoloi[2]

[1]Department of Fisheries Science, Alagappa University, Tamil Nadu

[2]Fishery Research Centre, Assam Agricultural University, Jorhat

*Corresponding author E-mail: lizadutta2002@gmail.com

Abstract:

Assam, located in India's northeastern region, is a prime area for aquaculture, thanks to its abundant water resources. The state's extensive network of rivers, ponds, and wetlands provides an ideal environment for fish farming, which is vital for the local economy and nutrition. This paper explores the current status of fish farming in Assam, highlighting challenges, opportunities, and advancements in the sector. Fish holds significant cultural and dietary importance for nearly 90% of Assam's population. The fish farming industry is crucial for rural livelihoods, nutritional security, and economic growth. Despite the state's potential, fish production is below its full capacity due to natural calamities, lack of scientific aquaculture practices, and reluctance of pond owners to commercialize fish farming. Assam boasts 447 registered beels, over half a million ponds, and significant river and forest fisheries, contributing to a diverse and vibrant aquaculture sector. The state also houses 608 hatcheries, producing over 20,843.08 million fish seeds annually. Despite these resources, Assam imports a substantial portion of its fish, indicating untapped potential. The state achieved a notable fish production of 4.43 lakh MT in 2022-23, with a significant increase in per capita fish consumption. The fisheries sector contributed Rs. 1,989,719 lakh to the state's GSDP at current prices, reflecting its economic significance. Major fish species cultivated include Rohu, Catla, Mrigal, and indigenous varieties like Assam Valley Carp, emphasizing the state's rich aquatic biodiversity. Government initiatives like the Pradhan Mantri Matsya Sampada Yojana aim to enhance fish production through new pond construction, fish seed hatcheries, and feed plants. However, fish farmers face challenges such as inadequate technical support, input shortages, irregular payments, and unorganized markets. Future prospects for Assam's fish farming include exploring national and international markets, adopting sustainable practices, and diversifying high-value fish species. A strategic shift towards conservation, value addition, and market linkages is essential to transform Assam into a major fish exporter, ensuring

economic prosperity and reduced reliance on imports. This paper provides a comprehensive overview of the sector, emphasizing the need for sustainable and responsible fisheries management to harness Assam's full potential.

Introduction:

Assam, located in the North Eastern part of India, emerges as a haven for aquaculture due to its abundant water resources.

The state's network of rivers, ponds, and wetlands provides an optimal environment for fish farming, playing a crucial role in both the local economy and the nutritional needs of its populace. This chapter aims to delve into the present status of fish farming in Assam, examining the challenges, opportunities, and recent advancements within this dynamic sector.

Assam stands out as the most water-abundant state in the northeastern region of India. Fish holds profound cultural and dietary significance for its residents, with almost 90% of the population incorporating fish into their daily meals. The longstanding practice of fish farming in rural areas has transformed the fishing industry into a vital economic activity, not only generating livelihood opportunities in rural settings but also acting as a pivotal sector for achieving nutritional security, income augmentation, and overall livelihood improvement for millions.

Endowed with abundant fisheries resources, Assam has the potential to serve as a crucial protein source for its continually growing population. The state's extensive network of perennial rivers, characterized by substantial seasonal variations in discharge due to periodic rainfall and dry spells, coupled with vast floodplain wetlands and ponds, contributes to the diverse aquatic ecosystems of the region. Nestled in the northeastern region, recognized as a biodiversity hotspot, Assam boasts a rich array of indigenous and endemic fish species.

Despite a consistent upward trajectory in fish production from Assam's available resources, the current productivity lags behind its full potential. This chapter endeavours to present a comprehensive overview of the existing scenario concerning fish production, available resources, fish diversity, and potential opportunities to enhance fish production in the state.

Fisheries in India have gained recognition as a significant economic activity, witnessing a remarkable 13-fold increase in fish production from 1950-51 to 2014-15. While states like West Bengal, Andhra Pradesh, Tamil Nadu, and Kerala lead in fish

production, the northeastern region faces deficiencies, presently importing fish from other states. The exploitation of aquatic resources in the region remains low, hampered by the lack of regulatory measures for fish stock conservation and industrial pollution. Assam emerges as one of the most resourceful states in the north-eastern part of the country, contributing approximately 77% of the total fish production in the region. Boasting an excellent sub-tropical climate, Assam provides an ideal setting for the development of freshwater fish culture across various water bodies. While having the potential to become a significant fish exporter, a substantial portion of Assam's internal demand is still met by importing fish, posing a strain on its resources. The tardy trend in Assam's fisheries development can be partially attributed to natural calamities, but more prominently to the lack of widespread implementation of scientific aquaculture and the disinclination of pond owners to undertake fishery on a commercial scale.

This chapter aims to provide a comprehensive exploration of fish farming in Assam, shedding light on its rich potential, existing challenges, and the promising avenues for future development.

Status of fish in Assam:

The fisheries sector in the region presents a tapestry of diversity and vibrancy, evident in the rich dataset provided. Assam has 447 registered beel, sprawling across an expansive 30,444.67 hectares, these aquatic habitats stand as a testament to the region's commitment to fostering a robust and sustainable aquaculture industry. Beel fisheries, characterized by their vastness and ecological significance, play a pivotal role in sustaining the region's aquatic biodiversity. The sheer number and expanse of these registered beel fisheries indicate a substantial presence and emphasize the importance of these water bodies in supporting diverse fish species. Ponds and tanks, numbering over half a million i.e. 552,607 in number and spanning an impressive 94,693.47 hectares, emerge as crucial components of the aquatic ecosystem. Beyond their ecological significance, these fisheries contribute significantly to the economic and nutritional needs of the region's population. Serving as artificial yet highly effective environments for fish farming, these water bodies contribute substantially to the overall fish production in the region. The sheer scale of pond and tank cultivation demonstrates the region's commitment to harnessing a variety of water bodies for sustainable aquaculture.

River fisheries carve out an area of 11,304.48 hectares, further adding to the diverse aquatic tapestry of the region. The rivers, with their varying seasonal flows, contribute to the dynamic nature of fish farming and add resilience to the aquaculture industry. Forest fisheries and derelict water bodies/swamps, encompassing 6,102.90 and 83,633.26 hectares respectively, reveal the region's proactive approach to utilizing diverse aquatic environments for fish cultivation. The adaptability of the fisheries industry is showcased by the allocation of 3,096 hectares to reservoir fisheries, highlighting the sector's ability to leverage different water bodies for optimal fish production.

The presence of 608 hatcheries in the region signifies a strategic focus on fish seed production. These hatcheries, both governmental and private, serve as critical components in sustaining and enhancing fish populations. The staggering production of 20,843.08 million fish seeds is a testament to the region's commitment to nurturing the lifecycle of aquatic species and ensuring a consistent supply of fish for both consumption and commercial purposes. Besides the seed production, the substantial output of fish, totalling 443,568.69 tonnes in raw and dry forms, underscores the economic and nutritional significance of the fisheries sector in the region. Beyond being a key economic contributor, this sector plays a vital role in meeting the dietary requirements of the population. The versatility of the region's fisheries industry, as reflected in the varied forms of fish production, highlights its adaptability to market demands and consumer preferences.

In the fiscal year 2022-23, the state achieved an admirable fish production level of 4.43 lakh MT, marking a commendable increase. Equally noteworthy is the rise in per capita consumption from 12.18 Kg to 13.06 Kg, indicating a growing reliance on fish as a staple in the regional diet. With over 90% of the state's population being avid fish consumers, the consistent demand for fish throughout the year creates an ever-increasing scope for harnessing the fish production potential to its optimum level in a sustainable manner.

The economic significance of the Fishery and Aquaculture sector is profound, as reflected in its contributions to the State's Gross State Domestic Product (GSDP). At current prices, the sector contributed a staggering Rs. 1,989,719 lakh for the year 2022-23, boasting an impressive growth rate of 16.38% over the previous year. This economic contribution is a testament to the sector's pivotal role in driving economic

growth and supporting livelihoods. In addition to the current prices, the sector's contribution to the GSDP at constant prices (2011-12 prices) amounted to Rs. 728,033 lakh for the year 2022-23, with a growth rate of 2.60% over the preceding year. This dual perspective on economic contributions underscores the sustained and resilient nature of the fisheries sector in contributing to the state's economic development.

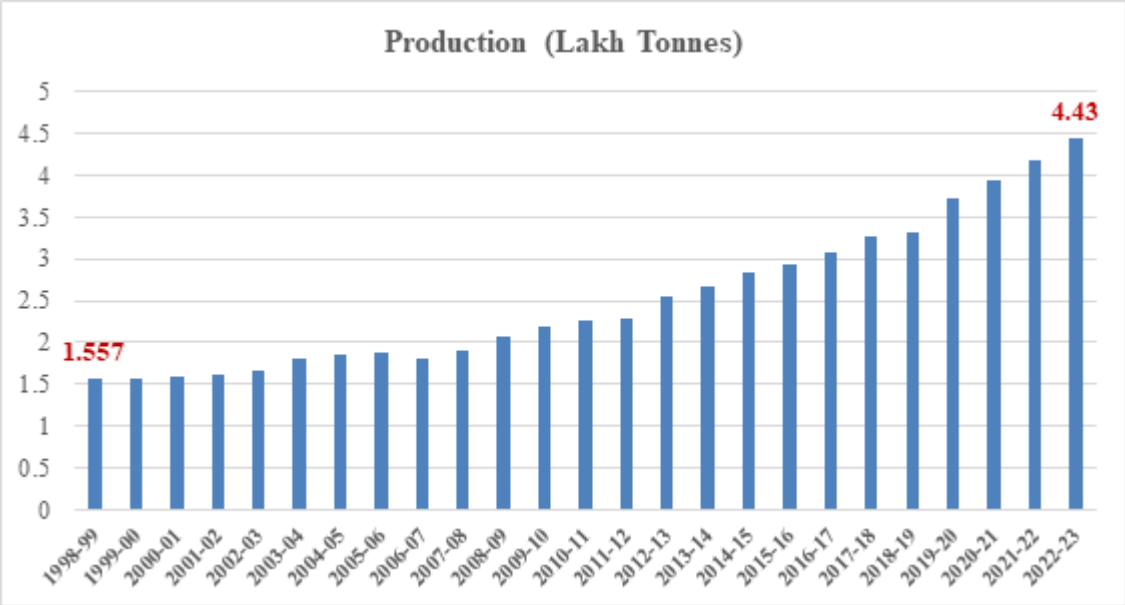

Figure 1: Fish production in Assam last 25 years (1998-99 to 2022-23)

Source: Economic Survey, Assam 2023-24

Major fish species cultivated:

Assam's aquaculture landscape is characterized by a diverse array of cultivated fish species, catering to both local consumption and commercial markets. Among the commonly farmed species are Rohu (Labeo rohita), Catla (Catla catla), Mrigal (Cirrhinus mrigala), Common Carp (Cyprinus carpio), and Pangasius (Pangasianodon hypophthalmus). These species, known for their taste, nutritional value, and market demand, contribute significantly to the state's thriving aquaculture industry. Additionally, indigenous varieties such as Assam Valley Carp (AVC) hold a special place, adding to the richness and uniqueness of Assam's aquaculture offerings. The extensive aquatic biodiversity of Assam is highlighted by a comprehensive record of 216 fish species documented in the state, as reported by Bhattacharjya *et al.* in 2003. These species span across 106 genera, 37 families, and 11 orders, showcasing the remarkable diversity within Assam's water bodies. Subsequent studies, such as the one by Bhattacharjya *et al.* in 2017, provide further insights into the finfish species occurring in

the river stretches of Assam, with 141 species identified across 84 genera and 29 families.

An interesting shift in catch dynamics is observed, with miscellaneous species emerging as the most dominant group in total catches. Notably, Aspidoparia morar (Cabdio morar), a small-sized minor carp, has become the most dominant species in the Brahmaputra and Barak rivers, showcasing its prevalence at major landing centres. This shift in dominance suggests evolving ecological dynamics in Assam's rivers and emphasizes the adaptability of the fisheries industry to changing conditions. As well, the floodplain wetlands significantly contribute to the ichthyofaunal richness of Assam. Deepor beel, a designated Ramsar site and one of the important wetlands in the region, supports a diverse community of 68 fish species, underscoring the ecological importance of these habitats. Similarly, Sone beel, the largest wetland in Assam, houses 69 fish species belonging to 49 genera, spanning 24 families and 11 orders (Kashyap, 2019). These wetlands serve as vital reservoirs of biodiversity, playing a crucial role in maintaining the ecological balance of the region.

The introduction of exotic fish species further adds to the complexity of Assam's aquatic ecosystems. Exotic carps such as Cyprinus carpio, Ctenopharyngodon idella, and Hypophthalmichthys molitrix have been reported in Assam's water bodies. Additionally, regular stocking of bighead carp (Hypopthalmichthys nobilis) and tawes (Barbonymus gonionotus) in floodplain wetlands, as documented by Bhattacharjya *et al.* in 2017, indicates strategic efforts to diversify fish populations and enhance aquaculture practices. Family wise distribution reveals intriguing patterns, with Cyprinidae emerging as the most dominant group comprising 80 fish species. Sisoridae, with 23 species, and Balitoridae, with 17 species, also play significant roles in the aquatic tapestry of Assam. These distributions offer valuable insights into the composition and structure of fish communities in the region, providing a foundation for sustainable fisheries management. Assam's aquaculture sector is a dynamic and diverse industry, encompassing a wide range of fish species that contribute to both local sustenance and commercial trade. The recorded diversity of 217 fish species, the notable dominance of miscellaneous species in catches, and the ecological significance of floodplain wetlands collectively portray a thriving and evolving aquatic ecosystem. The inclusion of exotic species and strategic stocking practices further reflect the region's commitment to enhancing and sustaining its fisheries resources. Understanding and preserving this

aquatic diversity are essential for maintaining the ecological balance, supporting local livelihoods, and ensuring the continued prosperity of Assam's aquaculture industry.

Government Initiatives and Interventions:

a. State Owned Priority Development (SOPD) Schemes

1. Fish & fish seed farming:

The Department has successfully implemented the Fish & Fish Seed Farming scheme as a pivotal initiative for enhancing fish and fish seed production. Numerous programs have been executed under this scheme, focusing on beneficiary-oriented activities in both general areas and the Scheduled Caste Sub Plan (SCSP). Key activities include:

a) Extension of Fish Culture Area: Expanding the area dedicated to fish culture to boost overall production.
b) Provision of Fish Culture Input and Material Supply: Supplying necessary inputs and materials to beneficiaries' ponds and departmental farms to increase fish productivity.

Moreover, an ambitious five-year project titled "Gene Bank - Scientific Conservation Programme for Indigenous Fish (SCoPIF)" is currently underway. Collaborating with the College of Fisheries, Raha, the project aims to conserve the state's fish biodiversity through scientific approaches. It involves developing standardized propagation technology for endangered fish species, creating a directory and database of indigenous fish species, and establishing a fish gene-bank.

2. Marketing and transport of fish:

Recognizing the importance of marketing fish in hygienic conditions for consumer safety and promoting fisheries as a livelihood, the scheme focuses on developing fish marketing infrastructure. This includes establishing hygienic fish markets and retail outlets to enhance the overall marketing and transport of fish.

b. Rural Infrastructure Development Fund (RIDF):

The Department of Fisheries in Assam actively participates in fishery-related infrastructure development programs under the Rural Infrastructure Development Fund (RIDF) instituted by NABARD. Projects under RIDF-XXVI encompass the establishment of refrigerated fish-carrying vehicles, mini and medium fish feed plants, and three-wheelers equipped with insulated ice boxes. Furthermore, RIDF-XXVIII has

been sanctioned for the development of 23 existing departmental fish farms with a budget provision of Rs. 6024.10 lakh.

c. Centrally sponsored schemes

1. Pradhan Mantri Matsya Sampada Yojana (PMMSY):

The PMMSY stands as an umbrella scheme comprising a Central Sector Scheme and a Centrally Sponsored Scheme (CSS) component, further divided into non-beneficiary-oriented and beneficiary-oriented schemes. The CSS component involves cost sharing between the center and the state, with different sharing patterns for general and specific categories. Key components under PMMSY include:

a) Construction of New Pond under NEH: Facilitating the creation of new ponds under the National e-Governance Plan in the North Eastern Region.
b) Construction of New Rearing Pond: Establishing new rearing ponds to support aquaculture activities.
c) Establishment of Fish Seed Hatchery: Creating facilities for the controlled breeding of fish seeds.
d) Establishment of Fish Feed Mill/Plant: Developing infrastructure for the production of fish feed.
e) Inputs for Fish Farming: Providing essential inputs to support efficient fish farming practices.
f) Fingerling Stocking in Wetlands: Enhancing wetland ecosystems by stocking fingerlings.
g) Construction of Backyard/Integrated Ornamental Unit: Supporting the establishment of ornamental fish units.

These comprehensive initiatives and schemes collectively contribute to the growth, sustainability, and development of the fisheries sector in Assam, addressing various facets from production and marketing to infrastructure development and conservation.

Challenges faced by fish farmers:

Fish producers grapple with a range of challenges during the production process, spanning production-related issues, price concerns, marketing hurdles, and miscellaneous problems.

Production-related challenges:

Production challenges encompass inadequacies in technical support, limited availability of inputs, insufficient subsidies, low product demand, seasonal fluctuations, losses during handling, inadequate packaging materials, and the absence of processing plants. In particular, inadequate technical assistance emerged as a predominant concern, cited by a substantial proportion of respondents. Scarcity of inputs, notably in Group-IV, further highlighted the need for targeted interventions in terms of technical support and input availability.

Price-related challenges:

Price-related challenges, while significant, were comparatively less pronounced. The most notable issue in this category was irregular payments, with Group I farmers experiencing the highest percentage. Other challenges included low product pricing, lack of pricing transparency, and limited awareness of prevailing market prices. Overall, the percentage of farmers facing price-related issues was lower compared to production-related challenges.

Marketing-related challenges:

Marketing-related challenges introduced additional complexities, including inadequate transportation, unorganized markets, limited access to consumer markets, and distant marketplaces. The absence of organized markets was a prevalent challenge across all groups, necessitating farmers to transport their produce to customers amidst scattered fisheries in the study area. The lack of an organized marketing channel compounded these challenges.

Assorted problems:

Beyond production, price, and marketing challenges, farmers faced miscellaneous issues, such as insufficient technical support for promotion, inadequate government support, and delayed subsidy disbursement. Lack of government support resulted in the absence of subsidies, amplifying financial strain. Additionally, the deficiency in technical assistance adversely impacted production efficiency. These challenges collectively highlight the comprehensive nature of hurdles faced by fish producers, emphasizing the need for a holistic approach to address multifaceted issues affecting productivity and economic well-being.

Opportunities and Future Prospects:

Despite the challenges, Fishery sector in Assam has potential for growth and development. It can explore both national and international fish markets provided there is a focused effort to improve infrastructure and implement stringent quality control measures. The expansion of the aquaculture sector in Assam can be a catalyst for employment generation, particularly in rural areas. As the industry grows, it has the capacity to create diverse job opportunities, contributing to the socio-economic development of the region and enhancing the livelihoods of communities involved in fish farming.

Another avenue for Fish farming in Assam is the adaptation of sustainable practices. By implementing eco- friendly methodologies, the sector can enhance its long-term productivity and mitigate environmental impacts simultaneously. This shift towards sustainability aligns with global trends and positions Assam as a responsible player in the aquaculture domain. Diversification emerges as a strategic move to bolster the resilience of fish farming in the state. Exploring the cultivation of high-value fish species and integrating aquaculture with other agricultural practices can provide farmers with additional income streams which will not only increases the economic viability of fish farming but also contributes to the overall agricultural landscape of Assam.

Despite being rich in fisheries resources and achieving self-sufficiency in fish seed production, Assam has not fully realized the complete potential of its fisheries sector. This shortfall is attributed to the absence of a comprehensive strategy and the underutilization of available resources. To address this, there is a pressing need for conservation and effective utilization of fisheries resources, focusing on responsible fishing practices and environmentally sound management programs. The current situation demands a strategic shift towards sustainable practices, aiming to augment fish production through aquaculture. Facilitating post-harvest practices, promoting value addition, and establishing robust market linkages are integral components of this strategy. These measures collectively work towards achieving the vision of Assam transforming into an exporting state, thereby reducing its dependency on fish imports and ensuring a prosperous future for its fisheries sector.

Conclusion:

Situated in India's northeastern region, Assam boasts abundant water resources, forming a conducive environment for a thriving fish farming sector. Despite challenges, such as irregular payments and unorganized markets, Assam's fish farming presents significant opportunities. The government has implemented strategic initiatives like the Pradhan Mantri Matsya Sampada Yojana, aiming to enhance fish production through various components like the construction of new ponds, fish seed hatcheries, and fish feed plants. These endeavours address challenges faced by fish farmers, promoting sustainable practices and market linkages.

Assam's rich aquatic biodiversity includes 217 fish species, reflecting the diverse ecosystem. The state holds potential for export, employment generation, and sustainable practices. The fisheries sector significantly contributes to the Gross State Domestic Product (GSDP), showcasing its economic importance. Assam's vision includes transforming into an exporting state, reducing reliance on fish imports, and ensuring a prosperous future for its fisheries sector through responsible and sustainable approaches, emphasizing conservation, value addition, and robust market connections.

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MICROBIAL L-ASPARAGINASE: PROPERTIES AND APPLICATIONS

Chandrasekaran Swaminathan*, Jayabalan Jayaprakash and Devadoss Johnmilton

PG & Research Department of Microbiology,

St. Joseph's College of Arts & Science (Autonomous),

Cuddalore – 607001, Tamil Nadu, India

*Corresponding author E-mail: actinosam@yahoo.com

Abstract:

L-Asparaginase is a therapeutic enzyme used in the treatment of a variety of lymphoproliferative disorders and lymphomas particularly acute lymphoblastic leukaemia and Hodgkin's lymphoma. In addition, L-asparaginase is preferred in food processing industries and in biosensor fabrication. Although several plants and terrestrial and marine microorganisms are found to produce L-asparaginase, only the purified enzymes from *Erwinia chrysanthemi* and *Escherichia coli* are employed in clinical and therapeutic applications in humans. This review aims to compile information on the properties and applications of L-asparaginase from various microorganisms.

Keywords: L-Asparaginase, Antileukemic Agent, Acrylamide

Introduction:

L-asparaginase is a therapeutic enzyme that has been widely studied by scientists for its antitumor properties. As a biopharmaceutical, L-asparaginase has been used in combination with other drugs to treat acute lymphoblastic leukaemia, acute myeloblastic leukaemia, and other malignancies of the lymphatic system (Castro *et al.,* 2021). Kidd (1953) described that guinea pig serum had anti-cancerous activity against murine lymphoma's and lymph sarcoma's strains in rats. Later Broome (1963) first identified that the anti-tumour activity was because of presence of L-asparaginase in the serum. In 1966, De lowery *et al.,* got positive result *in vivo* study, a boy having acute lymphocytic leukaemia when treated with purified guinea pig serum. It contains L-Asparaginase enzyme activity, catalyses the hydrolysis reaction of L-asparagine to aspartic acid and ammonia.

Production of L-asparaginase by *Escherichia coli* presented excellent anti-tumour activity (Mashburn and Wriston 1964). Whitecar *et al.* (1970) got positive response against acute lymphoblastic Leukaemia (ALL) in successive chemotherapy by L-

asparaginase. Campbell *et al.* (1967) identified types of L- asparaginases: type I and type II. Type I L-asparaginases are expressed constitutively in the cytoplasm and catalyse the hydrolysis of both L-Asparagine and L-Glutamine and type II L-asparaginase are expressed under anaerobic conditions in the periplasmic space of the bacterial membranes and shows higher specificity for L-Asparagine hydrolysis. Bilimoria (1969) has purified L-Asparaginase about 40-fold by a combination of ammonium sulphate and ethyl alcohol precipitations. Gulati *et al.* (1997) introduced the pH and dye-based method for screening L-asparaginase producing microorganisms.

Mechanism of action:

L-asparaginase catalyses the hydrolysis of the non-essential amino acid L-asparagine to L-aspartate and ammonia. L-asparagine is an essential amino acid for the growth of tumour cells, while the growth of normal cells does not depend on its need. Most normal tissues synthesize enough L-asparagine for their metabolic needs using their enzyme L-asparagine synthetase, but malignant cells require an external source of L-asparagine for growth and multiplication. In the presence of L-asparaginase, tumour cells lose an important growth factor and cannot survive. This fact suggested the development of this enzyme as an effective anti-tumour or anti-leukaemia drug (Savitri *et al.,* 2002).

Applications of L - Asparaginase:

Pharmaceutical industry

Table 1: L-asparaginase product and their manufacturer

S. No.	Trade name	Manufacturer
1	Oncaspar	Sigma-Tau Pharmaceuticals, Italy
2	Erwinase®	Porton Biopharma, UK
3	Elspar	Merck Sharp & Dohme, USA
4	Crisantas	Bayer, Germany
5	Leunase	Kyowa Hakko, Japan
6	Leucoginase	VHB Life Science Inc. (Cytocare), India
7	Oncoginase	Chandra Bhagat Pharma Pvt Ltd., India
8	L-Aspase	Miracalus Pharma Pvt Ltd, India
9	Asparget	GLS Pharmaceuticals Pvt Ltd, India
10	Acrylaway®	Novozymes, India

L-asparaginase is a medicinally important protein in combination with the other drugs in the treatment of various types of blood cancer such as acute lymphocytic leukaemia, Hodgkin disease, acute myelocytic leukaemia, acute myelomonocytic leukaemia, chronic lymphocytic leukaemia, lymphosarcoma, reticulosarcoma, and melanosarcoma surrounding tissue.

Food industry

Several studies indicate that L-asparagine is the main amino acid responsible for the production of acrylamide in fried and baked foods when reducing sugars are condensed with a carbonyl source. This phenomenon does not occur in cooked food (Tareke, 2000). Zyzak *et al.* (2003) found that the amide chain in the acrylamide structure is derived from L-asparagine. The researchers also confirmed that the use of the L-asparaginase enzyme before baking or frying can reduce the acrylamide content of the final processed product by more than 99%. This is because the enzyme reduces more than 88% of the L-asparagine content of the original raw material. In recent years, other works have addressed this application of l-asparaginase, which can reduce the negative effects of acrylamide-containing foods without changing their properties (Zhang *et al.,* 2015).

Biosensors

Due to the fact that L-asparaginase catalyses the hydrolysis of L-asparagine, which releases L-aspartic acid and ammonium ions, and causes a medium pH change followed by colour variation, L-asparaginase based biosensors are a promising and innovative technology. Most of these biosensors rely on colorimetric detection. The simplicity and quick responsiveness of L-asparaginase biosensing systems demonstrate its potential for L-asparagine concentration analysis in foods and L-asparagine monitoring in patients with acute lymphoblastic leukaemia (Nunes *et al.,* 2021).

Sources of L-Asparaginase:

Table 2: Microbial sources of L-asparaginase

Microorganisms	Reference
Bacteria	
Staphylococcus capitis	Paglla *et al.,* 2013
Thermus thermophilus	Pritsa *et al.,* 2001
Enterobacter aerogenes	Mukherjee *et al.,* 2000

Helicobacter pylori	Stark *et al.,* 1997
Erwinia aroideae	Tiwari and Dua, 1996
Pseudomonas stutzeri	Manna *et al.,* 1995
Staphylococcus aureus	Rozalska and Mikucki, 1992
Corynebacteriumglutamicum	Mesas *et al.,* 1990
Klebsiella pneumoniae	Reddy and Reddy, 1990
Pseudomonas ovalis	Badr and Foda, 1976
Serratia marcescens	Rowly and Wriston, 1967
Yeast	
Rhodotorula sp	Foda *et al.,* 1980
Pichiopolymorpha	Foda *et al.,* 1980
Candida utilis	Kil *et al.,* 1995
Rhodosporidium toruloides	Ramakrishnan *et al.,* 1996
Saccharomyces cerevisiae	Bon *et al.,* 1997
Fungi	
Penicillium sp.	Krishna and Gupta, 2012
Aspergillus nidulans	Drainas and Drainas, 1985
Aspergillus terreus	Seifert *et al.,* 1990
Aspergillus niger	Mishra, 2006
Aspergillus oryzae	Hendriksen *et al.,* 2009
Actinomycetes	
Streptomyces karnatakensis	Mostafa, 1979
Streptomyces venezuelae	Mostafa, 1979
Noccardia sp.	Gunasekaran *et al.,* 1995
Streptomyces tendae	Kavitha and Vijaylakshmi, 2010
Streptomyces gulbargensis	Amena *et al.,* 2010

Optimization of L-Asparaginase production:

The growth and fermentation product formation of an organism are strongly influenced by medium composition; thus, optimization of media components and cultural conditions is an important step for bioprocess development (Suresh and Raju, 2013). Production of L-asparaginase was greatly influenced by fermentation media

composition and cultural conditions such as pH, temperature, inoculum size, agitation rate and incubation time (Hymavathi *et al.,* 2009). Moorthy *et al.* (2010) reported the production of L-asparaginase from *Bacillus* species by submerged fermentation. Cultivation conditions were optimized to achieve higher enzyme yields. Two carbon sources, glucose and maltose, were used for enzyme production. The first gave better results. The enzyme was activated with MgCl2 and inhibited with EDTA.

Tippani and Sivadevuni (2012) investigated the nutrient requirements for the production of L-asparaginase by *Fusarium* species by submerged fermentation. The highest amount of enzyme production by *Fusarium semitectum* (328 IU/ml), *Fusarium moniliforme* (300 IU/ml) and *Fusarium oxysporum* (210 IU/ml) was obtained using glucose as carbon source, with lactose being the second-best carbon source for *Fusarium semitectum* (218 IU/ml) and *Fusarium oxysporum* (178 IU/ml) and mannose for *Fusarium moniliforme* (213 IU/ml). The most common production method for the enzyme L-asparaginase is submerged fermentation, which has been adopted worldwide. This technique has many disadvantages. It is expensive and has a low product content. In addition, it generates excessive wastewater, thus requiring large amounts of wastewater treatment and disposal during further processing (El-Bessoumy *et al.,* 2004).

Side effect of L-Asparaginase:

Overall, allergic reactions due to production of anti-asparaginase antibodies have been observed in up to 60% of patients, mainly to native E-coli asparaginase compared to the pegylated enzyme. The route of administration has been found to produce clinical symptoms, with the incidence of serious skin reactions being higher with intramuscular than intravenous administration (Hawkin *et al.,* 2004). Also cited are studies showing that antibodies, rather than causing clinical hypersensitivity, can cause rapid inactivation of asparaginase leading to suboptimal clearance of asparagine, often referred to as "silent hypersensitivity" or "silent inactivation", and their expected characteristics. occurs in approximately 30% of patients. Generally, patients with clinical signs of allergy to one asparaginase formulation are switched to another product to ensure the most successful regimen for them. However, the exchange may not be optimal because antibodies against E-coli asparaginase can cross-react with PEG-asparaginase.

PEG-asparaginase can also induce silent inactivation of antibodies, leading to a rapid decrease in asparaginase activity. Therefore, switching from PEG-asparaginase to E-coli-asparaginase after an allergic reaction is not the treatment of choice (Pieters *et al.* 2011). Hyperglycaemia, pancreatitis, abnormalities in hemostasis, abnormalities in lipid metabolism, etc., are other asparaginase-related toxicities that occur more often in adults than in younger children. Hepatotoxicity of liver enzymes or elevated bilirubin is a common clinical problem in adult patients (Barry *et al.,* 2007).

Conclusion:

The pharmaceutical and food industries use the intriguing enzyme L-asparaginase extensively. On the other hand, certain particular qualities are necessary for its application in food and pharmaceutical industrial sectors, such as human safety. Effective activity is necessary for chemotherapeutic agents, along with a decrease in side effects including immunological inactivation and hypersensitivity.

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EXPLORATION OF NUTRITIONAL AND ANTIOXIDANT PROFILE OF *ACHYRANTHUS ASPERA*

Madarakhandi Sujata* and Nataraj Durgannavar

Department of Food Processing and Nutrition,

Karnataka State Akkamahadevi Women's University, Vijayapura, Karnataka, India

*Corresponding author E-mail: sujatamadarakhandi@gmail.com

Introduction:

The importance of diet and nutrition in human health and disease is well established. Nutrients are required in preventing diseases. It is true that, nutrition is an essential part of every individual whether they are children, teenagers, adults or aged people. Nutrition refers to the nourishing of our body, in order to keep it healthy and proper functioning. It is a human responsibility to provide the body with all its necessary food, vitamins, and minerals to continue the daily life processes. A person can live healthily by using the proper nutrient composition in his food and if it is deprived then we have to take some nutritive supplements for compensation. It is reported that plants are good source for vital macro and micronutrients (Shendkar *et al.,* 2011).

Plants are gifts of God for mankind. India is a country with rich in biodiversity. There are 45,000 species of wild plants (Arora and Pandey, 1996), out of which 9,500 species are ethno-botanically important species (Bhattacharya, 1991). Of these 7,500 species are in medicinal use for indigenous health practices. About 3,900 plant species are used by tribal people as food (out of which 145 species comprise of root and tubers, 521 species of leafy vegetables). India is blessed with a vast resource of greeneries and wide array of Green Leafy Vegetables (GLVs). Green leafy vegetables are used since ancient periods as source of food as they contain many nutrients and minerals which are helpful in maintaining human health. Leafy vegetables are naturally available important constituent of Nutraceutical and are also called as pot herbs, greens, vegetable greens, leafy greens or salad greens.

With the increasing population and fast depletion of natural resources, it became necessary to explore the possibilities of using newer indigenous plant resources. There are many plants species still lying unexplored and underexploited. Therefore, there has been focused attention by the researchers on exploiting alternative or underutilized plant species for multifarious use. "Underutilized crops" are plant species that are used

traditionally for their food, fiber, fodder, oil or medicinal properties, but have yet to be adopted by large scale agriculturalists. Underutilized plants, in general, constitute those plant species that occur as life support species in extreme environmental conditions and threatened habitats, having genetic tolerance to survive under harsh conditions and possess qualities of nutritional and/or industrial importance for a variety of purposes.

The underutilized foods can be defined as "the foods which are less available, less utilized or rarely used or region specific" (William and Haq, 2002). Neglected and underutilized plants are those that could be - and, in many cases, historically have been - used for food and other uses on a larger scale. These underutilized crop species have also been described as "minor", "orphan", "promising" and "little-used".

In nature, there are many underutilized greens of promising nutritive value, which can nourish the ever increasing human population. Many of them are resilient, adaptive and tolerant to adverse climatic conditions. Although, they can be raised comparatively at lower management costs even on poor marginal lands, they have remained underutilized due to lack of awareness and popularization of technologies for utilization (Sheela *et al.,* 2004). Consumption of such food materials is confined to the people living in the areas where they grow. Recognizing the need for identification of such GLV, which are believed to be nutritious, may help in achieving nutritional (micronutrient) security (Gupta *et al.,* 2005).

There are various types of underutilized leafy vegetables, which are available seasonally, and practically no information is available on the nutrient content and antinutritional factors of such vegetables. One of such unknown and underutilized leafy vegetable is *Achyranthus aspera.*

A. aspera Linn. belongs to the family Amaranthaceae, is an annual, stiff erect or procumbent, annual or perennial herb, 1-2m in height, often with a woody base, commonly found as a weed of waysides, on roadsides (Anonymous 2005, Jain *et al.,* 2006 & Zafar 2009). It is an annual shrub found distributed throughout the tropical and subtropical regions. It is commonly found in India, Baluchistan, Sri Lanka, tropical Asia, Africa, Australia, and America (The Wealth of India 1985).

In the country, it is known by different names such as chirchita (Hindi), apamarga (Sanskrit), aghedi (Gujarati), apang (Bengali), nayurivi (Tamil) and kalalat (Malyalam). It grows as wasteland herb everywhere. Since time immemorial, it is in use as folk medicine.

According to Ayurveda, it is bitter, pungent, heating, laxative, stomachic, carminative and useful for the treatment of vomiting, bronchitis, heart disease, piles, itching abdominal pains, ascites, dyspepsia, dysentery, blood diseases etc. (Bhandari, 1990; Dwivedi *et al.,* 2007). In Ayurveda, two varieties, red and white are mentioned. In Sanskrit, synonyms describe this as a rough flowered stalk. It is described in 'Nighantas' as purgative, pungent, digestive, a remedy for inflammation of the internal organs, piles, itch, abdominal enlargements and enlarged cervical glands.

Conventionally the best harvesting time for *Achyranthus aspera* is in the noon at the time of open sun when temperature starts increasing. It flowers from July to September, and the seeds ripen in October. *Achyranthus aspera* like other herbal plants is consumed in variety of ways and various purposes. In addition to its fresh parts, other common processed forms of chaff flower include whole dry plant, freezing, powdered leaves and extracted essential oils.

Achyranthus aspera contains low amount of fat contents and less caloric value. It is also known as a good source of vitamin c and minerals. It also contains smaller amounts of other vitamins, minerals, proteins, carbohydrates and fiber. It contains 294 kcal of energy per kilogram. Its seeds are rich in dietary fiber. *Achyranthus aspera* is also known for flavonoids and antioxidant properties. *Achyranthus aspera* is on the GRAS (Generally Recognized as Safe) list of USDA to be used at less than 2000 mg/kg but because of the presence of carcinogenic compounds.

Achyranthus aspera was reported to contain many phytochemicals like alkaloids, flavonoids, tannins, Terpenoid, saponins, glycosides, steroids etc. *Achyranthus aspera* is a very important plant for its large number of medicinal properties as well as medicinally important chemicals like ecdysterone, achyranthine, betaine, pentatriaontane, 6-pentatriacontanone, hexatriacontane and tritriacontane. In India and China, this plant is extensively used as anti-microbial, cancer chemo-preventive, hepatoprotective, analgesic, anti-inflammatory and anti-arthritic, hypolipidemic, nephroprotective, diuretic and immunomodulatory etc.

There is a need for exploration of such underutilized foods to overcome the nutritional disorders. Further, there is a call for action to view the usage of these kinds of foods for folk remedies through scientific lenses and provide scientific evidences to support the multidisciplinary uses of underutilized plants. Therefore an attempt was made to identify and analyze one of such underutilized green leafy vegetables for their

nutrient content and antioxidant potential. The present study was undertaken with the following objectives *i.e.,*

1. To study the folk remedies and traditional uses of *Achyranthus aspera*

Taxonomical classification

Kingdom: *Plantae*

Subclass: *Caryophyllidae*

Order: *Caryophyllales*

Family: *Amaranthaceae*

Genus: *Achyranthes*

Species: *Aspera*

Vernacular names

Latin: *Achyranthus aspera*

Kannada: Uttrani soppu

Sanskrit: Aghata

Hindi: Latjira, Chirchira

Gujarati: Safad Aghedo

Punjabi: Kutri

Unani: Chirchitaa

Ayurvedic: Apaamaarga, Chirchitaa, Shikhari, Shaikharika

Results and Discussion:

Achyranthes aspera L. belong to the family *Amaranthaceae* and are found to possess lot of medicinal properties. *A. aspera* is a small herb found all over India possessing valuable medicinal properties. It is useful in cough, bronchitis, rheumatism, malarial fever, dysentery, asthma, renal and cardiac dropsy, hypertension and diabetes mellitus. *A. aspera* can stimulate the immunity, enhance the antigen clearance, potentiate antibody production, elevate thyroid hormone levels, decrease hepatic lipid peroxidation and also possessed spermicidal, chemo-preventive, anti-inflammatory, anti-arthritic and hypoglycemic activities.

In view of this, the study was undertaken to explore the nutritional and antioxidant profile of the chaff flower. The data from the research papers were collected, tabulated and presented in this section under following sub-headings.

Folk remedies and traditional uses of *Achyranthus aspera*

Documentation of the traditional ethnomedicinal uses of *Achyranthus aspera* is presented in table 1. The information on ethnomedicinal uses of Chaff flower were collected from different parts of the world. In Pakistan, whole plant was used for the treatment of cough, asthma, kidney stone, antiinflammator, diuretc as reported by the (Abbasi, 1999). In Bangladesh, the leaves were used for the stomach ache and abortion (Roy *et al.,* 2008). In Oman country, whole plant was used for the treatment of healing cuts and abrasion.

Ethnomedicinal uses of Chaff flower were also reported in different parts of the India. In Himachal Pradesh, the plant was used in different way. Husk free seeds are used for halwa preparation with milk. Seed flour was used to prepare chapati. Halwa prepared with seeds are highly nutritive and energetic. Generally, Hindu monk (naga) used before starting fast and meditation for several days. In Western Himalaya, the roots of the plant were used for the relieve toothache, jaundice, snakebites and gynecological disorders. In Odisha, they used tender leaves for edible purpose. The young leaves are directly fried with oil if present neither boiled with only salt and taken as leafy vegetable. In Punjab, the ash of roots is mixed with honey and given orally to cure cough. Decoction of spiny seeds is also used to cure cough reported by (Kaur *et al.* (2020). Mixture of Achyranthes and Tinospora stem powder is used to cure asthma. In Chattisgarh, they used for the Jaundice as reported by the Toppo, (2020).

Further, in some parts of the Karnataka this plant is been traditionally used, it is cooked as vegetable and also used in ayurvedic formulations as indicated from Hassan district. In south Karnataka region, the young leaves and shoots were collected, roasted then it is eaten as reported by (Gowthami *et al.,* 2016).

Table 1: Documentation on the traditional ethnomedicinal uses of *Achyranthus aspera*

Sl. No.	Location	Part(s) used	Folk remedies followed	Reference
01.	Haripur Basin, Pakistan	Whole plant	Cough, asthma, kidney stone, antiinflammator, diuretic	Abbasi, 1999; Marwat *et al.,* 2004; Hussain *et al.,* 2008
02.	Rangamati and Khagrachari districts of Dhaka, Bangaldesh	Leaves	Stomach ache, abortion	Roy *et al.* (2008)
03.	BR hills of Chamarajanagar district, Karnataka	Whole plant	Anthritis	Gireesha and Raju, 2013
04.	Hassan, Karnataka	Leaves Whole plant	Leaves are cooked as vegetable Used in ayurvedic formulations	Kumar and Shiddamallayya, 2016
05.	South Karnataka	Leaves	Young leaves and shoots are collected, roasted then Eaten	Gowthami *et al.,* 2016
06.	Hamirpur district, Himachal Pradesh	Whole plant	Husk free seeds used for halwa preparation with milk. In the past when the source was limited, seed flour was used to prepare chapati. Halwa prepared with seeds are highly nutritive and energetic. Generally, Hindu monk (naga) used before starting fast and meditation for several days.	Chand *et al.* 2017

07.	Satara, Maharashtra, India	Young leaves	Consumed as vegetable	Deshapande *et al.,* 2018
08.	Korva Tribe of Sitapur and Bagicha Block in Chattisgarh, India	Roots	Jaundice	Toppo, 2020
09.	Talwandi Sabo, Bathinda District, Punjab (India)	Roots Seeds Stem	The ash of roots is mixed with honey and given orally to cure cough. Decoction of spiny seeds is also used to cure cough. Mixture of Achyranthes and Tinospora stem powder is used to cure asthma.	Kaur *et al.* (2020)
10.	Odisha	Leaves	Mostly the tender leaves are collected for edible. The young leaves are directly fried with oil if present neither boiled with only salt and taken as leafy vegetable	Mallick *et al.,* 2020
11.	Jasrota hill and the surrounding mountains, J&K, Western Himalaya, India.	Root	Relieve toothache, jaundice, snakebites, gynecological disorders	Singh *et al.,* 2020
12.	Eastern Hajar Mountains, Oman	Whole plant	Healing cuts and abrasion	Hinai *et al.,* 2020

Conclusion:

The focus of this study was to explore the traditional and usage and to investigate the nutritional and antioxidant profile of one of the underutilized plant i.e., *Achyranthus aspera*.

From the reviews collected, it was obvious that the plant has been used traditionally in the treatment of various ailments and also used as vegetable in the daily diet by many tribal people.

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WOMEN AT THE HELM: SHAPING THE FUTURE OF THE FISHERIES INDUSTRY

Nanda Bhupal Jagtap
Department of Zoology,
Dapoli Urban Bank Senior Science College, Dapoli Ratnagiri- 415712
Corresponding author E-mail: jnsshinde80@gmail.com

Introduction:

The fishery industry, a cornerstone of global food security and a significant contributor to livelihoods, especially in coastal and island communities, has a complex relationship with gender roles. Women have long been integral to this sector, contributing through fishing, processing, marketing, and supporting activities. However, their contributions are often overlooked, and they face numerous challenges that hinder their full participation and advancement. This chapter explores the multifaceted roles of women in the fishery industry, the obstacles they encounter, and the potential pathways to creating a more inclusive and equitable sector.

Historical context and current roles of women in the fishery industry

Historical context:

Women have played significant roles in the fishery industry throughout history, particularly in coastal and island communities where fishing has been a primary source of livelihood. In many traditional fishing societies, women were involved in various aspects of the industry, including processing, trading, and supporting activities such as repairing nets and maintaining equipment. Their contributions were often essential for the sustainability and success of fishing communities.

However, with the advent of modernization and industrialization in the fishing sector, women's roles became increasingly marginalized. As fishing activities became more mechanized and commercialized, men often took on the primary fishing roles, relegating women to secondary positions such as processing and marketing. This shift in gender dynamics led to a decline in recognition and visibility of women's contributions to the industry.

Current roles of women:

Despite these challenges, women continue to play vital roles in the fishery industry worldwide. While the extent of their involvement varies across regions and

communities, women are actively engaged in diverse activities that contribute to the sector's functioning and sustainability.

In many small-scale fisheries, women are involved in all stages of the fishing process, from harvesting to processing and marketing. They often participate in traditional fishing methods, such as gleaning and shellfish collection, as well as operating small-scale fishing vessels. Additionally, women play crucial roles in post-harvest activities, including sorting, cleaning, and preserving fish products.

Moreover, women are increasingly involved in leadership and decision-making roles within fishing communities and organizations. They participate in community-based management initiatives, advocate for their rights and interests, and contribute to the development of policies and regulations governing the fishery sector.

Despite these contributions, women in the fishery industry face numerous challenges, including limited access to resources, gender-based discrimination, and lack of representation in decision-making processes. Addressing these barriers is essential for promoting gender equality and creating a more inclusive and equitable fishery sector.

In conclusion, understanding the historical context and current roles of women in the fishery industry is crucial for recognizing their contributions and addressing the challenges they face. By promoting gender equality and empowering women in the sector, we can enhance the sustainability and resilience of fishing communities worldwide.

Major challenges faced by women in fisheries

1. Gender discrimination and social norms

Social norms and cultural practices in many fishing communities restrict women's access to resources and decision-making roles. Traditional gender roles often confine women to specific tasks, limiting their opportunities for advancement and recognition.

2. Access to resources

Women in the fishery industry often have limited access to essential resources such as credit, training, technology, and information. This disparity hampers their ability to compete, innovate, and enhance productivity.

3. Economic marginalization

The economic contributions of women are frequently underestimated, leading to lower wages, fewer benefits, and less job security compared to their male counterparts. Women are often relegated to low-paying and less stable positions.

4. Health and safety issues

Women working in fisheries, particularly in processing and marketing, are exposed to health hazards including poor working conditions, long hours, and exposure to chemicals. These issues are compounded by inadequate healthcare access.

5. Legal and institutional barriers

Legal and regulatory frameworks in many countries do not adequately protect the rights and interests of women in fisheries. Policies often overlook women's contributions and fail to address their specific needs and challenges.

6. Climate change and environmental degradation

Women in fisheries are disproportionately affected by climate change and environmental degradation. As primary caregivers and community managers, they bear the brunt of the impacts on household food security and income.

Case Studies

1. West Africa: Women's fish processing cooperatives

In countries like Senegal and Ghana, women's cooperatives in fish processing have emerged as a model for economic empowerment. These cooperatives provide women with better bargaining power, access to credit, and improved working conditions, illustrating the potential of collective action.

2. Southeast Asia: Women in small-scale fisheries

In regions such as Indonesia and the Philippines, women play a crucial role in small- scale fisheries. Initiatives focused on capacity building, access to markets, and gender- sensitive policies have shown positive impacts on women's livelihoods and community resilience.

3. South Asia: Women's leadership in coastal management

In India and Bangladesh, women have taken on leadership roles in coastal management and conservation projects. These initiatives highlight the importance of involving women in decision-making processes for sustainable fisheries management.

Pathways to empowerment and inclusion

Policy reforms and legal protections

Governments need to implement gender-sensitive policies that recognize and support women's contributions to fisheries. Legal frameworks should protect women's rights to resources, fair wages, and safe working conditions.

Access to education and training

Providing women with access to education, training, and capacity-building programs can enhance their skills, increase productivity, and open up new opportunities in the sector.

Financial inclusion and support

Ensuring women's access to financial services such as credit, insurance, and savings can empower them economically. Microfinance and cooperative models have proven effective in supporting women in fisheries.

Community-based and cooperative models

Promoting community-based management and cooperative models can enhance women's participation, decision-making, and economic benefits. These models foster solidarity, resource sharing, and collective bargaining.

Awareness and advocacy

Raising awareness about the critical role of women in fisheries and advocating for gender equality can help shift societal perceptions and policies. Media, NGOs, and community organizations play vital roles in these efforts.

Research and data collection

Improving data collection and research on women's roles and challenges in fisheries is essential for informed policy-making. Disaggregated data by gender can highlight specific needs and areas for intervention.

Conclusion:

Women are indispensable to the fishery industry, yet they continue to face numerous challenges that hinder their full potential. Addressing these issues requires a multifaceted approach involving policy reforms, economic empowerment, education, and advocacy. By recognizing and supporting the contributions of women, the fishery sector can become more inclusive, sustainable, and resilient, benefiting entire communities and enhancing food security globally. Creating an equitable environment

where women can thrive is not just a matter of social justice but also a strategic imperative for the sustainable development of fisheries worldwide.

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PEDIATRIC PERSPECTIVES ON HIV: NAVIGATING CHALLENGES AND ADVANCES IN PEDIATRIC HIV CARE

Harshkumar Brahmbhatt*, Mahavir Sharma,
Ashimkumar Sen, Nirmal Shah and Ujjval P. Vaghela
Department of Pharmacy,
Sumandeep Vidyapeeth Deemed to be University, Vadodara, Gujarat, India
*Corresponding author E-mail: harshsvdu@gmail.com

Abstract:

An essential component of the international effort to stop the HIV/AIDS epidemic is the pediatric perspective on the virus. When it comes to psychosocial support, diagnosis, treatment, and transmission, children living with HIV have unique difficulties. It includes a summary of the distinctive features of pediatric HIV, including early identification techniques, mechanisms of transmission, and developments in pediatric-specific antiretroviral therapy. It explores the challenges of treating HIV infections in pediatric populations, both perinatal and non-perinatal, highlighting the importance of prompt intervention and all-encompassing care.

Keywords: HIV/AIDS, Pediatric Population, Challenges, Anti-retroviral Therapy

Introduction:

Human Immunodeficiency Virus (HIV) remains a significant global health challenge, affecting individuals across all age groups. In the realm of pediatrics, the impact of HIV takes on unique dimensions, presenting complex challenges that demand specialized attention and care. Pediatric HIV refers to the presence of the virus in children, encompassing those who acquire the infection during the perinatal period, through breastfeeding, or later in childhood. The management of HIV in pediatric populations involves a delicate balance of medical, social, and psychological considerations, necessitating a comprehensive understanding of the distinct aspects that characterize this demographic. [1]

Challenges in pediatric HIV care:

Pediatric HIV care poses unique challenges that necessitate a comprehensive and specialized approach. Some of the primary challenges include:

1. **Early diagnosis and treatment of HIV/AIDS:**

Identifying HIV infection in infants and children is complicated due to the persistence of maternal antibodies. Early and accurate diagnosis is crucial for timely intervention and improved outcomes.

Early diagnosis and treatment of HIV/AIDS play a pivotal role in mitigating the impact of the virus on individuals and communities. The key components of this critical aspect of HIV/AIDS management include:

i. **Timely testing and screening:**

Early diagnosis begins with widespread access to HIV testing and screening services. Routine testing, especially in high-risk populations and pregnant women, helps identify infections at an early stage.

ii. **Prenatal and perinatal testing:**

Ensuring pregnant women undergo HIV testing allows for early identification of maternal infections. This enables the implementation of preventive measures to reduce the risk of mother-to-child transmission during pregnancy, childbirth, and breastfeeding.

iii. **Point of Care Testing (POCT):**

The availability and utilization of rapid point-of-care testing contribute significantly to early diagnosis. POCT facilitates quick and convenient testing, enabling immediate counseling and initiation of treatment for those diagnosed positive.

iv. **Accessible healthcare services:**

Establishing accessible healthcare services, particularly in resource-limited areas, ensures that individuals can readily seek testing and diagnosis without facing barriers such as distance, cost, or stigma.[2]

v. **Awareness and education:**

Public awareness campaigns and education programs play a crucial role in encouraging individuals to undergo regular HIV testing. Knowledge about the importance of early diagnosis empowers communities to take proactive steps in managing the virus.

vi. **Integration with other health services:**

Integrating HIV testing with other healthcare services, such as maternal and child health clinics or tuberculosis clinics, enhances the likelihood of early detection, as individuals accessing these services may be at higher risk.[3]

vii. **Prompt initiation of Anti-retroviral Therapy (ART):**

Early diagnosis should be coupled with the immediate initiation of antiretroviral therapy (ART). Initiating treatment promptly helps suppress viral replication, preserves immune function, and improves long-term health outcomes.[4]

viii. **Pre-Exposure prophylaxis (PrEP) & Post Exposure Prophylaxis (PEP):**

Offering pre-exposure prophylaxis to high-risk individuals and post-exposure prophylaxis to those who may have been exposed to HIV helps prevent new infections. These strategies contribute to a comprehensive approach to early intervention.[5]-[6]

ix. **Continuity of care:**

Establishing a seamless continuum of care ensures that individuals diagnosed with HIV receive ongoing support, monitoring, and necessary interventions throughout their healthcare journey.

Efforts to enhance the early diagnosis and treatment of HIV/AIDS should be multifaceted, addressing both individual and systemic factors. A comprehensive approach, encompassing testing accessibility, treatment initiation, and ongoing care, is essential for improving outcomes and reducing the transmission and impact of HIV/AIDS in communities

2. Antiretroviral Therapy (ART) Adaptation:

Tailoring antiretroviral medications for pediatric use is intricate, considering factors such as weight-based dosing, palatability of formulations, and potential long-term side effects. The limited availability of pediatric formulations adds complexity.

Antiretroviral Therapy (ART) adaptation is a critical aspect of managing HIV/AIDS, requiring ongoing adjustments and considerations to optimize treatment outcomes. The key components of ART adaptation include:

i. **Individualized treatment plans:**

Tailoring ART regimens to the individual's specific virological, immunological, and clinical profile is crucial. Factors such as age, comorbidities, drug resistance, and potential side effects must be considered in the development of personalized treatment plans.

ii. **Pediatrics formulation:**

Adapting ART for pediatric populations involves the development and availability of age-appropriate formulations, considering factors such as weight-based dosing,

palatability, and ease of administration. Pediatric-friendly formulations help ensure adherence and efficacy in children living with HIV.

iii. Drug resistance monitoring:

Regular monitoring for the development of drug resistance is essential. Resistance testing enables healthcare providers to identify changes in the virus's susceptibility to specific medications, allowing for timely adjustments to the treatment regimen.

iv. New drug development & access:

Ongoing research and development of new antiretroviral drugs contribute to treatment adaptation. Ensuring timely access to these innovations, particularly in resource-limited settings, is critical for addressing emerging challenges, such as drug resistance and side effects.

v. Combination therapies:

Combining different classes of antiretroviral drugs in a treatment regimen is a common strategy to enhance efficacy and reduce the risk of resistance. The choice of combinations should be guided by individual patient characteristics and treatment history.

vi. Adherence support program:

Adherence to ART is essential for treatment success. Implementing adherence support programs, including educational initiatives, reminder systems, and counseling, helps patients maintain consistent and correct usage of medications.

vii. Management of side effects:

Anticipating and managing side effects is crucial for promoting treatment adherence. Regular monitoring for potential adverse reactions and providing appropriate interventions contribute to the overall well-being of individuals on ART.

viii. Integration with other healthcare services:

Integrating ART with other healthcare services, such as mental health support and treatment for comorbid conditions, ensures a holistic approach to patient care. This integration addresses the multifaceted needs of individuals living with HIV.

ix. Treatment of co-infections:

Addressing coinfections, such as tuberculosis or hepatitis, is integral to ART adaptation. Coordinated care for concurrent infections ensures a comprehensive approach to managing the overall health of individuals with HIV

x. Long-term monitoring & follow-up:

Long-term monitoring, including regular viral load and CD4 count assessments, is necessary to gauge treatment effectiveness and make timely adjustments as needed. Follow-up appointments and continuous engagement in care support sustained treatment success.

In summary, adapting ART for individuals with HIV involves a dynamic and patient-centered approach. Continuous monitoring, individualization of treatment plans, and addressing emerging challenges contribute to the ongoing success of antiretroviral therapy in improving the quality of life for those living with HIV/AIDS.[3] [7]

3. Vertical transmission and prevention:

Preventing mother-to-child transmission (PMTCT) remains a challenge in resource-limited settings. Access to antenatal care, HIV testing, and interventions to prevent transmission during childbirth and breastfeeding are critical.

Vertical transmission, or mother-to-child transmission (MTCT), remains a significant concern in the global efforts to combat HIV/AIDS. Preventing the transmission of the virus from an HIV-positive mother to her child is crucial for reducing the overall burden of pediatric HIV. Key components of vertical transmission prevention include:

i. Early & universal antenatal techniques:

Initiating prevention efforts begins with early and universal antenatal testing for HIV. Identifying maternal HIV status early in pregnancy allows for timely interventions to reduce the risk of transmission to the child.

ii. Antiretroviral therapies for pregnant women:

Administering ART to pregnant women living with HIV significantly reduces the risk of vertical transmission. Initiating ART early in pregnancy and continuing throughout breastfeeding, if applicable, helps suppress the viral load, minimizing the chances of transmission to the child.

iii. Optimal timing of ART initiation:

Administering antiretroviral medications during labor and delivery further reduces the risk of transmission. Intrapartum prophylaxis, often involving specific medications, is a critical component of the prevention strategy.

iv. **Intrapartum prophylaxis:**

Encouraging safe delivery practices, such as avoiding invasive procedures that may expose the infant to the mother's blood, helps minimize the risk of transmission during childbirth.

v. **Safe delivery practices:**

Encouraging safe delivery practices, such as avoiding invasive procedures that may expose the infant to the mother's blood, helps minimize the risk of transmission during childbirth.

vi. **Avoidance of breastfeeding:**

In regions where safe and affordable alternatives to breastfeeding are available, avoiding breastfeeding or providing formula feeding is recommended to eliminate the risk of postnatal transmission through breast milk.

vii. **Antiretroviral prophylaxis:**

Administering antiretroviral prophylaxis to the infant, particularly during the first weeks of life, further reduces the risk of transmission. The choice of medication and duration is influenced by factors such as maternal viral load and the infant's health status.

viii. **Routine monitoring and follow-up:**

Regular monitoring of both the mother and the child is essential to assess the effectiveness of prevention measures and promptly address any emerging challenges. Follow-up care supports the overall health and well-being of both individuals.

ix. **Maternal education & counseling:**

Providing comprehensive education and counseling to pregnant women living with HIV is essential. Empowering mothers with knowledge about transmission risks, prevention strategies, and the importance of adherence to recommended interventions enhances the effectiveness of prevention efforts.

x. **Community engagement & support:**

Community-based initiatives that raise awareness, reduce stigma, and provide support for pregnant women living with HIV contribute to the success of vertical transmission prevention programs. Ensuring community involvement helps create an enabling environment for optimal maternal and child health.

Efforts to prevent vertical transmission require a coordinated and multi-faceted approach involving healthcare providers, policymakers, communities, and individuals. A comprehensive strategy that integrates testing, early intervention, and ongoing support is essential for achieving the goal of eliminating pediatric HIV infections resulting from vertical transmission.[8]

4. **Adherence and long-term engagement:**

   Ensuring consistent adherence to medication regimens in children can be challenging due to issues like taste aversion, pill burden, and evolving developmental stages. Sustaining long-term engagement in care from childhood through adolescence is also a concern.

i. **Adherence challenges in pediatrics:**

   Pediatric patients often face distinct challenges in adhering to their prescribed HIV treatment regimens. Factors such as taste aversion, the physical form of medications, and the need for age-appropriate formulations contribute to adherence difficulties. Additionally, children's evolving understanding of their health condition and the necessity for consistent medication may impact adherence rates.

ii. **Age-appropriate adherence support:**

   Recognizing the diverse developmental stages of pediatric patients, healthcare providers play a crucial role in tailoring adherence support. Age-appropriate educational materials, interactive tools, and involving parents or caregivers in the medication management process are strategies to enhance adherence in younger children.

iii. **Psychosocial factors impacting adherence:**

   The psychosocial aspects of living with HIV, including stigma, discrimination, and mental health concerns, can significantly influence adherence. Addressing these factors through counselling, peer support, and integrated mental health services is crucial for sustaining long-term engagement in treatment.

iv. **Family & community support:**

   The involvement of families and communities is pivotal in maintaining adherence in pediatric HIV treatment. A supportive environment that fosters open communication, reduces stigma, and encourages shared responsibility for medication management enhances the overall well-being of the child.

v. **School based support:**

Collaborating with educational institutions to create a supportive environment for children living with HIV is essential. This includes training educators and classmates on HIV awareness, confidentiality, and fostering an inclusive atmosphere that minimizes potential stigma.

vi. **Regular monitoring & feedback:**

Continuous monitoring of medication adherence, viral load, and other relevant indicators provides valuable insights into the effectiveness of the treatment plan. Regular feedback and adjustments, when necessary, contribute to the optimization of care over the long term.

vii. **Holistic healthcare approach:**

Adopting a holistic approach to pediatric HIV care involves addressing not only the medical aspects but also the broader socio-economic determinants that impact adherence. This includes access to healthcare services, nutritional support, and addressing social determinants of health.

viii. **Technology integration:**

Leveraging technology, such as mobile applications for medication reminders or telehealth consultations, can enhance communication between healthcare providers and families, facilitating ongoing support and monitoring.

ix. **Transition to audit care:**

As pediatric patients transition to adult care, ensuring a seamless process that maintains continuity of care is crucial. Engaging adolescents in discussions about the transition, addressing concerns, and providing support during this phase can positively impact long-term engagement in HIV treatment.

5. Coexisting infections and comorbidities:

Pediatric patients with HIV often experience coexisting infections and comorbidities. Managing these conditions alongside HIV requires a multidisciplinary approach and careful consideration of potential drug interactions.

6. Psychosocial and stigma issue:

Children with HIV may face stigma and discrimination, impacting their mental health and adherence to treatment. Addressing psychosocial aspects, including family dynamics and school-related challenges, is crucial for holistic care

7. Transition to adolescent and adult care:

The transition from pediatric to adolescent and adult HIV care introduces additional complexities. Ensuring continuity of care, addressing psychosocial needs, and supporting self-management becomes critical during this phase.

8. Resource limitations:

Resource-limited settings often lack the infrastructure, healthcare workforce, and funding required for comprehensive pediatric HIV care. Access to diagnostic tools, medications, and specialized healthcare providers can be constrained.

Addressing these challenges requires a collaborative effort involving healthcare providers, policymakers, researchers, and communities. Tailoring interventions to the unique needs of pediatric populations and fostering a supportive environment are essential for improving outcomes in children living with HIV.[9]-[11]

Advances in pediatric HIV care:

The field of pediatric HIV care has witnessed remarkable advancements, reflecting a commitment to improving the health and well-being of children living with the virus. These progressive developments span various aspects of prevention, diagnosis, treatment, and psychosocial support, offering new hope and possibilities for pediatric populations affected by HIV.

1. **Early Infant Diagnosis (EID) and Point-of-Care Testing:**
   Advances in early infant diagnosis, including the integration of point-of-care testing, have significantly shortened the time between birth and HIV diagnosis. Early identification allows for prompt initiation of antiretroviral therapy (ART) and other interventions, improving overall outcomes.[12]
2. **Prevention of Mother-to-Child Transmission (PMTCT) strategies:**
   Enhanced PMTCT strategies have led to substantial reductions in vertical transmission rates. This includes the widespread use of antiretroviral medications during pregnancy, labor, and breastfeeding, as well as optimal maternal viral load management.[13]
3. **Optimized Pediatric Antiretroviral Therapy (ART) Regimen:**
   Tailored ART regimens for pediatric use, featuring improved formulations with better palatability and ease of administration, have contributed to enhanced adherence and treatment success in children. Age-appropriate dosages and innovative drug delivery systems support better tolerability.

4. **Long-Acting Antiretrovirals (LA-ART):**

   The development of long-acting antiretrovirals, including injectable formulations with extended durations, offers a paradigm shift in treatment. LA-ART provides an alternative for those facing challenges with daily oral medications, potentially improving adherence in pediatric patients.

5. **Telemedicine and digital health solutions:**

   Telemedicine and digital health solutions have become integral in pediatric HIV care, facilitating remote monitoring, teleconsultations, and medication adherence support. These technologies enhance accessibility to specialized care, particularly for families in geographically distant or resource-limited areas

6. **Psychosocial support and mental health integration:**

   Recognition of the psychosocial aspects of pediatric HIV has led to the integration of mental health support services. Holistic care now includes counseling, peer support programs, and initiatives to address stigma, anxiety, and depression among children and adolescents living with HIV.

7. **Community based care model:**

   Community-based care models have gained prominence, engaging local communities in the delivery of pediatric HIV services. These models not only increase access to care but also foster a supportive environment, reducing stigma and enhancing overall well-being.

8. **Adolescent-centered care:**

   An evolving focus on adolescent-centered care recognizes the unique needs and challenges faced by this demographic. Specialized programs address issues related to disclosure, treatment adherence, sexual and reproductive health, and the transition from pediatric to adult care.

9. **Research in pediatric HIV vaccines:**

   Ongoing research in pediatric HIV vaccines represents a significant step toward prevention. Efforts to develop safe and effective vaccines for children aim to provide an additional layer of protection, potentially reducing the transmission of the virus.

10. **Global collaboration and advocacy:**

    Increased global collaboration, advocacy efforts, and partnerships have played a pivotal role in advancing pediatric HIV care. These initiatives promote knowledge

exchange, resource mobilization, and the implementation of best practices on a broader scale.

These advances collectively contribute to a more optimistic outlook for children living with HIV. As research continues and healthcare systems evolve, the ongoing commitment to innovative approaches and comprehensive care ensures that pediatric HIV care continues to progress, bringing us closer to the goal of an HIV-free generation.[14]

Conclusion:

"Pediatric Perspectives on HIV: Navigating Challenges and Advances in Pediatric HIV Care" illuminates the intricate landscape of caring for children living with HIV. Through an exploration of challenges encompassing early diagnosis, treatment adaptation, prevention of vertical transmission, and psychosocial considerations, coupled with the recognition of significant advances such as optimized antiretroviral therapy regimens and adolescent-centered care, this examination underscores the ongoing evolution in pediatric HIV care. The synthesis of these challenges and advancements emphasizes the imperative for a holistic, multidisciplinary approach that integrates medical innovations with psychosocial support, community engagement, and global collaboration. By embracing these insights, the field is poised to continue making strides towards ensuring a brighter and healthier future for every child affected by HIV.

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A REPORT ON ETHNO-COLOUR CONCEPT AMONG THE GOND TRIBAL PEOPLES OF JHARIGAON BLOCK, NABARANGPUR DISTRICT, ODISHA, INDIA

Maninee Sahu[1] and Alok Ranjan Sahu*[2]

[1]Odisha Adarsha Vidyalaya, Jharigaon, Nabarangpur 764076

[2] Department of Botany, Vikash Degree College, Bargarh, Odisha- 768040

*Corresponding author E-mail: alok.btgene@gmail.com

Abstract:

The present communication deals with a report on 23 ethnobotanical important plants belonging to 17 families being traditionally used by the Gond tribal people of the Jharigaon block of Nabarangpur district, Odisha. Out of 23 species, a total of four species belonged to the family Fabaceae, followed by three species from Combretaceae, two species from Compositae, and the rest 14 families contribute one species each. Further, out of 23 species, 13 (57%) species were trees, followed by eight (35%) herb species and two (9%) shrub species inhabit. This is the first ethnobotanical study focusing on the Gond people's indigenous knowledge of plant-based dyes. The plant materials, used parts, dyeing methods, and uses are recorded, with data quantified. It provides a foundation for follow-up work to contribute to the maintenance of indigenous plant-dyeing knowledge and dyeing plant resources. More research for market development for products that use plant-based dye is necessary for the conservation of this valuable knowledge and biodiversity protection in Gond communities

Keywords: Ethno-Colour, Jharigaon Block, Nabarangpur District, Odisha.

Introduction:

The close interaction of localcommunities with the forests and variousproducts is the vital reason for the continued survival of forests. The invention of Indigo, the most important IndianNatural dye is as old as textile making itself. History reveals that Chinese have recorded the use of dyestuff even before 2600BC (Druding, 1982). Herbal dyes were used to colour clothing or other textiles but by mid-1800, chemists began producing synthetic substitutes for them. By early 20thcentury only a small percentage of textile dyes were extracted from plants. Lately, there has been increasing interest in

herbal dyes, as consumers have become aware of ecological and environmental problems related to the use of synthetic dyes (Gokhale *et al.*, 2004).

Different pigments, present in various parts of the plant are responsible for the variation of the colour. The most common herbal parts used for extracting dyes are roots, stems, barks, leaves, flowers, berries and seeds. Natural plant pigments like anthocyanin, carotenoids, and xanthophylls are medically active and also found to play an important role in the treatment of various human diseases. Biological investigation has shown that a rich variety of nutrients, energy rich sugars and pharmacologically active compounds are abundant in colourful vegetables and fruits (Laxmi *et al.,* 2006). Some parts may have more than one colour depending upon which part of the plant is used. The shade of colour**,** a plant produces will vary according to season at which the plant is picked, how it was grown, soil conditions, etc (Vankar, 2000). Pigment stabilityholding is apparentlya challenge for postharvest technologist. The use of natural pigments will us enable to minimise the use of potentially hazardous artificial pigments, post-harvest practices become crucial for the processing of medicinal plants containing colour and pigments. Several factors, both in the pre- and postharvest stages, influence colour and pigmentformation in medicinal plants (Laxmi *et al.*, 2006). In 19th century the discovery of synthetic dyes has been dealt a massive blow to Indian textile industry. Research has been shown that the vast uses of synthetic dyes associated with hazards effecting human body system; it causes skin cancer, temporary or permanent blindness and also the respiratory system etc. (Dubey, 2007). The aimof the present investigation that gatheringindigenous knowledge of the use of medicinal plants for dye yielding purposes.

Materials and Methods:

Study site

Nabarangpur district lies between 19° 23' North latitude and 82° 55' East longitudes and having 5,294 Sq Km of geographical area, most of the area is covered with dense forest. Nabarangpur district is a tribal dominated district having a population of 12,20,946 (Census of India, 2011). The population density of this district is 230 inhabitants per square K.M. It has a sex ratio of 1018 females for every 1000 males and the literacy rate is 48.2%. The Scheduled Castes and Scheduled Tribes are 14.53% and 55.79 % of the population respectively. This district is well known for its tribal culture. Some of the largest tribes are the Bhottadas and Gond, they have their

own language, customs and folk dances. The river Indravati forms the boundary between Nabarangpur and Koraput districts (Sahu and Sahu, 2022; 2023).

Collection of data and analysis

Before starting fieldwork, a literature survey of ethnomedicinal work in Odisha was carried out (Pattanaik *et. al.,* 2006; Sahu *et. al.,* 2010; Sahu *et. al.,* 2013; Dhal *et. al.,* 2015; Sahu *et. al.,* 2021). The study area was frequently visited and close interaction was made with the tribal peoples of Jharigaon Block. The plant species were collected and identified by using local flora book (Haines, 1925; Saxena and Brahman, 1996). The local names were crosschecked by using earlier published literature of different district of Odisha (Sahu *et. al.,* 2010; Sahu *et. al.,* 2013; Dhal *et. al.,* 2015; Sahu *et. al.,* 2021; Sahu and Sahu, 2022). The authority plant names were affirmed at http://worldfloraonline.com. The plants were enumerated alphabetically with botanical name, family, habit, vernacular name, dye yielding plant parts, dye produced compiled in a tabular form. The statistical analysis was carried out by using MS-Excel 2007.

Result and Discussion:

In this present study we reported on the use of 23 ethnobotanical plants belonging to 17 families by the Gond tribal people of the Jharigaon block of Nabarangpur district, Odisha (Table 1). Out of 23 species, a total of four species (*Butea monosperma* (Lam.) Taub., *Cassia fistula* L., *Pterocarpus marsupium* Roxb., and *Tamarindus indica* L.) belonged to the family Fabaceae, followed by three species (*Terminalia arjuna* (Roxb. Ex. DC.) W & A, *Terminalia bellarica* (Gaertn.) Roxb. and *Terminalia chebula* Retz.) from Combretaceae, two species (*Chrysanthemum coronarium* Linn. and *Tagetes patula* Linn.) from Compositae, and the rest 14 families contribute one species each (Figure 1). Further, out of 23 species, 13 (57%) species were trees, followed by eight (35%) herb species and two (9%) shrub species inhabit (Figure 2). This is the first ethnobotanical study focusing on the Gond people's indigenous knowledge of plant-based dyes.

Table 1: Important Natural dye yielding ethnomedicinal plants used by the native of Jharigaon Block of Nabarangpur district

Sl.No	Botanical name	Family	Vernacular name	Dye yielding plant part	Dye produced
1.	*Acacia catechu* Linn.	Mimosacae	Khair	Bark	Brown/ Black
2.	*Adathoda vasica* Nees.	Acanthaceae	Basang	Leaf	Yellow
3.	*Aegle marmelos* L.	Rutaceae	Bel	Fruit rind	Yellow
4.	*Azadirachta indica* Juss.	Meliaceae	Neem	Bark	Brown
5.	*Butea monosperma* (Lam.) Taub.	Fabaceae	Palasa	Flower	Orange
6.	*Cassia fistula* L.	Fabaceae	Sunari	Bark	Brown
7.	*Curcuma longa* Linn.	Zingiberaceae	Haladi	Stem	Yellow
8.	*Coriandrum sativum* Linn.	Umbelliferae	Dhania	Leaf	Green
9.	*Chrysanthemum coronarium* Linn.	Compositae	Sebati	Flower	Yellow
10.	*Delonix regia* (Boj. ex Hook) Raf.	Caesalpinaceae	Krushnachuda	Flower	Red
11.	*Emblica officinalis* Gaertn.	Euphorbiaceae	Aanla	Fruits/ Bark	Blue/ Black
12.	*Ficus racemosa* L.	Moraceae	Dumer	Bark	Red
13.	*Lawsonia inermis* Linn.	Lythraceae	Manjuati	Leaf	Red
14.	*Mentha piperita* Linn.	Lamiaceae	Podina	Leaf	Green

15.	*Oryza sativa* Linn.	Poaceae	Dhana	Seed	White
16.	*Pterocarpus marsupium* Roxb.	Fabaceae	Bija	Bark	Red
17.	*Punicagranatum* Linn.	Puniaceae	Dalimba	Fruit	Red
18.	*Spinacia oleracea* Linn.	Chenopodiaceae	Palanga	Leaf	Green
19.	*Tagetes patula* Linn.	Compositae	Gendu	Flower	Yellow
20.	*Tamarindus indica* L.	Fabaceae	Tentel	Bark	Black
21.	*Terminalia arjuna* (Roxb. Ex. DC.) W & A	Combretaceae	Kau	Fruit	Brown
22.	*Terminalia bellarica* (Gaertn.) Roxb.	Combretaceae	Behera	Bark/Fruit	Brown/Black
23.	*Terminalia chebula* Retz.	Combretaceae	Harda	Fruit	Black

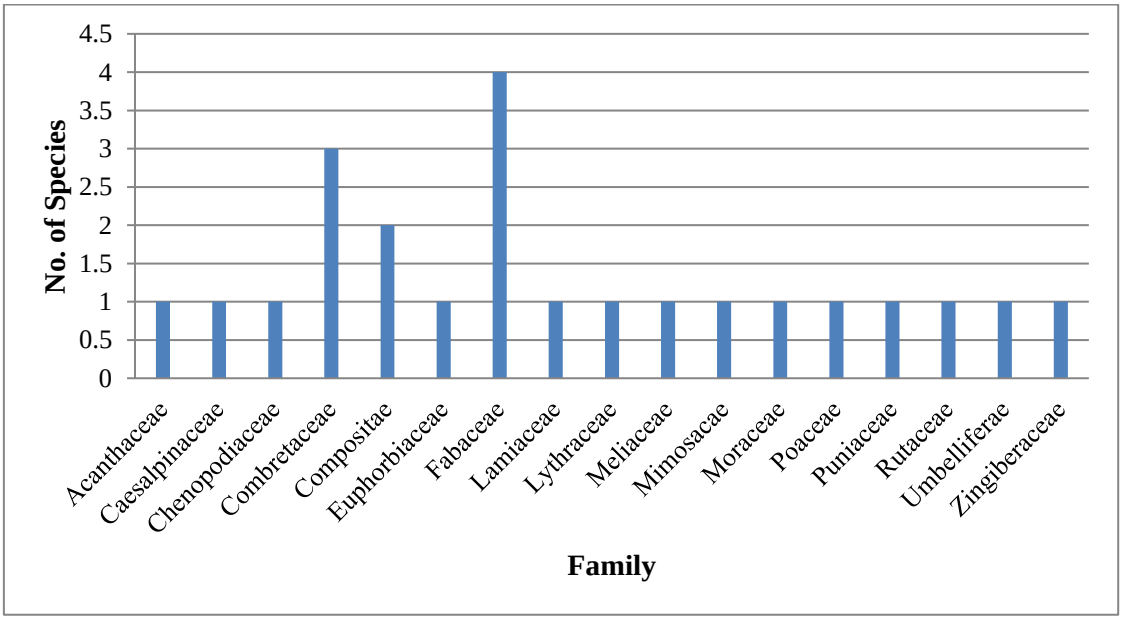

Figure 1: Family wise representation of dye yielding plants by the native of Jharigaon Block of Nabarangpur district, Odisha

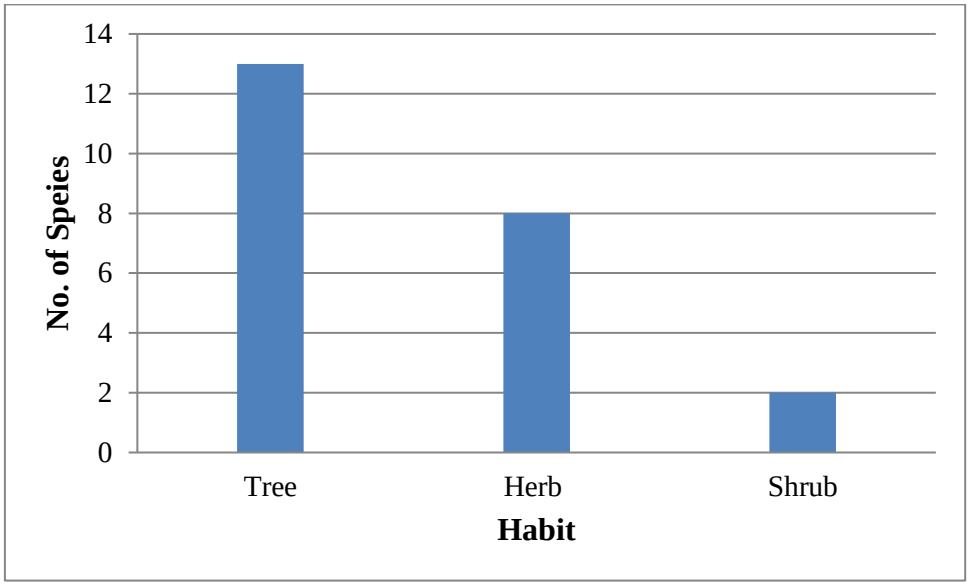

Figure 2: Natural habit wise distribution of selected dye yielding plants of study area

Similar kind of dye yielding study were reported from various parts of our country by various authors. Das (2010) reportedon 13 ethno-botanically important plants belonging to 12 families beingtraditionally used by some tribal of Ganjam district, Odisha, for developing various aesthetic colours and theircombinations used in household purposes like decoration, heritage rituals, functions, festivals, dye making andtraditional health care. Das *et al.* (2011) reported four plants namely *Acacia catechu* (L.) Willd. (Mimosaceae), *Pterocarpus marsupium* Roxb. (Papilionaceae), *Toddalia asiatica* (L.) Lamk. (Rutaceae) and *Ventilago denticulate* Willd. (Rhamnaceae), growing in West Midnapore district of West Bengal, an eastern state of India, yields dye which showed strongantimicrobial activity. Das and Mondal (2012) reported 15 dye yielding plants belonging to 11 families by the local people in two famous handicraft- 'Patchitra' in Pingla and 'Mat craft' in Sabang areas of paschim Medinipur district of West Bengal. Alawa *et al.* (2013) reported the use of 18 dye yielding plants for making specific colour or colour combinations was found to play an important role in the social and religious life of the tribal peoples of Dhar district, Madhya Pradesh. Nidhi and Nitan (2014) reported 64 dye yielding plant species belonging to 43 families were reported from the District Kathua, Jammu and Kashmir State, India. Khan and Sanghi (2016) reported 15 natural dye yielding plant species belong to 13 families from Rajgarh District (M.P.).

Conclusion:

The use of natural dyes has increased during the last few of years. This awareness grows to different side of the user's viz. designers, traditional art dyers and printers, academic institute and researches museum etc. We know that synthetic dyes commonly used to dyeing of fabric but it is earlier found associated with environmental hazards, pollutants and having azo groups which provide the harmful effect the skin, lungs and respiratory system etc. At present European and American country has been stopped the use of synthetic dyes for export market. The tribal people of the Nabarangpur district are practicing vegetable dyeing since generation often generation. They have followed the old traditional method for extraction of natural dyes. It has been noticed that many communities who have engaged in this traditional method, now they shifted to other profession. As a result, their knowledge has not been documented for further research and commercial interest. To promote the use and production of natural dyes it should be applied that younger person be trained as dyers and encourage them to providing some employment-oriented scheme in the rural areas. In mat crafts the traditional cultivars which they inherit their traditional method of mat weaving from their ancestor now they faced some problem in traditional mat weaving because their traditional technology is an age old and labour intensive. So, proper collection, documentation and protection should be needed for natural dye yielding plants. And further research work could be carried out based on the information available from these people; otherwise, we are bound to lose our indigenous knowledge system for ever.

Acknowledgement

The authors are especially thankful to the tribal peoples of Nabarangpur district for their cooperation and voluntarily shared a wealth of their accumulated knowledge regarding the ethnomedicinal practices of their communities and for their hospitality.

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BAMBOO PLANT PROPAGATION THROUGH TISSUE CULTURE

S. A. Belorkar* and N. Agrawal

Department of Microbiology and Bioinformatics,

Atal Bihari Vajpayee Vishwavidyalaya, Bilaspur- 495009, (C.G.), India

*Corresponding author E-mail: seema.belorkar@gmail.com

Abstract:

Bamboo has a great economic importance in today's market. The propagation of Bangkok bamboo offers a great challenge on the front of its cultivators. The challenges in the traditional bamboo propagation are space for cultivation time required for generating the new bamboolance. Tissue culture resolves all these issues and makes the propagation very fast process within limited space and the number of plants plant let's generated are exuberant. The technique of tissue culture is a boon for bamboo propagation because it requires very small explain as the starting material for cultivation the total potential of the cells are the main magic players in generating thousands of bamboo plants from the miniature explain s healthy parent plant. Fusion or protoplast hybridization is also a method for an alternative approach towards faster generation of plantlets.

Introduction:

Micropropagation

It is a very fast and efficient method of vegetative propagation. Generally nurseries opt for such fast, economic, ecofriendly, space and time delimiting technology. This technique rapidly multiplies the material into thousands of independent bamboo plantlets with no seasonal dependency (Chambers *et al.,* 1991; Ray and Ali, 2018; Hamalton *et al.,* 2022).

The principle of the technique lies in totipotency viz. the ability of a single cell to regenerate the whole plant. The material is selected from healthy parent plant. The small part which is excised for gaining a healthy totipotent cell is called as explants. The commonly used explants are axillary buds tips of shoot meristems and roots. Especially, in case of Bamboo leaf and roots of young plantlet, mature or immature embryos, mesocotyl or leaf sheath are chosen as source of explant.

Methods of bamboo propagation

Bamboo can be proliferated by means of seeds vegetative propagation and tissue culture (Yuan *et al.,* 2017). The propagation of bamboo through seeds offers constrain like. The vegetative means of proliferation can be executed by use of rhizomes, cuttings, macro proliferation and layering (Seethalakshami, 2015; Ray and Ali, 2017) as shown in Fig (1). Cuttings can be by Culm cuttings or Branch cuttings.

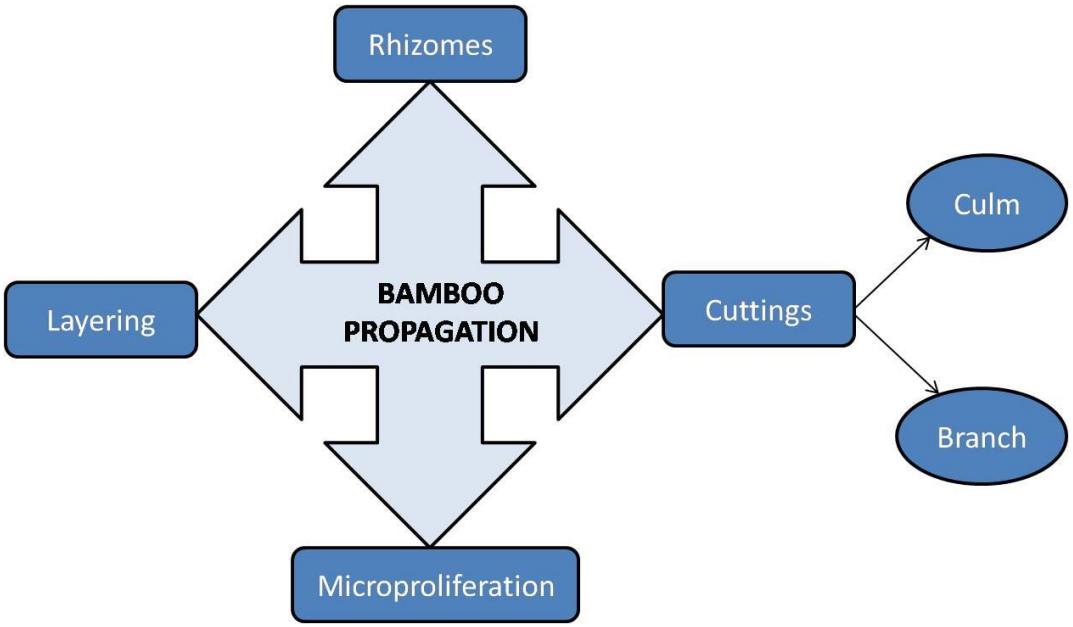

Figure 1: Methods of Bamboo cultivation

1. Rhizomes – use of rhizomes is a traditional approach towards bamboo culture. Rhizomes are the modified stems which are under the soil and traditionally exploited as propagation means. Fig (2)

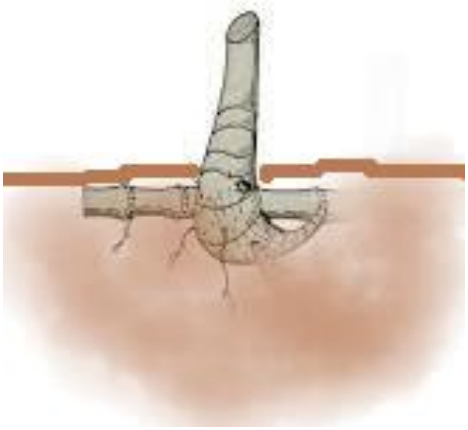

Figure 2: Rhizomes of Bamboo

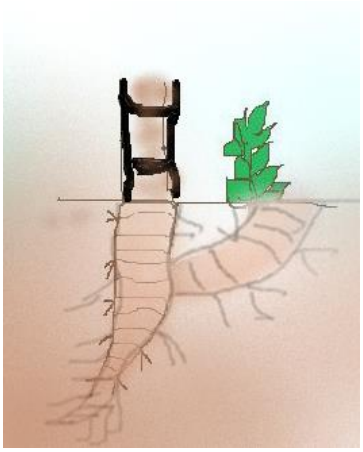

Figure 3: Offset as means of propagation

2. Offsets – when the propagation involves the upper plantlets attached to the rhizome it is referred as an offset.

3. Cuttings – It is one of most common method for planting a new plant where a part of culm or branch is placed in soil and plantlet develop after rooting.

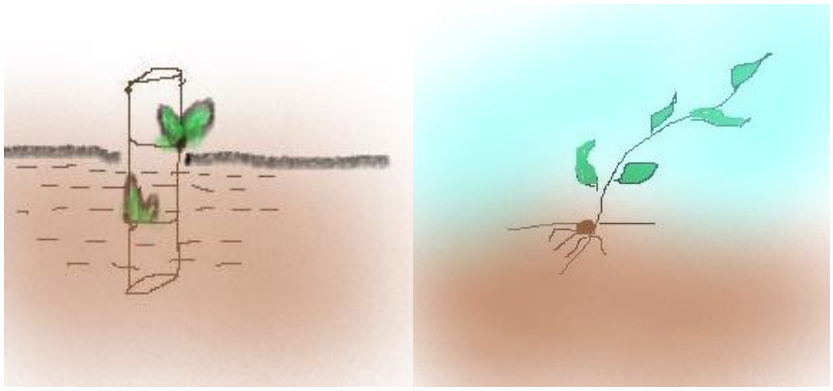

Figure 4: (a) - Soiling of culm, (b) – soiling of a branch

4. Layering – This method is simplified approach of the above. The only difference in the culm or branch is separated from the parent till rooting occurs in the soiled part of culm or branch.

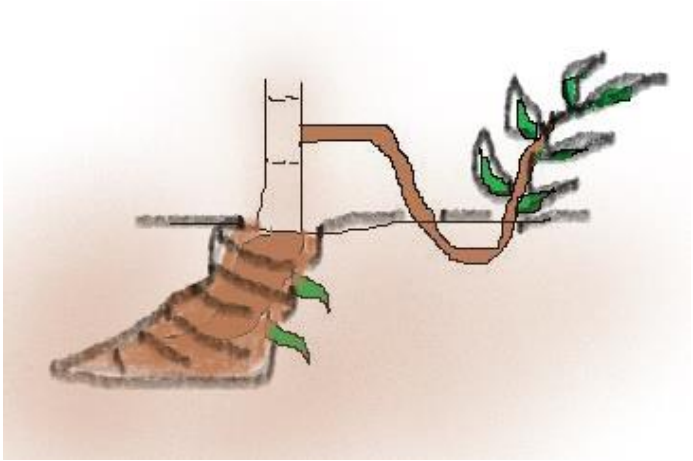

Figure 5: Layering of branch

Table 1: Advantages and disadvantages of vegetative propagation

S. No.	Advantages	Disadvantages
1.	Identical to mother plant.	Transportation is difficult.
2.	Growth performances are already known.	Process is labourious.
3.	Easy to perform.	Limited number of plantlets can be generated.
4.	Time required is less than cases where seeds are used.	Season dependency.
5.	Space requirement curtailed.	Life cannot be predicted.

Due to above stated limitation, now a days the mass propagation of bamboo is favoured through micropropagation or tissue culture.

Micropropagation – This as one of the most popular techniques rendering exhaustive number of plantlets in limited space. This method is based on the culture of plant cells, tissues or organs by aiding optimum physico-chemical standards for growth (Mudoi *et al.,* 2013). The advantages of micropropagation are depicted in Figure- 6.

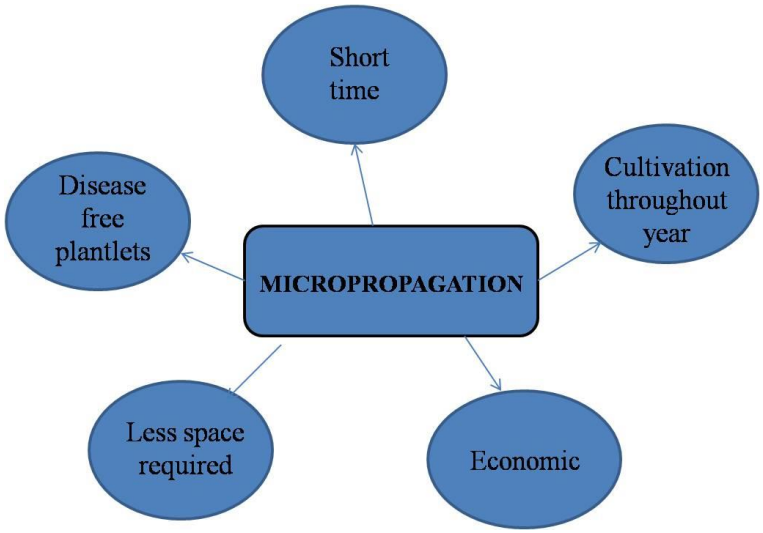

Figure 6: Advantages of Micropropogation

Micropropagation shows excellent results through use of axillary branching methods.

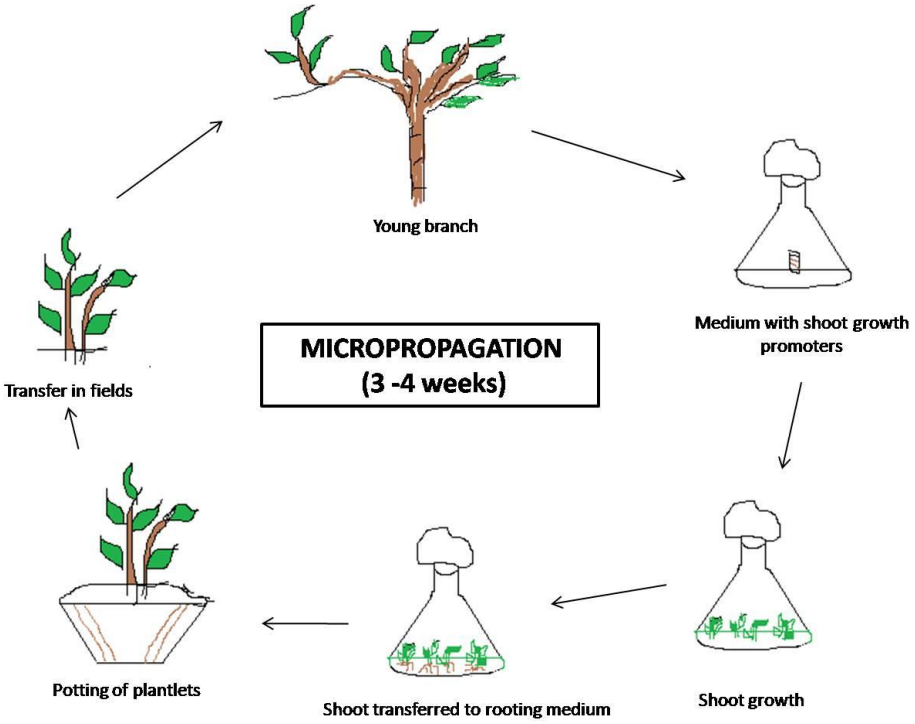

Figure 7: Important steps in micropropagation

Somatic embryogenesis

It is yet another time saving method for cultivation of Bamboo (Mehta *et al.,* 1982). It uses somatic cells internodes or petioles which are directed towards development of callus (undifferentiated mass of cells) (Yeh and chang, 1986).

The medium used is MS medium and culture conditions are dark. Callus formation is induced through medium supplemented with Auxin (NAA) (Saini *et al.,* 2016).

The embryos are allowed to mature by shifting them to auxin free medium with high sucrose and low concentration of ABA. The matured embryos are transferred to medium containing rooting and shooting hormones, generally referred as germination medium. This step requires adequate maintenance of conditions which result in satisfactory germination. The embryo differentiates into different plant parts under the direction of plant hormones.

Although micropropagation has overwhelming benefits but there are certain limitations to the technique as shown in Figure-8.

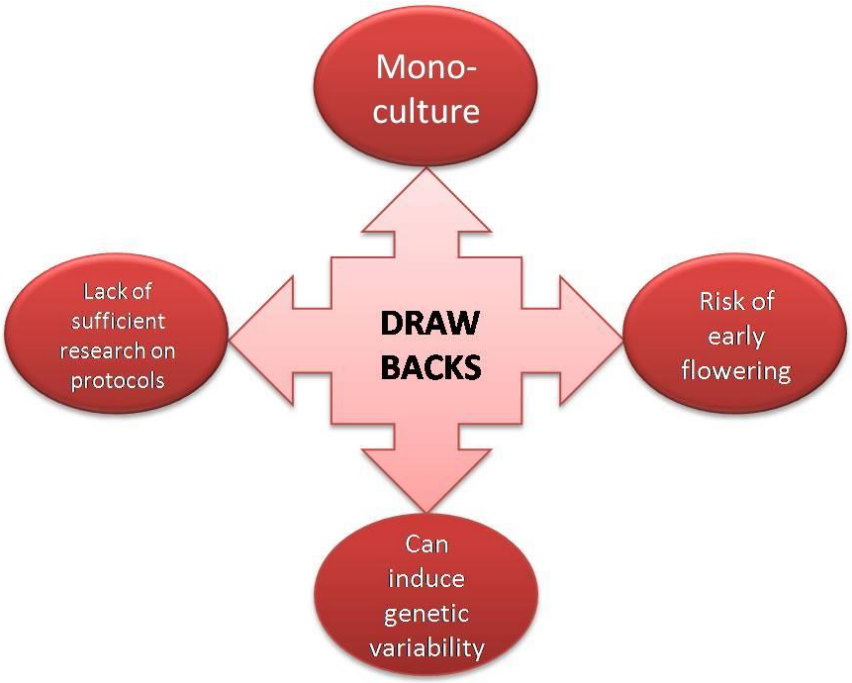

Figure 8: Limitations of Micropropogation

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PRODUCTION OF GUMS AND RESINS: A MICROBIAL APPROACH

S. A. Belorkar*[1] and H. Kausar[2]

[1]Department of Microbiology and Bioinformatics,

Atal Bihari Vajpayee Vishwavidyalaya, Bilaspur- 495009, (C.G.), India

[2]Department of Microbiology,

Govt ERR Postgraduate Science College, Bilaspur (C.G), India

*Corresponding author E-mail: seema.belorkar@gmail.com

Abstract:

Gums and resins are used in a variety of medicinal and food items, as well as in a number of other technical applications. Exocellular, cell wall, and intercellular polysaccharides or gums are the three types of microbial polysaccharides or gums. They have a unique role within the cell in regulating energy resources, resisting water stress, performing defensive functions, and so on. However, because of their distinctive gelling and viscosity qualities, as well as their neutral actions, they have a wide range of uses in our daily lives. Only a few microbial gums have been produced commercially despite the wide variety of molecular architectures. Texturization, viscosity, flavour releaser, appearance, and water-control qualities are all required for a variety of today's meals and medications. These polysaccharides are used in foods and pharmaceuticals as thickeners, gelling agents, and ice crystal formation inhibitors in frozen meals. Since they are non-toxic, stable, easily accessible, associated with fewer regulatory issues than their synthetic counterpart, and inexpensive, plant-derived gums and mucilages meet many requirements for pharmaceutical percipients. They can also be easily modified to meet the need. The majority of these mucilages and gums originating from plants are hydrophilic and gel-forming by nature.

Introduction:

Ongoing research into the biochemical characteristics and synthesis methods of biopolymers, such as polysaccharides, has improved manufacturing processes and produced novel uses in a variety of fields, primarily in the food and pharmaceutical sectors [1]. Microbial polysaccharides provide a variety of biological roles, including intracellular storage, envelope formation, and extracellular polymerization. Gums are biomolecules made of carbohydrates that have the capacity to bind water and produce gels. Proteins and minerals are frequently found in the production of gums [2,3]. Gums come in a variety of types, including mucilage gums, seed gums, exudate gums, and

others. Due to their bioavailability, plant gums are among the most significant gums. Plant gums are organic polysaccharide polymers that are safe, nontoxic, and readily accessible in nature [4]. They are suitable for use in many applications because of their high stabilisation, viscosity, adhesive property, emulsification action, and surface-active activity. They are used in food, cosmetics, medications, and other industrial products. Plant-based gums and mucilages are commonly used in pharmaceutical formulations because of their bioavailability, accessibility, non-toxicity, and affordable cost [5,6,7]. Natural resins and gums can be found as exudates that form after an injury or in the intercellular space (ducts or cavities) of plant parts. Traumatic ducts/cavities are the cavities or ducts that develop as a result of damage. There is still much to learn about the biosynthesis of gum and resin as well as its causes [8]. Drought, other unfavourable environmental conditions, and poor soil can encourage their formation. Gums and resins are thought of as byproducts or end products of certain metabolic processes since they do not re-enter the metabolism of the plant in which they are formed [9,10].

Table 1: Different Microbial gums from different microorganisms

S. No.	Name of Producer Microorganisms	Name of Microbial gum
1	*Xanthomonas campestris*	Xanthan
2	*Pseudomonas aeruginosa, Azotobacter vinelandii*	Alginate
3	*Sphingomonas paucimobilis*	Gellan
4	*Bacillus subtilis, Zymomonas mobili*	Levan
5	*Pseudomonas aeruginosa, Pasteurella multocida*	Hyaluronan
6	*Alcaligenes faecali, Cellulomonas flauigena*	Curdlan
7	*Leuconostoc mesenteroides*	Dextran

Microbial gums can be linear or highly branched and are made up of sugar residues connected by glycosidic bonds. Exo polysaccharides (EPSs), end polysaccharides, and polyhydroxyalkanoates are only a few examples of the physicomechanical properties of biopolymers generated by microbes [11,12]. These microbial gums are largely made of uronic acids, noncarbohydrate components, and carbohydrate components. Since carbohydrates make up the majority of biopolymers formed from microorganisms, films made of these biopolymers have hydrophilic structures as polysaccharides, which are popular due to their rheological properties

throughout a broad range of temperatures and pH. Many researchers have used an edible coating made of microbial natural gums to increase the shelf life of fruits and vegetables [13].

Xanthan gum:

The microbial exopolysaccharide known as xanthan gum, which is generated by the Xanthomonas species such as *X. campestris, X. carotae, X. malvacearum*, and *X. phaseoli,* is the most often used example in industry [14]. These microscopic, aerobic, motile, Gram-negative rods of bacteria create yellow pigments. To get the best possible output, gum quality, and cost-of-production ratio, these factors must be carefully assessed [15].

Structure of xanthan gum:

A high molecular weight helical heteropolymer with a molar ratio of 2:2:1 for D-glucose, d-mannose, and d-glucuronic acid, xanthan is made up of these three sugars [16]. The composition of Xanthan gum depends on a variety of parameters throughout the production process; however, it is made up of a backbone of repeated sub-units that are either branched or not and consist of 3–8 monosaccharides [17]. Quantitative variance among various polymers made by Xanthomonas gene-carrying bacteria.

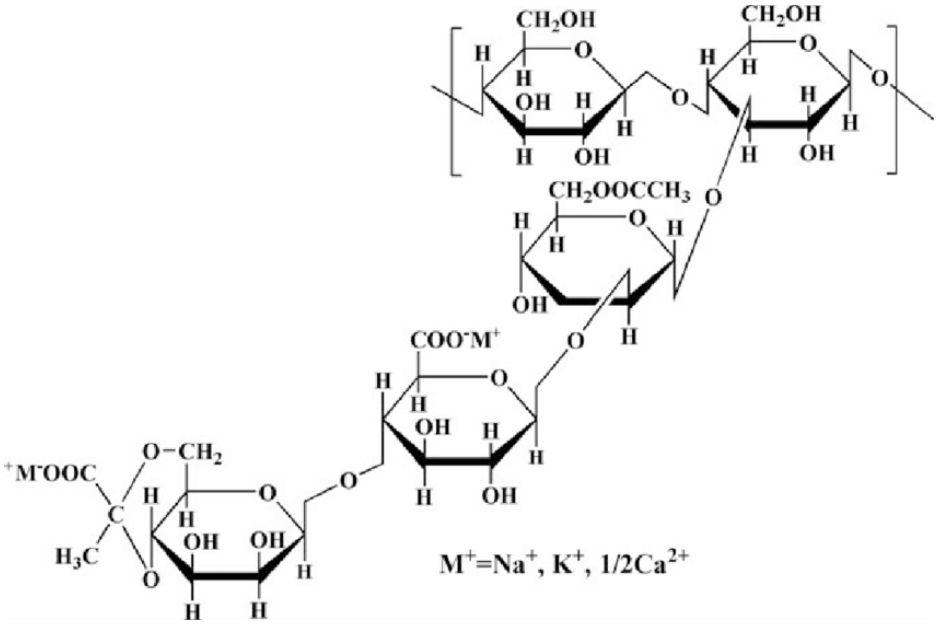

Figure 1: Chemical Structure of Xanthan Gum

Production of xanthan gum

The microorganisms utilized in the manufacture of xanthan gum. The formation of Xanthan gum is accelerated by the presence of organic acids during aerobic fermentation, which takes place at a temperature between 27°C and 30°C [18]. The microbes may convert around 70% of the substrate to gum in the commercial

procedure. The process conditions must be carefully considered in order to achieve optimum efficiency at a high level of product quality. the pH, temperature, stirrer speed, and air flow rate necessary for fermentation [19]. On a commercial scale, Xanthan gum is often made by a batch fermentation method, which is then followed by heating the fermentation, removing the cells, recovering with alcohol drying, and grinding the gum [20].

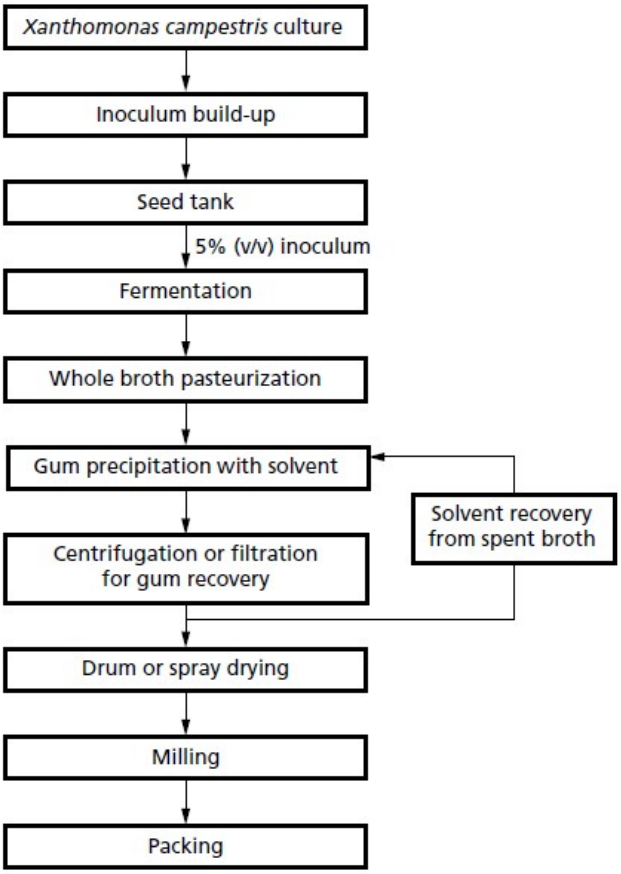

Figure 2: Production of xanthan gum by fed batch fermentation

Advantages:

1. Xanthan gum use fantastic thickening, suspending, and stabilising ingredient for many products.
2. Many foods can benefit from using xanthan gum by having better texture, consistency, flavour, shelf life, and appearance.
3. Additionally, it stabilises food, enabling some meals to survive a range of temperatures and pH levels.
4. It keeps meals from separating and enables them to easily flow out of their containers.
5. Since it can replicate the flexibility and fluffiness that gluten lends to typical baked products, it is widely employed in gluten-free cuisine.

Applications of xanthan gum:

1. **In food products-** Many foods benefit from xanthan gum in terms of texture, consistency, flavour, shelf life, and appearance. It also keeps meals from separating and allows them to flow freely out of their containers. It's commonly used in gluten-free baking because it may provide the flexibility and fluffiness that gluten does. It also stabilises meals, allowing them to survive varying temperatures and pH levels. Ex. Toothpaste, Creams, Lotions, Shampoo [21].
2. **In industrial products-** Due to its capacity to resist a range of temperatures and pH levels, adhere to surfaces, and thicken liquids while maintaining good flow, xanthan gum is employed in many industrial goods. Ex. Fungicides, herbicides and insecticides Tile, grout, oven and toilet bowl cleaners Paints etc [21,22].

Resin

A solid or semi-solid substance that is often a complex combination of terpenes, which are chemical molecules that are soluble in certain organic solvents but insoluble in water. Resins are generally fluid materials that undergo curing to become stiff polymers [23]. Despite their natural occurrence, resins are now frequently created synthetically. While many synthetic resins are substantially different from natural plant resins, some share characteristics with them.

Types of Resin

Resin is of two types:

1. Natural resin
2. Synthetic resin

1. **Natural resin:** These resins have a natural origin. They come from natural sources. They mostly come from the plants. It is referred to as plant resin as a result. It can be isolated by the entire plant, a specific portion, or plants that have been cut or injured may emit it. Rarely, an animal will provide some natural resin. Plants like Benzoin, ginger, podophyllum, asafoetida, and capsicum are examples of sources for resin. Shellac or lac, fossils, and other animal products are examples of materials from which resin can be made [24].
2. **Synthetic Resin:** In the industry, these kinds of resin are manufactured. The stiff polymer is cured to create synthetic resins. They include reactive end groups like epoxides or acrylates, which cause them to cure. It can be of different kinds: Epoxy Resins, Casting Resins, Epoxy Resins, Ion exchange Resins, Acetal Resins, Acrylic glass etc [25].

Applications of resin

1. **Paints and coatings**: Due to its great qualities, such as ease of production, high safety, good solvent and chemical resistance, toughness, minimal shrinkage upon curing, mechanical and corrosion resistance, and excellent adhesion to a variety of substrates, heavy-duty anticorrosion coatings are utilised extensively [25].
2. **Unsaturated polyester**: Given the variety of unsaturated polyester resins that are manufactured, considerable thought should be given to the selection of coatings, taking into account factors like the necessity for no heat for a full reaction and the absence of a soap reaction in the presence of alkalis like concrete.
3. **Water purification & Water treatment chemicals**: Resin beads are used to treat water for ion exchange. Ion exchange is really a method of water treatment that is frequently used for demineralization or water softening, but it is also employed in processes like dealkalization, deionization, and disinfection to remove specific impurities from water [26].

Conclusion:

Gum and resins are used in pharmaceutical applications because they are convenient, affordable, non-toxic, chemically modifiable, possibly biodegradable, and, with a few exceptions, also biocompatible. The majority of research on natural polymers used in medication delivery systems is focused on polysaccharides.

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About Editors

Dr. Surendra S. Kadam, with an M.Sc. and Ph.D. in Zoology, is Vice Principal at Gokhale Education Society's Arts, Commerce, and Science College in Jawahar, Palghar District, Maharashtra. He has 25 years of teaching and 20 years of research experience, during which he has published extensively in national and international journals. Dr. Kadam has presented his work at numerous conferences and participated in various training programs and workshops. He has completed several research projects funded by the University Grants Commission, the Ministry of Forest and Environment, and the University of Mumbai. As a registered PhD guide in Zoology at Mumbai University, he supervises five PhD students. His research interests include phytoplankton ecology, zooplankton vertical migration, marine benthic fauna, mangrove diversity, and marine conservation. Dr. Kadam is a life member of the Odisha Environmental Society, Indian Science Congress, Bangalore Society of India, Bombay Natural History Society, and the Society of Biological Chemists.

Dr. Alok Ranjan Sahu is an Assistant Professor in Botany at Vikash Degree College, Bargarh, Odisha. He holds an M.Sc., M.Phil. in Life Science, and a Ph.D. in Biotechnology from the School of Life Sciences, Sambalpur University, Odisha, India. Dr. Sahu has published over 52 research papers in national and international journals and books and has obtained five national patents. He is the sole author of two books and co-author of five others. A Fellow and Life Member of six prestigious academic societies, Dr. Sahu also serves as a reviewer and editorial board member for over 32 national and international journals. His accolades include the Research Excellence Award (2023), Academic Excellence Award (2022), Young Achiever Award (2022), Outstanding Scientist Award (2022), Best Faculty Award (2021), Young Plant Breeder Award (2021), Best Researcher Award (2020), Young Scientist Award (2014), and Best Poster Presentation Award (2013). His research focuses on plant molecular biology, genome mapping, medicinal plant conservation, and natural products and therapeutics.

Mr. Bhuvaneshwaran T is currently pursuing a PhD in Fish Nutrition and Feed Technology from ICAR - Central Institute of Fisheries Education, Mumbai. He has demonstrated exceptional academic prowess, qualifying for the ICAR JRF (AIR 5) in 2021, ASRB NET in 2023, and ICAR PhD in 2024. His dedication to his field is evident from his receipt of 10 gold medals for securing university first rank and being the best outgoing student in B.F.Sc. Mr. Bhuvaneshwaran has been recognized for his contributions at a national level, receiving the best oral presentation award and publishing numerous review papers and popular articles in reputed journals. He firmly believes that hard work leads to success and aims to provide valuable insights through his work, making it an asset for those who are committed to diligence and perseverance.

Dr. Shrikant Verma is currently working in the Department of Personalized and Molecular Medicine, at Era University, Lucknow, U.P. His area of specialization include Molecular Biology, Infectious Diseases, Genome Analysis, and Pharmacogenomics all culminating in Personalized Medicine. He has more than 4 years of working Research Experience. In a recent 3rd International Conference, Mr. Verma was bestowed Young Scientist Award organized by the Indian Society of Personalized Medicine. He is the Life Member of several Scientific Societies. Mr. Verma has published more than 30 Research Papers, Reviews, Books, and several Book Chapters in journals of repute. Currently, he is pursuing translational research taking into consideration recently launched pharmacogenomics approach infusing into modern medical practices, especially in the Indian population, to bring the concept of Personalized Medicine from Laboratory to bed in clinical setup.

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